MSc "Hydrocarbon Exploration and Exploitation"

Natural Gas Networks in Greece: The present and the prospects of the future

by

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Abstract

The current thesis refers to natural gas as a significant component of the energy landscape in Greece, the dynamics of which give impetus to developments in the process of decarbonization of the country creating prospects for energy security in the European market. In the first chapter reference is made to the historical route starting from the 9th BC in China and 17th century in England, the origin and use of natural gas, its reserves as well as a comprehensive description of its basic characteristics and properties. The second chapter refers to the national legislative, regulatory and development framework for the transmission and distribution of natural gas in Greece. In the same chapter reference is made to the Regulatory Authority for Energy (RAE), the National Gas Transmission System Operator (DESFA) the Public Gas Corporation (DEPA) and the National Natural Gas System (ESFA). The mapping of the National Gas Transmission System and the development program of ESFA complete the chapter. In the third chapter reference is made both to the existing infrastructure and to the future gas projects, with the description of the new pipelines, the independent systems and the projects of common interest. The Trans Adriatic Pipeline, the Greece-Bulgaria Interconnector Pipeline (IGB), the Eastern Mediterranean Pipeline (EastMed) and the Greece-Italy POSEIDON Interconnector Pipeline are described in the same chapter. Chapter 3 concludes with a list of the risks and hazards of the gas transmission and distribution system and the safety measures of facilities to avoid them. The fourth chapter refers to the development program of EDATHESS, detailing the network expansion plan in various areas of its area of responsibility during the period 2021-2025. In the fifth chapter reference is made to Liquefied Natural Gas with a listing of the respective Terminals both in operation in Revithousa and the upcoming one in Alexandroupolis as well as the Independent natural gas system "Dioriga Gas". Chapter 5 concludes with an analysis of the role of these Terminals in the energy security of the European market. The sixth and the last chapter (conclusions) describe the latest developments in the treatment of natural gas by mixing hydrogen or biomethane in the natural gas networks to a new improved and more environmentally friendly form of natural gas, an innovation whose implementation will be an additional measure of transition in a low carbon economy. Low-carbon gas technologies could play a major role in the low-carbon transition.

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Acronyms and Abbreviations

ACER	European Union Agency for the Cooperation of Energy Regulators
ASFA	Independent Natural Gas System
BCM	Billion Cubic Meters
BEH	Bulgarian Energy Holding
CEF	Connecting Europe Facility
CHP	Combined Heat and Power
DEDA	Public Gas Distribution Network Corporation
DEPA	Public Gas Corporation
DESFA	Hellenic Gas Transmission System Operator
DSO	Distribution System Operator
EDA ATTIKIS	Attiki Natural Gas Distribution Company
EDA THESS	EDA THESSALONIKI-THESSALIA S.A.
EPA	Ga Supply Company
ESFA	National Natural Gas System
FJO	Final Joint Opinion
FSRU	Floating Storage and Regasification Unit
HRADF	Hellenic Republic Asset Development Fund
IEA	International Energy Agency
IGA	Intergovernmental Agreement
IGB	Gas Interconnector Greece-Bulgaria
IGNM	Interconnector Gas Pipeline Greece-North Macedonia
IGI	Greece-Italy Interconnector Gas Pipeline
IPCEI	Important Projects of Common European Interest
INGS	Independent Natural Gas System
ITGI	Interconnector Turkey-Greece-Italy
LNG	Liquified Natural Gas
LPG	Liquified Petroleum Gas
NGS	Natural Gas Liquids
OLPA	Patras Port Authority
PCI	Project of Common Interest
P2G	Power to Gas
PPC	Public Power Corporation
RAE	Regulatory Authority for Energy
RES	Renewable Energy Sources
SCADA	Supervisory Control and Data Acquisition
SOCAR	State Oil Company of the Azerbaijan Republic
SSLNG	Small Scale LNG
TANAP	Trans Anatolian Natural Gas Pipeline Project
TAP	Trans Adriatic Pipeline
TCM	Trillion Cubic Meters
TSO	Transmission System Operator
TYNDP	Ten Year Network Development Plan
UGS	Underground Storage Facility for Natural Gas

CHAPTER 1. NATURAL GAS

1.1 Historical background

Natural gas, although unknown in Europe until 1659, when it was discovered in England, was used in China, transported by bamboo pipelines from 900 BC. Natural gas from coal distillation began to be used in 1790, due to its ease of transport and storage and use in internal combustion engines and street lighting. In the early 1800s natural gas was used for cities lighting, with the first gas pipelines being installed, while in 1821 its first commercial use was made in North America, in Fredonia, New York, with the use of gas for lighting, originating from a New York field. Between 1820 and 1850, large companies in London and Baltimore set up extensive gas distribution networks and from 1880 to 1920 gas was used in the US steel industry, where new fields from the early 1900s led to the formation of large production - distribution companies with long distance transmission pipelines. (Heron.gr, 2021)

In 1944-1950 there was a huge construction development with the length of the gas transmission pipelines exceeding that of oil. In 1950 gas covered 12% of world energy consumption, rising to 14.6% in 1960 and 25% in 1980. In 1960, world gas production amounted to 470 billion cubic meters (bcm), which increased to 1459 trillion cubic meters in 1979. Intercontinental trade in LNG begins in 1964 and the following year begins to spread gas outside the United States. Since 1970, the large number of new fields around the world, combined with the construction of large pipelines, have led to the widespread use of natural gas in developed countries. According to the International Energy Agency (IEA) in 2030 natural gas will be cover a quarter of global energy demand. (Wikipedia.org, 2020)

Image 1: Construction of natural gas pipeline by Northwestern Utilities Company Limited in Canada, 1923

Source: (Aboutpipelines.com, n.d.)

From gas lighting to natural gas

From the supply of the networks of Athens for its lighting with gas lighting, which even before the founding of the Greek gas energy company, mediated by modern requirements and technological development, natural gas enters dynamically in consumption at the end of the 20th century.

- In 1857 the gas lighting factory starts in Gazi.
- In 1887 Giovanni Baptista Serpieri becames the director of the factory and the use of gas was extended to homes and factories.
- In 1897 the production of gas lighting begins in a factory in Gazi with the raw material coal.
- In 1938 the company is called the Municipal Gas Lighting Exploitation of Athens.
- In 1952 the Municipal Gas Lighting Company of Athens is created.
- In 1985 the operation of the gas lighting plant stopped, and the production of naphtha gas begins in the Public Refineries of Aspropyrgos. (Edaattikis.gr, n.d.)

In Greece, since the 1990s, agreements have been signed for the supply of natural gas to the country.

- In 1987 a Transnational Agreement on the Supply of Natural Gas with the Soviet Union is signed.

- The following are agreements of the Public Oil Company with the Russian Sojuzgazexport, the current Gazprom-Export and the Algerian Sonatrach. In February 1988, with the signing of the first transnational agreement between Greece and Algeria, the supply of Greece with Liquefied Natural Gas (LNG) was secured.
- In September 1988, DEPA (Public Gas Corporation) signed the first agreement concerning the construction of the 512km long gas pipeline from the Greek-Bulgarian border to Athens.
- In 1994, a very crucial for the subsequent development in the natural gas sector takes place, the signing of a Natural Gas Sale Agreement by DEPA and PPC (Public Power Corporation).
- In 1995 the road is opened and the framework for the establishment of regional Natural Gas Distribution Companies, the Distribution Companies of Attica, Thessaloniki, Thessaly, and the establishment of the Gas Supply Companies SA with the participation of private investors and DEPA is launched. A key achievement that shaped the framework is the enactment of a law (N.2364) on the import, transport, trade and distribution of natural gas.
- In 1996, natural gas is imported and tested in the natural gas pipeline from the Greek-Bulgarian border to Attica, the construction of which was completed at the beginning of the same year.
- In November of 1996 Hellenic Sugar Industry in Larissa was connected, which was the first consumer of natural gas in Greece. (Edaattikis.gr, n.d.)
- At the beginning of the third millennium, in 2000 the installation of temporary storage and gasification of Liquefied Natural Gas (LNG) in Revithousa is completed and the imports of LNG from Algeria begins.
- In the same year (2000), the first two Gas Supply Companies (EPA) are established in Thessaloniki and Thessaly, following an international tender for the selection of private investors. DEPA participates in the share capital of the two by 51% and by 49% and with the responsibility of managing a private investor.
- In 2001, after an international tender for the selection of private investors, the third Natural Gas Supply Company (EPA) was established in Attica.
- In 2003, the way is opened for the supply of natural gas from Turkey with the signing of a transnational agreement between Greece and Turkey, with the

construction of the respective interconnector of the natural gas pipeline starting in 2005.

- In 2005 the legal separation and the functional independence of the two DEPA Companies and its subsidiary DESFA SA (Hellenic Gas Transmission System Operator) is carried out by secondment from DEPA of the National Natural Gas System branch. The provision of the two companies was made by the law N. 3428, passed in the same year, on the liberalization of the natural gas market.
- In November 2005, the commitment of Italy and Greece is achieved in support of the connection project of the Greek and Italian natural gas network IGI (Greece - Italy Interconnector Gas Pipeline) with the signing of the respective Transnational Agreement.
- In 2007, the company DESFA is established as a 100% subsidiary of DEPA, in accordance with the provisions of Law 3428/2005, which will be the administrator of the National Natural Gas System (ESFA) and the system of Transmission and Installation of Liquefied Natural Gas.
- In July of the same year (2007) Greece, Turkey and Italy commit themselves for the timely implementation of the Interconnector Turkey-Greece-Italy (ITGI) pipeline with the signing of a Transnational Agreement of the three countries.
- In August 2007, the signing of a Memorandum of Cooperation between Greece and Azerbaijan laid the basis for the upcoming gas supply agreements to Greece and Italy through the IGI pipeline.
- In November 2007 gas was imported through the Greece-Turkey Natural Gas Interconnector. (Edaattikis.gr, n.d.)
- In June 2008 the Greece-Italy offshore gas pipeline company (ITGI Poseidon S.A.) was incorporated.
- In 2009 the foundations are laid for the implementation of part of the IGI Pipeline to Bulgaria, of the Interconnection Pipeline Greece - Bulgaria IGB, with the signing of a Memorandum of Cooperation of DEPA SA. - Edison S.p.A - Bulgarian Energy Holding EAD (BEH EAD).
- In 2010, agreement was signed between ITGI Poseidon S.A. and Bulgarian Energy Holding (BEH) for the realization of the Greece-Bulgaria Interconnector following the previous signing of a Memorandum of Cooperation between respective parties.

- In 2011 the liberalization of the natural gas market is strengthened, with the enactment of the energy law N. 4001/2011 (Government Gazette A 179) to replace Law 3428/2005 and the incorporation of the Third Energy Package of the provisions 2009/73 / EU.
- In 2012, an Attica-Evia submarine pipeline and a medium and low-pressure network installed to supply the region of Evia. The same year the first Electronic Gas Auction takes place.
- In 2013, FISIKON, the natural gas for vehicles in the Greek market, is premiered by DEPA and an agreement is signed with SOCAR (State Oil Company of the Azerbaijan Republic), the state-owned Azeri company for the supply of natural gas from the Shah Deniz 2 field.
- In 2014, the reduction of the gas supply price is foreseen with the signing of an agreement with GAZPROM EXPORT. The technical specifications for the establishment and operation of gas stations are defined and a decision was taken to to convert vehicles into dual fuel with CNG gas.
- In 2015, the final decision for the construction of a Greek-Bulgarian Interconnected Gas Pipeline is taken by the shareholders of ICGB AD (Gas Interconnector Greece-Bulgaria), Bulgarian Energy Holding (BEH) by 50% and IGI POSEIDON by 50%, which is a partnership between DEPA and EDISON). In the same year, an amendment to Law 4001/2011 was voted, according to which the consumers of natural gas are given the opportunity to choose a supplier, while at the same time the distribution and marketing of EPA Attica is separated.
- In 2016, Law 4414/2016 is passed on the operational and legal separation of gas distribution and supply sectors.
- In 2017, for the construction, expansion and activation of networks and services in Greece except Thessaloniki, Thessaly and Attica, the Distribution Company of Other Greece is established, a 100% subsidiary of DEPA.

(Depa.gr, n.d.) (Tosios, 2012)

1.2 Chemical composition - Properties of Natural Gas

Natural gas, the natural product belonging to the mineral gaseous hydrocarbons and is found in underground deposits, is a gaseous mixture of hydrocarbons, consisting mainly of 85% or more of methane (CH_4), propane (C_3H_3), ethane (C_2H_6), butane

(C_2H_{10}) and pentane (H_5H_{12}) in lower concentrations and small amounts of carbon dioxide (CO_2), nitrogen (N_2) and hydrogen sulfide (H_2S).

The composition of the gas varies depending on its source, depending on the origin of the type of organic matter from which it was formed. (Economy.com.gr, n.d.) (Gastrade.gr, n.d.)

The composition of natural gas varies depending on its source and it differs from field to field. However, methane is a thermodynamically stable compound, even at temperatures of 500^{o}C or more and is the most common as it occupies the highest percentage in the composition of natural gas. (Hyne, 2012) (Bjørlykke, 2010)

The specifications of the natural gas are given in the following table:

Table 1: Composition of natural gas

Methane (CH_4)	Min 85%
Ethane (C_2H_6)	Max 8,6%
Propane (C_3H_8)	Max 3%
Butane	Max 2%
Pentane and other hydrocarbons	Max 1%
Nitrogen(N_2)	Max 5%
Carbon dioxide (CO_2)	Max 3%

Source: (Economy.com.gr, n.d.)

Natural gas depending on the presence of other hydrocarbons other than methane, or not, is divided into liquefied natural gas and dry natural gas respectively. With a relative density of 0.55 it is lighter than air and this property in case of leakage causes it to escape and diffuse into the atmosphere.

Table 2: Typical Gas Composition

Chemical composition of natural gas (mole %)	Russian natural gas	Algerian natural gas
Methane(CH_4)	98	91,2
Ethane (C_2H_6)	0.6	6,5
Propane (C_3H_8)	0.2	1,1
Butane (C_4H_{10})	0.2	0,2
Pentane (C_5H_{12})	0.1	
Nitrogen(N_2)	0.8	1.0
Carbon dioxide (CO_2)	0.1	

Source: (EDA THESS, n.d.)

- Higher Calorific value of Russian natural gas: from 8,600 kcal / Nm^3 to 9,500 kcal / Nm^3
- Higher Calorific value of Algerian natural gas: from 9,640 kcal / Nm^3 to 10,650 kcal / Nm^3 (Edathess.gr, n.d.)

Properties

Natural gas is light, colorless, odorless and non-toxic. The characteristic odor, which makes it detectable in case of leakage, is given by aromatic substances with which it is enriched after production. Its property to be lighter than air, with a relative density of 0.55 makes it non-hazardous in case of escape, where rising to a high altitude diffuses, dilutes and escapes directly into the atmosphere. The limits of explosion of natural gas are 4.5% -15%, with it impossible to maintain combustion beyond these limits. Its composition makes it the fuel with the lowest emission of pollutants among conventional fuels, while the absence of carbon monoxide and sulfur compounds makes it non-toxic and environmentally friendly. The volume of one cubic meter of natural gas in the "normal" state is a "normal cubic meter" of gas, with the "normal" state where the temperature is 0 °C and the temperature is 1.01325 bar. The higher calorific value of natural gas ranges from 9,000 to 11,000 Kcal / Nm^3 and its explosion limits are 4.5% - 15%.

The three statutory quantities, in relation to equilibrium interdependence, are what characterize natural gas:

- Absolute Pressure p (Force per unit area) as a sum of overpressure and atmospheric Pressure
- Absolute density ρ varies according to its composition and
- Absolute Temperature T

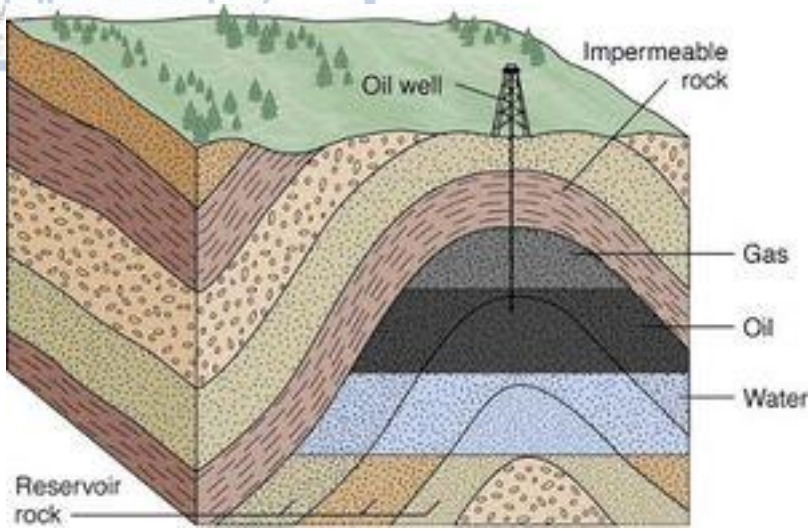
These are related to each other by the equation p = ZρRT where R is a specific constant of natural gas varying according to its composition and Z is the coefficient of compression or real gas with a valid value Z = 1 (Gastrade.gr, n.d.)

The higher calorific value of natural gas, defined as the energy released during the combustion of one Nm^3 of natural gas when the water in the combustion products is in a liquid state, is not constant but depends on the composition of the natural gas, with an average value of 11,5 KWh / Nm^3. The price of higher calorific value is in accordance with the measurements implemented at the gas receiving stations, calculated every month by DEPA. The lower calorific value defined as the energy released during the combustion of one Nm^3 of natural gas when the water in the combustion products is in a gaseous state, is 10% lower than the higher calorific value, with an average value of 10.4 KWh / Nm^3. (Edaattikis.gr, n.d.)

1.3 Origin - Formation & Drilling of Natural Gas

Large quantities of organic matter submerged due to geological subsidence on the earth millions of years ago formed rocks. The firing of a series of chemical processes as a result of the development of high temperatures and high pressures, mobilized the conversion of organic matter into hydrocarbons, which absorbed by porous rocks created the deposits. The gaseous part of the hydrocarbons for millions of years shows an upward course separated from the heavier liquid part (oil) and trapped in special subsoil structures, forms the gas cavities, which meet the specifications of porous rocks (sand, sand) covered by impermeable rocks ("cap rocks") which are found in certain areas and certain sizes. (Edathess.gr, n.d) (Deda.gr, n.d.)

Image 2: Natural Gas Formation



Source: (Energyeducation.ca, 2019)

The thermal decomposition primary organic matter which has high molecular weight from organic land or sea sediments, under conditions of high pressure and temperature and depths of many kilometers, forms the thermogenic methane, the raw material of natural gas which, trapped in impermeable geological formations, creates deposits. (Sciencealpha.com, 2019)

Formed by microscopic organisms, they create biogenic methane, trapped in subsoil near the earth's surface. Abiogenic processes at great depths of the subsoil between hydrogen-rich gases and carbon compounds and their interaction with subsoil minerals in the absence of oxygen are the third way to create natural gas. (Repository.kallipos.gr, n.d.) (Gastrade.gr, n.d.)

Drilling

Trapped in geological formations consisting of layers of porous sedimentary rock, quantities of natural gas are mined by drillings that create wells. Gas extraction is often an ancillary function of oil extraction because it is quite often in the same deposits as it is. The extraction is followed by desulphurization processes, filtration processes, removal of heavier hydrocarbons, removal of moisture and compression or liquefaction and its transfer to the gaseous state by high pressure pipelines and in liquid form by ships.

Natural gas deposits also contain natural gas liquids (NGL) which are heavier hydrocarbons collected during the extraction process. (Repository.kallipos.gr, n.d.) (Wikipedia.org, 2020)

1.4 Natural Gas Uses

Natural gas is either a primary fuel as a raw material of the chemical industry and used for heat production and direct restoration of electricity (residential uses, commercial uses and industrial processes) or secondary to the production of electricity by thermal power plants.

Natural gas by substituting liquid conventional fuels and having as main advantages the increased degree of efficiency during its combustion which in well-maintained facilities reaches 94% achieving energy savings and reduced gaseous pollutants, is an energy source that meets modern environmental needs. Being 20% cheaper than oil and with a less time-consuming supply and distribution process, it is an economical and more environmentally friendly fuel. The determination of its price in Attica, for example, is formed every two months and depends on the price of heating oil and specifically on the average price according to the freely formed refinery price according to the notifications of the Ministry of Development. (Cres.gr, n.d.)

Residential use

- Central heating
- Autonomous heating
- Cooking
- Hot water
- Air conditioning

In Greece, according to legislation, all new buildings under construction will be intended for natural gas supply. In modern appliances, "condensing boilers" are highly efficient, while boilers, water heaters and radiators with "closed combustion chambers", characterized by flexibility of installation and safety of operation, are options that make natural gas a very good choice for residential use. (Edathess.gr, n.d.)

Commercial use

- Technological equipment
- Heating

- Air conditioning
- Cogeneration

Occupational spaces such as hospitals, hotels, educational institutions, sports and cultural centers, shopping malls, large office buildings and recreation areas, use natural gas to take advantage of reduced maintenance needs, and operating costs, lack of preoccupation with fuel orders and receipts, increased cleanliness of premises and appliances, higher efficiency, and possibility of exploiting storage spaces (tanks). (Edathess.gr, n.d.)

Natural gas in the industrial sector

Natural gas as a raw material in industry, which accounts for 67% of world natural gas consumption, is used to produce products such as fertilizers, plastics, polyolefins and methanol in the industries of cement, metals, glass, metal constructions, building materials, electrical appliances. The following characteristics of natural gas create a positive sign for its use in the industrial sector.

- Increased energy efficiency and economy
- The ease of control and handling
- Energy saving
- Reduced operating maintenance and management costs.
- Reduced pollutant emissions resulting in reduced environmental pollution.
- The accuracy of payments based on meter readings.
- Reduced equipment maintenance due to minimal waste.
- Coverage of refrigeration needs
- The possibility of continuous and uninterrupted fuel supply that leads to uninterrupted operation without the need for storage space.
- Payment after consumption

Industrial applications of Natural Gas

- Industrial Cogeneration of Electricity and Heat: The operation of cogeneration systems of electricity, heat and combined heating, cooling and gas power with natural gas, is a very beneficial choice for the industry. In the production of electricity using natural gas, excess steam and heat are used in other industrial applications.

- Industrial Combined Combustion: The use of natural gas as a complementary fuel to the combustion of other fuels such as biomass and coal

and in:

- Coverage of thermal needs of all production processes
- Cogeneration of electricity and heat
- Meeting refrigeration needs

(Repository.kallipos.gr, n.d.) (Edathess.gr, n.d.) (Wikipedia.org, 2020)

Public sector

The great potential for energy improvement of the approximately 200,000 public buildings in Greece, which were captured in studies, led to the issuance by the State of Ministerial Decision D5-EL/B/RES.16954 (Government Gazette B '1343 / 26.09.2005) where, among others it was decided to connect the buildings of the Public Sector, the Local Government and the Supervised Bodies with the natural gas network to replace the use of heating oil. (Edathess.gr, 2021)

The use in power plants as a fuel, in industry replacing liquid conventional fuels (oil, diesel, fuel oil) for the production of thermal energy in boilers, ovens, furnaces, etc. in commercial activities (hotel facilities, mass catering, etc.) in homes and in vehicles whose engines produce 80% less nitrogen oxides and hydrocarbons and 50% less carbon monoxide than diesel engines. (Gastrade.gr, n.d.)

Its two major advantages, the increased efficiency of combustion, up to 94% in well-maintained facilities with consequent energy savings and the lower emissions that result, make its use as the best choice. This is aided by the accessibility of supply and distribution, the 20% lower cost compared to oil.

In shipping, on commercial and passenger ships, the use of natural gas in its liquefied form has gradually begun.

In the floating unit of ASFA in Alexandroupoli the liquefied natural gas will be used as fuel for own consumption in service of power plant and gasification. (Cres.gr, n.d.)

1.5 Advantages of Natural Gas

Natural gas, being a fuel with a dynamic role in the European energy environment of decarbonization, is adapting to the new market data, implementing necessary changes with the help of technological, environmental, economic, commercial and regulatory factors. Factors that enhance the position of natural gas in the energy landscape are:

- The environmental and energy characteristics of natural gas which make it the best and most efficient fuel choice.
- Its significant reserves can cover the demand for the next 70-80 years.
- The continuous abolition of market pricing mechanisms in force in oil (indexed price mechanisms) and the introduction of market pricing mechanisms (hub-indexed price mechanisms) which changed the trading and pricing data of gas, creating favorable conditions for this.
- The launch of LNG exports on flexible terms and the technological revolution in shale gas in the United States have greatly strengthened the role of natural gas.
- The reduction of costs along the gas chain due to technological achievements (horizontal drilling, technology for shale gas extraction, deep water extraction, digital deposit detection technologies, etc.) leading to a reduction in natural gas prices, making it a good choice.
- All technological advances along the LNG production chain have established gas in both traditional and new markets, creating a global gas market (Floating Liquefaction Plants - FLNGs- Floating Storage and Re-gasification Units - FSRUs) (Energia.gr, 2019)

The use of natural gas

Due to its characteristics and properties, natural gas is a fuel:

- Easy to use and immediately available in areas without storage tanks and orders.
- Economical with higher combustion efficiency and lower maintenance costs (50% cheaper energy compared to electricity) natural gas is the best long-term energy investment and the most economical option.
- Safe with guarantees of highest levels of safety European specifications of Technical Regulation. Natural gas is a completely natural product lighter than air, a

feature that in case of its release into the air, is removed immediately. Moreover, the facilities and the construction projects of the natural gas network are safe. (Edaattikis.gr, n.d)

- With longer service life of the appliances, due to non-production of ash during its combustion, which is achieved with proper operation and regular maintenance.
- Distributed and transported by pipeline networks and is direct and easy to use such as water supply.
- Better manageable with direct knowledge of the amount of natural gas consumed by recording the meter.
- Practical fuel using new type devices.
- Ecological and environmentally friendly fuel without residues or sulfur compounds produced (does not emit soot and hydrocarbons) (Edathess.gr, n.d)

The natural gas produces the least carbon dioxide compared to other conventional fuels, does not contain sulfur compounds. Consequently, does not emit soot and air particles. (Edaattikis.gr, n.d.)

The combustion of natural gas is clean, contributing to environmental protection. The pollutants emitted during combustion are lower than other conventional fuels.

The following table shows the emitted pollutants from the combustion of natural gas compared with other fuels. (g of pollutant per kWh of imported fuel heat)

Table 3: Emitted pollutants per fuel category

Fuel type	Carbon dioxide	Sulfur dioxide	Carbon monoxide	Nitrogen oxide	HC	Particles
Low sulfur fuel oil	260	1,147	0,046	0,0439	0,02	0,15
Heating oil	249	0,056	0,045	0,189	0,02	0,023
Diesel	244	0,054	0,044	0,185	0,02	0,022
LPG	227	0	0,025	0,157	0,01	0,007
Natural Gas	177	0	0,022	0,137	0,01	0,007

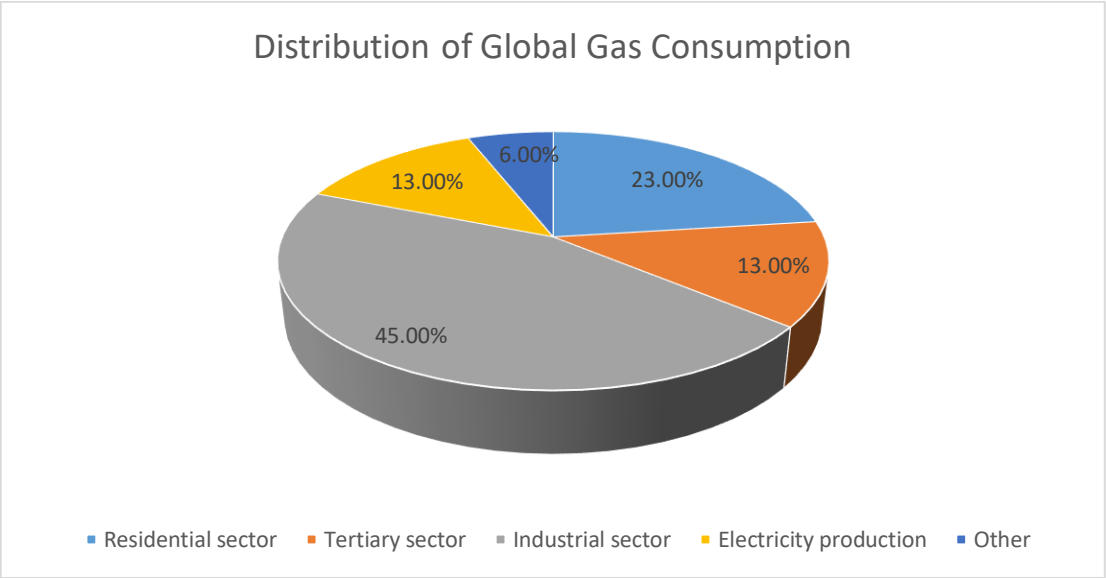
Source: (EDA ATTIKIS, n.d.)

1.6 Natural Gas Reserves

In the 1960s, global gas handling was around 29 billion cubic meters per year, with the energy crisis of the 1970s changing the global energy landscape with the development of pipelines and gas transport ships in the context of a long-distance transmission network from the export points. In the early 1980s, gas transactions amounted to 180 billion cubic meters annually, making it the fastest growing primary form of energy, whose consumption reached 2.400 billion cubic meters in 1999 covering 23% of global energy demand. (Aeriodynamiki.gr, n.d.)

Global gas consumption is divided into four main sectors. The residential sector holds 23%, the tertiary sector 13% and the industrial sector 45%, a particularly high percentage. Finally, electricity production holds 13%.

Chart 1: Distribution of Global Gas Consumption



Gas has been found to exist in large reserves that are sufficient for the next hundred years in countries such as Algeria, Iran, Iraq, Qatar, Russia, Nigeria, the United States and others. (Edaattikis.gr, n.d.)

Gas reserves amount to 6,798.3 trillion cubic feet or 185.7 trillion cubic meters (tcm) with Russia holding about 18.1% of the world's proven natural gas reserves, according to BP 'Statistical Review of World Energy 2018's, with 35 tcm and Iran to follow with 33.2 tcm. Qatar, a leader in the LNG sector is in third place with 24.9 tcm as we observe in the following table. (Energia.gr, 2018)

The Middle East is the region with 79.1 tcm of gas reserves worldwide, while Europe with 3 tcm reserves is ranked last in the world. (Edathess.gr, n.d.)

Table 4: Total proven reserves by country

Total proven reserves by country	**Trillion cubic meters (tcm)**
Russia	35
Iran	33,2
Qatar	9,24
Turkmenistan	19,5
USA	8,7
Saudi Arabia	8
Venezuela	6,4
United Arab Emirates	5,9
China	5,5
Iraq	3,5

Source: (Energia.gr, 2018)

In gas production, as we see in the following table, the US with 734.5 billion cubic meters (bcm) in 2017, which corresponds to 20% of world gas production worldwide, has been the leader of world production since 2009 and is ranked first in gas consumption since 1985.

According to the BP report, the sufficiency of global gas reserves for world production covers a period of 52.6 years.

Table 5: Natural gas production by country

Natural gas production by country	**Billion cubic meters (bcm)**
USA	734,5
Russia	635,6
Iran	223,9
Canada	176,4
Qatar	175,7
China	149,2
Norway	123,2
Australia	113,5
Saudi Arabia	111,4
Algeria	91,2

Source: (Energia.gr, 2018)

CHAPTER 2. NATURAL GAS IN GREECE

2.1 National Natural Gas Transmission System

With the National Natural Gas Transmission System, natural gas is transported from the Greek-Turkish border under the management of BOTAS, from the Greek-Bulgarian border under the management of BULGARTRANSGAZ and from the Liquefied Natural Gas Terminal (LNG) of Revithousa to consumers in continental Greece.

Image 3: National Natural Gas Transmission System

Source: (DESFA, n.d.)

The National Natural Gas Transmission System consists of:

- The main gas transmission pipeline with a total length of 512 km, diameter 36 " and 30 " and design pressure of 70 barg extending from Promachonas to Attica and the branches of 953.2 km, which supply a range of areas extending from East Macedonia to Corinth.
- The Natural Gas Metering and Regulating Stations
- The Border Metering Station at Sidirokastro
- The Border Metering Station at Kipoi, near Evros
- The Compression station in Nea Mesimvria, Thessaloniki, at the point where the diameter of the pipeline changes from 36 " to 30 " whose operation began in 2012
- The Natural Gas Control and Dispatching Centers, in the facilities of the Operation and Maintenance Center of the Southern Sector (Patima Magoulas) with a backup Control and Maintenance Center of the Northern Sector (Nea Mesimvria, Thessaloniki).
- The Operating and Maintenance Centers of the Metering Station are at:
    - Sidirokastro Border, in the Municipality of Sindiki, center of responsibility of 30 km high pressure pipeline with diameter 36 " and 70 km high pressure pipeline with diameter 24".
    - Eastern Greece, at the 2nd km of Diomidia-Lefki at a distance of 5km from Xanthi, under the responsibility of which there are 87 km high pressure pipelines with diameter 36 "and 145 km with diameter 24"
    - Northern Greece, in Nea Mesimvria, Thessaloniki, with an area of responsibility of 38 km, 92 km, 32 km, and 13 km, with variation in the diameter of the high-pressure pipeline
    - Central Greece, in Ampelia Farsala, with an area of responsibility for a pipeline 206 km long, 40 km long and 72 km long high-pressure diameters from 10 " to 30 ".
    - Southern Greece in Patima Elefsina in Attica with a pipeline liability area of 212 km, 12 km, 127 km, 20 km, 3 km and 6.5 km high pressure diameters from 6 "to 30".
    - Peloponnese, in Spathovouni, Corinth, with an area of responsibility extending from the island of Revithousa up to PPC Megalopoli Metering

Station and 68 km high-pressure pipelines with diameter 30 "and 156 km high-pressure pipelines with diameter 24".

- The Remote Control and Communication System with the primary goal of securing the supply of sufficient quantities from the natural gas transmission system under predictable and exceptional circumstances and with secondary objectives:
    - the television of natural gas stations.
    - the management of alarms
    - the provision of technical and statistical data

(Desfa.gr, n.d.) (Ypen.gov.gr, n.d.)

Natural Gas Distribution Network

EDA (Gas Distribution Company) in accordance with the new legal framework for the restructuring of the environment of the natural gas retail market and the separation of distribution and marketing activities, two functionally and administratively autonomous companies were created. EDA ATTIKIS as an Operator of the Natural Gas Distribution Network in Attica has been operating since January 2, 2017 based on the provisions of Law 4001/2011 on the operation of the natural gas market. Project of the sole proprietorship, in which DEPA Infrastructure SA participates 100% is the operation, maintenance and development of the Distribution Network in Attica. (Edaattikis.gr, n.d.)

DEPA Infrastructure SA established in April 2020 aims to ensure the supply of natural gas throughout the country.

Law 4336/2015 separated the distribution of natural gas - as a monopoly activity - from its supply. The consequence of this was the establishment of the following companies:

- EDA ATTIKIS, as the owner and operator of the Attica regional network (Government Gazette Sheet No. 5904, second issue, December 31, 2018)
- EDA THESSSALONIKI-THESSALIA SA, acting as operator and manager of the natural gas networks within the geographical areas of Prefecture of Thessaloniki and Region of Thessaly (merger of two operators in one company) of Government Sheet No. 5922, second issue, December 31, 2018.

- Furthermore, the above activities include the construction, maintenance, operation, management and general usage of the Natural Gas Distribution Network in the aforementioned geographical areas as defined above by the Distribution License and the Natural Gas Distribution Network Management License. (Rae.gr, n.d.)

  DEDA (Public Gas Distribution Network Corporation), as the main administrator of the Rest of Greece, except for the areas of EDA ATTIKIS and EDA THESSALONIKI-THESSALIA (Government Gazette Sheet No. 5905, second issue, December 31, 2018)

Gas Distribution Licenses have been also issued by the Regulatory Authority for Energy:

- In the company "ILIOCHORA SA" for the Municipality of Mantoudi - Limni - Agia Anna of Evia and
- In the Company "HENGAS SA" for the Municipalities of Polygyros, Deskati of Grevena, Peonia of the Regional Community of Kilkis, Edessa, Megalopolis of Corinth and Tripoli.

The distribution networks of the country, based on the operating pressure criterion are distinguished in:

- Medium pressure network, with a nominal pressure of 19.0 bar.
- Low pressure network, with nominal pressure of 0.025-4.0 bar.

The Management Code of the Natural Gas Distribution Network, issued by RAE Decision 589/2013 (Government Gazette B '487 / 20.07.2017) regulates:

- rights and obligations of the Distribution Network Operator, Distribution Network Users and End Customers connected to the Distribution Network.
- issues of operation, maintenance, and development of the Distribution Network
- terms and conditions of access of the Distribution Users to the Distribution Network and the services provided by the Network Operator.

The 1st Amendment of the Distribution Network Management Code (Government Gazette B '1507 / 02.05.2018) was carried out with the RAE Decision 298/2018.

The 2nd Amendment of the Distribution Network Management Code (Government Gazette B '3334 / 10.08.2018) was carried out with the RAE Decision 642/2018.

Gas Distribution Network Management Code

Gas Distribution Network Management Code operates in the following key areas:

- Inspection, maintenance, replacement, and upgrade of the Distribution Network
- Development - design and construction - of the Distribution Network
- Promoting the use of Natural Gas for the development of the Distribution Network and the connection of End Customers with it.
- Providing access to the use of the Distribution Network to the Distribution Users with objective criteria
- Management of emergencies, crises and responding to them. (Rae.gr, n.d.)

Distribution Network Metering Regulation, approved by the decision of RAE 235/2019 GG B '4818/2019 defines obligations and responsibilities of the Operators of the Natural Gas Distribution Networks and rights of the Users, the process of controlling the measurements.

The Tariff Regulation of the Basic Gas Distribution Activity (RAE Decision 328/2016) regulates the methodology for determining the tariffs of the Basic Distribution Activity defined in accordance with the provisions of article 88 of Law 4001/2011 of the Distribution Networks of Attica, Thessaloniki, Thessaly and the rest of Greece. (Rae.gr, n.d.). Issuance of Distribution Licenses and Distribution Network Management Licenses is defined in the Regulation of Natural Gas Licenses.

According to the published in the second issue of the Government Gazette with No. 3430, a competition is held with general and special evaluation criteria, terms and restrictions for exercising rights provided by the license, duration - renewal, modification - revocation of Licenses and other provisions on the issuance of Licenses. The granting of a license is followed by an application for certification in RAE,

according to the Ownership Separation model and then obtaining a Distribution Network Management license, according to the provisions of articles 80D-ST of Law 4001/2001, amended by Law 4602/2019 (Government Gazette A 45 / 9.3.2019).

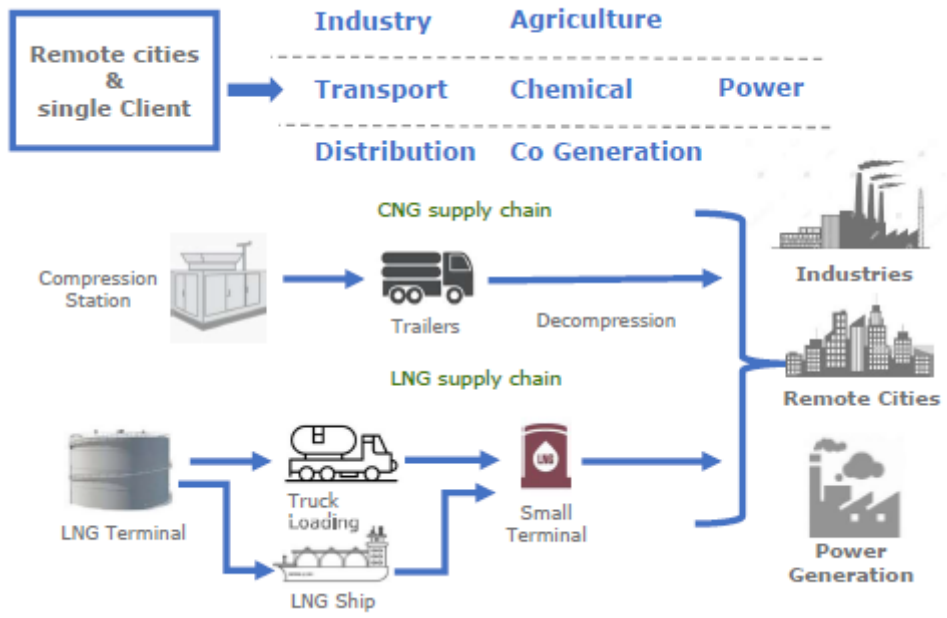
(Government Gazette No.3430: Regulation of Natural Gas Licenses, 2018)

CNG-LNG

In the remote areas in which the construction of pipeline is costly, the technologies of CNG and LNG can offer reliable solutions. With this way DSO's can provide natural gas through these technologies to remote areas where the market is inexistent. This is very important not only for residential customers in these areas but also for commercial and industrial customers. At present there are some CNG Stations in the Prefecture of Thessaloniki and in the region of Thessaly, but LNG truck loading is not an option currently, as there is no sufficient infrastructure constructed in Revithousa terminal. Both LNG and pipeline infrastructure will be critical to deliver continuous supply to end users.

The following figure shows these two technologies and how they contribute to supply customers with natural gas. CNG technology uses compression stations which compress the natural gas and then there are trucks which transport it to decompression stations which are in remote areas. So, from this point natural gas either enters the network which is constructed in this area and reaches end customers or industries supplied through network. The technology of LNG has a similar way of operation and natural gas starts from LNG terminals, transported by trucks or LNG ships to small terminals and then reaches end customers or industries.

Image 4: CNG-LNG Supply Chain



Source: Greek Energy Market, 2020

2.2 National Infrastructures and Agencies of the Natural Gas Market

- **Regulatory Authority for Energy (RAE)**

The Regulatory Authority for Energy (RAE), which supervises the domestic gas market, suggests to bodies of State, and takes measures to achieve goals for the liberalization of the gas market. It is an independent regulatory authority established by Law N. 2773/1999 and in accordance with Directives 2003/54/EC and 2003/55/EC. The responsibilities of monitoring and controlling the energy market have been assigned to RAE with the Laws: N. 2773/1999, its amendments, and the Law N. 4001/2011. (Ypen.gov.gr, n.d.)

Regulatory Framework

The Regulatory Authority for Energy is solely responsible for issuing the regulatory framework that governs the transmission activity and within the framework of its responsibilities includes the monitoring and control of the exercise of the activities of DESFA. Gas transportation is a monopoly activity. The Management Code of ESFA as a regulator of the Operator's relations with the users of the System (registered suppliers in the ESFA Register), is responsible for the management, maintenance, and development of the national natural gas system.

The registration requests in the Register of ESFA Users are examined by RAE and are made in accordance with the provisions of the Regulation of the ESFA User Register (Government Gazette B '451 / 16.04.2010).

The methodology for setting billing tariffs for each basic activity of the Operator is regulated by the ESFA Tariff Regulation. (Rae.gr, n.d.)

Institutional framework of Natural Gas

The country's gas market included:

- the development of infrastructure and licenses
- security of supply
- the granting of licenses
- monitoring a development program
- the management of Closed Distribution Networks
- Certification of Transmission System Operators and Gas Distribution Networks
- the exemption from third party access obligations
- the obligation for Property Separation
- consumer protection
- Supervision of Independent Transport Operators as well as the Separation of Operators
- Invoices for Non-Competitive Activities

is monitored in its entire spectrum by the Regulatory Authority for Energy in accordance with Law 4001 Government Gazette A 179 / 22.8.2011.

Competent Authority to ensure the implementation of the measures set out in the Natural Gas Supply Security Regulation 994/2010 of the European Parliament and of the Council of 20 October 2010 (L295) has been designated RAE, which holds the Competent Authority in the provisions of Articles 6 and 7 of Regulation 994/2010 / EC.

The Regulatory Authority for Energy monitors:

- The projected additional capacity of production, transmission and distribution of Natural Gas under planning or under construction.
- The security of energy supply mainly in relation to the balance of supply and demand in the Greek energy market.

- The quality as well as the level of maintenance and reliability of transmission systems and distribution networks.
- The implementation of measures to meet peak demand.
- Energy market conditions in relation to the possibility of developing new production capacity.
- The implementation of safeguard measures when there is a sudden crisis in the energy market, or a threat to the safety of persons and installations.

The Development Programs prepared by the competent Distribution Operators are modified based on decisions that result from RAE's public consultation with existing and potential users and in anticipation of the respective inter-community, non-binding ten-year natural gas transmission system development program in accordance with relevant regulations. (Rae.gr, n.d.)

- **Operator of the National Natural Gas System**

The company DESFA SA (Hellenic Gas Transmission System Operator) being the main operator of the National Natural Gas System, which was established on March 30, 2007 based on Law 3428/2005 Government Gazette 313/27.12.2005 and European Directive 2003/55/EC. DESFA was created as a subsidiary of DEPA SA by transfer to that of the branch of the National Natural Gas System. DESFA has been certified as a "Separated Property Gas Transmission System Operator" according to the Ownership Unbundling model of Directive 2009/73/EC under no. 1220/2018 decision of RAE, as it was revised with the no. 460/2019 Decision of the Authority. (Ypen.gov.gr, n.d.)

The company is exclusively and fully responsible for operation, management, exploitation, and development of the National Natural Gas System which includes the Natural Gas Transmission System which includes the pipeline system with a pressure of more than 19 barg and the Liquefied Natural Gas Station of Revithousa. (Desfa.gr, n.d.)

The shareholders of DESFA are the Greek State by 34% and the SENFLOUGA ENERGY HOLDINGS SA. by 66%. The 66% shareholder is a consortium of companies "Spam S.p.A." (Transmission System Operator of Italy). “Enagas International S.L.U.” (Transmission System Operator of Spain), “Fluxys S.A.” (Belgium Transmission System Operator) and “DAMCO S.A.” her as a passive

shareholder. The responsibilities of DESFA SA are in the operation, maintenance, management, exploitation, and development of ESFA and its interconnections with the aim of making the ESFA integrated, technically sound and cost-effective to serve the needs of gas users in a reliable, adequate, safe, and cost-effective manner. Another goal of the operation of DESFA is to ensure the functioning of a single natural gas market in the European Union and to ensure environmental protection conditions. (Ypen.gov.gr, n.d.)

- **Public Gas Company (DEPA) SA**

The Public Gas Company (DEPA) SA was established in September 1988 as an agency for the development of all sectors of the natural gas market, since then concluding gas supply contracts with the Turkish BOTAS, the Algerian SONATRACH and the Russian GAZPROM. With the law N.4643/2019 GG A '193/03.12.19 DEPA SA is transformed into:

- DEPA INFRASTRUCTURE SA with subsidiaries:

  1. ATTICA NATURAL GAS DISTRIBUTION COMPANY (EDA ATTIKIS SA) 100%

  2. GAS DISTRIBUTION COMPANY OF THESSALONIKI - THESSALIA SA (EDA THESSALONIKI-THESSALIA SA) 51%

  3. PUBLIC OPERATION OF GAS DISTRIBUTION NETWORKS SA (DEDA) 100%

- DEPA INTERNATIONAL PROJECTS
- DEPA COMMERCIAL with subsidiary the company "NATURAL GAS HELLENIC ENERGY COMPANY SA (former EPA ATTICA) 100%

(Ypen.gov.gr, n.d.)

DEPA Commercial

As the main provider of natural gas in Greece, DEPA, after or without related transport services, considering the regulatory framework under development of natural gas, is addressed to:

- Large mainly industrial consumers of annual consumption of more than 10 million cubic meters

- Power generators
- End consumers of areas without the establishment of Gas Supply Companies
- Existing Gas Supply Companies
- Gas-powered sectors, bus fleet supply, municipal garbage trucks and private vehicles.

New applications of interest with examination of new technologies and new sectors of commercial activity are:

- The supply of remote areas with CNG
- The use of natural gas in the cogeneration of electricity - heat and air conditioning.
- The use of natural gas in greenhouses. (Depa.gr, n.d.)

The main importer of natural gas in Greece, seeking and achieving the optimal combination of international market and domestic demand, has signed long-term gas supply contracts with the Russian Gazprom (until 2026), the Turkish BOTAS (until 2021) and Algerian Sonatrach (until 2021). (Depa.gr, n.d.)

Table 6: Natural Gas Imports and Contracts of DEPA Commercial

Company	**Source (pipeline and LNG)**	**Contract expiration**
Gazprom	Russia	2026
Sonatrach (LNG)	Algeria	2021
BOTAS	Turkey	2021

Source: (Depa.gr, n.d.)

The long-term gas supply contracts of the main natural gas supplier, the relationships of trust that have been developed through twenty years of cooperation with the largest producers of natural gas and the variety of sources and routes used, are strong guarantees of protection against natural gas availability disruptions in the Greek market. The constant contact with the international suppliers in order to achieve favorable terms of supply of natural gas in combination with the possibility of supplying LNG quantities from the global opportunity market (spot) ensure a seamless supply. Security of supply is an issue achieved through the diversification of sources and routes

of gas import and is implemented through the development of projects such as pipelines:

- IGI Poseidon (offshore connection between Greece- Italy)
- IGB (Interconnector Greece-Bulgaria)
- East Med (offshore connection of East Mediterranean gas fins with Greece)

Responsible for the management of commercial activities, maximizing returns of its portfolio, minimizing risks, and optimizing decision-making of supply and transmission of natural gas, as well as commercial transactions, is the Portfolio and Gas Supply Division. Portfolio Management, using specialized tools and techniques of risk identification - analysis - hedging, utilizes available information and technical forecasts aiming at achieving better performance. (Depa.gr, n.d.)

Private Gas Company in Greece, with the possibility of producing energy with natural gas and renewable energy sources, which represents more than 41% of natural gas imports in Greece, MYTILINEOS, through "Protergia" diversifying its portfolio becomes competitive increasing the supply opportunities in third parties. (Ypen.gov.gr, n.d.)

2.3 National Legislative and Regulatory Framework of the Gas Energy Market

National Legislative and Regulatory Framework

- L.2364 / 1995 (Government Gazette A '252 / 6.12.1995) on the import, marketing, and development of natural gas distribution.
- Law 3428/2005 (Government Gazette A '313 / 27.12.2005) on "Liberalization of the Natural Gas Market" according to the directives 2003/55 / EC and EC. 1775/2005 - 2nd energy package.
- Law 3428/2005 article 13 transmission agreement between the Operator (DESFA) and entities that have been registered into the Users Registry of the ESFA for the natural gas transmission services through the National Natural Gas Transmission System (Desfa.gr, n.d.)
- L.4001 / 2011 (Government Gazette A '179 / 22.8.2011) as a replacement of L.3428 / 2005 to harmonize the national legislation with the provisions of the "3rd energy package" in accordance with the directive 2009/73 / EC and the EC regulations

713/2009 and 715/2009. Defines the legal framework of energy activities in Greece, the operation of energy gas markets for research, production and hydrocarbon transmission networks.

- Directives 2003/55 / EC and 2009/73 / EC on the legal and operational separation of natural gas distribution from the other activities of a vertically integrated business
- Legislative Content Act (Government Gazette A '262 / 16.12.2011) on the selection of an Independent Transport Operator (ITO) in the context of the separation of transport and supply
- Law 4001/2011 on Independent System Operator
- Law 4093/2012 (Government Gazette A '222 / 12.11.2012) and Law 4011/2013 (Government Gazette A' 18 / 25.01.2013) to amend the provisions of Law 4001/2011
- L.4203 / 2013 (Government Gazette A '235) Article 17 par.13 and L.4336 / 2015 (Government Gazette A' 94 / 14.8.2015) Article 2 par.2 to amend L.4001 / 2011 on security of supply.
- L.4223 / 2013 (Government Gazette A '287) article 55, par. 8 to replace article 85 of L.3175 / 2003 (Government Gazette A' 287) (Edaattikis.gr, n.d.) (Depa.gr, n.d.)
- L.4336 / 2015 (Government Gazette A '94 / 14.8.2015) on determining the conditions for full liberalization of the natural gas market in Greece and on the reform of the natural gas distribution framework in Greece with the separation of distribution and supply of natural gas (until 31.12.2016 distribution and operation of natural gas were exercised exclusively by DEPA SA, EPA Attica SA, EPA Thessaloniki SA and EPA Thessaly SA. With Law 4336/2015, 4414/2016 and 4425/2016, Law 4001/2011 was amended, imposing a legal and operational separation of Distribution and Supply.
- Law 4337/2015 (Government Gazette A '129 / 17.10.2015), Law 4414/2016 (Government Gazette A' 149 / 09.08.2016), Law 4423/2016 (Government Gazette A '182 / 27.09.2016), Law .4425 / 2016 (Government Gazette A '185 / 30.09.2016) additionally to the national energy network, whose legal framework is based on the Union Energy Law.
  (Edathess.gr, n.d.)
- Law 4512/2018 (Government Gazette A '5 / 17.1.2018) article 96 on the reorganization of the Greek energy market

- Law 4513/2018 (Government Gazette A '9 / 23.1.2018) on framework changes
- Law 4546/2018 (Government Gazette A '94 / 14.8.2018) on compliance of holders of procurement, management, distribution licenses.
- Law 4546/2018 (Government Gazette A '101 / 12.06.2018) on Distribution and Management licenses
- No. 178065 / 08.08.2018 Government Gazette B '3430 / 17.08.2018 as the latest version of the Natural Gas License Regulation
- Law 4602/2019 (Government Gazette A '45 / 09.03.2019) on the separation of companies of the Natural Gas Distribution Network from the activities of production or supply of natural gas.
- L.4643 / 2019 (Government Gazette A '193 / 03.12.2019) on the establishment of regulations and transformation of DEPA SA in DEPA Commercial SA, DEPA Infrastructure SA and EPA International Works SA
- L.4685 / 2020 (Government Gazette A '92 / 07.05.2020) which contains additional Provisions on the demarcation of natural gas pipeline installation projects.

(Edaattikis.gr, n.d.)

National Gas Transmission System - Management Code of ESFA

- (Government Gazette B '379 / 01.04.2010) Ministerial Decision D1 / A / 5346/2010 First edition of the ESFA Management Code and publications of the "Standard Contracts for the Transmission of Natural Gas and the Use of LNG Installation" (Depa.gr, n.d.)
- (Government Gazette B '2227 / 14.10.2011) First revision of the ESFA Management Code and an attempt to harmonize with provisions of the European Gas Target Model.
- (Government Gazette B '3131 / 09.12.2013) Second Revision of the ESFA Management Code.
- (Government Gazette B '1549 / 05.05.2017) Third Revision of the ESFA Management Code with incorporation of the provisions of the European Regulations on the establishment of a network code.
- (Government Gazette B '788 / 07.03.2018) Fourth Revision of the ESFA Management Code

- (Government Gazette B '2840 / 13.07.2020) Fifth Revision of the ESFA Management Code
- (Government Gazette B '4799 / 30.10.2020) Sixth Revision of the Management Code

(Edaattikis.gr, n.d.)

About the ESFA Tariff Regulation

- RAE decision no. 1434/2020 Fifth Revision of the Tariff Regulation of Basic Activities of ESFA

Distribution Network Management - Distribution Network Management Code

- RAE decision no. 589/2016 Government Gazette B '487 / 20.02.2017) on the issuance and approval of Gas Distribution Network Management Code, which regulates the rights and obligations of the Distribution Network Operator and issues of management, development and operation of the Distribution Network.
- RAE decision no. 1314/2018 and 1315/2018 on the issuance to EDATHESS of the Natural Gas Distribution License Government Gazette B '5922 / 31.12.2018) and the Management License of the Natural Gas Distribution Network Government Gazette B' 5916 / 31.12.2018
- Government Gazette B '1507 / 02.05.2018) revision of the RAE decision no. 589/2016 Government Gazette B '3334 / 10.08.2018) on the modification of the Distribution Network Code, in agreement with the Framework for the Development of Remote Distribution Networks using Compressed Liquefied Natural Gas

(Edaattikis.gr, n.d.) (Edathess.gr, n.d.)

Tariff Regulation of Basic Distribution Activity

- RAE decision no. 328/2016 of the issuance of the Tariff Regulation of the Basic Gas Distribution Activity
- Government Gazette B '3067 / 26.09.2016) approval of the Tariff Regulation of the Basic Natural Gas Distribution Activity of the distribution networks of Attica, Thessaloniki, Thessaly and Thessaly and the rest of Greece.

- Government Gazette B '4925 / 09.11.2020) approval of the 1st Revision of tariffs of the regulatory period 2019-2022 for Attica
- Government Gazette B '4882 / 04.11.2020) approval of the 1st Revision of tariffs of the regulatory period 2019-2022 for the Distribution Network of Thessaloniki and Thessaly and with the RAE Decision no. 1430/2020 for the Network in the rest of Greece.

(Edaattikis.gr, n.d.) (Depa.gr, n.d.)

Development Framework of Remote Distribution Networks - CNG

- Government Gazette B '3334 / 10.08.2018) approval of the Development Framework for Remote Distribution Networks with the Use of Compressed - Liquefied Natural Gas
- Government Gazette B '3430 / 17.08.2018) Regulation of Natural Gas Licenses
- Government Gazette B '4298 / 27.09.2018) for the application of the Decision of Government Gazette B' 3334 / 10.08.2018)
- Government Gazette B '2945 / 16.07.2019) to amend the Decision of Government Gazette B' 3334 / 10.08.2018)
- Government Gazette B '1809 / 21.05.2018) for the approval of the Technical Regulation of Compressed Natural Decompression Installations and Auxiliary Devices for determining the design, construction, testing, operation, maintenance, operation and fire protection of CNG decompression installations.
- Government Gazette B '5661 / 17.12.2018) to determine technical specifications, terms and conditions for the establishment and operation of service stations. (Edaattikis.gr, n.d.) (Depa.gr, n.d.)

Measurement Regulation

- Government Gazette B '4818 /24.12.2019) on the approval of the Regulation of Measurements of the Natural Gas Distribution Network
- Government Gazette B '1788 /11.05.2020) on the approval of the Standard Distribution Network Connection Contract
- Government Gazette B '4818 /24.12.2019)
- Government Gazette B '4818 /24.12.2019)

(Edaattikis.gr, n.d.)

Gas Supply Security

RAE decision no. 567/2019 issued (Government Gazette B '2501 /25.06.2019) and 500/2018 (Government Gazette B' 2672 /06.07.2018) and (Government Gazette B '3329 /10.08.2018) on the approval of the Emergency plan. (Edathess.gr, n.d.)

2.4 Development Program of National Natural Gas System (ESFA) for the period 2021-2030

The Development Program of ESFA 2021-2030 drafted by the current legislation in accordance with article 14 of Law 4001/2011 and the provisions of the ESFA's Management Code, approved by the Regulatory Authority for Energy with no. Decision 116/2021 of 28 January 2021 provides:

1. New Projects

1.1. Interconnection Projects of ESFA with other Natural Gas Systems

1.2. User connection projects

1.3. Development Projects: ESFA extensions in new areas

1.3.1. High-pressure pipeline to Western Macedonia

1.3.2. High-pressure pipeline to Patra

1.3.3. Metering - Regulatory Station in Korinthos

1.3.4. Metering - Regulatory Station in Argos-Nauplio

1.3.5. Metering - Regulatory Station in Tripoli

1.4. Development Projects: Increasing capacity and security of ESFA

1.5. Development Projects: ESFA improvement - modernization and maintenance projects

1.6. Impact of Development Projects on the Average Charge of Use of ESFA

2. Scheduled Projects

2.1. Interconnection Projects of ESFA with other Natural Gas Systems

2.1.1. Metering - Regulatory Station in N. Mesimvria for the connection of ESFA with TAP

2.1.2. N. Mesimvria - Evzoni / Gevgelija pipeline and Metering Station

2.1.3. Interconnection of the IGB Pipeline with the ESFA in Komotini

2.1.4. Interconnection with FSRU Alexandroupoli

2.2. User Connection Projects

2.2.1. Installation of Station in SALFA Ano Liossia

2.2.2. ADG III Metering / Regulating Station

2.2.3. Connection with the CNG Station of DEPA Commercial SA in Komotini

2.2.4. Connection with the CNG Station of DEPA Commercial SA in Tripoli

2.2.5. Connection of KAVALA Oil Industry with ESFA

2.2.6. Metering Station in Agios Nikolaos, Voiotia (ADG IV)

2.2.7. ELVAL connection with ESFA

2.2.8. Connection of the TERNA Power Station with the ESFA

2.2.9. Connection of the new ELPEDISON Power Station with the ESFA

2.3. Development Projects: NSRF extensions to new areas or markets

2.3.1. Installation of Metering / Regulating Station in Kavala

2.3.2. Pilot Tanker Loading Station

2.3.3. New Small Scale LNG pier at Revythousa Terminal

2.3.4. Operational-Regulatory Station in the area of Poria

2.3.5. CNG station in the area of Poria

2.3.6. Metering and Regulating Station in the area of Aspros

2.3.7. Metering and Regulating Station in the area of Perdikka Eordea

2.3.8. Metering and Regulating Station in Livadia

2.3.9. Metering and Regulating Station in Megalopoli

2.3.10. Metering and Regulating Station of the city of Drymos - Liti

2.4. Development Projects: Increasing capacity and security of supply.

2.4.1. Compression Station in Kipoi and Regulatory Station in Komotini

2.4.2. Compression Station in Ampelia

2.4.3. Upgrade of Compression Station in Nea Mesimvria

2.4.4. Compression Station for the supply of the TAP pipeline to Nea Mesimvria (Booster Compressor)

2.5. Development Projects: Improvement - Modernization - Maintenance projects of ESFA

2.5.1. Upgrading of electrical and electronic tariff system equipment and SCADA field equipment in 1st generation M / R stations (1995-2000)

2.5.2. Modernization projects of ESFA - 1st Group

2.5.3. Modernization of LNG Station

2.5.4. LNG Exhaust Compression Station

2.5.5. Modernization projects of ESFA - 1st Group

2.5.6. Upgrading the Security of DESFA facilities - Physical Security Control Center

2.5.7. Optimization of measurement accuracy in ESFA stations

2.5.8. Replacement of Measurement Management and Supervision - Control Systems in Metering and Regulating Stations of ESFA

2.5.9. New DESFA office building

2.5.10. Technical training center in Nea Mesimvria

2.5.11. Increase of the electric Backup power at the LNG Terminal of Revithousa

2.5.12. Modernization projects of ESFA - 4th Group

2.5.13. Energy upgrade of building installations LNG and Centers of Operation and Maintenance

2.5.14. Technical Upgrade of Corrosion Protection System

2.5.15. Real-time hydraulic simulation software of ESFA

2.5.16. Upgrading IT applications

2.5.17. Upgrade of LNG Installation equipment

2.5.18. Upgrading of Integrated Natural Gas Information System (year 2020)

2.5.19. Installation of Electronic Monitoring Systems in Metering and Regulating Stations HAR- ELPE L / V Korinthos and L / V Tripoli

2.5.20. Auction procedure information system (year 2020)

3. Projects outside the 3-year Development Period

3.1. New Projects

3.1.1. Interconnection projects of ESFA with other Natural Gas Systems - Metering and Regulating Station for the Connection of DIORYGA GAS with ESFA

3.1.2. User connection projects

3.1.3. Development Projects

3.2. Scheduled Projects

3.2.1. Interconnection Projects of ESFA with other Natural Gas Systems. Metering and Regulating Station for the Connection with the Underground Gas Storage in South Kavala.

3.2.2. User connection works - Construction of High pressure pipeline Mavromati- Larymna and the necessary Metering Station for the connection of LARCO with the NSRF62

3.2.3. Development Projects - Projects that are excluded from the Development Program 2021-2030 (Government Gazette No.1392, 2021)

CHAPTER 3. CRITICAL INFRASTRUCTURES AND FUTURE PROJECTS

3.1 New pipelines

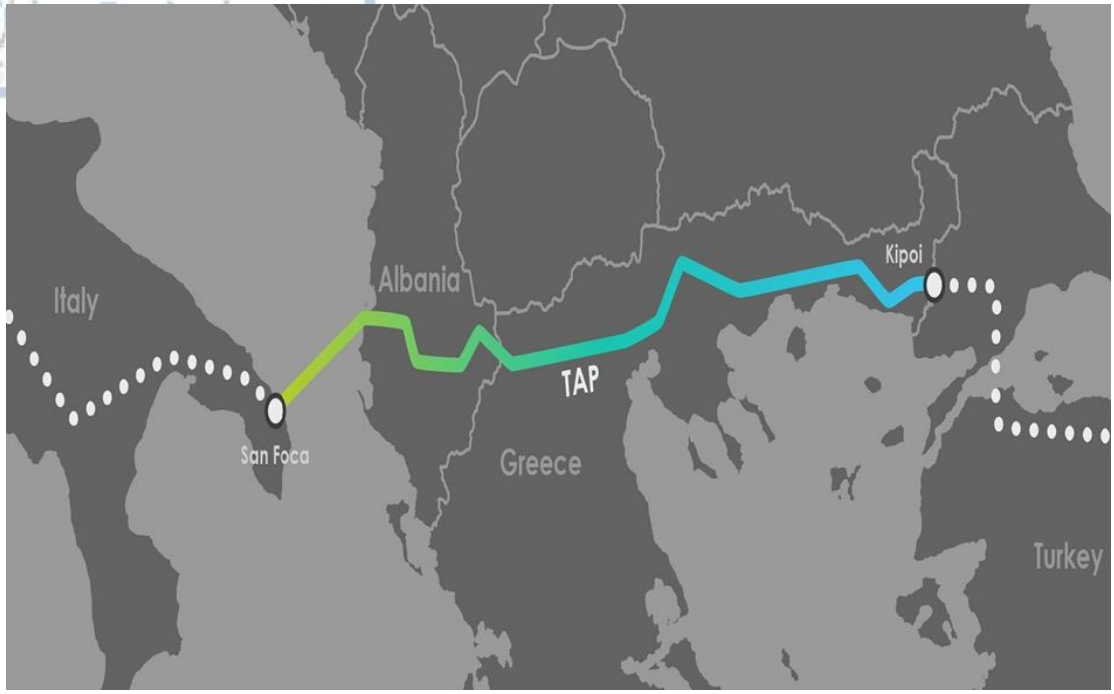
Europe's main gas supplier is Russia (47%) followed by Norway (34%) while Algeria and Libya together account for 8.6% with Ukraine as the main transit route for Russian gas to Europe via the Brotherhood pipeline (almost 50% of imports from Russia), Belarus with the Yamal pipeline (20%) and Nord Stream 2 (30%). The percentage of natural gas which is imported through pipelines is 89%, while the remaining as liquefied natural gas (LNG).

- Tap Pipeline

The 878 km long TAP pipeline, starting from the Kipoi in Evros on the Greek-Turkish border, its connection point with the Trans Anatolian Pipeline (TANAP) crossing Greece, Albania, and the Adriatic ends in Southern Italy. The pipeline with intermediate exit points in Greece and Albania transporting natural gas from Azerbaijan. in both cross countries, being the last part of the Southern corridor of the union of the natural gas field «Shah Deniz II» in the Caspian with its markets in Southern and Southeastern Europe, increases energy diversification and security in Southern Europe by relieving it of its energy dependence on a single supplier. (Capital.gr, 2021)

The Interactive TAP pipeline, whose operation contributes to the "Internationalization" of the national transmission system, constitutes a transit point to other European destinations in combination with the natural gas pipeline of TANAP and the South Caucasus Pipeline (SCPX) the south transmission corridor from the Shah Deniz II field in Azerbaijan to the gas network of Italy.

Image 5: TAP Pipeline



Source: TAP, n.d.

Its role is catalytic in the implementation of the interconnection natural gas pipeline Greece - Bulgaria (TAP) making Greece the starting point of the Vertical Corridor of the Aegean-Central Europe. The Greek-Bulgarian pipeline will also operate as a new "gateway" for fuel entry into Romania and Hungary.

The "gateway" of the pipeline will be utilized by the floating terminal for storage and regasification of liquefied gas FSRU Alexandroupolis.

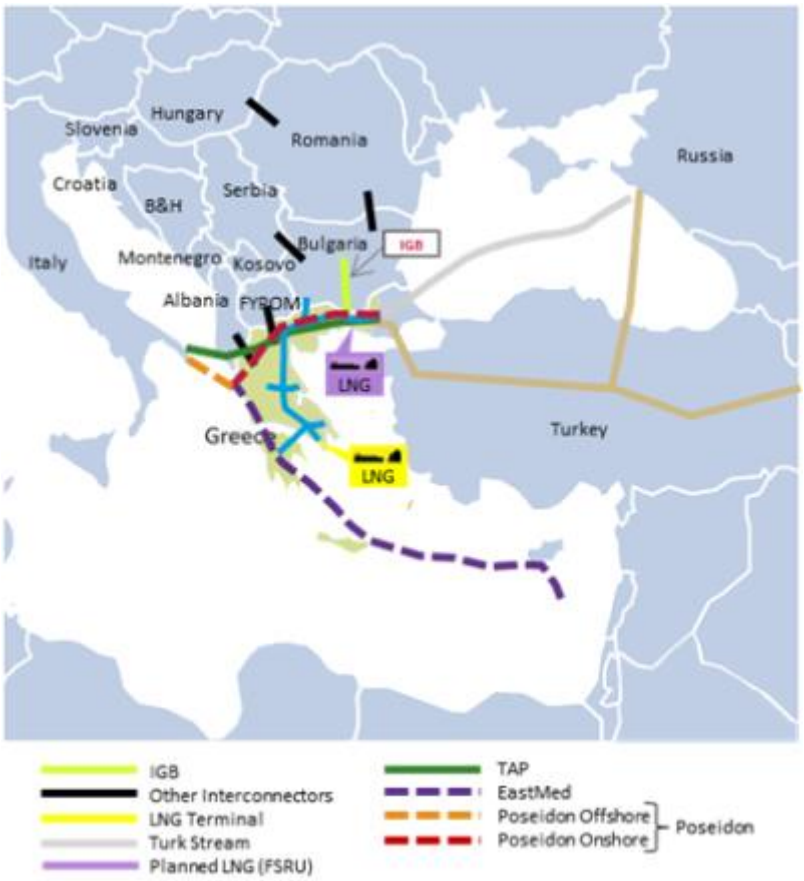
- IGB Pipeline (Gas Interconnector Greece-Bulgaria)

It is a 182 km long pipeline, of which 31 km are located within the Greek territory with necessary support facilities (metering Stations, valve stations, and operation centers), starting point in Komotini, where it connects with the TAP pipeline and ends at Stara Zagora in Bulgaria, with the possibility of reverse flow and provision of its interconnection with the TAP pipeline. (M. naftemporiki.gr, 2020) (Depa-int.gr, n.d.)

The initial capacity of the pipeline is 3 billion cubic meters of natural gas per year with the possibility of increasing to 5 billion cubic meters with the construction of a Compression Station. The ICGB AD Company with shareholders the state company «Bulgarian Energy Holding» and the Greek «YAFA POSEIDON» with the participation of DEPA and EDISON, undertook the construction and operation of the

project which was supported by Greece (Law 4001/2011, article 176) and Bulgaria (Decision of the Council of Ministers No. 452 of 07.06.2012). In 2018 the EU approved the financial planning compatibility and the tax status of the project, for which the tenders were completed in May 2019. On May 22, 2019, in Kirkovo, Bulgaria, the construction ceremony of the project took place, leading to the start of works in the summer of 2019. (Depa.gr, n.d.)

Image 6: IGB Pipeline



Source: Depa.gr, n.d.

- Eastern Mediterranean Pipeline (EastMed)

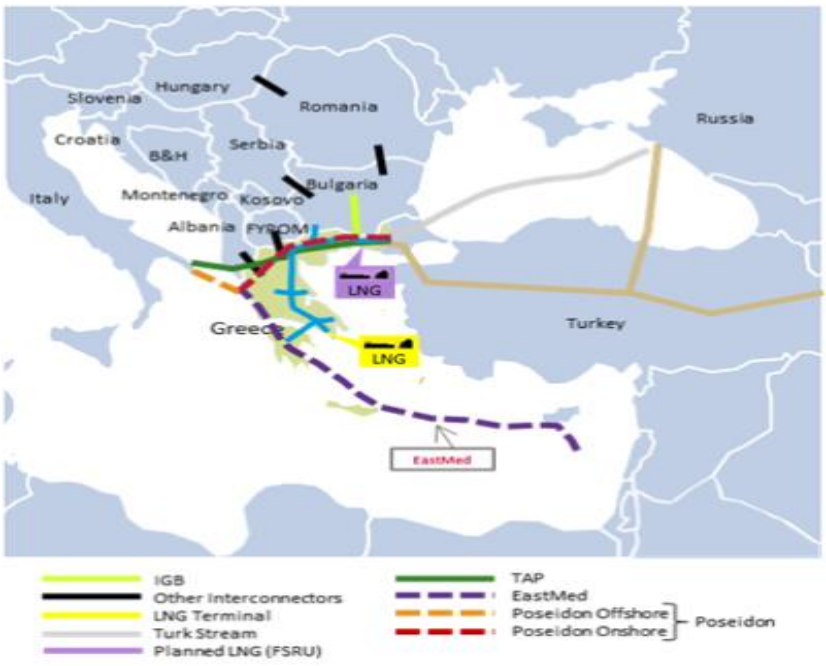
The EastMed interconnector pipeline, with a capacity of 10 billion cubic meters, aims to transport natural gas directly from the fields in the Levantine basin in the Southeastern Mediterranean, through Greece to the Markets of Western Europe and the European System via Greece and Cyprus. (Depa-int.gr, n.d.)

With the implementation of the IGI Poseidon join venture after negotiations between Cyprus, Greece, Israel and Italy and the signing of an intergovernmental agreement, the European Commission co-financed the remaining stages of

development and maturation of the project (Phase of Application Design - Front End Engineering Design). The 1900km EastMed pipeline carrying 10 bcm per year is included by the EU in the projects of common interest (PCIs - Projects of Common Interest) of the energy balance of Europe according to the European Regulation 347/2013. The EastMed pipeline runs submarine to Cyprus, following the route Crete, Peloponnese, Western Greece, coasts of Thesprotia and Italy and also is an added value to the prospects of gas exports to the Southeastern Mediterranean, to enhance Europe's energy security. (Depa-int.gr, n.d.)

In 2015, the implementation studies of the project (Pre-Feed Studies) started with the co-financing of the EU which were completed in 2018, while in June of the same year a co-financing is signed with a percentage of 50% of the implementation phase of the Grant Agreement - Front End Engineering Design - FEED through the Grant Agreement and conducting a Detailed Marine Survey. The onshore and offshore implementation studies, the onshore and offshore environmental studies (ESIA Offshore & Onshore) and the Design Appraisal & Verification contract are in progress since June 2020. In January 2020, an Intergovernmental Agreement (IGA) was signed between Greece-Cyprus-Israel and validated by the respective parliaments. The project is expected to start in 2025. (Depa-int.gr, n.d.)

Image 7: East Med Pipeline

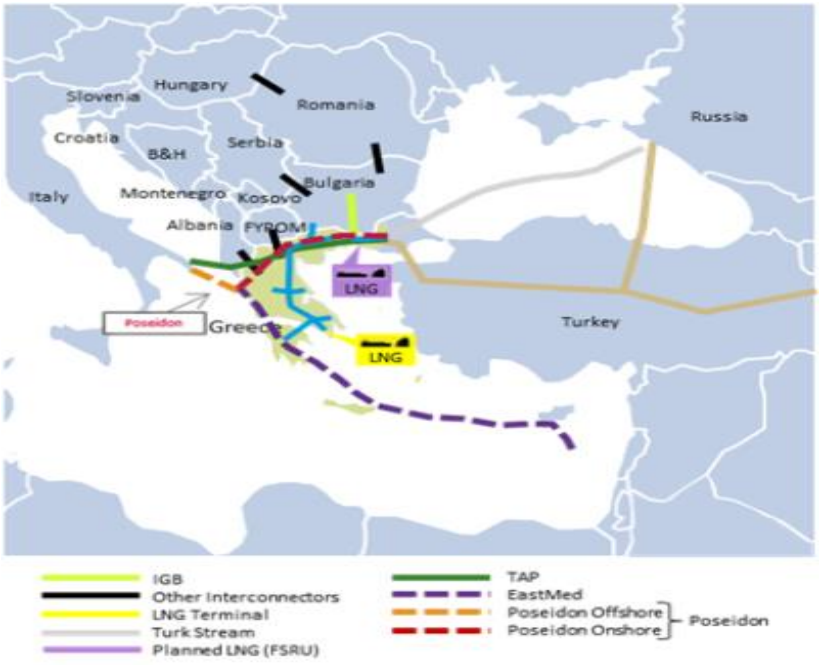


Source: Depa-int.gr, n.d.

- Poseidon Pipeline

The Greece-Italy Poseidon interconnector, consisting of a 760 km long onshore section extending from the Greek-Turkish border of Kipoi, Evros through the regions of Eastern Macedonia and Thrace, Central and Western Macedonia, Thessaly and Epirus and the onshore section which connects the coasts of Thesprotia with Otranto in Italy, developed by the Greek company YAFA POSEIDON (Greek Underwater Gas Pipeline). The POSEIDON pipeline, connecting the EU with gas sources in the Caspian, Middle East and Eastern Mediterranean, enhances its energy security. The initial capacity of the project which amounted to 12 billion cubic meters of natural gas per year to Italy, with the possibility of upgrading up to 20 billion cubic meters of gas per year, makes it in combination with its characteristics and position of strategic importance a very important project and this is a reason for its recognition and inclusion by the EU in Projects of Common interest (PCIs). Its completion and start of operation is expected at the end of 2022 - beginning of 2023.

Image 8: Poseidon Pipeline



Source: Depa-int.gr, n.d.

The progress made in their implementation and their strategic importance in the European energy map led to the inclusion of the IGB, EastMed and POSEIDON pipelines in the ten-year network development plan (TYNDP). (Depa-int.gr, n.d.)

In May 2020, the East Med-Poseidon Pipeline project is defined as a project of national importance by Law 4685 / 7-5-2020, which together with the IGB project will complete the energy system of Southeast Europe.

New LNG Terminal of Alexandroupolis

A modern and innovative high-tech project consisting of:

- Floating offshore unit for the receipt, storage, and gasification of liquefied natural gas in the offshore area, in 10 km. from Alexandroupolis
- Underwater system with a total length of 24 km and onshore pipeline with a length of 4 km for the supply of natural gas to the National Natural Gas System (ESFA) with a total length of 24 km

ASFA Alexandroupolis with a capacity of 15 million cubic meters of natural gas per year and a storage capacity of up to 170,000 cubic meters liquefied natural gas, is potentially a fourth gateway of import natural gas to Greece with the prospect of commercial operation in 2023. (Depa.gr, n.d.)

3.2 Independent Natural Gas Systems (ASFA)

A Natural Gas System that is not part of the National Natural Gas System (ESFA) is an Independent Natural Gas System (ASFA). The regulatory framework for both the construction and operation of ASFA, such as the Tariff Regulation and the Management Code, is defined and monitored by the Regulatory Authority for Energy (RAE). (Rae.gr, n.d.)

Holders of ASFA License, which is granted only to legal entities by decision of the Energy Regulatory Authority, which defines and monitors the regulatory framework for their construction and operation (Certification, Management Code, Tariff Regulation), have the right to build, own and use the Independent Natural Gas Systems based on National Law and European regulations and in accordance with Law 4001/2011 and the Regulation of Natural Gas Licenses. The cooperation of relevant Regulatory Authorities takes place when an ASFA is located in more than one country. (Rae.gr, n.d.)

Independent Natural Gas Systems are:

1. The **Trans Adriatic Pipeline (TAP)** connected to the Anatolian Pipeline with a length of 878 km of which 550 km in Greece, 215 in Albania, 105 km in the

Adriatic and 8 km in Italy. TAP has a capacity of 10 bcm/y with the possibility of increasing 20 bcm/y and shareholders BP by 20%, SNAM 20%, SOCAR 20%, Fluxys 19%, Enagas 16%, and Axpo 5%. The Regulatory Authority for Energy approved with no. 269/2013 Decision on the operating conditions and the regulatory framework of TAP, which were set and defined in the "Final Joint Opinion of the Energy Regulators on TAP AC's Exemption Application: Autorita per l'energia elettrica e il gas (Italy), Enti Regullator i Energjise (Albania), Regulatory Authority for Energy (Greece). The pipeline approved by RAE with the no. 269/2013 Decision with conditions set by the triptych of the three Regulatory Authorities, the Energy Community and the European Commission.

2. The **Gas Interconnector Greece-Bulgaria (IGB Pipeline)**, capacity up to 3bcm/y and 5bcm/y in the 2nd phase with possibility of reverse flow consisting of a pipeline 182 km long and:

- Metering Stations
- Operation Center
- Valve station

The Regulatory Authority for Energy approved with no. 768 / 06.08.2018 Decision on the operating conditions and the regulatory framework of the IGB, which were set and determined jointly by the Regulatory Authorities of Greece and Bulgaria based on final decision no. C (2018) 5058/25.07.2018 of the European Commission approved by RAE with Decision no.768 / 06.08.2018 Decision.

3. The **Floating Storage Regasification Unit (FSRU) in Alexandroupoli**. A project of Common Interest, length 28 km, diameter 30" and capacity 6.1 bcm/y consisting of:

- An offshore floating unit for the receipt, storage and gasification of Liquefied Natural Gas and
- A System of offshore and onshore pipeline for the promotion of natural gas to the National Natural Gas System. (Rae.gr, n.d.)

4. The Underground Gas Storage Facility in South Kavala (UGS) with a capacity of 1 bcm and an annual active distributing volume (Annual Volume throughout) of 360 million Nm^3 for one cycle per year and maximum daily capacity for

natural gas extraction and import into the National Natural Gas Transmission System at 4 million Nm^3/d. This is the project that results from the modification of the offshore field that is in a state of depletion in South Kavala. The maximum daily efficiency of import into the National Natural Gas System is 4 million Nm^3/d. The implementation of the project is in the tender stage of the HRADF for the promotion of a Contractor, who will undertake its use, development and exploitation.

5. The **Floating Storage Regasification Unit (FSRU) in Agioi Theodoroi, Corinth**, with length 2.15 km and capacity 1.6-2.6 bcm/y with the possibility to reach 4 bcm/y consisting of:

- Floating Storage and Regasification Unit
- A Gasification unit
- Four LNG Storage Tanks
- Gasification unit
- Natural gas connection pipelines - offshore length 500 m and onshore length 1650 m which introduce the natural gas to the National Natural Gas System (Rae.gr, n.d.)

3.3 Projects of Common Interest (Pcls)

Projects of Common Interest (Pcls), being projects connecting the Trans-European Energy Networks (the energy systems of the countries of the European Union), as cross-border infrastructure projects, are proposed by implementing bodies, evaluated by the European Union Agency for the Cooperation of Energy Regulators (ACER), Regulators and other bodies, aiming to achieve the European Union's energy policy objectives. European Union goals for energy, climate, affordable economy, safe and sustainable energy and long-term dependence on carbon emissions as set out in the Paris Agreement. Projects of Common Interest:

- They are selected according to criteria defined by the policy for the trans-European energy networks, the main ones of which are:
  - Enhancing competition in the energy market
  - Contributing to the European Union's climate and energy goals through the integration of renewable energy sources

- Enhancing the energy security of the European Union by diversifying energy sources
- Influence on energy markets and energy market integration in at least two European Union countries
- They are proposed by their implementing bodies.
- Evaluated by:
    - The regional groups of the European Union
    - The European Commission
    - The Transmission System Operators (TSOs) of the Member States
    - The Regulatory Principles
    - The European Union Agency for the Cooperation of Energy Regulators (ACER), which evaluates the compliance of gas projects with the PCI criteria and their added value in the European Union.
    - The Transmission System Operators of the European Networks (Rae.gr, n.d.)

The development and interoperability of the projects of the trans-European energy infrastructure, the PCI infrastructure connecting the European Union with third countries concerning natural gas, are determined by EU Regulation no. 347/2013. The European Commission is responsible for the authorization of the drafting of acts of the Union List (PCI List) of Projects of Common Interest of the EU, which is issued every two years, with four having been issued to date. (Energy.gov.cy, n.d.)

According to EU Regulation no. Regulation (EC) No 347/2013 of the European Parliament and of the Council of 17 April 2013:

- PCI is prioritized at national level to ensure immediate administrative treatment in the Member States with the National Competent Authority to consolidate and coordinate licensing procedures.
- The conditions for the eligibility of PCI are defined in relation to financial support from the Union.
- The Project of Common Interest of the EastMed offshore pipeline connecting Israel-Cyprus-Greece, aiming at the connection of the European market with the

reserves of the Levantine Basin in the Eastern Mediterranean is implemented with Implementing Agency IGI POSEIDON S.A.

- A new framework for infrastructure design and project implementation is defined beyond 2020.
- Improved regulation, financial support as well as simplified licensing procedures are defined. (Energy.gov.cy, n.d.) (Ypen.gov.gr, n.d.)

Projects of Common Interest, necessary for the implementation of priority areas and corridors of energy infrastructure of the European Union, are addressed by granting advantages such as:

- Very fast issuance of licenses with a maximum limit of up to three and a half years.
- Regulatory incentives and improved regulatory treatment with cost sharing of net debts.
- Funding from the Connecting Europe Facility (CEF).
- Rapid and improved environmental assessment.
- Transparency and improved public consultation.
- Licensing by a single competent Authority (one stop shop) with the General Directorate of Strategic Investments of the Ministry of Economy and Development as responsible for licensing.

3.4 Facility safety measures

Metering and regulating stations aiming at measuring consumption and reducing the gas supply pressure, by applying strict safety devices, are secured with high-tech devices - which ensure reliability, safety, and absolute control - safety and accuracy of measurements. (Georgiadou et al., 2008)

Failure of the pressure regulators may cause the operating pressure at the gas metering and regulating stations to increase, exceeding the permissible limits. Safety valves are:

- Instant shut-off valves and dual pressure regulators
- Gas detectors, in case of leak detection

- Special filters supervised by differential pressure gauges and liquid level controllers, which hold and remove solid and liquid particles,
- Gas station safety devices
- The special dosing pumps enrich it by the nature of the odorless natural gas with additional substances of distinct odor detect the natural gas in case of leakage. (Georgiadou et al., 2008)

Supervisory Control and Data Acquisition (SCADA Systems) control the security systems, intervening and leading to additional measures. They may include the following systems.

• Gas leak detection system with alarm system and shutdown automation.

• Automatic network tightness control system for gas consumption devices, two automatic valves and two controls per day.

• Gas leak detection system with alarm system and shutdown automation.

• Artificial ventilation.

(Georgiadou et al., 2008)

Pipeline operation and maintenance

The operation of the pipeline includes maintenance, repair work and emergency response such as:

- Detection of low-pressure mains gas leaks
- Central control (SCADA) with monitoring from SCADA control room.
- Actions for smooth operation of measuring and regulating stations.
- Actions - manipulations to change the status of facilities, operation, and maintenance.
- Maintenance work to avoid interruption and repair of localized faults. (Georgiadou et al., 2008)

The existence of potential risks to the health and safety of workers during the installation, operation and maintenance of gas transmission and distribution networks have made it necessary to take measures to prevent, avoid and deal with such adverse situations. The main risk to the health and safety of both workers and the public is that

of an explosion - fire from sources of ignition due to a gas leak or a complete rupture of a pipeline. The main causes of explosion-fire are the following:

- Maintenance work to release the gas.
- Control and maintenance work of the valve station
- Work in confined spaces without security measures
- Corrosion of networks
- Troubleshooting errors
- Pipeline failure due to natural phenomenon (e.g., earthquake)
- Hitting pipes during work
- Installation of new pipe sections (tie-in) with hot tapping in active or inactive network. (Schoolpress.sch.gr, 2014) (Moa.gov.cy, 2010)

Combustion of natural gas because of leakage, releasing volatile organic compounds and toxic fumes creates serious problems such as pneumonia, memory loss, nausea, vomiting, etc. Inhalation of methanethiol (methyl mercaptan) or ethanethiol (ethyl mercaptan) causes dizziness, fever, and loss of consciousness. Gas-containing impurities - benzene, radon, cause carcinogenesis and genetic damage.

The coexistence of natural gas with ambient air at the flammability limit and a heat source (flame) cause ignition. Fuel, the right temperature and the oxidizing agent (the so-called "fire triangle") are the three factors whose coexistence contributes to the start and spread of fire. Sources of ignition are:

- Static electricity generated by gas flow in a plastic pipe.
- Power tools (wheels, drills, hammers)
- The naked flames
- Electric motors (generators, vehicles)
- Non-explosive lights
- Sparks from wheel use, pipe cutting or metal impact.
- Smoking (Georgiadou et al., 2008)

The use of anti-explosive equipment and tools, as well as the grounding of the facilities, works as a precaution. The non-simultaneous coexistence in time and place of all three factors of the fire triangle, with the removal of even one factor, is

preventable for the occurrence of explosion and fire condition. zero pressure the gas flows and the risk of explosion is real.

To prevent leaks in gas distribution systems, measures subject to international standards and regulations are applied. Recommended measures include:

- Welding of pipes and their components, in line with international standards
- Prevention of corrosion of ferrous metal pipelines with coating techniques, with alternative use of polyethylene pipelines
- Check the tightness of pipes and their components, in terms of pressure specifications and the presence of leaks before operation.
- Leak detection and corrosion programs, use of appropriate leak assessment techniques and equipment.
- Detection of leaks and faults with the SCADA system by a special workshop, checking, recording, prioritizing, and repairing them. (Securitymanager.gr, 2020)

When transporting natural gas, various measures and prevention methods ensure guarantees of safe and uninterrupted operation. Preventive measures include the placement of:

- Cathodic protection systems applied along.
- Acoustic sensors
- Sensors using fiber optics (SCADA Remote Control - Supervisory Control and Data Acquisition)
- Satellite monitoring

Accident prevention is vital for gas companies and is their priority. Existing legislation requires a clear statement of the pipeline owner's indicators, flow direction and distance from a control station, contributing to increased safety. (Bianchini, Donini, Guzzini, Pellegrini & Saccani, 2015)

Risks of working in confined - enclosed spaces, resulting from a gas leak, such as toxic atmosphere and explosion caused by the existence of the "fire triangle":

- oxygen at a rate of more than 23%
- gas leakage and

- sources of ignition (sparks, naked flames, static electricity, chemical reaction, etc.)

treated with

- Appropriate access controls
- Ventilation and oxygen level detection
- Risk assessment
- Necessary equipment
- Employee training
- Rescue and escape plan

(International Finance Corporation, 2007) (Georgiadou et al., 2008)

Necessary safety rules must be followed in the Gas Regulatory Stations, with predetermined working procedures to prevent gas leakage, the pressure adjustments must be made by authorized persons and there must be adequate ventilation.

Risks during the operation of gas distribution systems are prevented by strict adherence to safety rules that include:

- The clearance of gas from pipelines and their fittings and removal of ignition sources.
- The identification of the existing gas before the work to be performed.
- The appropriate protection of the pipes to be installed.
- The odor of the gas to facilitate the detection of any leakage.
- The necessary equipment in accordance with the Greek legislation on health and safety at work and the standards of international experience (International Finance Corporation, 2007) (Georgiadou et al., 2008)

CHAPTER 4. CASE STUDY: EDA THESSALONIKI - THESSALIA SA

4.1 Development Program of EDA THESS for the period 2021-2025

EDA THESS is competent for the development of the network and new consumer connections, according to the Regulatory framework. Obligation of the Company is to submit to Regulatory Authority for Energy (RAE), a five-year Development Network Distribution program. (Rae.gr, 2020)

EDA THESS's Development Program 2021-2025 was approved with 1582/2020 RAE decision. With this decision the total of Development Program 2021-2025 actions is approved, **excluding investments in remote distribution networks in the years 2023-2025**, in view of establishing of a new CNG regulatory framework. (Rae.gr, 2020)

In the above context, the areas which are not included by RAE are **Asprovalta/ N. Vrasna of Volvi Municipality (2023), Sochos of Lagadas Municipality (2024) and Zagliveri of Lagadas Municipality (2024).** So, in the Tables which are presented on the next pages all data of these areas are not included in the Development Program of EDA THESS for the years 2021-2025. (Rae.gr, 2020)

The Company prepared the five-year Distribution Network Development Program for the period 2021-2025, considering:

- The demand for natural gas in the geographical areas of activity
- The connection needs of new End Customers
- Improving the adequacy and efficiency of the Distribution Network and ensuring its smooth operation for security of supply
- Fulfillment of utility obligations and security of gas supply in a reliable manner
- Improving the efficiency and quality of services provided
- The application of new technologies and as far as possible uniform technical specifications
- The expansion of the use of Natural Gas, with the aim of regional development and ensuring the accessibility of new Distribution Users, in terms of economic, technical adequacy, functionality and efficiency.

- The financial efficiency of the projects included in the Development Program, as described in article 12 of the Distribution Activity Tariff Regulation (Government Gazette B '3067 / 26.09.2016), as well as the possibility of their financing.
- The Development Framework for Remote Distribution Networks using Compressed / Liquefied Natural Gas (Government Gazette B '3334 / 10.08.2018).
- The protection of the environment

(Rae.gr, 2020)

Distribution Networks of EDA THESS extend to the Regional Unit of Thessaloniki and to the Regional Units of Larissa, Magnesia, Karditsa and Trikala of the Region of Thessaly. The areas that will be supplied on 31/12/2020 by the Distribution Networks cover 13 Municipalities of the Regional Unit of Thessaloniki and 17 Municipalities of the Region of Thessaly, which are presented in the following Table. (Rae.gr, 2020)

Table 7: Municipalities with an active Natural Gas Network (2020)

Distribution Network of Thessaloniki	**Distribution Network of Thessaly**
• Municipality of Thessaloniki (Network)	• Municipality of Larisa (Network)
• Municipality of Ampelokipi-Menemeni (Network)	• Municipality of Volos (Network)
• Municipality of Delta (Network & CNG)	• Municipality of Karditsa (Network)
• Municipality of Thermaikos (Network)	• Municipality of Trikkaion (Network)
• Municipality of Thermi (Network)	• Municipality of Kileler (Network)
• Municipality of Kalamaria (Network)	• Municipality of Almiros (Network)
• Municipality of Kordelio-Euosmos (Network)	• Municipality of Farsala (Network)
• Municipality of Neapoli-Sikies (Network)	•Municipality of Rigas Feraios (Network)
• Municipality of Pavlos Mela (Network)	• Municipality of Tirnavos (CNG)
• Municipality of Pilea-Chortiati (Network)	• Municipality of Elassona (CNG)
• Municipality of Chalkidona (Network & CNG)	• Municipality of Meteora (CNG)
• Municipality of Oreokastro (Network)	• Municipality of Palama (CNG)
• Municipality of Lagada (CNG)	• Municipality of Sofades (CNG)
	• Municipality of Agia (CNG)
	• Municipality of Tempi (CNG)
	• Municipality of Pili (CNG)
	• Municipality of Mouzaki (CNG)

Source: (Rae.gr, 2020)

The data of the following table were actual data until 31/08/2020 and estimates from September to 31/12/2020.

Table 8: Gas Distribution Network Data (2020)

Distribution Network Data - 2020	**U.M**	**Distribution Network of Thessaloniki**	**Distribution Network of Thessaly**	**Total**
Low Pressure Network (4 bar) Progressive	Km	1.319,6	1.005,1	**2.324,7**
Medium Pressure Network (19 bar) Progressive	Km	152,5	108,9	**261,3**
New Connections Progressive	thousands	270,1	115,0	**385,2**
Distribution Volumes	GWh	3.169,4	1.829,9	**4.999,3**

Source: (Rae.gr, 2020)

The further expansion of the Distribution Networks is foreseen for the areas that are supplied both through a pipeline network and through a Virtual CNG Pipeline. The following areas are already connected via a Virtual CNG Pipeline and a CNG decompressor is supplied. (Rae.gr, 2020)

Table 9: Municipalities/Areas with connection of Natural Gas CNG Decompressor in 2020

Distribution Network of Thessaloniki	**Distribution Network of Thessaly**
• Municipality of Lagadas (Lagadas) – 2 Decompressors	• Municipality of Tyrnavos (Tyrnavos) - 1 Decompressor
• Municipality of Chalkidona (Koufalia) - 2 Decompressers	• Municipality of Elassona (Elassona) - 2 Decompressers
• Municipality of Delta (Chalastra) - 1 Decompressor to be connected to a pipeline within 2020	• Municipality of Meteora (Kalampaka) - 1 Decompressor
	• Municipality of Palamas (Palamas) - 1 Decompressor
	• Municipality of Sofades (Sofades) - 1 Decompressor

	• Municipality of Agia (Agia) - 1 Decompressor
	• Municipality of Pyli (Pyli) - 1 Decompressor
	• Municipality of Mouzaki (Mouzaki) - 1 Decompressor
	• Municipality of Tempi (Sykourio) - 1 Decompressor
	• Municipality of Tyrnavos (Ampelonas) - 1 Decompressor

Source: (Rae.gr, 2020)

For the area of Chalastra of the Municipality of Delta in Thessaloniki, it was planned to replace the CNG decompressor and connection it with a pipeline by the end of 2020.

The new Municipalities / areas that will be developed the Distribution Network of EDA THESS in the next 5 years, are presented in the following 2 Tables. (Rae.gr, 2020)

Table 10: Municipalities / Areas with scheduled connection of CNG Gas Decompressor 2021-2025

Distribution Network of Thessaloniki	**Distribution Network of Thessaly**
• Municipality of Volvi (Stavros, 2021)	•Municipality of Larissa (Falani, 2022)
• Municipality of Volvi (Asprovalta & N. Vrasna, 2023)	•Municipality of Farkadona (Farkadona, 2022)
•Municipality of Lagada (Sochos, Zagliveri, 2024)	

Source: (Rae.gr, 2020)

We observe that with the connection of Stavros with CNG in Municipality of Volvi, the total of the Municipalities of Thessaloniki are supplied with natural gas in 2021. Respectively the total of Municipalities of Thessaly will be supplied with natural gas in 2022 with the connection of CNG station in Farkadona.

Table 11: Municipalities / Areas with planned connection through pipeline of the Natural Gas Distribution Network 2021-2025

Distribution Network of Thessaloniki	Distribution Network of Thessaly
• Chalkidona (Ag. Athanasios, 2021)	• Killerer (Halki, Platykampos, 2023)
• Thermi (Kato Scholari, 2021)	• Killerer (Galini, Melissochori, 2024)
• Thermaikos (Mesimeri, 2021)	
• Delta (N. Malgara & Kymina, Anatoliko 2021)	
• Chalkidona (Chalkidona, Gefyra 2022)	
• Oreokastro (Liti, Drymos, Melissochori 2022)	
• Oreokastro (Pentalofos & Neochorouda, 2023)	
• Chalkidona (Vathilakkos 2023)	
• Lagada (Lagyna, 2023)	

Source: (Rae.gr, 2020)

By connecting the above areas through pipeline, EDA THESS enhances the penetration of natural gas in Municipalities with low coverage ratio and low percentage in connected buildings.

Construction of Distribution Networks

The expansion of the Distribution Networks will be carried out through the construction of Medium Pressure Networks (19 bar) and Low Pressure (4bar).

For the period 2021-2025 the following Network extensions are planned, both for the Development and for the Strengthening of the Network:

- Medium Pressure Network Extensions 19bar 52km for the area of Thessaloniki and 39km for the area of Thessaly.
- Low Pressure Network Extensions 4bar 279km and 225km for the areas of Thessaloniki and Thessaly, respectively.

The following Tables present the Network extensions for the period 2021-2025, in Thessaloniki and Thessaly. (Rae.gr, 2020)

Low Pressure Networks (4bar)

Table 12: Construction of 4 bar Low Pressure Network 2021-2025

Network L.P 4bar (km)	2020	2021	2022	2023	2024	2025	Total 2021-2025
Thessaloniki	77,1	65,4	59,3	59,2	52,6	42,4	279,0
Thessaly	63,9	61,1	53,0	45,2	33,0	32,9	225,2
Total EDA THESS	**141,0**	**126,6**	**112,4**	**104,4**	**85,6**	**75,3**	**504,2**

Source: (Rae.gr, 2020)

The increase of the Low Pressure network by 22% from 2020 to 2025 in total, shows the strength of this Development Program and has many advantages to the residential, commercial and industrial customers. These new gas network meters include meters both for the strengthening of the existing network and for the supply of new areas.

The following 3 Tables present the development and the strengthening of Low Pressure (4bar) Gas Distribution Network in Thessaloniki.

Table 13: Development of Thessaloniki Low Pressure Distribution Network 4bar per Municipality 2021-2025

Network L.P 4bar (m)	2021	2022	2023	2024	2025	TOTAL
Municipality of Delta	16.015	2.892	2.892	2.166	1.926	**25.890**
Municipality of Thessaloniki	1.000	1.000	995	995	500	**4.490**
Municipality of Thermaikos	7.347	3.865	2.865	2.659	2.357	**19.093**
Municipality of Ampelokipi-Menemeni	507	507	507	507	453	**2.482**
Municipality of Thermi	13.172	5.091	2.873	2.467	2.248	**25.852**
Municipality of Kalamaria	379	303	228	228	164	**1.302**
Municipality of Kordelio-Euosmos	1.540	1.164	964	876	743	**5.286**
Municipality of Neapoli-Sikies	1.497	1.198	999	999	974	**5.666**
Municipality of Pavlos Mela	1.599	1.200	1.000	900	900	**5.599**

Municipality of Pilea-Chortiatis	3.409	3.139	1.804	1.735	1.535	**11.621**
Municipality of Chalkidona	1.843	9.654	3.564	4.953	4.173	**24.186**
Municipality of Oreokastro	2.000	17.629	18.811	9.128	8.866	**56.435**
Municipality of Lagada	1.600	1.202	6.815	12.958	6.306	**28.881**
Municipality of Volvi	5.000	3.000	6.912	3.528	2.760	**21.200**
Total	**56.908**	**51.845**	**51.229**	**44.097**	**33.905**	**237.983**

Source: (Rae.gr, 2020)

Table 14: Strengthening of Thessaloniki Low Pressure Distribution Network 4bar per Municipality 2021-2025

Network L.P 4bar (m)	**2021**	**2022**	**2023**	**2024**	**2025**	**TOTAL**
Municipality of Delta	0	0	0	1.442	500	**1.942**
Municipality of Thessaloniki	0	0	0	0	0	**0**
Municipality of Thermaikos	0	0	796	0	1.000	**1.796**
Municipality of Ampelokipi-Menemeni	0	0	0	0	0	**0**
Municipality of Thermi	296	0	0	1.482	0	**1.778**
Municipality of Kalamaria	0	0	396	0	0	**396**
Municipality of Kordelio-Euosmos	0	2.284	907	0	0	**3.191**
Municipality of Neapoli-Sikies	1.432	0	1.000	0	0	**2.432**
Municipality of Pavlos Mela	0	1.796	0	0	0	**1.796**
Municipality of Pilea-Chortiatis	0	0	1.749	0	0	**1.749**
Municipality of Chalkidona	897	0	0	0	1.500	**2.397**
Municipality of Oreokastro	3.267	677	0	2.345	1.500	**7.789**
Municipality of Lagada	0	0	0	0	0	**0**

Municipality of Volvi	0	0	0	0	0	**0**
Various Municipalities	108	243	652	731	1.500	**3.234**
Total	**6.000**	**5.000**	**5.500**	**6.000**	**6.000**	**28.500**

Source: (Rae.gr, 2020)

Table 15: Thessaloniki Low Pressure Distribution Network Extensions 4bar 2021-2025, with payment of Expansion Fees

Network L.P 4bar (m)	**2021**	**2022**	**2023**	**2024**	**2025**	**TOTAL**
Various Municipalities	2.500	2.500	2.500	2.500	2.500	**12.500**

Source: (Rae.gr, 2020)

The following 3 Tables present the development and the strengthening of Low Pressure (4bar) Gas Distribution Network in the area of Thessaly.

Table 16: Development of Thessaly Low Pressure Distribution Network 4bar per Municipality 2021-2025

Network L.P 4bar (m)	**2021**	**2022**	**2023**	**2024**	**2025**	**TOTAL**
Municipality of Larissa	4.000	5.000	3.697	2.890	2.500	**18.087**
Municipality of Volos	7.000	6.821	4.670	3.114	3.114	**24.719**
Municipality of Karditsa	4.250	2.479	1.239	1.239	1.000	**10.207**
Municipality of Trikala	6.000	2.402	1.601	1.601	1.500	**13.104**
Municipality of Almiros	3.400	1.005	503	503	500	**5.911**
Municipality of Farsala	3.000	1.200	514	500	500	**5.714**
Municipality of Kileler	1.200	700	10.600	7.535	4.250	**24.285**
Municipality of Riga Ferraiou	2.000	1.500	500	500	500	**5.000**
Municipality of Tirnavos	5.500	4.765	2.940	1.800	1.500	**16.505**
Municipality of Elassona	3.500	2.049	1.000	1.000	1.000	**8.549**
Municipality of Meteora	2.500	5.184	1.293	1.293	8.000	**18.270**
Municipality of Agia	2.500	1.955	800	600	400	**6.255**
Municipality of Palama	2.500	2.670	2.653	1.283	1.000	**10.106**
Municipality of Sofades	2.000	1.260	945	945	900	**6.050**
Municipality of Pili	2.000	850	500	500	500	**4.350**
Municipality of Mouzaki	2.000	2.154	2.140	1.000	500	**7.794**
Municipality of Tempi	2.000	1.754	1.740	700	500	**6.694**

Municipality of Farkadona	0	3.500	1.500	1.500	1.000	**7.500**
Total	**55.350**	**47.248**	**38.835**	**28.503**	**29.164**	**199.100**

Source: (Rae.gr, 2020)

Table 17: Strengthening of Thessaly Low Pressure Distribution Network 4bar per Municipality 2021-2025

Network L.P 4bar (m)	**2021**	**2022**	**2023**	**2024**	**2025**	**TOTAL**
Municipality of Larissa	1.370	3.301	1.195	0	1.200	**7.066**
Municipality of Volos	528	0	2.644	495	0	**3.667**
Municipality of Karditsa	0	0	0	1.497	0	**1.497**
Municipality of Trikala	1.399	0	0	0	0	**1.399**
Municipality of Almiros	0	0	0	0	0	**0**
Municipality of Farsala	0	0	0	0	0	**0**
Municipality of Kileler	0	0	0	0	0	**0**
Municipality of Riga Ferraiou	0	0	0	0	0	**0**
Municipality of Tirnavos	0	0	0	0	0	**0**
Municipality of Elassona	0	0	0	0	0	**0**
Municipality of Meteora	0	0	0	0	0	**0**
Municipality of Agia	0	0	0	0	0	**0**
Municipality of Palama	0	0	0	0	0	**0**
Municipality of Sofades	0	0	0	0	0	**0**
Municipality of Pili	0	0	0	0	0	**0**
Municipality of Mouzaki	0	0	0	0	0	**0**
Municipality of Tempi	0	0	0	0	0	**0**
Municipality of Farkadona	0	0	0	0	0	**0**
Total	**3.297**	**3.301**	**3.839**	**1.992**	**1.200**	**13.629**

Source: (Rae.gr, 2020)

Table 18: Thessaly Low Pressure Distribution Network Extensions 4bar 2021-2025, with payment of Expansion Fees

Network L.P 4bar (m)	**2021**	**2022**	**2023**	**2024**	**2025**	**TOTAL**
Various Municipalities	2.500	2.500	2.500	2.500	2.500	**12.500**

Source: (Rae.gr, 2020)

CNG Decompressors

The years 2021-2025 EDA THESS plans to construct CNG Decompressors for the development of Gas Distribution Networks in the Prefecture of Thessaloniki and in the region of Thessaly. (Rae.gr, 2020)

Prefecture of Thessaloniki

Table 19: CNG Decompressors for the development of Thessaloniki Gas Distribution Network per Municipality 2021-2025

CNG Decompressors (n)	2021	2022	2023	2024	2025	TOTAL
Municipality of Lagada	0	0	0	2	0	**2**
Municipality of Volvi	1	0	1	0	0	**2**
Total	**1**	**0**	**1**	**2**	**0**	**4**

Source: (Rae.gr, 2020)

Region of Thessaly

Table 20: CNG Decompressors for the development of Thessaly Gas Distribution Network per Municipality 2021-2025

CNG Decompressors (n)	2021	2022	2023	2024	2025	TOTAL
Municipality of Larissa	0	1	0	0	0	**1**
Municipality of Farkadona	0	1	0	0	0	**1**
Total	**0**	**2**	**0**	**0**	**0**	**2**

Source: (Rae.gr, 2020)

New Connections

The following Tables present the new connections that are expected for the period 2021-2025, considering the development of the Distribution Networks and related promotion actions. (Rae.gr, 2020)

It is noted that a forecast has been made for the recognition of a 100% discount rate for the year 2021 and a 0% discount for the years 2022-2025 in the Connection Fees for the years of the Development Program, while no subsidy is provided for the Internal Installations. (Rae.gr, 2020)

Table 21: Number of New Connections 2021-2025

New Connections - Thessaloniki	2020	2021	2022	2023	2024	2025	Total 2021-2025
Thessaloniki	15.027	13.422	12.508	12.012	11.421	10.736	60.100
Thessaly	7.049	6.199	6.100	6.030	5.993	5.928	30.250
Total EDA THESS	**22.076**	**19.622**	**18.608**	**18.042**	**17.414**	**16.664**	**90.350**

Source: (Rae.gr, 2020)

Connection contracts will be increased from 2021 to 2025 by 22% and 26% in Thessaloniki and Thessaly respectively as we observe from the above Tables 8 and 21. All these new end customers will reap the benefits of using natural gas, helping Country's goals for decarbonization.

Table 22: New Connections of Thessaloniki Distribution Network per Municipality 2021-2025

Number of New Connections (n)	2021	2022	2023	2024	2025	TOTAL
Municipality of Delta	620	608	599	589	529	**2.946**
Municipality of Thessaloniki	3.542	3.063	2.963	2.446	2.394	**14.408**
Municipality of Thermaikos	615	827	777	829	716	**3.765**
Municipality of Ampelokipi-Menemeni	352	308	235	235	212	**1.342**
Municipality of Thermi	1.008	976	958	985	948	**4.876**
Municipality of Kalamaria	894	832	838	858	733	**4.154**
Municipality of Kordelio-Euosmos	1.392	1.233	1.140	1.047	909	**5.720**
Municipality of Neapoli-Sikies	1.156	1.055	1.005	938	846	**5.000**
Municipality of Pavlos Mela	1.707	1.293	1.199	926	880	**6.005**
Municipality of Pilea-Chortiatis	1.273	983	899	802	746	**4.703**
Municipality of Chalkidona	125	301	352	419	390	**1.587**

Municipality of Oreokastro	452	688	530	526	491	**2.687**
Municipality of Lagada	255	209	303	605	727	**2.099**
Municipality of Volvi	32	131	213	218	214	**808**
Total	**13.422**	**12.508**	**12.012**	**11.421**	**10.736**	**60.100**

Source: (Rae.gr, 2020)

Table 23: New Connections of Thessaly Distribution Network per Municipality 2021-2025

Number of New Connections (n)	**2021**	**2022**	**2023**	**2024**	**2025**	**TOTAL**
Municipality of Larissa	1.523	1.533	1.462	1.568	1.605	**7.691**
Municipality of Volos	1.618	1.447	1.540	1.619	1.656	**7.879**
Municipality of Karditsa	625	479	462	450	455	**2.471**
Municipality of Trikala	693	804	807	809	820	**3.932**
Municipality of Almiros	97	101	91	87	98	**474**
Municipality of Farsala	168	179	181	101	107	**735**
Municipality of Kileler	50	46	120	137	108	**460**
Municipality of Riga Ferraiou	92	92	76	46	46	**352**
Municipality of Tirnavos	247	309	334	280	263	**1.433**
Municipality of Elassona	245	261	203	163	154	**1.027**
Municipality of Meteora	406	281	239	346	270	**1.542**
Municipality of Agia	68	74	53	36	34	**266**
Municipality of Palama	84	87	89	56	51	**367**
Municipality of Sofades	101	68	68	61	61	**359**
Municipality of Pili	57	63	63	50	42	**275**
Municipality of Mouzaki	66	87	94	61	43	**352**
Municipality of Tempi	58	77	68	61	62	**326**
Municipality of Farkadona	0	113	81	61	54	**309**
Total	**6.199**	**6.100**	**6.030**	**5.993**	**5.928**	**30.250**

Source: (Rae.gr, 2020)

Table 24: Number of Progressive Active Customers 2021-2025

Active Customers	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**

Thessaloniki	248.133	261.594	274.170	286.216	297.643	308.436
Thessaly	104.802	111.081	117.231	123.281	129.281	135.231
Total EDA THESS	**352.935**	**372.675**	**391.401**	**409.497**	**426.924**	**443.667**

Source: (Rae.gr, 2020)

Distributed Volumes of Natural Gas

The distributed volumes of natural gas for the period 2021-2025 is presented in the following Tables.

Table 25: Distribution volumes of natural gas 2021-2025

Distribution Volumes (MWh) – EDA THESS	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
Residential/Commercial	3.909.809	4.040.623	4.295.193	4.492.243	4.682.868	4.864.538
Industrial	1.063.524	1.106.841	1.228.793	1.425.139	1.501.090	1.573.874
CNG	25.906	24.084	24.084	24.084	24.084	24.084
Total	**4.999.238**	**5.171.548**	**5.548.071**	**5.941.466**	**6.208.041**	**6.462.496**

Source: (Rae.gr, 2020)

Table 26: Distribution volumes of natural gas Thessaloniki 2021-2025

Distributed Volumes (MWh)– Distribution Network of Thessaloniki	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
Residential/Commercial	2.654.934	2.693.849	2.851.912	2.974.702	3.091.946	3.201.592
Industrial	498.233	510.431	554.775	709.679	743.120	774.454
CNG	16.208	8.028	8.028	8.028	8.028	8.028

Total	**3.169.374**	**3.212.307**	**3.414.715**	**3.692.409**	**3.843.094**	**3.984.075**

Source: (Rae.gr, 2020)

Table 27: Distributed Volumes of Thessaloniki Distribution Network per Municipality 2021-2025

Distributed Volumes (MWh)	**2021**	**2022**	**2023**	**2024**	**2025**	**TOTAL**
Municipality of Delta	529.904	562.692	589.184	612.518	634.100	**2.928.399**
Municipality of Thessaloniki	1.174.681	1.247.365	1.306.091	1.357.819	1.405.660	**6.491.616**
Municipality of Thermaikos	32.769	34.797	36.435	37.878	39.212	**181.090**
Municipality of Ampelokipi-Menemeni	109.522	116.299	121.774	126.597	131.058	**605.250**
Municipality of Thermi	110.252	117.074	122.585	127.440	131.931	**609.282**
Municipality of Kalamaria	313.683	333.092	348.774	362.587	375.363	**1.733.500**
Municipality of Kordelio-Euosmos	205.705	218.433	228.717	237.775	246.153	**1.136.782**
Municipality of Neapoli-Sikies	180.682	191.862	200.894	208.851	216.210	**998.498**
Municipality of Pavlos Mela	202.936	215.493	225.639	234.575	242.840	**1.121.484**
Municipality of Pilea-Chortiatis	226.490	240.504	251.827	261.800	271.025	**1.251.646**
Municipality of Chalkidona	27.673	30.604	145.317	149.127	152.662	**505.384**
Municipality of Oreokastro	83.617	88.791	92.971	96.653	100.059	**462.091**
Municipality of Lagada	14.141	16.375	19.133	24.639	31.244	**105.532**
Municipality of Volvi	252	1.334	3.068	4.834	6.558	**16.047**
Total	**3.212.307**	**3.414.715**	**3.692.409**	**3.843.094**	**3.984.075**	**18.146.600**

Source: (Rae.gr, 2020)

Table 28: Distribution volumes of natural gas Thessaly 2021-2025

Distributed Volumes (MWh) – Distribution Network of Thessaly	2020	2021	2022	2023	2024	2025
Residential/Commercial	1.254.875	1.346.775	1.443.282	1.517.541	1.590.922	1.662.946
Industrial	565.291	596.410	674.018	715.459	757.969	799.420
CNG	9.698	16.056	16.056	16.056	16.056	16.056
Total	**1.829.864**	**1.959.241**	**2.133.356**	**2.249.057**	**2.364.947**	**2.478.422**

Source: (Rae.gr, 2020)

Table 29: Distributed Volumes of Thessaly Distribution Network per Municipality 2021-2025

Distributed Volumes (MWh)	2021	2022	2023	2024	2025	TOTAL
Municipality of Larissa	762.302	821.158	861.841	902.890	943.187	**4.291.377**
Municipality of Volos	548.899	591.279	620.573	650.130	679.147	**3.090.028**
Municipality of Karditsa	144.323	155.466	163.169	170.940	178.570	**812.468**
Municipality of Trikala	138.063	148.722	156.091	163.525	170.823	**777.224**
Municipality of Almiros	32.060	34.535	36.246	37.972	39.667	**180.480**
Municipality of Farsala	58.706	63.238	66.371	69.533	72.636	**330.484**
Municipality of Kileler	13.650	14.704	15.432	16.167	16.889	**76.841**
Municipality of Riga Ferraiou	208.713	224.827	235.966	247.205	258.238	**1.174.950**
Municipality of Tirnavos	8.812	11.475	14.949	18.347	22.929	**76.511**
Municipality of Elassona	17.401	31.047	33.219	34.939	36.540	**153.145**

Municipality of Meteora	13.562	17.538	20.283	24.272	27.111	**102.765**
Municipality of Agia	1.254	2.109	2.677	3.063	3.417	**12.521**
Municipality of Palama	3.428	4.497	5.448	6.032	6.562	**25.967**
Municipality of Sofades	2.113	2.923	3.652	4.302	4.951	**17.942**
Municipality of Pili	1.505	2.245	2.919	3.451	3.896	**14.017**
Municipality of Mouzaki	2.953	3.962	4.976	5.626	6.080	**23.598**
Municipality of Tempi	1.498	2.397	3.128	3.780	4.434	**15.237**
Municipality of Farkadona	0	1.233	2.116	2.772	3.344	**9.466**
Total	**1.959.241**	**2.133.356**	**2.249.057**	**2.364.947**	**2.478.422**	**11.185.022**

Source: (Rae.gr, 2020)

Main Operational Data of Distribution Networks 2020-2025

The main data of the Distribution Networks for the years 2020 and 2025 are presented below.

Table 30: Data of Thessaloniki Distribution Network - 2020 and 2025

Distribution Network Data - Thessaloniki	**U.M**	**2020**	**2025**	**Difference (%)**
Low Pressure Network (4 bar) Progressive	Km	1.319,6	1.598,6	21,1%
Medium Pressure Network (19 bar) Progressive	Km	152,5	204,3	34,0%
New Connections Progressive	thousands	270,1	330,2	22,2%
Distribution volumes	GWh	3.169,4	3.984,1	25,7%
Penetration Rate – Total Connected/Total Appartments	%	52%	63%	11,0%
Distribution Network Coverage	%	57%	65%	8,0%

Network Length 4bar/Road length				

Source: (Rae.gr, 2020)

Table 31: Data of Thessaly Distribution Network - 2020 and 2025

Distribution Network Data - Thessaly	**U.M**	**2020**	**2025**	**Difference (%)**
Low Pressure Network (4 bar) Progressive	Km	1.005,1	1.230,3	22,4%
Medium Pressure Network (19 bar) Progressive	Km	108,9	148,0	35,9%
New Connections Progressive	thousands	115,0	145,3	26,3%
Distribution volumes	GWh	1.829,9	2.478,4	35,4%
Penetration Rate – Total Connected/Total Appartments	%	52%	64%	12,0%
Distribution Network Coverage Network Length 4bar/Road length	%	55%	64%	9,0%

Source: (Rae.gr, 2020)

The importance of the development shown in the above Table is reflected the decrease of Distribution Tariffs which is one of the most essential benefits of the penetration of natural gas along with the reduction of pollutant emissions. Moreover, this remains a goal of the Regulatory Authority for Energy according with the Tariff Regulation.

The following tables present the efficiency indicators of Distribution Networks.

Table 32: Distribution Network Efficiency Indicators

Annual Quantity (MWh) per Network Meter 4 bar	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
Distribution Network of Thessaloniki	2,4	2,3	2,4	2,5	2,5	2,5
Distribution Network of Thessaly	1,8	1,8	1,9	1,9	2,0	2,0
Total	**2,1**	**2,1**	**2,2**	**2,2**	**2,3**	**2,3**

Network meters 4 bar / Activated Delivery Points	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**

Distribution Network of Thessaloniki	5,0	5,0	5,0	5,0	5,0	5,0
Distribution Network of Thessaly	9,0	9,1	9,0	9,0	8,8	8,7
Total	**6,2**	**6,2**	**6,2**	**6,1**	**6,1**	**6,1**

Source: (Rae.gr, 2020)

As a result of the high increase in acquire contracts, we observe from the Table 32 the increase of the indicator of annual quantity (MWh) per meter of low pressure network from 2,1 MWh/m in 2020 to 2,3 MWh/m in 2025 in total for EDA THESS especially with the increase of connected households.

Furthermore, the decrease of the indicator of low pressure network meters per activated delivery point from 6,2 in 2021 to 2.1 in 2025 in total for EDA THESS is another benefit from the expansion of natural gas network because each 6 m there is 1 connected household.

Financing of the Development Program

Distribution Network Investments

The cost of the development investments of the Distribution Networks will amount to € 149.4 million, which includes the investments in Distribution Networks up to the Delivery Points (gas meters). (Rae.gr, 2020)

Investments are calculated considering the unit cost for each category of construction that includes the cost of contractors, materials and personnel costs. (Rae.gr, 2020)

The amount of investments per year for the period 2021-2025, as well as the cost analysis per category is presented in the following Tables.

Table 33: Distribution Network Investments EDA THESS 2021-2025

Network & New Connections Investments (€ mil.) - Total EDA THESS	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**Total 2021-2025**
Medium Pressure Network	5,49	6,37	5,51	4,54	5,97	4,30	26,69

Low Pressure Network	12,83	14,16	13,50	12,79	11,24	14,04	65,73
New Connections	13,16	11,87	11,51	11,00	10,52	10,15	55,04
Decompressors	2,95	0,33	0,66	0,33	0,67	0,00	1,98
Total Investments	**34,43**	**32,72**	**31,18**	**28,66**	**28,40**	**28,48**	**149,44**

Source: (Rae.gr, 2020)

According to the Table 33 the investments in 4bar network reflects the strengthening of the existing network and the high number of meters which will be constructed in the 2 geographical areas in which EDA THESS has license to develop its distribution network. We observe a steady pace of 19bar network construction from 2021 to 2025 which help the Company to acquire more customers in new areas.

Distribution Network of Thessaloniki

Table 34: Investments in the Distribution Network of Thessaloniki 2021-2025

Network & New Connections Investments (€ mil.) -Thessaloniki	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**Total 2021-2025**
Medium Pressure Network	4,54	5,11	5,00	2,98	2,07	0,07	15,23
Low Pressure Network	7,12	7,68	7,51	7,64	7,12	9,37	39,33
New Connections	8,95	7,68	7,22	7,01	6,74	6,40	35,05
Decompressors	0,74	0,33	0,00	0,33	0,67	0,00	1,33
Total Investments	**21,35**	**20,80**	**19,73**	**17,97**	**16,60**	**15,85**	**90,94**

Source: (Rae.gr, 2020)

Distribution Network of Thessaly

Table 35: Investments in the Distribution Network of Thessaly 2021-2025

Network & New Connections Investments (€ mil.) - Thessaly	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**Total 2021-2025**
Medium Pressure Network	0,95	1,26	0,51	1,55	3,91	4,23	11,46
Low Pressure Network	5,71	6,48	5,99	5,15	4,11	4,67	26,40
New Connections	4,21	4,18	4,29	3,99	3,78	3,74	19,98
Decompressors	2,21	0,00	0,66	0,00	0,00	0,00	0,66
Total Investments	**13,08**	**11,92**	**11,45**	**10,70**	**11,80**	**12,64**	**58,50**

Source: (Rae.gr, 2020)

Additional Investments

In addition to the investments in Network Infrastructure and Connections presented above, the Company will make additional investments of € 8.83 million in the period 2021-2025 to improve its financial and operational efficiency. These include investments mainly in information systems and software infrastructure, but also in buildings, furniture, and equipment. (Rae.gr, 2020)

Table 36: Additional Investments 2021-2025

Additional Investments (€ mil.) - Distribution Network of Thessaloniki	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**Total 2021-2025**
Buildings	0,04	0,04	0,04	0,04	0,04	0,04	0,20
Furnitures and fittings	0,11	0,02	0,03	0,02	0,02	0,02	0,12
IT Hardware	0,17	0,14	0,10	0,18	0,42	0,23	1,07
IT Software	0,53	0,73	0,75	1,36	0,79	0,85	4,48
Total Additional Investments	**0,85**	**0,93**	**0,92**	**1,61**	**1,27**	**1,14**	**5,88**

Additional Investments (€ mil.) - Distribution Network of Thessaloniki	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**Total 2021-2025**
Buildings	0,00	0,01	0,01	0,01	0,01	0,01	0,06
Furnitures and fittings	0,02	0,05	0,01	0,01	0,01	0,01	0,11
IT Hardware	0,08	0,07	0,05	0,09	0,21	0,12	0,54
IT Software	0,09	0,37	0,38	0,68	0,40	0,42	2,24
Total Additional Investments	**0,27**	**0,50**	**0,45**	**0,80**	**0,63**	**0,57**	**2,95**

Additional Investments (€ mil.) - EDA THESS	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**Total 2021-2025**
Buildings	0,04	0,05	0,05	0,05	0,05	0,05	0,27
Furnitures and fittings	0,12	0,07	0,04	0,04	0,04	0,04	0,23

IT Hardware	0,25	0,21	0,15	0,28	0,62	0,35	1,61
IT Software	0,62	1,09	1,13	2,04	1,19	1,27	6,72
Total Additional Investments	**1,12**	**1,43**	**1,37**	**2,41**	**1,90**	**1,71**	**8,83**

Source: (Rae.gr, 2020)

Financing of Investments

The investments of this Development Program which will be 158.3 million euros, will be financed with both equity and borrowing, while from the year 2022 onwards 100% of the cost of the new connections will be recovered from the connection fees.

Table 37: Borrowing

Borrowing (€ mil.)	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**Total 2021-2025**
New Borrowing	**16,0**	**38,5**	**24,3**	**23,8**	**25,8**	**25,0**	**137,4**

Source: (Rae.gr, 2020)

Economic Efficiency of Projects

According to Article 12 of the of the Basic Distribution Activity Tariff Regulation, the impact of the project implementation on the Distribution Network Average Charge during the new evaluation Period is calculated, for the evaluation of the economic efficiency of a new distribution network development project. (Rae.gr, 2020)

The Average Distribution Network Usage Charge is calculated as:

- the quotient of the sum of the budgeted Distribution Network Required Revenue for each year (x) of the New Project Evaluation Period, reduced to the present value of the first year of the Project Evaluation Period
- to quantities of natural gas from all delivery points of the distribution network for each year (x) of the New Project Evaluation Period and reduced to the present value of the first Year of the New Project Evaluation Period.

The Evaluation Period of a new project may be different from the Distribution Tariff Calculation Period to take into account the degree of utilization of the distribution

network with a long-term horizon, as the penetration in the new areas takes place gradually while the network investments in them take place mainly first years.

Based on the above, the impact of the Distribution Network Development Project 2021-2025 on the Average Charge has been calculated and a reduction occurs as we observe in the next table. (Rae.gr, 2020)

Table 38: Economic efficiency of projects 2020-2022

Average Distribution Charge (€/MWh)	**BP 20-24**	**BP 21-25**	**BP 21-25 vs BP 20-24**
Distribution Network of Thessaloniki	10,6468	9,8716	-0,7753
Distribution Network of Thessaly	9,5413	8,8138	-0,7275

Source: (Rae.gr, 2020)

From the above Table we understand the economic efficiency of EDA THESS Development Plan for the period 2021-2025 as the average distribution charge decreases both for the Perfecture of Thessaloniki and the region of Thessaly. This means that natural gas is an economic fuel with a lot of benefits.

Remote Distribution Networks

The development of Remote Distribution Networks of EDA THESS will be done in accordance with RAE Decision 643 02.07.2018 "Development Framework for Remote Distribution Networks using Compressed / Liquefied Natural Gas" (Government Gazette B '3334 / 10.08.2018). There is no provision for the development of a Remote Distribution Network with direct access of Users to its entry points. (Rae.gr, 2020)

The following criteria of point 7 of the above RAE Decision 643/2018 have been considered:

1. Distance from existing network (km).
2. Impact on the Average Distribution Usage Charge but also a possible impact on the average final price of natural gas of the remote network customers.
3. Ensuring the security of supply of the Customers of the Remote Network, the equal access terms of the Distribution Users and the quality of the Natural Gas.
4. Economic efficiency of the various technologies available.

(Rae.gr, 2020)

Cost-benefit study

For each Remote Distribution Network, the results of the cost-benefit study are submitted to RAE, according to par. 3 of RAE Decision 643/2018, which includes at least:

- The predicted consumption (number of connections per customer category and volume of natural gas)
- The estimated cost of construction of the Remote Distribution Network.
- How to supply the Remote Gas Distribution Network.
- The estimated cost of connecting the Remote Distribution Network to an existing Transmission System or Distribution Network, if it were to be connected through pipeline, if this is technically feasible.
- The evaluation results of the criterion of article 12 of the Tariff Regulation and specifically the impact on the Average Distribution Charge: a) in the case of its construction as a Remote Network and even distinct for its supply with CNG / LNG and b) in the case of its connection through pipeline

In addition, according to par. 2 of Decision RAE 860/2019 (Government Gazette B '4642 / 17.12.2019) with the cost-benefit studies, the cost of connection of each Remote Distribution Network through a medium pressure pipeline to the central network is examined, in comparison with the cost of its supply with Virtual Pipeline. The relevant assumptions are based on the analysis of the data with a horizon of the total validity period of the Distribution Network Management License which lasts until 31.12.2043. (Rae.gr, 2020)

From the analysis of the results for the period of the Development Program 2021-2025 in the Prefecture of Thessaloniki and in the Region of Thessaly, the connection through pipeline of the following areas is examined in relation to the connection through Virtual Pipeline, based on the criterion of economic efficiency:

Prefecture of Thessaloniki

- Chalastra (Municipality of Delta) through a pipeline (during the year 2020, according to the approved Development Plan 2020-2024)
- Lagadas (Municipality of Lagadas) through a pipeline (during the year 2023, according to the Development Plan 2021-2025)

- Koufalia (Municipality of Chalkidona) (during the year 2022, according to the Development Plan 2021-2025)

Region of Thessaly

- Tyrnavos and Ampelonas (Municipality of Tyrnavos) through a pipeline (during the year 2024, according to the Development Program 2021-2025)
- Kalampaka (Municipality of Meteora) through a pipeline (during the year 2025, according to the Development Program 2021-2025)

(Rae.gr, 2020)

CHAPTER 5. LNG

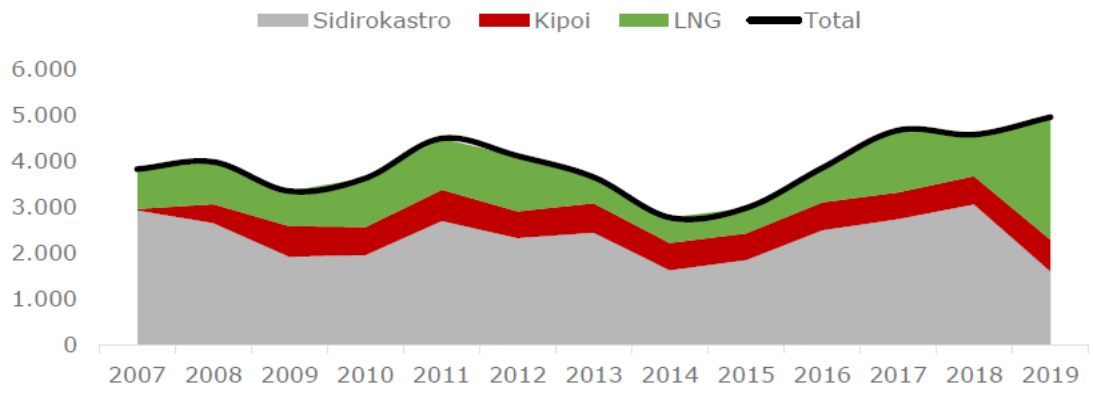
5.1 LNG Terminal Stations in Greece

Entry Points - LNG

In the natural gas network of Greece there are three entry points from which natural gas is flowing to Greece. One is at Kipoi which carrying natural gas from Azerbaijan and is located at the Greek-Turkish borders. The second entry point is located at the Greek-Bulgarian borders, in Sidirokastro, carrying natural gas from Russia and the third is the LNG terminal at Revithousa Island near Athens. (Greek Energy Market Report 2020, p.93)

In 2019 the entry point with the highest quantities of natural gas was the LNG terminal at Revithousa and its role was high importance. The following chart shows all the entry points of Greek gas network and the quantities of natural gas which were transferred through the network from 2007 until 2019. We observe that the importance of Revithousa LNG terminal increased the last years and occupies an increasing percentage of imports. (Greek Energy Market Report 2020, p.93)

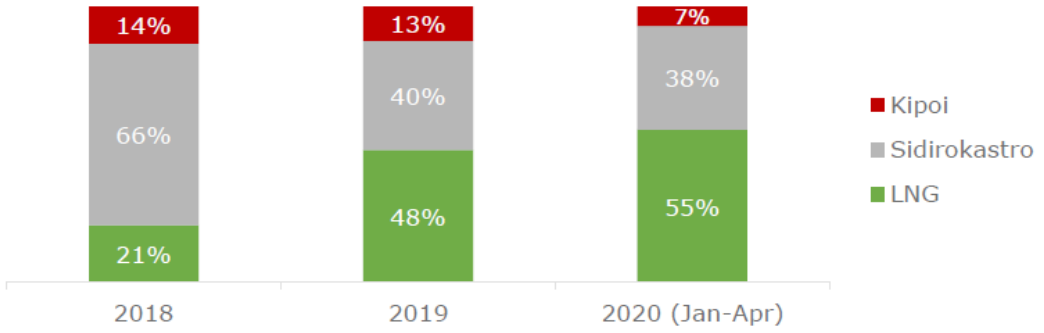
Chart 2: Entry points and Quantities (mil. Nm3), [2007-2019]



Greek Energy Market Report 2020, p.93

The percentage of natural gas imports from the entry point at Kipoi decreased from 14% in 2018 to 7% in the first quarter of 2020. Similarly, the imports from Sidirokastro entry point decreased from 2018 until 2020. Revithousa LNG terminal, in contrast, played a crucial role and was the primary entry point for natural gas in 2019 for the first time (almost half of the gas imports). This trend continued in 2020 when the percentage of imports from this entry point reached 55% in 2020 from 21% in 2018. (Greek Energy Market Report 2020, p.93)

Chart 3: Import Entry Points (%), [2018-2020]



Source: Greek Energy Market Report 2020, p.93

5.1.1 Revithousa Liquefied Natural Gas Terminal

The Liquefied Natural Gas Terminal of Revithousa, located on the island of Revithousa in the gulf of Pachi at Megara, 45 km west of Athens, is one of the twenty-eight (28) liquefied natural gas stations in the Mediterranean and Europe and the only station in Greece which supplies the National Transmission System, receives LNG cargoes, stores and gasifies liquefied natural gas.

Operating since 1999, it is the most important infrastructure of the country, with great efficiency in:

- Providing energy supply security
- Significant ability to face and cover emergencies.
- Flexibility of functionality towards the National Natural Gas Transmission System.

The operation of the Revithousa Terminal, which is certified according to ISO 45001 and ISO 14001, is governed by compliance with strict safety standards and is fully compliant with the requirements of the European Directive SEVESO III (Directive 2012/18 / EU) and safety standards protection of the environment in accordance with Greek and European Legislation. (Desfa.gr, n.d.)

Revithousa Liquefied Natural Gas Terminal Structure

The Revithousa Liquefied Natural Gas Terminal consists of:

- LNG gasification facilities
- A subsea pipeline with a diameter of 24 inches and a length of 510 meters
- LNG ship unloading facilities.
- Three LNG storage tanks

- A subsea pipeline with a diameter of 24 inches and a length of 620 meters

The upgrade of this Terminal, by increasing the storage capacity through the 3rd storage tank and the LNG gasification capacity as well as the ability to receive larger ships, was carried out in two phases. The upgrade phases were completed the first in October 2007 and the second in December 2018, providing the station with the ability to manage large quantities of LNG - triple quantities - enhancing the country's security of supply and market liquidity and supplying the National Transmission System with 5.2 -5.3 billion cubic meters annually.

The electrical autonomy of the terminal facilities was achieved in April 2009 with the operation of a high efficiency Cogeneration Unit (CHP) with natural gas fuel and power 13MW. (Desfa.gr, n.d.)

Operation of Revithousa Liquefied Natural Gas Terminal

The procedures that take place at the station are the following:

- Pumping and gasification of LNG
- Re-liquefaction of gases resulting from natural evaporation of LNG in tanks
- LNG injection from transport ships
- Injection of natural gas at the point of entry (Agia Triada) in the National Natural Gas Transmission System
- Storage of LNG quantities at a temperature of about -160 OC and at almost atmospheric pressure

Capacity of Revithousa Liquefied Natural Gas Terminal

- Total gasification capacity (Constant maximum gasification rate: 1250 m3 LNG / h (365 days * 24 hours) in normal operating conditions (Sustained Maximum Send out Rate - SMSR).
- Total LNG unloading capacity: 7.250 m3 / h
- Available capacity of LNG storage tanks: 225.000 m3
- Possibility of temporary storage of quantities of natural gas: 221.815,677 m3 LNG (Desfa.gr, n.d.)

For the period 2010-2029 the Development Plan of ESFA includes the construction of a new pier (Small Scale LNG, SSLNG) starting in June 2022 which will serve the loading of LNG on small scale ships (1,000 m^3 to 28,000 m^3). (Desfa.gr, n.d.)

According to the Plan of the Development Program of ESFA for the period 2010-2029, the construction of a new pier (SSLNG) northeast of Revithousa for LNG loading on small-scale ships (1000 m^3 to 28.000 m^3) is scheduled for June 22nd. DESFA in 2020, signing a contract for the creation of a tanker loading station at the Terminal, published studies of the project included in the broader supply plan of POSEIDON MED II LNG ships. The smaller ships will supply with LNG other fuel ships and boats in the port of Piraeus mainly and in other ports, and the larger ones supplying LNG storage facilities and distribution stations in the port of Patra and others, will make the Greek ports a stable base of LNG use. (Desfa.gr, n.d.)

The role and benefits of Revithousa Liquefied Natural Gas Terminal

The reduced shipping cost due to the short distance from Algeria, the country of origin of LNG, which also shapes its disposal price, is a strong advantage of the Station.

The completed upgrades of the Terminal allow both the management of large quantities of LNG and the provision of larger energy reserves to enhance the security of natural gas supply in Greece. (Desfa.gr, n.d.) (Iene.gr, 2021)

5.1.2 Liquefied Natural Gas Terminal of Alexandroupoli

The Independent Natural Gas System (INGS) Terminal of Alexandroupoli, an offshore floating unit for receiving, storing, gasifying LNG and a subsea and offshore pipeline system, is a fourth gateway for natural gas to Greece, as the ESFA imports natural gas from Greek-Bulgarian borders (Administrator BULGARTRANSGAZ), as well as from LNG Station of Revithousa. The project will be inextricably linked to the TAP (Trans Adriatic Pipeline) pipeline and the Greek-Bulgarian IGB pipeline (Gas Interconnector Greece-Bulgaria).

Image 9: Location of the Alexandroupolis INGS

Source: Gastrade.gr

The INGS of Alexandroupoli, consisting of a floating Receipt Station and a natural gas transmission pipeline of 28 km, of which 24 km underwater and 4 km by land, which will be the connection of the Alexandroupolis INGS to the ESFA in Amfitriti. The onshore pipeline with a nominal diameter of 762mm and a design pressure of 110 barg, consisting of three sections, will be assisted by a shore valve station which will act as a safety valve isolating the onshore from the offshore pipeline in the event of a leak in the first. (Desfa.gr, n.d.)

Basic parts of ASFA Alexandroupolis

A) Offshore Floating LNG Storage and Regasification Unit

- Metering unit for the measurement of the regasified volumes
- Four LNG storage tanks and four regasification units
- Tanker mooring and LNG transfusion systems.
- Power plants to meet the needs of the floating unit for electricity.

(Gastrade.gr, n.d.)

Floating Unit features

- Length: about 300 meters
- Width: 32.5 meters
- Height: 26.5 meters
- Storage capacity (LNG tank capacity): up to 170,000 m^3
- Maximum hourly gasification capacity in normal operating conditions: up to 700,000 cubic meters / hour or 6.1 billion. cubic meters / year
- LNG transfusion rate: 10,000 m^3 / h
- Possibility of rotation downstream of the wind (360^o) and mooring at the anchorage point, through a turret device.

(Gastrade.gr, n.d.)

B) Permanent offshore facilities

Permanent offshore facilities include:

- the mooring of the floating unit
- the mooring turret of the floating unit,
- the subsea Pipeline End Mnifold (PLEM) and two flexible pipelines

(Gastrade.gr, n.d.)

Image 10: Existing and Planned LNG Terminals

Source: Stambolis & Mezartasoglou, 2018

C. Subsea and onshore sections of the gas transmission Pipeline

The subsea part of ASFA has a depth of up to fifteen meters while for a smaller depth and at 6km from the shore it is embanked after being placed in a trench. It continues its course underground to the north for four km until the new Metering Station built by DESFA in Amfitriti. The land section of the pipeline will be connected to a pipeline with a diameter of 30 inches with a maximum operating pressure of 30 barg of the ESFA in the section of Kipoi - Komotini. (Stambolis & Mezartasoglou, 2019)

Legislative Framework of the Independent Natural Gas System (INGS) of Alexandroupoli

The construction and operation of ASFA Alexandroupoli is governed by compliance with Greek and European legislation, following instructions, laws and regulations:

- Law 2971/2001 regard to seashore and other provisions
- Ministerial Decision 12044/613/2007 on safety regulations in accordance with Directive 2003/105 / EC (SEVESO II)
- Law 4001/2011 on the operation of Energy markets for Natural Gas for research Production and transmission networks of Hydrocarbons
- Law 3982/2011 on the licensing of technical activities
- Law 4014/2011 on environmental licensing of the Ministry of Environment
- Law 26510/2012 on Technical Regulation of Natural Gas Transmission Systems with Maximum Operating Pressure over 16 bar.
- Law 4277/2014 no. 45 on provisions for the New Regulatory Framework
- Regulation 347/2013 on the trans-European energy infrastructure guidelines

(Gastrade.gr, n.d.)

Contribution of Alexandroupoli INGS to the energy security of Greece and the Balkans

The Alexandroupolis LNG floating receipt, storage and gasification Unit, by expanding natural gas sources and supply routes, and supplying the Greek and regional

market of SE Europe, ensures improved reliability and flexibility of both National and International and Trans-European Systems. As a new energy gateway for Greece and SE Europe, it holds a strategic position at the meeting point of energy corridors and pipelines:

- Connected to the Hellenic Natural Gas Transmission System (ESFA).

- Having access to the markets of Bulgaria, Romania, Serbia, and Hungary.

- Having the ability to supply the Turkish market, through reverse flow of the existing Interconnection Network.

- Gaining access to the gas network in the Western Balkans and in the markets of Western Europe through the possibility of interconnection with the future gas infrastructure of the Southern Corridor (TAP). (Stambolis & Mezartasoglou, 2019)

- Strengthens the National Natural Gas System by contributing to the energy security of the Greek market while supporting the reduction of gaseous pollutant emissions and energy sustainability.
- Enhances the energy security of the countries of the Balkans and SE Europe, creating new alternative supply routes with interconnectors and providing access to alternative sources of gas supply.
- Contributes to EU energy security following and supporting its strategy for diversified sources and energy supply routes.
- Supports the competitive regional transaction hub, enhancing competition in the SE region of Europe.
- Improves the durability, reliability, and flexibility of the National Natural Gas System and the Regional and Trans-European Systems.
- It can help reduce the dependence of Central and Eastern European countries on Russian gas supplies.
- Provides the opportunity to export gas to Europe to many different LNG suppliers such as USA and Australia. (Stambolis & Mezartasoglou, 2019)

The Independent Natural Gas System of Alexandroupoli is building the foundations for the establishment of a Euro-Asian natural gas hub being an important regulatory factor of Greek and wider policies. The benefits for Greece in the triptych of increasing exports, strengthening competitiveness, and providing jobs, are added to the

commercial importance of the project which reduces the energy costs of the countries that have access to it and contributes to liquidity, efficiency and energy security of the country. (Gastrade.gr, n.d.)

5.1.3 Independent Natural Gas System "Dioriga Gas"

The Independent Natural Gas System "Dioriga Gas" is a goal for the construction of a floating gasification and LNG storage unit, in the bay of Ag. Theodoroi with its inclusion in the Ten-Year Development Program of the ESFA for the period 2021-2030. The project is licensed by RAE as the issuing authority, with the license of the Independent Natural Gas System, with commercial operation in December 2022. The Independent Natural Gas System "Dioriga Gas" will consist of:

- An Offshore floating LNG terminal 1.5 km SW of the MOTOR OIL refinery (HELLAS) CORINTH REFINERIES SA and the project will include:
    - Floating Storage and Regasification Unit (FSRU)
    - Floating anchorage with multiple mooring points
    - Specific pipelines for the connection of FSRU to the ESFA through a new metering station
    - Four LNG storage tanks. (Energyin.gr, 2020)
- A 500 m Subsea pipeline part of which will be inside the trench for safety reasons.
- A terrestrial gas pipeline to the National Gas Transmission System (Desfa.gr, 2020)

Technical characteristics of the project

- Capacity of gasification unit: 300-500 m^3 LNG / hour
- Total storage capacity of tanks: 130.000-180.000 m^3
- Ability to supply natural gas to the system: 2.0-3.0 bcm / year (Energyin.gr, 2020)

The "Dioriga Gas" project will be a new energy gateway for the country, securing new quantities of natural gas in the ESFA. It will ensure the penetration of natural gas in remote areas of the country and will promote competition for the benefit of final consumers. (Energypress.gr, 2020)

The development of new LNG infrastructure in Greece is a guarantee of European Energy Security in the coming years as the reduction of Norway's gas

production from 2022 combined with the reduction of European domestic gas production, threaten this security. (Pitatzis, 2018)

The right direction of European Energy Security in the coming years will be the choice of LNG, as it is expected to reduce Norway's gas production from 2022 in combination with the reduction of European domestic gas production. (Pitatzis, 2018)

The benefits of the Independent Natural Gas System "Dioriga Gas"

- It will diversify the energy supply sources of Greece.
- Promoting competition will make the price of gas more competitive.
- Will ensure new quantities of natural gas in the ESFA by enhancing its flexibility.
- Ensures the penetration of natural gas in remote areas by developing activities of compressed natural gas or LNG on a small scale.
- It will be a new energy gateway by decongesting the LNG Terminal of Revithousa (Energypress.gr, 2019)

5.1.4 Small Scale Liquefied Natural Gas Facilities in Patra

On July 2, 2020, a memorandum of cooperation was signed by DESFA, DEPA and Port Authority of Patras (OLPA) for the construction of the Small-Scale LNG facilities in the southern port of Patra, with a storage capacity of 3,000 m^3. (Energypress.gr, 2019)

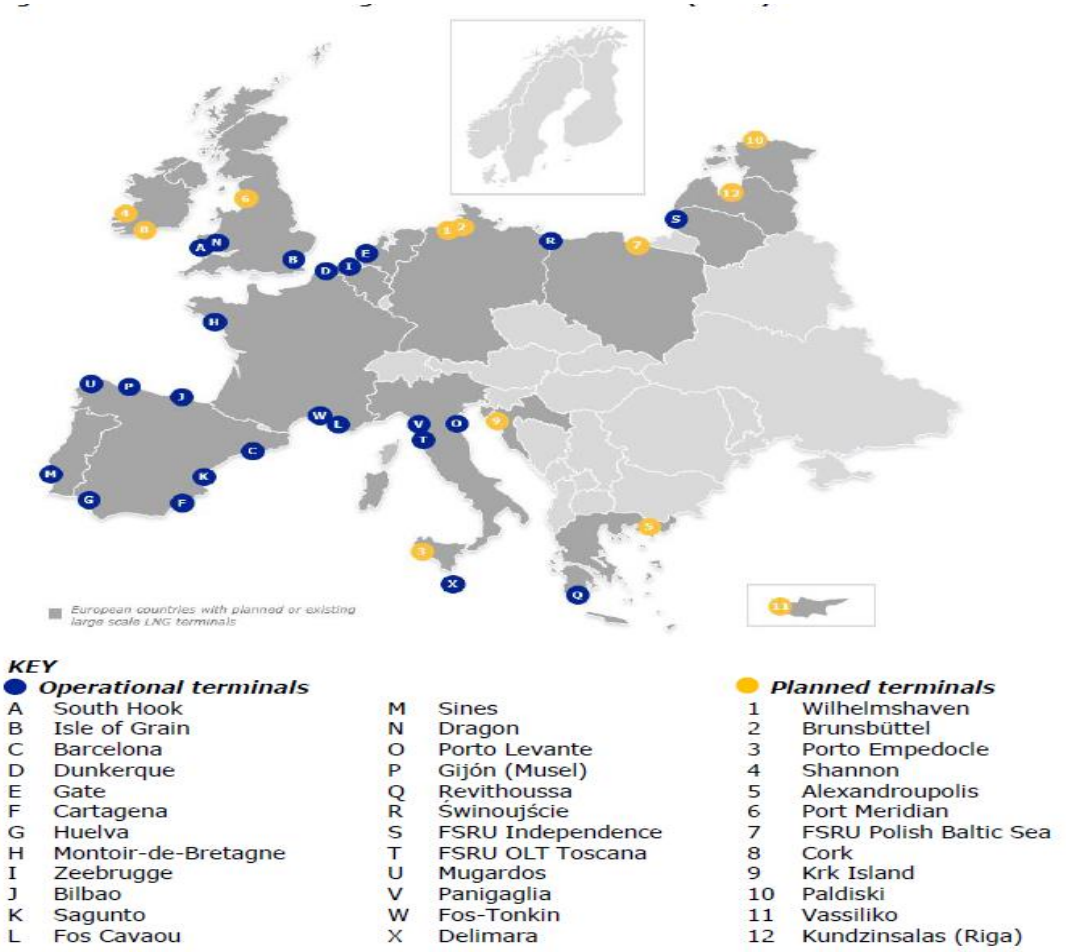
The project is part of the European program POSEIDON MED II with a total planning of 53 million Euros, co-financed by 50% by the EU, by 50% from twenty-six companies from Greece, Cyprus and Italy and under the supervision and coordination of DEPA for the creation of appropriate infrastructure, follows the National Policy Framework for alternative fuels and according to this until December 31, 2025, is provided a sufficient number of refueling points for LNG ships in domestic central ports. (Energypress.gr, 2019)

5.2 The role of Greek LNG Terminals in the energy security of the European Market

LNG imports in Europe and LNG Terminals

LNG Terminals have been operating reliably in Europe for the last fifty years as a source of energy. The existing LNG Reception Terminals are twenty-four, with the largest in the South Hook of United Kingdom with an annual capacity of 21 billion Nm^3 while twelve are to be built and operated immediately.

Image 11: European LNG Terminals



Source: European Commission, 2020

The EU needs for natural gas, according to the annual data of the European Commission for 2019, are covered by imports:

- From Russia at a rate of 31%
- From Norway at a rate of 28%

- From Algeria at a rate of 5%

The percentage of imports in 2019 doubled compared to 2018. (European Commission, 2020)

The following table shows the quantities of natural gas that are expected to be transported through Greece for the years 2020-2030. The relatively low gas prices of competing Asian markets combined with the development of new liquefaction capacities in the United States have led to an increase in LNG imports in Europe.

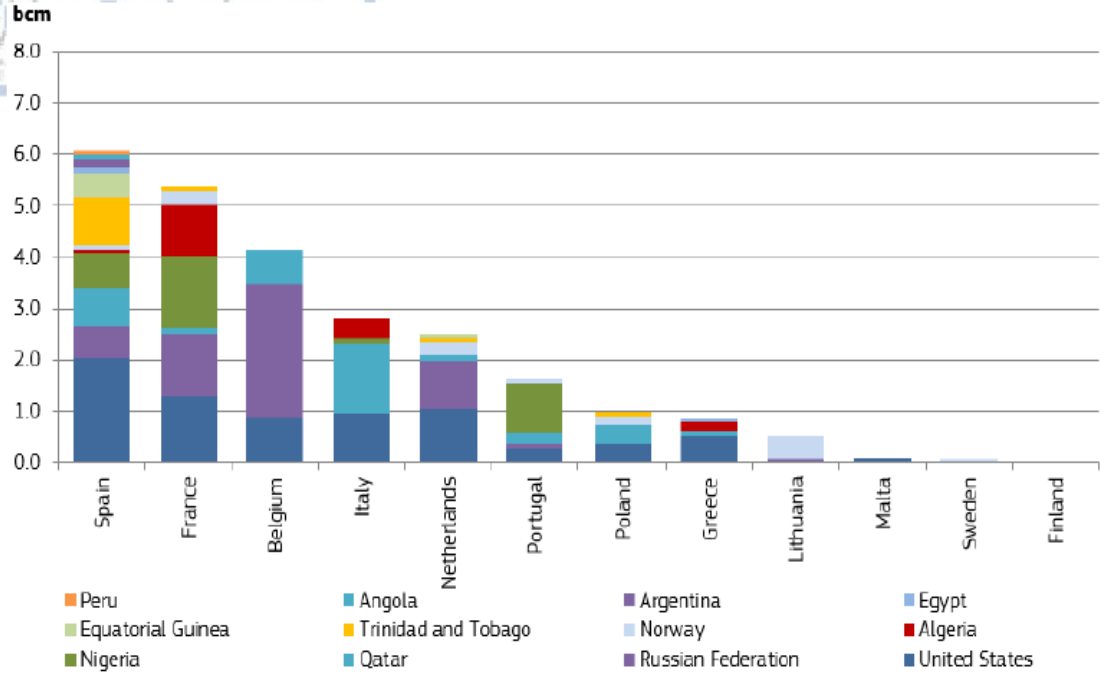
Table 39: Future Natural Gas Imports

Future natural gas imports	
Through TAP	10,0 bcm in 2020 (1,0 bcm in Greece, 1,0 bcm in Bulgary and 8,0 bcm in Italy) with the perspective 20,0 bcm in 2030 (2,5 bcm in Greece, 1,5 bcm in Bulgary and 16,0 bcm in Italy)
Through IGB pipeline	1,0 bcm (2020) with perspective 4,0 bcm (2030)
Through IGNM pipeline	1,0 bcm (2020) with perspective 1,5 bcm (2030)
Through LNG Terminal of Revithousa	1,5 bcm (2020) with perspective 3,0 bcm (2030)
Through INGS of Alexandroupoli	1,5 bcm (2020) with perspective 4,0 bcm (2030)
Through East Med pipeline	0,0 bcm (2020) with perspective 10,0 bcm (2030)

Source: IENE Annual Report 2019

The chart below shows LNG imports from EU Member States from various sources in the first quarter of 2020.

Chart 4: EU Member States' LNG supply countries



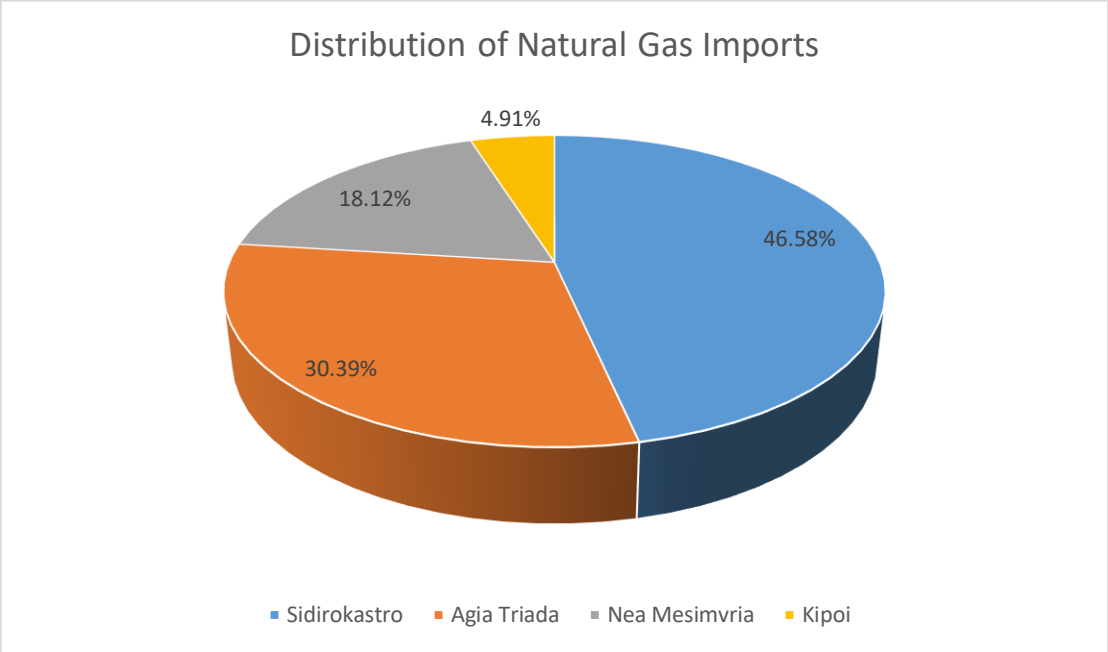
Source: Study on Gas market upgrading and modernisation - Regulatory framework for LNG terminals, 2020

Imports of Liquefied Natural Gas in Greece

The increase of LNG imports due to low prices in the last year and a half, changed the landscape of recent decades where gas imports from Russia covered 70% of gas imports to Greece. (Stambolis & Mezartasoglou, 2018)

From January to September 2020 the increased consumption of 4 billion sq.m. According to DESFA data, 48% was covered by admission to the LNG Terminal in Revithousa, recording an increase of 20% compared to 2019. (Desfa.gr, 2020)

Chart 5: Distribution of Natural Gas Imports



Source: Desfa.gr, 2021

Below there are DESFA's results on natural gas consumption in the first quarter of 2021:

- 4.56% increase in natural gas consumption in Greece in the first quarter of 2021 compared to the same period of 2020.
- Significant inflow of natural gas from the new entry point of ESFA in Nea Messimvria following the interconnection with TAP (The interconnection point with TAP in Nea Mesimvria was put into commercial operation on 31/12/2020)
- Sidirokastro is the main gas entry gateway of Greece in the first quarter of 2021.
- Electricity producers covered 53% of domestic gas consumption - Increased demand by industries & CNG. (Desfa.gr, 2021)

Image 12: Natural Gas Data Q1 2021

Source: Desfa.gr, 2021

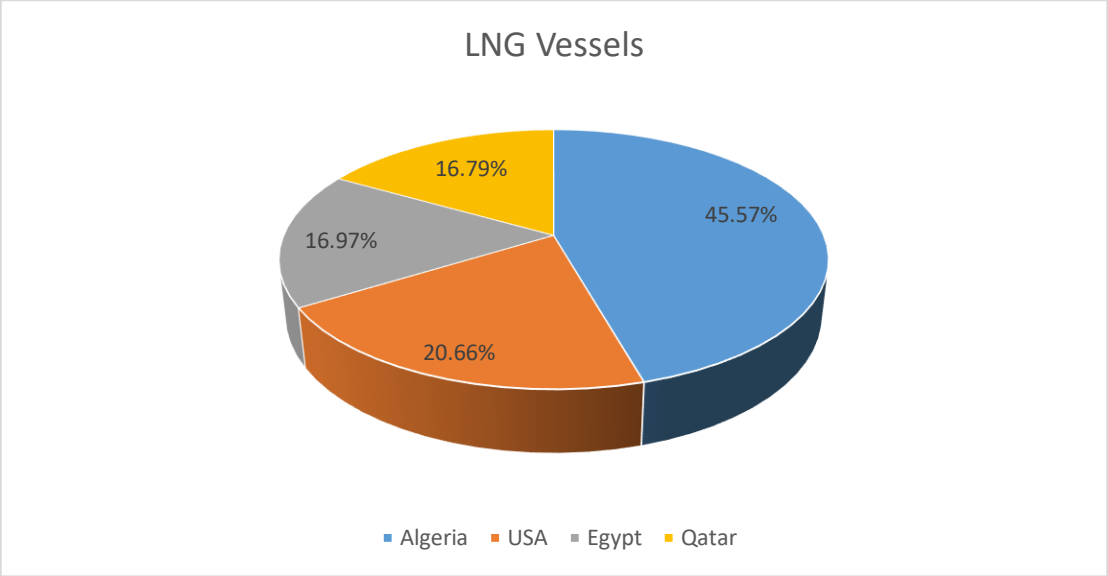
Regarding the LNG unloadings at the Revithousa Terminal, in the period January-March 2021, about 5.43 TWh were unloaded from 9 tankers compared to about 10.78 TWh from 15 tankers in the corresponding period of the previous year. The reductions mainly concern LNG shipments from the USA and Qatar, while imports from Algeria increased significantly, with 2.47 TWh of LNG compared to about 0.98 TWh imported in the same period last year, as shown in the image below. There was an increase of 10.84% compared to the first quarter of last year in LNG imports from Egypt, which in the first quarter of this year reached 0.92 TWh. As a result, during the period January - March 2021, Algeria was the largest importer of LNG in our country with 45%. The USA followed with 21% of the total quantities imported, while 17% is the share for Egypt and Qatar. (Desfa.gr, 2021)

Image 13: LNG Vessels in Revithousa Terminal

Source: Desfa.gr, 2021

As we see in the following chart about half of the total LNG quantities were imported from Algeria, 21% from USA and both Egypt and Qatar occupied about 17% of total imports in the first quarter of 2021.

Chart 6: Percentage of LNG Vessels from importing countries.

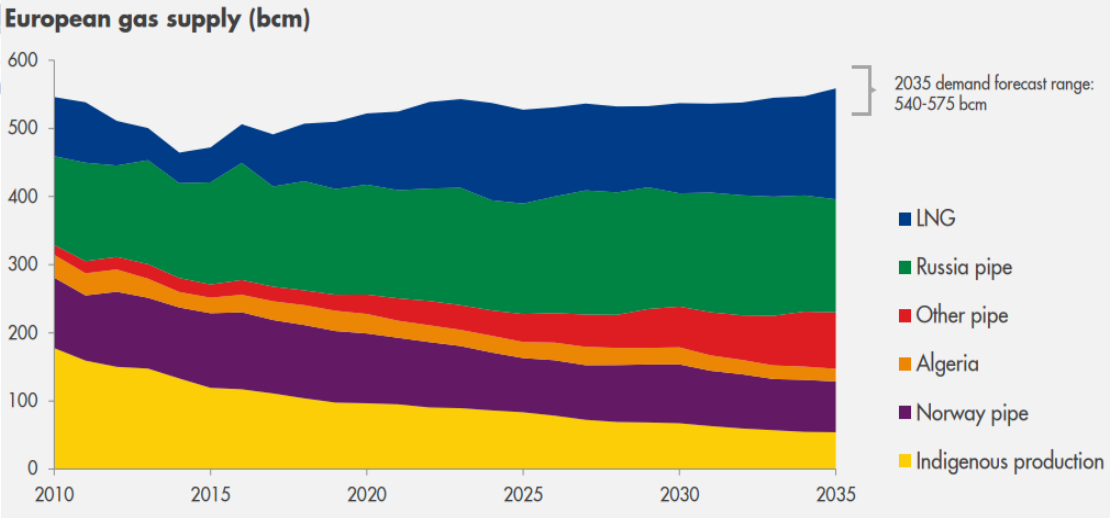


Source: Desfa.gr, 2021

The role of the development of new LNG infrastructure in Greece

The forthcoming reduction of Norway's natural gas production, which is expected from 2022, and the reduction of domestic European gas production, are two components that support the choice of LNG as the right direction of European Energy Security. (Pitatzis, 2018)

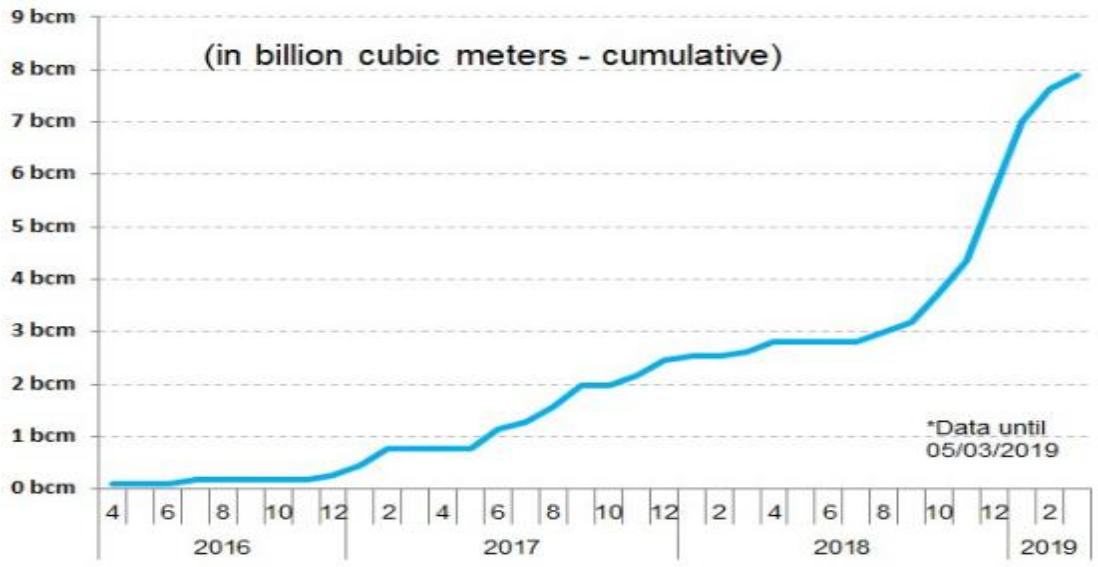
Chart 7: LNG share in Europe's total energy mix



Source: Pitatzis, 2018

As early as 2017, there was a rapid increase in US LNG exports to Europe, demonstrating the role of LNG in European Energy Security.

Chart 8: US LNG exports to Europe



Source: Ec.europa.eu, 2019

The role of the Greek LNG Terminals is crucial, and these stations are important in the international gas supply chain. By connecting to Europe's existing pipelines, they achieve opportunities to diversify their sources of supply by enhancing the energy security of European countries with common interests.

The emergence of the role of Greece as a hub in the energy events of Europe, through the creation of a regional trade hub of natural gas based on it, is possible under two basic conditions:

- The existence of sufficient quantities of natural gas to ensure import from various points.
- The operation of the Energy Exchange, which has already started with the aim of offering the necessary mechanism and transparent operating conditions for conducting transactions. (Stampolis & Mezartasoglou, 2018)

CHAPTER 6. DECARBONIZING OPPORTUNITIES FOR GAS: FOCUS ON HYDROGEN

Gas technologies can play a major role in the low-carbon transition.

Gas technologies can play a major role in the low-carbon transition. As countries and regions pursue a low-carbon transition, technologies such as biomethane, hydrogen and gas with carbon capture could play an important role, serving to decarbonize sectors of the economy that are currently seen as 'hard to abate', and providing opportunities for long-term growth for the gas industry. However, investment and policy support are needed to scale up these solutions. (Global Gas Report 2020, p.5)

The Energy Transition will be an ongoing project, so it requires a plan and zero inaction of the parties involved. In this context, the European Commission promotes the so-called "renewable gases" as an energy solution that transforms in practice the characteristics of the Energy Transition. Biomethane, synthetic methane, ammonia, methanol and of course hydrogen are typical examples of this category, which already plays a leading role in the energy agenda of European countries. This is not just a trend but a strategic choice that we believe our country (Greece) will soon adopt. On the one hand because it will allow us to highlight its comparative advantages, on the other hand because it will make our transition to 2050 smoother.

By using energy more efficiently and thereby consuming less, citizens can lower their energy bills, help protect the environment and use natural gas as a transitional fuel to low-carbon market. In order to achieve these benefits, energy efficiency needs to be improved throughout the full energy chain, from production to final consumption. At the same time, the benefits of energy savings must outweigh the costs, for instance those that result from carrying out renovations. National policies therefore should focus on sectors where the potential for savings is the greatest, such as energy efficient buildings, appliances and reduction in energy intensity of industrial output. (Greek Energy Market Report 2020, p.173)

6.1 Hydrogen: The fuel of the new era needs funding and infrastructure.

Hydrogen has the potential to become one of the most important energy carriers of the 21st century and that is why we must timely integrate its production - transport - distribution in the energy planning of the EU and the Member States, starting with the strengthening of research so that we have accessible technology at good prices.

The European Union already supports R&D programs with further upgrades to P2G (Power to Gas) technology as well as separation technologies. The new Horizon Europe has many opportunities for advanced and applied research in this field. However, it is important to upgrade hydrogen support to European level. One way to do this is through a hydrogen initiative as a major project of common European interest (IPCEI) that will increase the allocation of Community funds and interest in private sector involvement. At the same time, to facilitate the end consumers, the possible additional costs of mixing hydrogen in the gas network should be considered.

Coordinated steps in the EU and in this field can be based on a strategy proposed by the Commission and considering the real potential for hydrogen production in the EU, the existing gas pipeline infrastructure, underground storage facilities and liquefied natural gas (LNG) terminals, as well as in end-use devices. The same study will present the costs and benefits of remodeling, where required, gas infrastructure and end-use appliances for the use of primarily green and blue hydrogen in either pure or mixed, gaseous or liquid form.

For hydrogen to achieve its potential, not only will strong policy action be needed to drive scale, but there will also be a significant need for infrastructure investment. Large-scale hydrogen networks will be necessary to connect high quality production and storage resources to users, which can help lower supply costs, increase security, enable competitive markets and facilitate international trade. (Global Gas Report 2020, p.48)

6.2 Regulatory framework for the use of Hydrogen

The mobility that develops internationally and within the EU around hydrogen and its three shades (green, gray and blue) is also monitored by Greece and prepared for its use. Large energy groups such as ELPE, PPC, DEPA, Mytilineos are integrating into the depth of their energy transition the hydrogen, while at regulatory level the

political leadership of the Ministry of Environment and Energy aims in the autumn to have drawn up an integrated regulatory framework based on the objectives of the ESEK (National Plan for Energy and Climate) and a timetable for the introduction of the new fuel into the energy balance, in a way that will not burden the consumer. Given that the technology of "green" hydrogen with which our country (Greece) is more integrated because of the comparative advantage offered by the exploitation of solar energy, it remains very expensive.

The cost factor continues to divide Europe both at state and business level, which is why the debate on promoting 'green', 'grey' or 'blue' hydrogen continues to dominate the relevant EU institutions and following the Commission's communication of the European project consolidating hydrogen as a key part of the renewable fuel puzzle for decarbonization and the transition to the zero-pollution economy. The shades of hydrogen are connected to its carbon footprint. The so-called "green" hydrogen is produced by electrolysis from the energy of the photovoltaics that is lost, either because it is not absorbed by the grid or because the demand during the hours produced is low and emits zero pollutants. 'Grey' hydrogen is produced from fossil fuels (natural gas) and during its production significant amounts of CO2 are emitted and so-called 'blue' hydrogen is also produced from fossil fuels, but the emitted amounts of CO2 are bound and stored. The cost of "green" or renewable hydrogen is extremely high, five times the cost of energy generated by wind or photovoltaics, which is why so far, any production projects are piloted. The EU itself, because of the high cost, sees its use in sectors that should be decarbonized but this cannot be done with electricity, such as in transport large trucks, ships and industrial sectors such as steel mills and cement mills.

Greece, through the regulatory framework, is expected to support basically "green" hydrogen and this at a time when technology will mature, and its costs will not be borne by consumers. "Grey" hydrogen is treated with scepticism because it leads to greater dependence on natural gas, which goes against the objectives of the ESEK. What the country (Greece) sees centrally and in cooperation with the respective companies is the "greening" of natural gas infrastructures, within the framework of a relevant Community Directive and the creation of a "window" for the continuation of the financing of natural gas projects beyond 2021, since this is a prerequisite for their financing by the ETEP (Greek Technical Specifications). In this context it has already been decided to transport hydrogen via the Tap pipeline, while the transfer of hydrogen through the National Gas Transmission System by the DESFA administration and the

transport of hydrogen through the networks of the EDA and the DEDA are also being considered. DEPA and Edison also see partnerships to transport hydrogen through the East Med pipeline.

Greece is also in an equally advantageous position to harmoniously integrate hydrogen in its energy planning. For example, the potential utility of hydrogen as a method of storing energy produced by Renewable Energy Sources. Pending continuous improvements in the efficiency and cost of electrolysis technologies, any surplus electricity from Renewable Energy Sources may in the future be able to supply electrolytes to produce hydrogen, which can be stored for future use.

6.3 Biomethane

Our country (Greece) is currently promoting the development of standard Waste Processing Units (WPUs) throughout the Territory. Admittedly lagging in this area, Greece is now accelerating its pace to regain "lost ground". Therefore, in the auctioned WPUs our Country can specify the construction of biomethane production units. As far as several of the existing WPUs are concerned, it can also encourage the upgrading of the produced biogas to biomethane.

At the same time, Greece has heaps of unexploited sources of organic waste (agricultural production, livestock, fish farming, food industry, biological cleaning stations) that could be exploited in the same direction. Therefore, biomethane production can drastically reduce the pollutants emitted by waste and waste, as long as there are applications for utilizing this biomethane. For example, the main field for the absorption of biomethane throughout Europe, which is undoubtedly the existing gas network.

Biomethane, depending on its origin, can be considered up to 100% renewable energy and in any case can replace natural gas. Therefore, biomethane would allow a significant increase in renewable energy consumption in areas difficult to "claim" from traditional Renewable Energy Sources such as heat generation. At the same time, it would ensure a high degree of utilization of the Greek gas network, an infrastructure that is worth remembering as having less than 25 years of operation in our country (and in some places even fewer years) and therefore has another significant stock of "commercial and business life."

Another area that is suitable for the absorption of quantities of biomethane is the sector of road and sea transport. The increasing penetration of natural gas as a

propellant for vehicles and ships also creates the background for the penetration of renewable gaseous fuels such as biomethane. The mixing of LNG with liquefied biomethane (Bio-LNG) will allow the immediate improvement of the environmental footprint of heavy vehicles and ships that will choose to switch to natural gas. In recent years, the Greek State has practically embraced the utilization of natural gas as fuel both on land and at sea and therefore has the resources to activate this prospect of significant discharge of the highly energy-intensive transport sector.

6.4 Renewable Gases

Besides that, there are many other potential applications of hydrogen that would easily harmonize with the Greek energy reality. The first would be using hydrogen to generate electricity, by utilizing the gas turbines of modern gas stations already in operation or in design process. After all, large manufacturers are already installing gas turbines that can consume a fuel mixture with up to 50% hydrogen content. This is an encouraging prospect for an energy market like the Greek one, in which significant investments are currently being made in new gas-fired power stations. It is also an equally encouraging prospect for our islands, where there are currently no alternatives other than petroleum products to meet base power load needs. Another application of hydrogen utilization is its injection into the gas pipeline network. Depending on the technical specifications of each national or even local network, the maximum hydrogen concentration allowed by the Administrator varies considerably. But it remains an effective and immediately feasible way of "decarbonizing" the electricity sector and heating.

It seems, therefore, that renewable gases have the potential to acquire a significant future footprint in the energy mix of our country. So, Greece could include renewable gases not only in the national public debate but in its strategic roadmap for 2050. The data so far show that their assistance is necessary to achieve the Energy Transition, as defined by the European Commission.

CHAPTER 7. CONCLUSIONS

The energy sector, being a field of continuous developments, which are constantly harmonized with environmental and economic goals, adapts its choices to fuels based on these goals. In recent decades, natural gas, as a superior conventional form of energy, has been the fastest growing energy source with significant advantages over oil and coal being less polluting and more efficient and safer. The difficulty of transportation and the need to invest in pipelines and specialized technologies are incentives for further developments.

In the field of natural gas, the Greek national strategy in recent decades, producing tangible results over time with positive effects on both the energy and natural environment and the Greek economy and society, is considered successful and effective. In the context of this strategy, the gas market, being a pole of attraction for both public and private investments, highlighting the country's geostrategic advantages and strengthening the role of Greece in the SE Mediterranean and Europe, can contribute to regional development, economic recovery and boosting employment and creating a single and competitive energy market in the country, making energy companies important in SE Europe.

In such an energy environment, it is appropriate to ensure that energy policies and decisions are governed by appropriate choices which will be reflected in similar implementations. In conclusion, proposals and required actions, which I believe contribute to the optimal treatment of the current energy environment, with possibilities for optimal future developments, are the following:

- The transition to decarbonization with natural gas as transitional fuel, in order to be economically feasible, requires the utilization of the existing transmission infrastructure (pipelines).
- The need to utilize all forms of gas and all technologies is imperative, especially at this critical time when new supply pipeline projects and many new interconnection projects are underway. Achieving the net-zero goal in 2050 requires vigilance in project implementation and flexibility in new technologies.
- The import, transport, distribution and use of natural gas requires stability and clarity of regulations and regulatory framework at both national and European level to ensure safe long-term investments. The constant changes of rules and legislative framework, cause uncertainty and put obstacles in investments.

- The large quantities of natural gas that can be extracted through pipelines, new technologies and the FSRU an feasible investment of short depreciation time can meet a great demand in SE Europe and worldwide. The projected increase in gas consumption in the coming years, combined with the geographical position of Greece and the vessels of Greek shipowners to transport LNG, can transform the country from a transit country to a natural gas export country and a geostrategic hub.
- Regarding the use of natural gas in vehicles, the creation of a sufficient number of gas stations will be an important step in the development of gas in the country since the current small number of these stations is currently a deterrent.
- Increased supply diversification such as improved cross-border flows is very important, to avoid the risk of dependence on a single point of supply.
- The creation of infrastructure, storage areas, liquefaction capacity is crucial, to avoid the risk of dependence on one or a few sources.
- Strengthening the three pillars of energy policy, security of supply, market integration and the sustainability and diversification of both sources and supply routes in Europe are prerequisites for consolidating the country in the European energy plan.
- Gas distribution companies, only by setting long-term goals, with the preparation and implementation of development programs can lead to network expansion, infrastructure investments and technological innovations, creating a very auspicious and flexible framework for both integration and expansion of natural gas.
- Gas Distribution Companies, with the typical example of EDATHESS, setting long-term goals, prepare and implement Development Programs for network expansion of their regions, investments in infrastructure and innovations in technological achievements, creating a very auspicious and flexible framework for both consolidation and expansion of natural gas in its current form as well as new because of climate-neutral impurities, inside and outside borders.
- The development of new gas infrastructure in Greece, supporting the three pillars of European energy policy, security of supply, market integration and sustainability and the important role of Greek terminals in diversifying both sources and supply routes in Europe constitute the auspicious energy landscape of the country.

- The new gas entry points that will be implemented in the coming years in our country, which are expected to further strengthen the role of Greece as a transit hub will make the role of Greek LNG terminals at the point of independence from Russia, but also in achieving the EU's environmental objectives.
- The upgrade of Greece's geostrategic position as a natural gas transit hub, as it will remove the exclusion of other countries in the region from their access to liquefied natural gas, given that they do not have the ability to develop such infrastructure, makes it an important player on the future energy and geopolitical chessboard of Europe against Russia.
- The LNG stations in Greece, with the terminal in Revithousa highlighting the strategic importance of gas infrastructure and with the FSRU of Alexandroupolis entering its final stage of implementation and building the energy hub bases that can contribute to the energy independence of Greece and Europe of natural gas, as well as with the launch of the construction of an independent natural gas system "Dioriga Gas" and Small Scale LNG facilities in Patra, create a set of specifications, which strengthen the role of liquefied natural gas in Europe's energy security.
- The flexibility, the promotion of necessary reforms at operational, institutional and regulatory level and the strengthening of the irreplaceable role of natural gas in the policy of reducing pollution and decarbonization and reducing the carbon footprint.
- The long-term national strategy strengthens the role of natural gas by confirming its role as a fuel bridge over 2030, due to its reduced emissions competitiveness against solid fuels. Natural gas, being an option of great importance for final energy consumption due to cost, convenience and special applications, especially in industry, is difficult to be fully substituted by electricity with reduced pollution. However, the exclusive flow in the transmission and distribution system in our country, whether imported gas, through interconnection pipelines or through LNG loads, which prevails in the current situation, does not make the gas distribution system climatically neutral. In the long run, changes in the composition and distribution of natural gas will consolidate its position in the list of desirable environmentally friendly fuels.
- In the future, the main component of the gas fuel distribution and transmission system will not be natural gas in its original form and gas impurities will be integrated with it into the networks.

- The transformation of natural gas at the level of composition and supply is a goal of the next decades as an expression of political harmonization with the demand of the zero-carbon footprint. The maturation of liquefaction and regasification technologies for natural gas and hydrogen will enable their distribution and use in areas not covered by the central interconnected natural gas transmission and distribution system.
- Reducing carbon dioxide emissions from fossil fuels in industry is possible and achievable through a combination of measures, one of which is the use of natural gas and the replacement of oil, which is already underway but is expected to be extended under the National Plan for Energy and Climate for 2030 and onwards.
- The use of liquefied natural gas in maritime transport is foreseen and is expected to acquire a large share, provided that the creation of climate-neutral gas containing biomethane and synthetically climate-neutral methane, in order to achieve long-term use. The further reduction of the carbon footprint of the gas may be achieved through the admixture of low to zero climate footprint gases such as hydrogen, biomethane and synthetic methane (e-gas, synthetic methane).

The following are options for implementation, the implementation of which raises technical issues related to infrastructure management and requires the launch of action planning to ensure the uninterrupted supply and storage of natural gas. Appropriate policies, plans, implementations, and applications are required to be highly successful actions in the field of natural gas and the wider energy environment. The options that need action planning routing to avoid technical issues are:

- The supply of shipping, inaccessible areas and the supply of liquefied gas loads with which the power stations of commercial vehicles will operate.
- The expansion of the interconnected system
- The supply of individual points through liquefied natural gas
- The decentralized self-production of hydrogen or biomethane
- The development of the hydrogen and biomethane production units with the mixing to be done in different positions of the network and not in the high pressure as the natural gas is injected today.

- The complete revision of the injection regulations, safety, and balancing obligation in order to achieve the operation of such a new model of use of gases with zero carbon footprint.
- Flexibility, the promotion of necessary reforms at operational, institutional, and regulatory level and the strengthening of the irreplaceable role of natural gas in the policy of reducing emissions, decarbonization and reducing the carbon footprint are the preconditions and guarantees of its objectives.
- Proper planning and implementation of energy policies in the country based on compliance with zero carbon footprint environmental regulations, is the framework of the natural gas market, which aims to achieve the goals set with a milestone in 2030 and in the long run in 2050.
- New trends and technologies are changing the way energy is produced, delivered and consumed. Investment, innovation and public-private partnerships are needed to accelerate the transition to a more sustainable, secure and affordable energy system, while optimizing the net social and economic value provided by materials.

Aiming to achieve energy-friendly, human and environment-friendly decarbonization policies, five global energy trends - including the use of natural gas - are shaping current and future way of living:

- Climate change in combination with the risk of pandemic (COVID-19) that arose bringing to the forefront demands for a healthy and sustainable planet and healthy people.
- Renewable Energy Sources to reduce greenhouse gas emissions and carbon dioxide emissions.
- Digitization to create more efficient and sustainable urban environments, connectivity, publicly accessible data, interconnected IT platforms and other advanced technologies. Being a game-change with profound effects on the economy, society and cities, as it can be considered as a broader and long-term social transition, affecting, among other things, work and communication.
- Circularity (Circularity) the new economic model of circular flow of use and reuse of resources, materials and products. to serve a rapidly growing population with a rising standard of living.

- Energy efficiency and its improvement with the introduction of natural gas as a bridge for the economy of low carbon dioxide emissions. Hydrogen networks could play an important role in the transition to low carbon dioxide emissions and require infrastructure investments, and gas is the bridge. Greece is well on its way to achieving its targets for greenhouse gas emissions and renewable energy sources, and the new projects will significantly improve the diversification of gas supply.

- Cooperation between gas networks and renewable gases (biomethane, renewable hydrogen) being an important parameter in the development of natural gas, is necessary on the way to climate neutrality by 2050 and to achieve higher climate targets by 2030 gases contribute to carbon and some of their advantages are:
    - The potential of renewable gases is proven and offers a reliable and affordable solution to address emissions in heating, mobility and industry.
    - Renewable gases promote a circular economy model by converting waste into value, creating jobs and bringing additional profits to farmers.
    - Renewable gases reduce energy dependence on foreign sources and thus enhance the security of supply of the European Union.

To consolidate the role of gas networks as a solution to energy and climate change, investments will be required to make the necessary adjustments, including the digitization of the network and the injection of renewable gases and hydrogen.

In terms of future technologies, biogas is planned to replace fossil gas, which is being transferred to the same network infrastructure that already uses natural gas. According to the new EU energy directive, among the new targets set, there is a final target of 14% of renewable energy sources in the transport sector by 2030.

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