UNIVERSITY OF PIREAUS

DEPARTMENT OF INTERNATIONAL & EUROPEAN STUDIES

MASTER PROGRAMME in ENERGY: STRATEGY, LAW & ECONOMICS

Dissertation

NUCLEAR POWER DEVELOPMENT IN GREECE

Nikolaos Papadantonakis

Pireaus, 2020

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Table of contents

Introduction

Nuclear power has been over the recent years one of the most hotly debated and controversial issues when it comes to both energy supply and strategic importance alike. Its uses are far from limited to the provision of clean energy, but extend through the acquisition of technological know-how to a state's ability to develop nuclear weapons in order to enhance its security and protect its strategic interests. Today, a limited number of states maintain the latter capability, while a growing number pursues the development of the former in an effort to increase energy security supply and at the same time decarbonize their energy mixture.

Greece, being a member of the European Union and at the same time situated in one of the most strategic areas in the globe, faces multiple energy and security challenges that make the exploration of the nuclear option worthwhile.

This dissertation aims at analyzing this topic from a dual standpoint; firstly, the developments in energy supply and energy mixture of Greece will be presented under the light of the commitments to the European Union's environmental policies and the interaction with the interconnected energy markets around the country. It will be shown that the need for abandonment of Greece's "national fuel", the lignite, necessitates the replacement of the base load electrical fuel with a source reliable, cheap in its variable cost and clean in its carbon emissions. Secondly, nuclear option will be explored in the context of the constantly growing security threats that Greece faces from its Eastern neighbor. Turkey, which although tangled in its own financial problems, poses a significant security risk to the country's territorial integrity which is doubtful whether it can be contained by diplomatic or conventional military means. In addition, Turkey's recent endeavor to build nuclear reactors for power generation leaves little room for misinterpretation that the nuclear era has already reached our country's doorstep, and it might be proven a costly mistake to be left behind in this technological race.

It is important to highlight that the purpose of this thesis is not to give answers to how, but to why the nuclear option needs to be explored for our country. Being a nuclear state requires an immense degree of organization, secrecy, funds, specialized personnel and significant resources of all kinds to be put together in order for this national strategic goal to be accomplished. It is highly debatable whether Greece at the moment maintains such resources, or that it would appear favorable to other global players that Greece acquired them. However, this paper being an academic endeavor, aims to demonstrate the rationale behind such a target and not the delineation and undertaking of the possible obstructions towards its accomplishment. This is left to the political leadership of the country which will need to evaluate, assess and prepare the Greek people for the sacrifices required to achieve this strategic objective which could grant to Greece access to the elite club of nuclear nations.

PART 1: ELECTRICITY

Overview

In this part of the thesis, the current and future energy mix of Greece will be examined, and they will be contrasted with the energy mix of neighboring countries. The particularities of the Greek Grid will be analyzed and the reasons behind the uncompetitive electricity prices will be presented. Following this analysis, the benefits of nuclear power in the energy mix will be clear.

Electricity is perhaps the most important means of production to a state or organization. Its secure supply, competitive price and steady availability constitute defining factors to a nation's economic output and prosperity. In fact, from a macroeconomic perspective, electricity consumption is highly correlated to GDP, and is adversely affected during economic crises as will be shown for the case of Greece.

Electricity prices vary throughout the South Eastern Europe markets for reasons related to the energy mix utilized by each respective country, its raw materials availability or price volatility and the European Union's directives mainly related to the reduction of CO2 emissions which, as will be shown, facilitate a continental shift in the way EU countries will cover their energy needs from now on.

Before assessing the potential benefits arising from Greece's transition to the nuclear age of electricity generation, it is worth examining some important aspects that shape its surrounding environment:

1. The energy mix of Greece
2. The energy mix of its neighbors, and
3. The Interconnections between the SEE countries

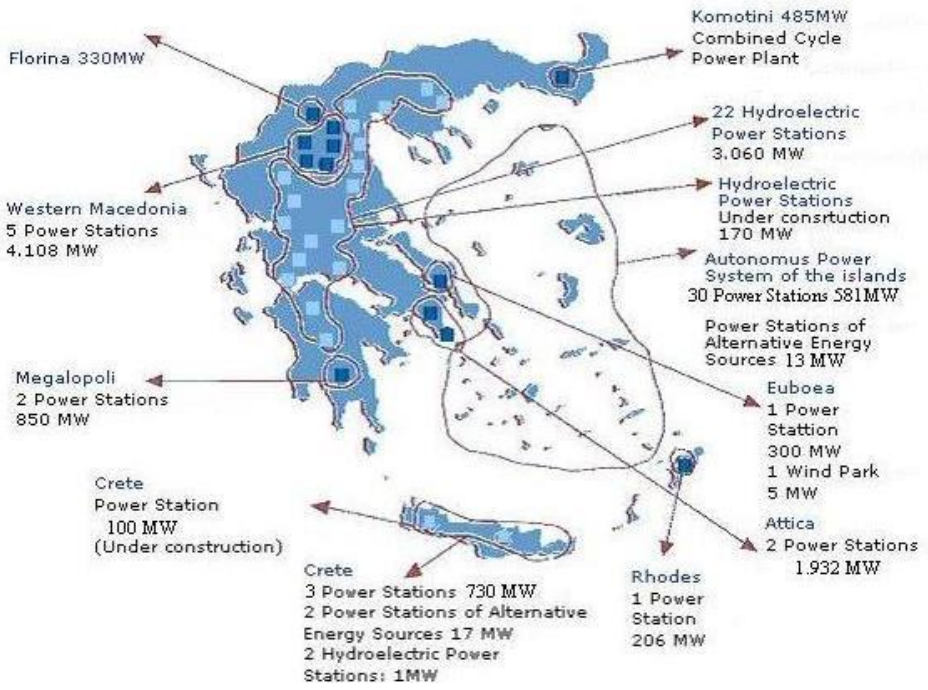
These parameters define the wholesale energy price in each country, thus affecting significantly the course of their respective economies. This part will demonstrate that the competitive advantage held by Greece's northern neighbors, mainly Bulgaria and Romania, lies in the access to cheap energy mainly produced by nuclear which is then exported to other countries.

1. The energy mix of Greece

For years, Greece has relied upon domestic fossil fuels, and more specifically lignite, to cover its energy needs with respect to electricity. It is therefore no coincidence that for more than 60 years, the Public Power Corporation (PPC) has installed significant numbers of power plants close to lignite reserves in order to utilize this cheap-but excessively dirty- form of energy generation. The latest developments pertaining to the EU's decarbonisation policies have created immense pressures to the country to restructure its energy portfolio to a more environmentally friendly mix, however this cannot be achieved without cost.

As depicted in Figure 1, Greece at the moment holds around 17.500 MW of installed capacity, the largest amount of which is attributed to the country's energy giant PPC. More than 60% of the total installed capacity belongs to PPC, while the rest 40 % belongs to Independent Power Producers (IPPs) both large and small scale.

Figure 1: ***PPC powerplants***



Source: PPC website, 2018 [1]

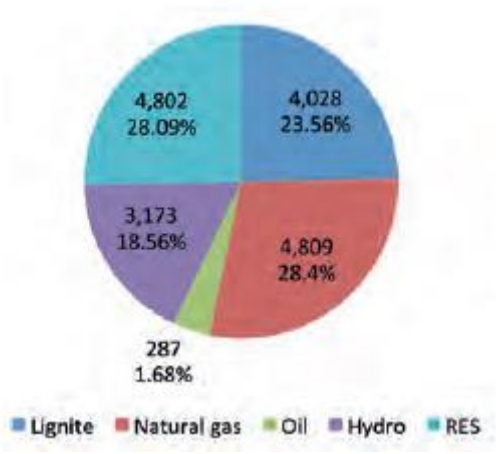
Figure 2: ***Total installed capacity and capacity factor by fuel and ownership (2014)***

	Ownership	Installed Capacity (MW)	Total Production (GWh)	Capacity Factor
Lignite	PPC	4456	23231	59.51%
Oil	PPC	698	0	0%
OCGT	PPC	339	1	0.03%
	Heron Thermoelectric	148	0	0.01%
	Total	**487**	**1**	**0.02%**
CCGT	PPC	1998	3875	22.14%
	Elpedison	799	2676	38.23%
	Heron Thermoelectric	422	1442	39.01%
	Protergia (Mytilineos)	433	1532	40.39%
	Korinthos Power (Mytilineos + Motoroil)	434	1457	38.32%
	Total	**4086**	**10982**	**30.68%**
Large-scale CHP	Alouminio (Mytilineos)	334	1098	37.53%
Total Thermal		10061	35312	40.07%
Large Hydro	PPC	3018	5640	21.33%
Small Cogeneration	IPPs	90	119	15.09%
Wind	IPPs (mainly)	1520	3392	25.48%
Small Hydro	IPPs (mainly)	220	771	40.00%
Biofuels-Biomass	IPPs (mainly)	46	210	52.11%
PVs & PVs on buildings	IPPs (mainly)	2070	2929	16.15%
		349	457	14.95%
Total Renewables (Grid + Network)		4295	7878	20.94%
TOTAL		**17374**	**48830**	**-**

Source: RAE (December 2014)

It is evident from the above Figure 2 that Greece's energy mix is mainly thermal, more specifically lignite, oil and Natural Gas. The following figure demonstrates in a pie chart the contribution of each fuel as percentage to the energy mix.

Figure 3: **Total installed capacity per fuel type in the Interconnected System**



Source: LAGIE (September 2016) [2]

More than 53 % of the country's Interconnected System needs in electricity are covered by thermal means. This percentage is further increased taking into account the non-interconnected system (islands) which is almost solely covered by expensive oil. Therefore, it

is clear that the country suffers from a heavy reliance on fossil fuels which are for the most part imported and price-volatile.

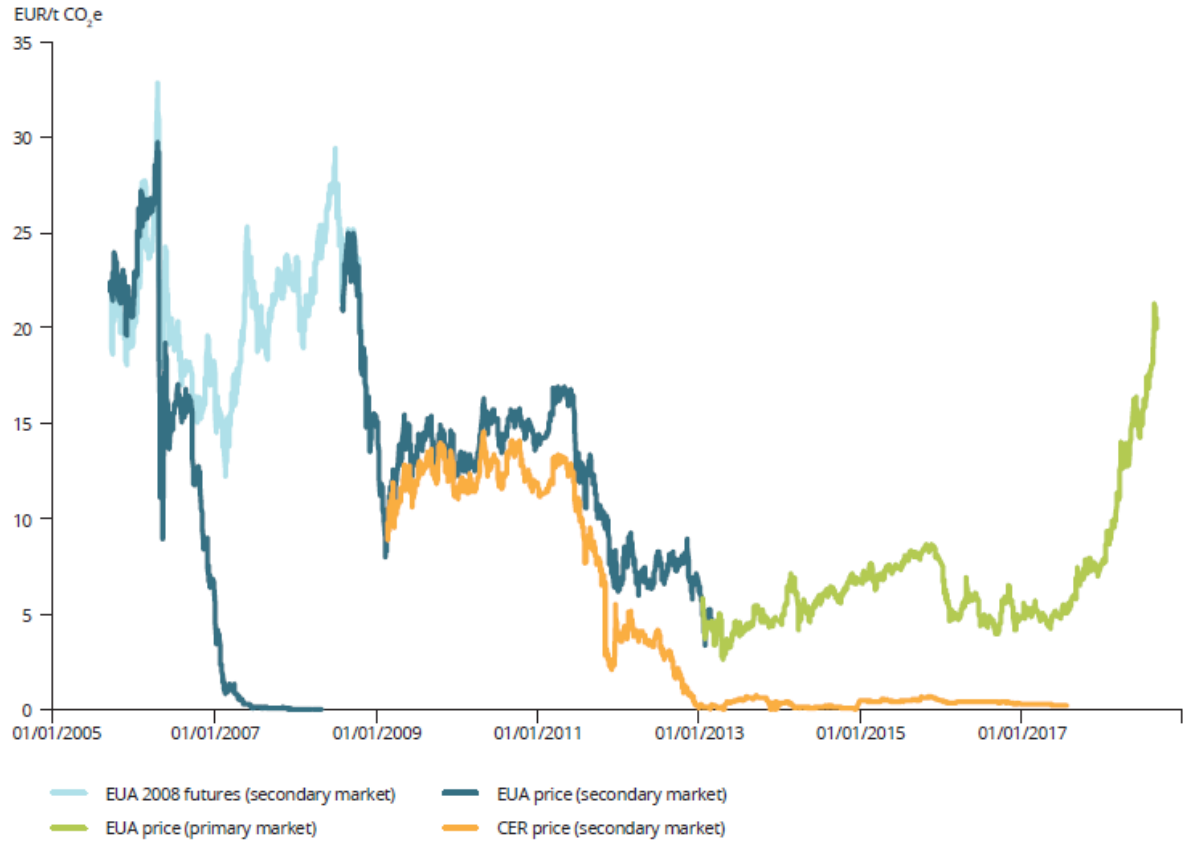
It is worth noting that, although energy generation from thermal power plants comes with important deficiencies, as the import dependence, price instabilities etc, it also holds a significant advantage in comparison to RES or Hydro generation; it can be used as base load.

The baseload on a grid is the minimum level of demand on an electrical grid over a span of time. This demand can be met by unvarying power plants, dispatchable generation or by a collection of smaller intermittent energy sources, depending on which approach has the best mix of low cost, availability and high reliability in any particular market. The remainder of demand, varying throughout a day, is met by dispatchable generation, load following power plants, and peaking power plants, which can be turned up or down quickly, operating reserve, demand response and energy storage.

Since lignite plants are difficult and very costly to switch on and off, they are used as base load and therefore constitute the backbone of Greece's electrical energy generation (*Hellenic Market Operator, 2019*) . On the other hand, RES due to their stochastic nature cannot be used as base load as power output cannot be reliably predicted. Additionally, Combined Cycle Natural Gas plants can be used as load following because they are the easiest to increase or decrease power output in order to meet changes in demand.

From the above it is clear that thermal plants are important to the stability of the energy network of Greece. The domestically produced lignite serves as an excellent baseload power source, is cheap, readily available, with predictable price and practically infinite supply. However it holds two significant drawbacks: It needs to be phased out due to the commitments undertaken by Greece in the context of the EU and also the rising CO2 prices based on the EU's Emission Trading Scheme will very soon render the energy generation by lignite economically infeasible. (*Greece's Energy Security and suggestions for its improvement, IENE working paper, November 2018*)

Figure 4: **Price trends for EUA's and certified Emission Reductions**



Sources: Point Carbon, 2012; EEX, 2018; ICE, 2018.

In just a few years, from a price of around 5 €/tn of CO2 the price has sky-rocketed to 25 €/tn and is expected to keep rising as a result of the political commitment of the EU to keep curtailing emissions to an increasingly elevated rate. Since lignite is the worst CO2 polluter in terms of energy generation, it is evident that Greece runs the risk of being left with little reliable alternatives for a base load, or ending up paying huge energy wholesale prices as a result of the CO2 emission levies imposed. These facts have a detrimental effect to both energy security and competitiveness of the economy, since as pointed out earlier energy prices are highly correlated to GDP growth. Greece, being entangled in the vortex of its financial problems cannot afford to have less competitive energy prices in relation to its neighboring countries, namely Bulgaria, Romania and Turkey as this will jeopardize its economic rebound and at the same time will strengthen the neighboring economies at its expense.

Renewable Energy Sources

The penetration of Renewable Energy sources to the Hellenic energy mix is considerable, with almost 25 % of the total output being attributed to solar, wind and small hydro plants. Greece has undertaken the commitment to reach by 2020 20% of its installed capacity by RES, and to this extent the Hellenic Parliament voted the Law 4414/2016 with the aim to developing a new support scheme for RES consistent with the guidelines on State aid for environmental protection.

Figure 5: **RES share target 2020**

Source: European Commission (November 2015)

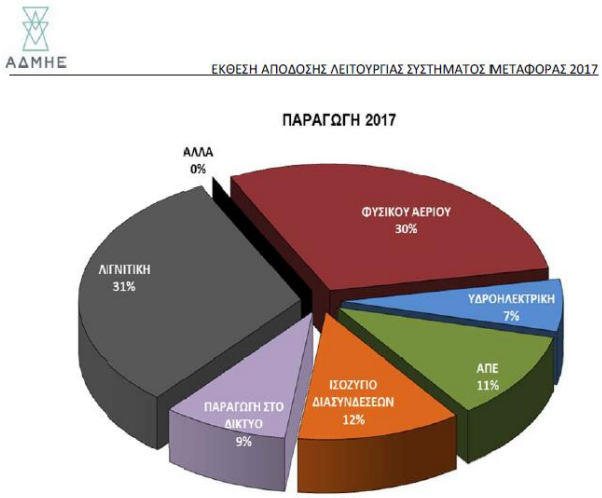
The European commitment to steadily promote RES constitutes a strategic decision on a central level to reduce the exposure of the European Union to risks associated with its increased dependence on Natural Gas and Oil, mainly from Russia. The current reliance on imported Oil & Gas leaves the European Union vulnerable to external pressures and reduces its geostrategic leverage. To this extent, the advancement of RES technologies will assist to reduce the level of reliance, advance its internal economy as EU is a major producer of RES technology and at the same time exert geopolitical pressure on both friends and foes to better approach its strategic interests.

To this extent, Greece finds itself amidst a difficult position as the adherence to its EU commitments will signify the end of the low energy cost era. Greece needs to find a way to replace its main power source, lignite, with a cost competitive source while at the same time respect its obligations as a EU member and keep promoting the Union's strategic objectives with the increasing development of RES and the decreasing CO2 emissions.

Electricity imports

The Greek Electricity Grid is reliant to a significant degree to electricity imports from Interconnected countries, mainly Bulgaria.

Figure 6: **Distribution of total produced electricity per source, 2017**



Source: ADMIE Performance report 2017[3]

According to figure 6, in 2017 Greece was a net importer of electricity to an amount of 12%. This percentage is considered low in comparison to previous years where net imports accounted for 17%.

Figure 7: **Electricity Balance (GWh) in Greece over 2001-2012**

	Imports (GWh)	Exports (GWh)	Balance (GWh)
2001	3562.00	1061.62	2500.39
2002	4601.88	1705.35	2896.53
2003	4168.91	2093.29	2075.62
2004	4853.99	2033.41	2820.58
2005	5616.42	1835.51	3780.91
2006	6139.46	1937.08	4202.38
2007	6411.50	2057.31	4354.19
2008	7574.76	1960.79	5613.97
2009	7600.77	3233.07	4367.70
2010	8517.36	2811.23	5706.13
2011	7179.77	3947.44	3232.33
2012	5954.04	4169.88	1784.17

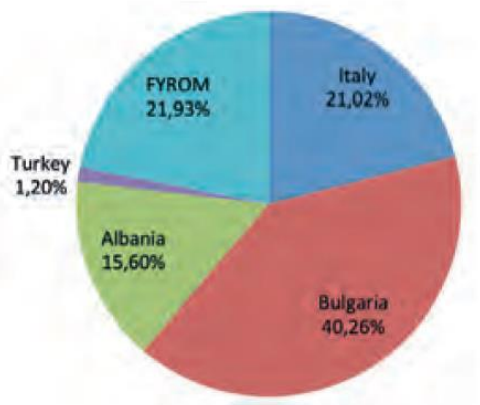
Source: ADMIE (October 2013)

The above figure 7 clearly depicts that Greece has been constantly a net importer of electrical energy for its needs.

Apart from the quantitative approach to the interconnections, one needs to also examine the qualitative characteristics. It is important to evaluate the countries from which Greece imports its electricity and their attributes that render them more economical in the production of energy in relation to Greek power plants.

The following figure 8 depicts the share of imports per interconnection for the Hellenic Grid

Figure 8: **Share (%) in Total Monthly Electricity Imports per Interconnection- 09/16**



Source: LAGIE (September 2016)

As is seen from the above pie chart, the vast majority of electricity imports come from nuclear Bulgaria, while FYROM and Albania with their significant water reservoirs that power their hydro plants account for 21,93 % and 15,60 % respectively. Lastly, Italy through its underwater HVDC interconnection provides 21,02 % of our imports while Turkey's contribution is insignificant.

Figure 9 demonstrates the electricity interconnections in the Balkan Grids

Figure 9: **Description of electricity interconnected grids in the Balkans (2013)**

** Black lines show the current interconnectors, blue lines depict the under construction interconnectors, green lines illustrate the planned ones and the red lines the under study interconnectors.*

Source: ADMIE (October 2013)

The energy mix of neighboring nuclear countries

Bulgaria

Bulgaria energy mix is well diversified as a result of the country's usage of multiple energy sources. Bulgaria covers almost 60% of its needs by sources entirely domestic [4]: solid fuels, renewables and nuclear. In addition, Bulgaria enjoys a less than EU average degree of dependency on energy imports in terms of crude oil and gas, with its main provider being Russia.

Figure 10: **Energy dependence of Bulgaria**

	2010	2011	2012	2013	2014
Energy Dependence	39.6	36.0	36.1	37.8	n.a.

Source: Eurostat

This low degree of dependence in comparison to Greece's level of energy dependence constitutes a tremendous competitive advantage, since the economy of Bulgaria and the production costs of energy are less susceptible to the fluctuations of oil & gas prices. One of the key factors contributing to this degree of diminished dependence is Bulgaria's reliance on Soviet-era nuclear plants for the production of electricity.

Figure 11: **Energy dependence of Greece**

Import dependency (%)	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Solid Fuels	4.1	2.6	4.1	5.0	2.0	5.1	2.9	2.3	3.2	2.9	2.8
Total petroleum products	97.7	101.3	100.9	101.3	96.7	98.6	93.8	101.2	94.6	99.8	105.4
Gas	99.1	99.1	99.1	100.0	99.7	99.9	100.0	100.3	100.0	99.3	99.9
All products	**68.6**	**71.9**	**71.2**	**73.3**	**67.6**	**69.1**	**65.0**	**66.5**	**62.2**	**66.2**	**71.9**

Source: Eurostat

As a result of the above, and in combination with the reduced economic output given the late financial crisis, Bulgaria has established itself as a net electricity exporter, exporting energy mainly to Greece and FYROM. According to 2014 data, Bulgaria consumes around 80% of gross electricity generation while it exports 20%

Figure 12: **Gross Electricity generation (TWh) 2010-2014**

	2010	2011	2012	2013	2014
Gross electricity generation	46.0	50.3	47.4	44	47.2
Import	1.2	1.2	2.4	3.4	4.3
Export	9.6	12.1	10.7	9.5	13.8
Gross inland consumption	37.6	39.7	39.1	37.9	37.7

Source: National Statistical Institute of Bulgaria

To that extent, Bulgaria has established multiple interconnections with its neighbours in order to exploit this excess of electrical energy by exporting it at competitive prices. Given the EU commitment for decarbonisation, the production of carbon free electricity through the development of RES and nuclear is expected to increase, while on the other hand consumption is expected to decrease as a result of energy efficiency measures, thus freeing up more energy for export and, by extension, more revenues.

Figure 13: **High Voltage Interconnections of Bulgarian Electricity System**

Nominal voltage	Neighbour country	Bulgarian S/S	Neighbour S/S	Neighbour TSO	Length, km	Parallel operation	Cross section	Thermal rating, A
400KV	Romania	Dobrudzha	Rahman	TEL	175.19	YES	3xACO 400	2475
400KV	Romania	Kozloduy	TIntareni	TEL	115.7	YES	2xACO500	1890
400KV	Romania	Kozloduy	TIntareni	TEL	115.7	YES	2xACO500	1890
400KV	Romania	Varna	Stupina	TEL	152.81	YES	5xACO300	2835
400KV	Serbia	Sofia West	Nis	EMS	122.5	YES	2xACO500	1890
400KV	FYROM	ChervenaMogila	Stip	MEPSO	150.1	YES	2xACO500	1890
400KV	Greece	Blagoevgrad	Thessaloniki	IPTO	176.8	YES	2xACO500	1890
400KV	Turkey	Marisa East 3	Hanitabat	TEIAS	148.8	YES	3xACO 400	2475
400KV	Turkey	Marisa East 3	Hanitabat	TEIAS	158.8	YES	2xACO500	1890
110KV	Serbia	Kula	Zajecar	EMS	20.2	No	AC185	510
110KV	Serbia	Breznik	Vrla	EMS	64.1	No	AC185	510
110KV	FYROM	Skakavitsa	KrivaPalanka	MEPSO	18.1	No	ACO400	825
110KV	FYROM	Petrich	Susica	MEPSO	32.6	No	ACO400	825

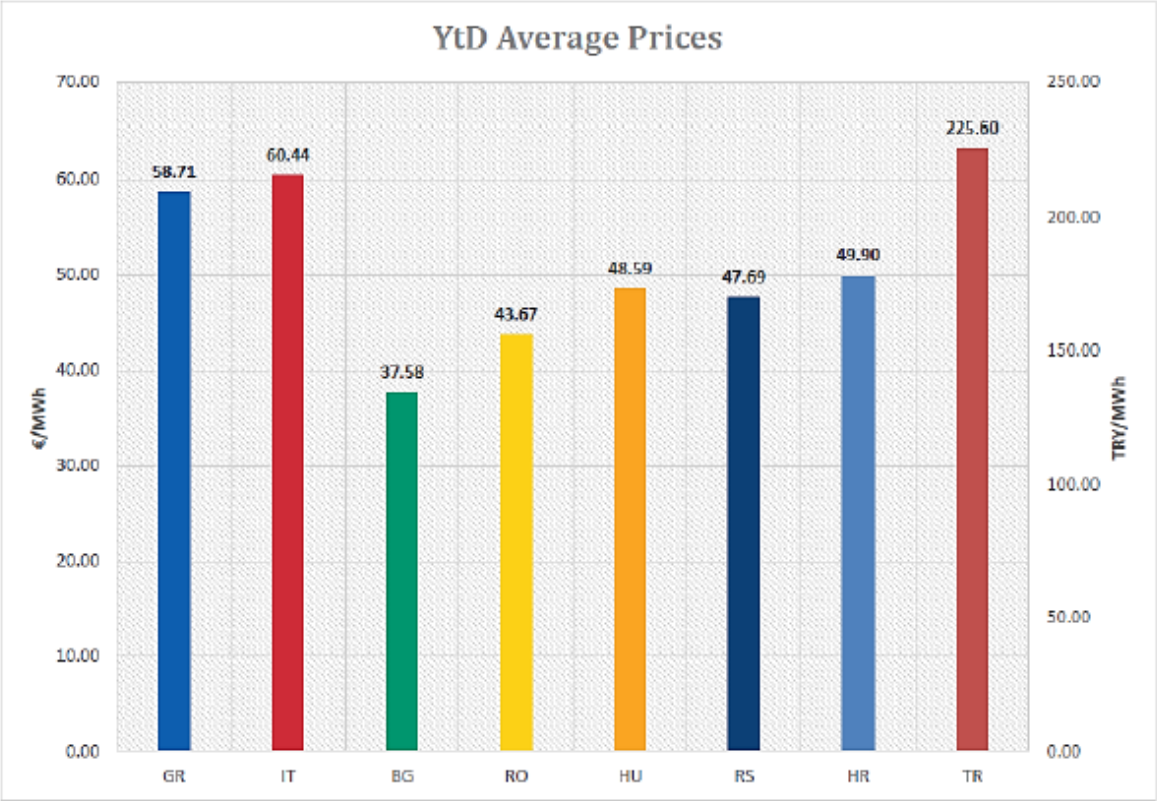
Source: IENE SE Europe Energy Outlook 2016/2017

Nuclear Power Plants

Bulgaria maintains the Kozloduy Nuclear Power Plant, situated 120 km north of Sofia, near the border with Romania. The Power Plant manages two water reactors with a total power output of 2.000 MW, constructed in 1987 and 1991. In addition, Bulgaria is attempting to revive the frozen Belene nuclear plant [5] which could add another 2.000 MW of power output, further increasing the potential for exports and carbon free energy.

This excess of produced energy in combination with the regulated energy prices regime currently in place has led to a significant reduction in the Marginal System Price of Bulgaria in comparison to its neighbors. The following figure depicts the yearly average electricity prices for the South Eastern Europe countries

Figure 14: **Electricity market clearing prices-yearly level (€/MWh)**



Source: IENE SEE Electricity Market Analysis No7, November 2018

It is clear from the above graph that Bulgaria enjoys the cheapest electricity price among its South Eastern Europe neighbors, closely followed by nuclear Romania. In comparison to Greece, Bulgaria has almost 37% cheaper energy, providing in this way incentives to businesses and industries to establish their production facilities in its territory, and at the same time it profits from the export of energy. However, the cost for Greece is not only financial but also one of energy security. In order for Gas power plants to be profitable in the absence of other support mechanisms such as availability payments, they need to operate a minimum amount of hours and inject electricity to the Grid. Given that imports are generally cheaper than ramping up generation, Gas plants find themselves in dire straits especially when international gas prices increase, a fact that impacts greatly their profit margin. As a result, the reluctance of investors to increase Greece's Gas Power Plant capacity, which is considered to be a very flexible and cleaner than coal power source, poses a risk to the future security of supply. It is commonly accepted that Gas will be the transition fuel to the new carbon free era, so its sustainability and development should enjoy support from the Greek state. Given the market trends presented, it is questionable whether such support exists, at least to a satisfactory level.

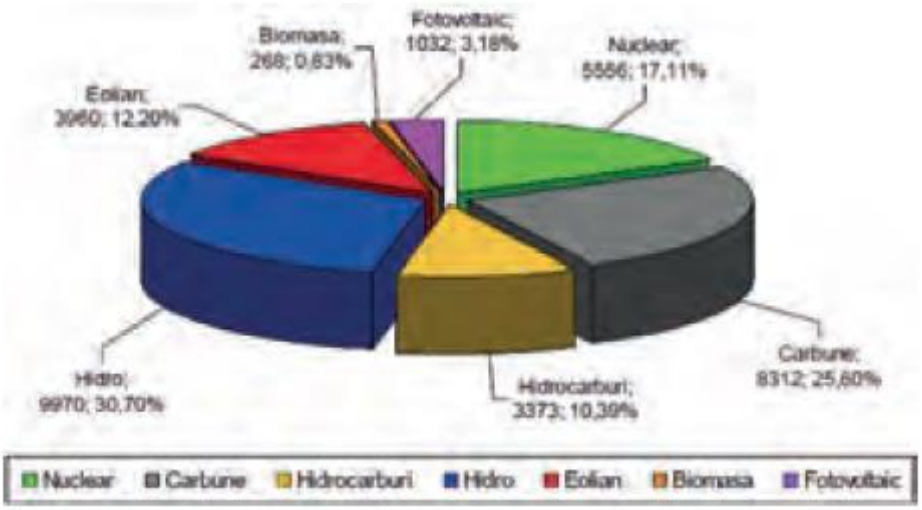
Romania

Romania is the second nuclear neighbor of Greece in the Balkans, having a diversified energy mix consisting of nuclear, hydro, wind, coal and natural gas. The country, apart from its nuclear power generation capabilities, is also favored by the existence of oil and gas fields. The majority of those fields have been in operation for over 30 years, while Romania invests continuously in exploration of both onshore and offshore reserves.

Given the abundance of natural resources and the modest consumption, Romania enjoys a particularly low energy dependence figure in comparison to its Balkan counterparts and European Union members alike. In fact, based on 2013 Eurostat data [6] Romania had a 18,6% dependence on energy imports, placing it on the 3rd place in EU behind Estonia and Denmark [7].

The following pie chart depicts the gross electricity production structure of the country for 2015

Figure 15: **Gross electricity production structure 2015**



Source: Transelectrica, 2015

Almost 20% of the country's needs are covered by nuclear power, a percentage that will be doubled with the completion of the two new nuclear reactors scheduled.

Nuclear Power Plants

Romania maintains one NPP comprising of 2 reactors of combined peak power of approximately 1.400 MW at Cernavoda, close to the Black Sea. Unitt 1 was completed in 1996 while Unit 2 at 2007. Another two units are scheduled to be completed which will add another 1.400 MW to the power capacity of the country. There are also plans for the

construction of a second nuclear power plant in Transylvania that will either have 2 reactors of 1,200 MW each or 4 reactors of 600 MW each with an electricity generating capacity of 2,400 MW[8] and will be constructed after 2020. When this construction is completed, Romania will be able to cover more than 60 % of its needs by nuclear alone. This fact combined with the ever increasing addition of RES and hydro is a key factor to the low energy dependence of the country and the reduced electricity prices. As seen in figure 14, Romania already enjoys reduced Marginal System Price for electricity (2nd lowest in the region behind Bulgaria) and therefore presents a major competitive advantage to energy intensive industries operating or planning to be established in its territory.

The nuclear neighborhood of Greece

Much concern has been raised regarding the potential adverse effects from even a small scale accident of a nuclear power plant. This argument has been the most vocal when it comes to discussing the possibility of installation of NPPs.

Before going into details regarding the pros and cons of nuclear energy, it is useful to examine the map depicting the nuclear power plants of Europe

Figure 16: **Nuclear Power Plants in operation in Europe**

As seen from the above map, Greece already is exposed to the potential damaging repercussions of a nuclear accident. Bulgaria and Romania have been operating their NPPs for decades with less than modern technology, while the potential threat from other former Soviet bloc countries (Russia, Ukraine, Lithuania) is in place and cannot be overlooked.

As a matter of fact, as of November 2016 186 Nuclear Power Plants with a combined capacity of 164.000 MW are in operation across Europe, while another 14.000 MW are under construction [8]

Figure 16: **Nuclear Power Plants in Europe, in operation and under construction, 2016**

Country	in operation		under construction	
	number	net capacity MWe	number	net capacity MWe
Belarus	-	-	2	2.218
Belgium	7	5.913	-	-
Bulgaria	2	1.926	-	-
Czech Repuplic	6	3.930	-	-
Finland	4	2.752	1	1.600
France	58	63.130	1	1.630
Germany	8	10.799	-	-
Hungary	4	1.889	-	-
Netherlands	1	482	-	-
Romania	2	1.300	-	-
Russia	36	26.557	7	5.468
Slovakia	4	1.814	2	880
Slovenia	1	688	-	-
Spain	7	7.121	-	-
Sweden	10	9.651	-	-
Switzerland	5	3.333	-	-
Ukraine	15	13.107	2	1.900
United Kingdom	15	8.918	-	-
total	**186**	**163.685**	**15**	**13.696**

Given the increased penetration of nuclear power generation, the concerns regarding the potential damaging repercussions can be considered as moot. ***If such danger exists, Greece already is experiencing it while not harvesting the benefits of the reduced energy prices***. It would be unreasonable to suggest that Greek territory is not susceptible to the adverse side effects of a nuclear accident, while a significant number of NPPs lie within some hundreds of kilometers from its Northern borders.

Turkish Nuclear ambitions

Another important aspect to be taken into account is the nuclear ambitions of Turkey. Turkey is in the process of introducing three Nuclear Power Plants, one in Akkuyu the construction of which has already started [9], one in Sinop in the Black Sea coast and one in Trace, close to Constantinople [10].

The Akkuyu power plant consists of four units with a total capacity of 4800 megawatts (electrical) (MWe) of the Russian VVER technology and is planned to be constructed in cooperation with Russia. The four units at the site on the Mediterranean coast, 500 kilometres south of Ankara, are scheduled to be in operation by 2026.

Turkey decided to introduce nuclear power to meet a surge in energy demand and reduce its dependence on imported energy sources, which amounted to 72 percent of its total energy consumption in 2016. It plans to install three nuclear power plants by 2030, which are expected to generate 15% of its electricity, according to the country's Ministry of Energy and Natural Resources.

In May 2010, Turkey and Russia signed an agreement for the construction and operation of the nuclear power plant at the Akkuyu site. Three years later, an intergovernmental agreement was signed with Japan to develop a second nuclear power plant project at the Sinop site on the Black Sea. On May 3, 2013, an intergovernmental agreement on nuclear power plant construction and cooperation for the Sinop Nuclear Power Plant (NPP) was signed with Japan. As stipulated by the agreement, the Turkey Electricity Generation Company (EÜAŞ) will hold a 49 percent stake in the plant, while a Japanese and French company will have 30 and 21 percent stakes, respectively. The project is estimated to cost more than $16 billion according to Japanese sources. The Sinop plant will have a total 4,480-MW capacity of electricity generation with four reactors each having a 1,120-MW capacity.

Site selection studies are underway for a third nuclear power plant in Thrace (Igneada) close to the Bulgarian border. This third Nuclear Plant will most likely utilize Chinese technology.

It is important to highlight that Turkey seems to be willing to diversify the sources of nuclear technology procurement, at the expense of increased costs, in order to safeguard unhindered access to it. This is a prudent tactic since reliance on a single provider could result in the country being exposed to international pressures and would be providing leverage over it. However, ***the most alarming fact remains the insistence of Turkey to maintain the spent fuel rods of the facilities, which implies that it maintains military nuclear ambitions***. According to analysts [11] Turkey's nuclear contracts reveal that the nuclear projects are not just about improving the country's energy supply, but also aim to consciously open the door to a military nuclear option.

Turkey insisted that the deal would neither include the provision of uranium nor the return of the spent fuel rods. Turkey wants to maintain the option to run the reactors with its own low enriched uranium and to reprocess the spent fuel rods itself. This in turn means that Turkey

intends to enrich uranium, and at least to a low level the country wants to deal with this matter separately.

Figure 17: **Map of planned Turkish Nuclear Power Plants**

It is therefore more than obvious that apart from the nuclear reactors at its northern borders, soon Greece will be facing a similar situation eastwards. There is little room for doubt that the introduction of yet another NPP in the Balkan region will push Turkish energy prices lower, thus boosting the Turkish economy at the expense of Greece.

Levelized Cost of Energy (LCOE): Comparison of technologies

In attempting to identify the most suitable base load technology for electricity, one needs to examine various parameters among which the **Levelized Cost of Energy (LCOE)** plays the most important role. Since in electrical generation the distinct ways of generating electricity incur significantly different costs, the Levelized Cost of Energy (LCOE) is a measure that allows comparison of different methods of electricity generation on a consistent basis. It is an economic assessment of the average total cost to build and operate a power-generating asset over its lifetime divided by the total energy output of the asset over that lifetime. The LCOE can also be regarded as the average minimum price at which electricity must be sold in order to break-even over the lifetime of the project.

In order to assess the attractiveness of nuclear power generation, one needs to examine the particularities that define the Levelized Cost of nuclear energy in comparison to the other base load technologies available.

The levelized cost of electricity (LCOE) demonstrates the net present value of the unit-cost of electricity over the lifetime of a generating asset. It is often taken as a proxy for the average

price that the generating asset must receive in a market to break even over its lifetime. It is a first-order economic assessment of the cost competitiveness of an electricity-generating system that incorporates all costs over its lifetime: initial investment, operations and maintenance, cost of fuel, cost of capital.

The levelized cost is that value for which an equal-valued fixed revenue delivered over the life of the asset's generating profile would cause the project to break even. This can be roughly calculated as the net present value of all costs over the lifetime of the asset divided by the total electrical energy output of the asset.[12]

The levelized cost of electricity (LCOE) is given by:

$$\mathrm{LCOE} = \frac{\text{sum of costs over lifetime}}{\text{sum of electrical energy produced over lifetime}} = \frac{\sum_{t=1}^{n} \frac{I_t + M_t + F_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}}$$

It : investment expenditures in the year t

Mt : operations and maintenance expenditures in the year t

Ft : fuel expenditures in the year t

Et : electrical energy generated in the year t

r : discount rate

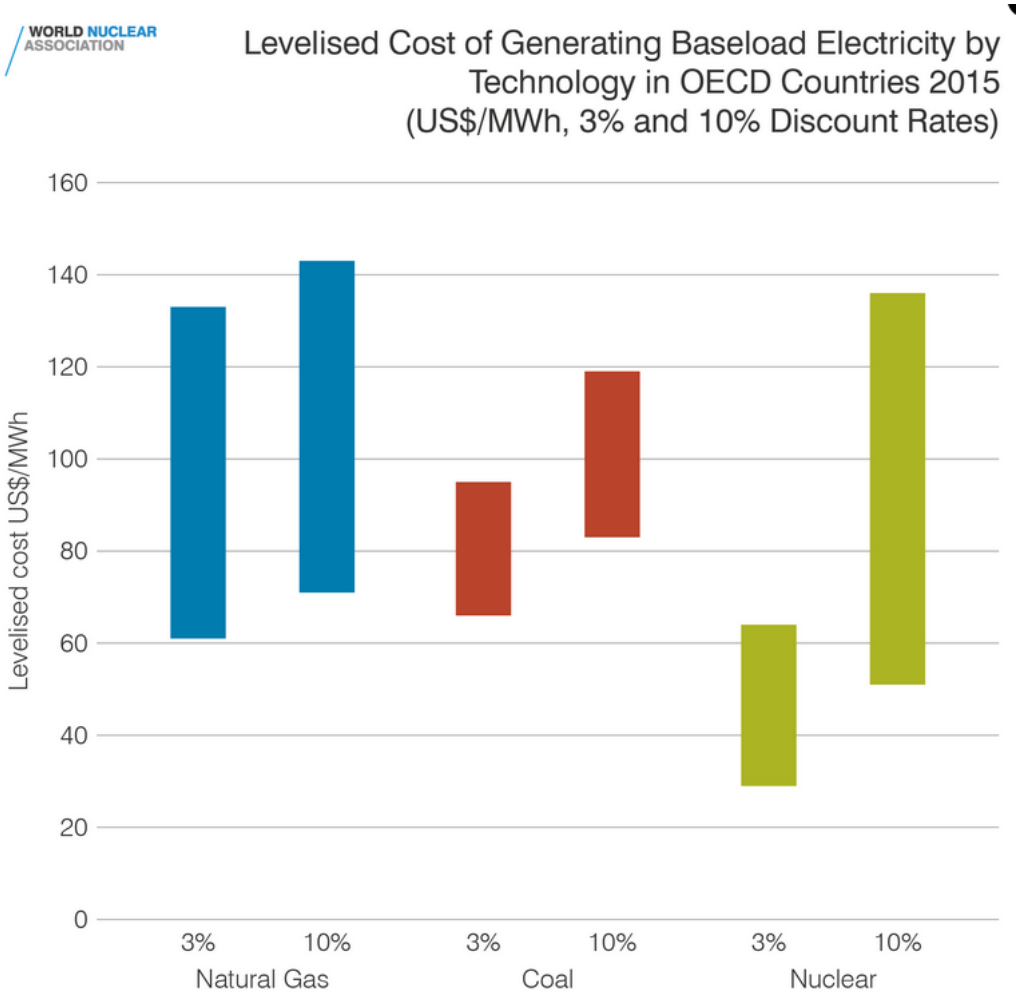
n : expected lifetime of system or power station

Typically the LCOE is calculated over the design lifetime of a plant, which is usually 20 to 40 years, and given in the units of currency per kilowatt-hour. However, care should be taken in comparing different LCOE studies and the sources of the information as the LCOE for a given energy source is highly dependent on the assumptions, financing terms and technological deployment analyzed. In particular, assumption of capacity factor has significant impact on the calculation of LCOE. Thus, a key requirement for the analysis is a clear statement of the applicability of the analysis based on justified assumptions.

An investment in a nuclear power generation factory is a capital intensive one, and sunk costs represent the largest part of its LCOE. On the other hand, during operation, Operation and Maintenance (O&M) costs are not significant and present the advantage that the raw material (Uranium) has a predictable price with limited fluctuation-in contrast with Natural Gas and Diesel, produces no CO2 emissions and is easy to store and maintain in stock since it is not large in volume.

The following Figure depicts a comparison between the most prominent base load electricity technologies LCOE

Figure 18**: Levelized Cost of Generating Base load Electricity in OECD countries**

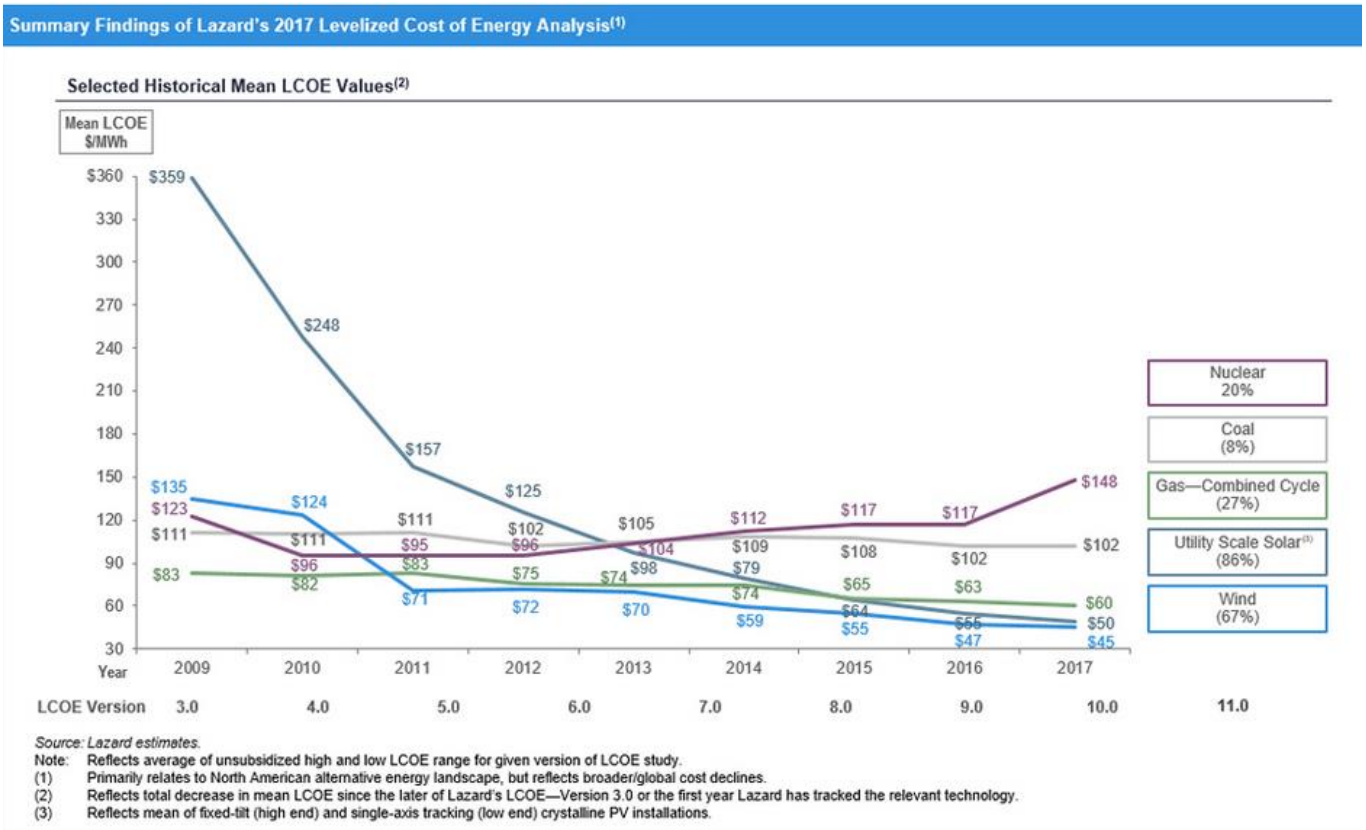


Source: Projected Costs of Generating Electricity, 2015 Edition, OECD-NEA & IEA

As can be seen, and depending on the discount rate assumed, nuclear has an attractive LCOE figure when compared with other conventional base load technologies. It is important to note that this figure does not reflect the adverse effect of CO2 emissions levies which as demonstrated in Figure 4 are on an upward trending path and will not drop in the future, thus significantly affecting the LCOE and profit margins of CO2 emitting technologies. Since Nuclear produces no CO2 emissions, the competitive advantage will be more obvious in the years to come.

Another interesting figure from Lazard's 2017 LCOE study paints a clear picture when it comes to comparing the LCOE's of different electricity production technologies.

Figure 19: **Levelized Cost of Energy, Lazard's study**



Source: Lazard's Levelized cost of energy analysis 2017

The above diagram depicts the LCOE variations over time and it is useful in extracting results from the price trends. The first and most important notice is the dramatic decrease in the LCOE for Renewable Energy Sources, primarily Solar and Wind power. This is the result of the global shift towards RES in the spirit of the Paris accords and the EU's commitment to curb CO2 emissions drastically in an attempt to battle climate change. It is also the product of an electricity market coming to maturity, as the RES no longer require backing by subsidies in order to be competitive, and therefore their decreasing LCOE reflects their transition towards "grid parity", meaning that they can generate power at LCOE that is less than or equal to the price of purchasing power from the electricity Grid.

Of course, this global transition to RES which is considered to be a certainty for the future, will not come without its challenges, the most important being the intermittent and stochastic nature of these technologies. As electricity cannot be stored-at least with a financially sensible way- there exists the need for constant matching between production and demand for electrical energy. Since an ever increasing number of RES power plants will be added to the energy mixture, it is critical for the stability of the Grid to maintain such power plant technologies that a) can provide reliable and predictable base load electricity, b) can follow the variations of RES ramping up or down production fast and c) providing balancing to the Grid by keeping frequency and voltage figures to the levels required for safe operation.

Each power production technology has different characteristics that cover different needs of the Power Grid. Nuclear power and Coal -fired generation, in contrast to Combined Cycle Gas Turbines (CCGT) cannot ramp up or down production fast enough to follow load variations. Therefore, Nuclear and Coal is generally reserved for Base Load production and maintain a steady rate during operation. The variations in demand are usually followed by Gas plants and Hydro plants, which can easily increase their output by burning more Natural Gas or allowing more water to pass through their fan blades respectively.

Given that Greece is obliged to withdraw from operation its Coal fired plants in the near future [13], there is an increasing need for the replacement of these base load assets with a technology that is environmentally friendly, low in variable cost and safe in its supply. Nuclear seems to be a very attractive option as its utilization would serve many purposes at once:

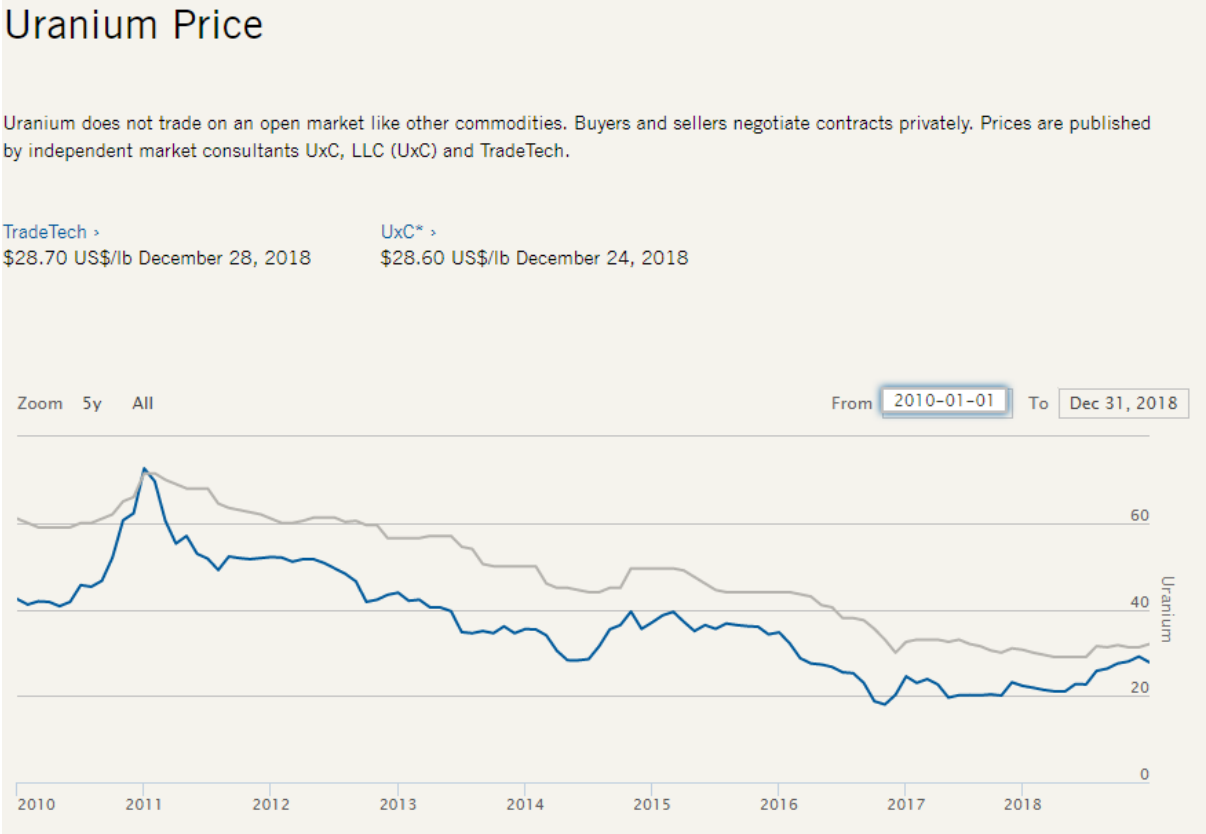
- It will drastically reduce CO2 emissions in line with the country's obligations
- It will reduce the environmental impact caused by the mining operation for lignite in Northern Greece [14] and the subsequent increased costs for restoration, rehabilitation and insurance claims
- It will enhance Grid stability, as nuclear is considered by the Grid Code as a "first order" stability mechanism due to the increased rotary inertia of its generator that assists in keeping voltage and frequency within safe limits
- It will bolster energy supply security, as it would be easy to store the necessary raw material (uranium or plutonium) for prolonged periods
- It will create a more attractive economic environment due to the predictability of electricity prices which tend to follow the raw material prices. Since nuclear raw material prices do not fluctuate excessively, this will help in bringing down energy prices
- In sufficient quantities, it can allow Greece to be transformed from a net importer to a net exporter of electricity, thus providing valuable influx of currency
- It will allow Greece to enter the elite club of nuclear powers
- It will allow Greece to develop nuclear know-how

On the other hand, nuclear cannot stand on its own without the complementary contribution of Gas and RES. Gas turbines are necessary for the incorporation of RES in the Grid, and therefore a sufficient number of MWs needs to be maintained in reserve. It is important to highlight that RES technologies should not be seen as competitive against nuclear, but rather as complementing. The European and national target for the increase in RES penetration is binding for Greece and the country needs to adapt its national policies and create the necessary business and legislative environment in order to accommodate this transition. Nevertheless, the technical particularities of RES incorporation necessitate the existence of a reliable base load and load-following mechanism, and nuclear can serve this role in a cost-efficient and reliable way in terms of security of supply.

The cost of raw materials

In order to highlight the attractiveness of nuclear in terms of its price stability when it comes to raw materials, the following figure depicts the price of Uranium ($/lb) the past 8 years

Figure 19: **Uranium long term (grey line) and spot (blue line) prices, 2010-2019**



Source: Cameco.com, 2019

It is obvious that the price of Uranium does not fluctuate excessively for a large period of 8 years. In comparison, the price of oil ($/br) for a period of just 4 years is seen in the next figure

Figure 20: **Oil price (OPEC basket) 2014-2019**

Source: Oilprice.com, 2019

The price for Natural Gas ($/MMBtu) for the period 2009-2019 is shown in the following figure:

Figure 21: **Natural Gas price, 2009-2019**

Source: Macrotrends.net, 2019

The above figures paint a quite clear picture: Oil and Gas present a very volatile behavior which can cause excessive fluctuations to the price of electricity produced by CCGT and Oil plants. In comparison, the price of Uranium shows a stable trend and is generally predictable.

In addition, the low volume of Uranium needed for electricity production presents the advantage of producers being able to stockpile sufficient amounts of it in order to ensure security of supply at stable pricing. To the contrary, CCGT and Oil plants are very exposed to the danger of price fluctuations [15] and also to possible supply cuts for various reasons (political, technical, weather etc). Quite recently, Eastern European countries suffered Natural gas shortages amidst harsh winter as a result of the Ukraine crisis that led to Russia shutting off the valves of pipelines transiting through Ukraine to Europe [16]. This fact has led to the harsh realization that the EU's degree of exposure to Natural Gas severely limits its leverage against Russia and has been one of the defining factors for the increased commitment to achieve fossil fuels reduction in the energy mixture [17].

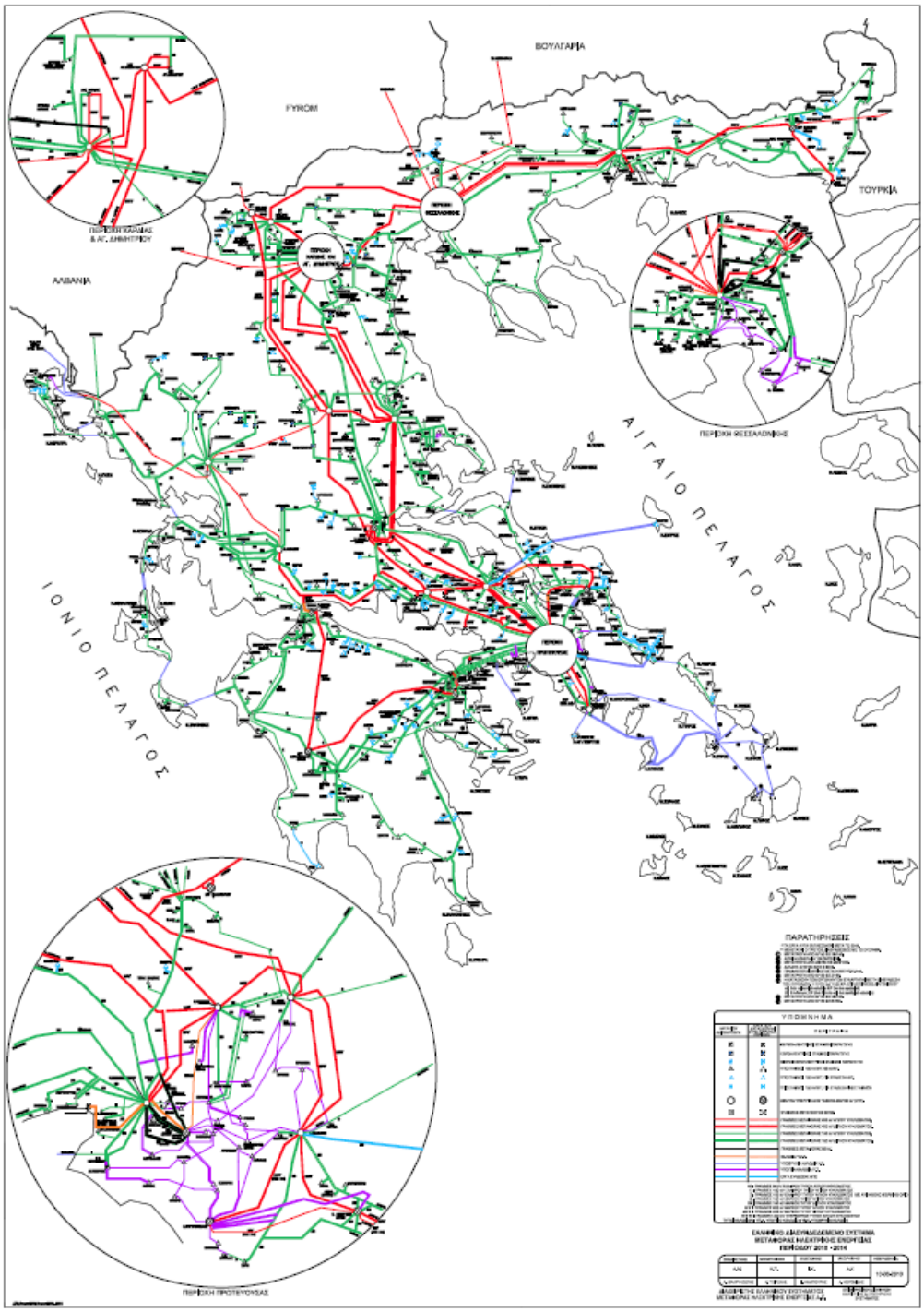
Interconnection of Greek islands

Another important aspect highlighting the need for the establishment of a consistent and reliable electrical power mechanism is the ongoing and future development of Interconnections between the Aegean islands and the mainland Grid.

For decades, the Aegean islands had found themselves in electrical isolation from the rest of the country, relying in very expensive fuel oil generators to provide electricity. This proved to be a challenging and costly solution to a problem that has been known for many years and although the technology and the know-how had already been developed (for example, Interconnection between mainland Greece and Italy was established in 2001) bureaucracy and business interests prevented the realization of this strategic project.

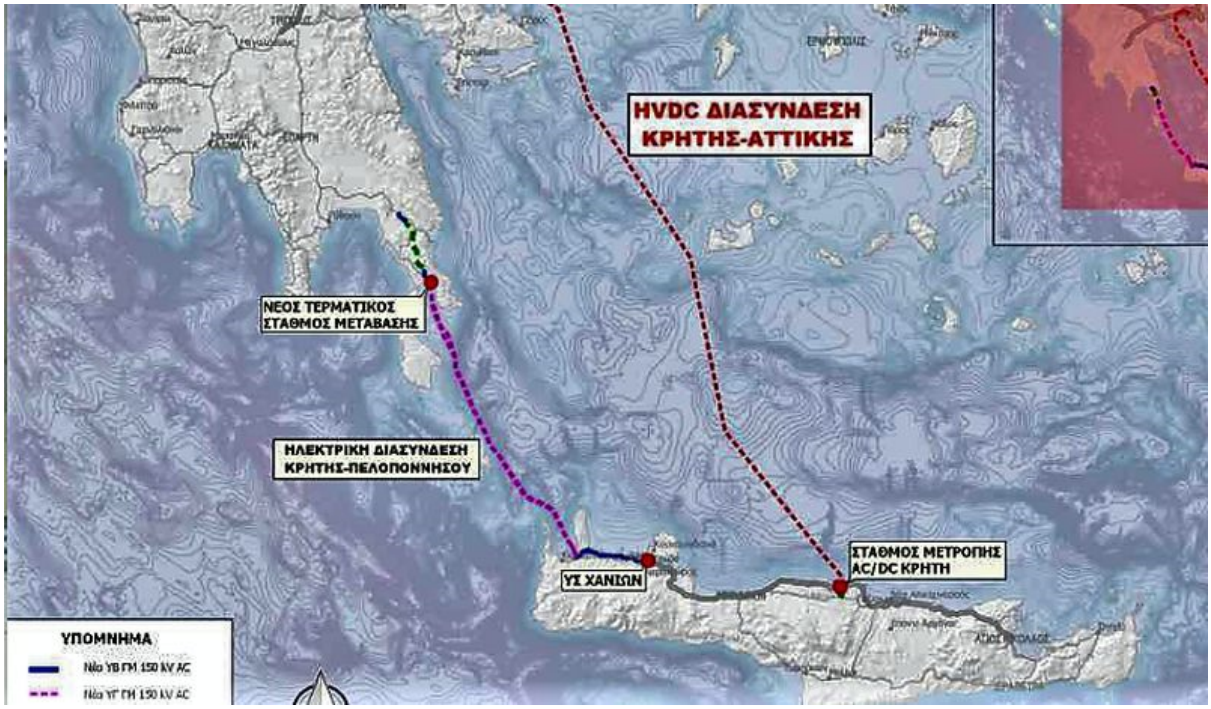
The following figures present the planned and future interconnections of Aegean islands

Figure 22: **Planned Interconnections of Cyclades islands**



Source: Hellenic Transmission System Operator (2019)

Figure 23**: Planned Interconnections of Crete**



Source: Hellenic Transmission System Operator (2019)

The planned Interconnection of the Aegean islands is expected to be a project that will yield significant and instant results in the security of supply and cost reduction in terms of electricity generation:

- It will reduce drastically the regulated charges paid by consumers related to "public utility charges"
- It enhances security of supply. Islands have traditionally been subjected to power cuts and voltage/frequency fluctuations due to the instability of the local Grid. These effects are exacerbated during the summer due to the increased need for electricity as a result of tourism.
- It strengthens the tourism sector. Greece has experienced recently power cuts in Santorini which severely damaged its touristic product [18]
- It frees up electrical space for the introduction of Renewable Energy Sources in the Grid. Until now, the excellent wind potential of the Aegean could not be utilized as the electricity produced could not be safely absorbed by the local Grid. With the introduction of Interconnections the RES plants to be installed in the Aegean will possess the means of injecting power to the mainland
- It reduces the country's exposure to oil imports. The need for this expensive fuel will be diminished with positive results for the country's trade deficit.

However, at the same time the Interconnection of the Aegean islands also means that the generating capacity of the Interconnected Grid needs to be strengthened in order to accommodate the extra loads to be fed. Given that the Coal-fired plants are in the process of either being divested of or closed down for environmental reasons, it is evident that

Greece has to come up with a long term solution that will both secure the uninterrupted supply of clean and cost competitive electricity and on the other hand replace the ageing and dirty thermal units serving as base-load units. Nuclear power is a solution that satisfies both such needs and is worth examining as a way of enhancing the long term strategic prospects of the country.

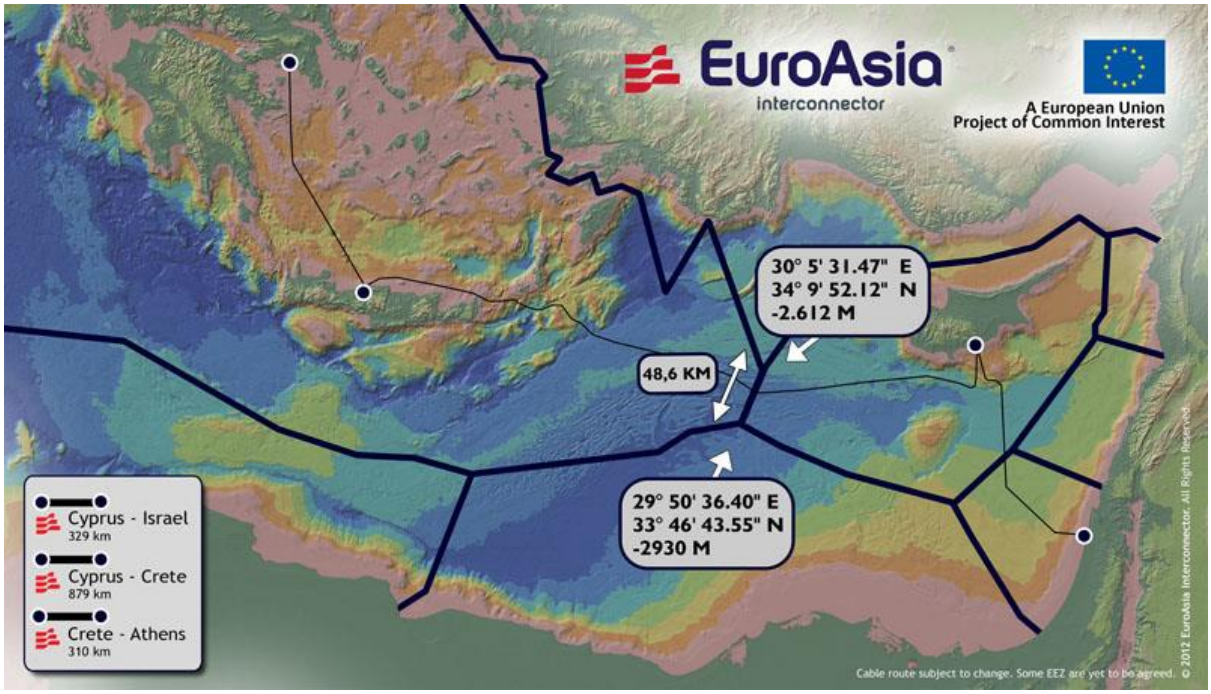
Interconnection of Cyprus to the European Grid

Another important reason necessitating the introduction to the Hellenic Grid of baseload power is the planned Interconnection of the Grid of Cyprus to mainland Europe, as part of the EuroAsia Interconnector project.

The EuroAsia Interconnector is the official EU project developer of the 2,000MW electricity interconnector between Israel, Cyprus Crete – Attica, Greece and Europe. The EuroAsia Interconnector is a leading European Project of Common Interest (PCI) labelled as an EU "electricity highway" connecting the national electricity grids of Israel, Cyprus and Crete-Attica, Greece through a 1,518km subsea HVDC cable.

The European Commission, with the support of the Cyprus Government and in agreement with the Greek Government, has appointed EuroAsia Interconnector Limited as the owner Project Promoter of EuroAsia Interconnector. [19]

Figure 24: **Euroasia Interconnector**



Source: Euroasia Interconnector, 2019

The EuroAsia Interconnector comprises the electricity interconnection between the grids of Israel, Cyprus and Crete-Attica, Greece (Europe) through a subsea DC cable and with HVDC

onshore converter stations at each connection point, with a total capacity of 2000MW. The project is an energy highway bridging Asia and Europe, with a total length of 1518km. It creates a reliable alternative route for the transfer of electric energy to and from Europe.

The EuroAsia Interconnector enjoys a high rating by the European Union, falls within the EU energy policy and contributes to the following energy targets:

- Ends the Energy Isolation of Cyprus as an EU member state. Cyprus is the last member of the European Union which remains fully isolated without any electricity or gas interconnections. Ending the energy isolation is an important EU objective.
- EuroAsia Interconnector creates an electricity highway from Israel-Cyprus-Crete-Attica, Greece (Europe) through which the European Union can securely be supplied with electricity produced by the gas reserves of Cyprus and Israel, as well as from the available Renewable Energy Sources (RES), contributing at the same time to the completion of the European Internal Market.
- The EuroAsia Interconnector ensures the security of energy supply of the three involved countries and of the EU system altogether, through the integration of the isolated small systems of Cyprus and Crete with the Israeli and European networks and the uninterrupted – multidirectional flow of energy.
- Promotes the substantial development of the Renewable Energy Sources and contributes to the reduction of CO_2 emissions.
- Offers significant economic and geopolitical benefits to the involved countries.
- Contributes to the target of the European Union for 10% of electricity interconnection between Member States.
- Provides significant socio-economic benefits in the range of 10 billion euros which will derive from the decrease of electricity cost by using more efficient methods in power generation, i.e. natural gas, renewable energy sources, and from the reduced cost of replacing old power plants which will be avoided.

Given the need of Cyprus for reliable and steady power supply at a competitive cost, and taking into account the difficult geopolitical situation it finds itself in as a result of the ongoing Turkish occupation of the Northern Cyprus part, it is clear that Greece will be the main source of this power supply provision. However, Greece is now facing security of electricity supply challenges associated with the energy injection limitations of the Coal-fired plants imposed by the EU and the future withdrawing of said plants from operation in an effort to decrease its environmental footprint. Therefore, Greece will require sufficient numbers of MWs to replace the coal fired plants and on top of that to increase capacity to an extent capable of supporting the Cyprus and Crete Grids as well.

The Nuclear Power Plants offer an attractive solution to these requirements as they can serve as reliable baseload platforms with zero CO2 emissions. The increased electricity prices of Cyprus as a result of the utilization of old oil fuel power plants offer important profit margins to new producers injecting clean and stable electricity, while the market coupling achieved between Greece-Cyprus and Israel will assist in keeping prices reasonable and stimulate

economic growth, since the price of power is one of the most important factors defining the economic prospects of a country. In addition, the abundance of electrical power provided by nuclear can pave the way for the introduction of the energy-intensive desalination plants necessary to increase the water supplies of the island [20]. At this moment, Cyprus is facing a water crisis with regular shortages affecting both the quality of life of its citizen and also putting in danger its touristic product.

PART 2: GEOPOLITICS

The previous chapter presented the impetus for the development of nuclear power in Greece from the perspective of its electricity needs. However, energy is not the only drive behind nuclear power development. Equal, if not more important, is the need to balance the scale of power between Greece and Turkey, which is tipping in favor of the latter in a wide variety of political parameters, from population and economy to military power and geopolitical importance. This chapter will examine the past, current situation and future trends of these parameters and will present the prospects of nuclear development through the lens of the need for political parity between Greece and Turkey, which is not unreasonable to say that is not the case today.

Greece and Turkey: Implacable "allies"

Since Greece's independence and the geographical expansion of the relevantly newly formed modern Hellenic State, Greece and Turkey have been locking horns in regular intervals. Starting from the Greek War of Independence, the war of 1897, the Balkan Wars, the Asia Minor Campaign, World War I and the Cyprus conflict, Greece and Turkey have engaged in fierce conflicts which although regional, can be examined in the broader perspective of the geopolitical interests of the Great powers, namely Great Britain, France, Russia and the United States. The relevant geopolitical importance of each state varied throughout history, however the most recent historical developments, such as the energy transition from coal to oil in the beginning of the 20th century and the rise of the Soviet Union in 1917, elevated Turkey's significance to the eyes of both parties' Western allies due to its favorable geographic location close to oil exporting nations and, of course, the Iron Curtain. This fact is highlighted by the "7 to 10 ratio" [21] of military aid, a policy voted in 1978 by the United States Congress stating that for every $7 of military aid to Greece, Turkey receives $10.

However, regardless of the geopolitical importance, nearly all factors weighing in on the strategic significance of Greece present a diminishing dynamic which accelerates at an alarming rate. Population is shrinking dramatically-especially after 2009 and the economic crisis in Greece, the economy is crumbling and the lack of strong leadership is becoming evident. In this chapter the parameters affecting Greece's political displacement will be examined in relation to Turkey and analogies will be presented with other nations that share similar characteristics with Greece.

The populations of Greece and Turkey

The following table presents the main population characteristics of the two nations. Useful conclusions can be drawn by their comparison, which paints a quite clear picture as to the growth of each respective country's population and its qualitative, apart from quantitative, characteristics.

Figure 25: **Comparison of demographic characteristics, Greece and Turkey, 2016**

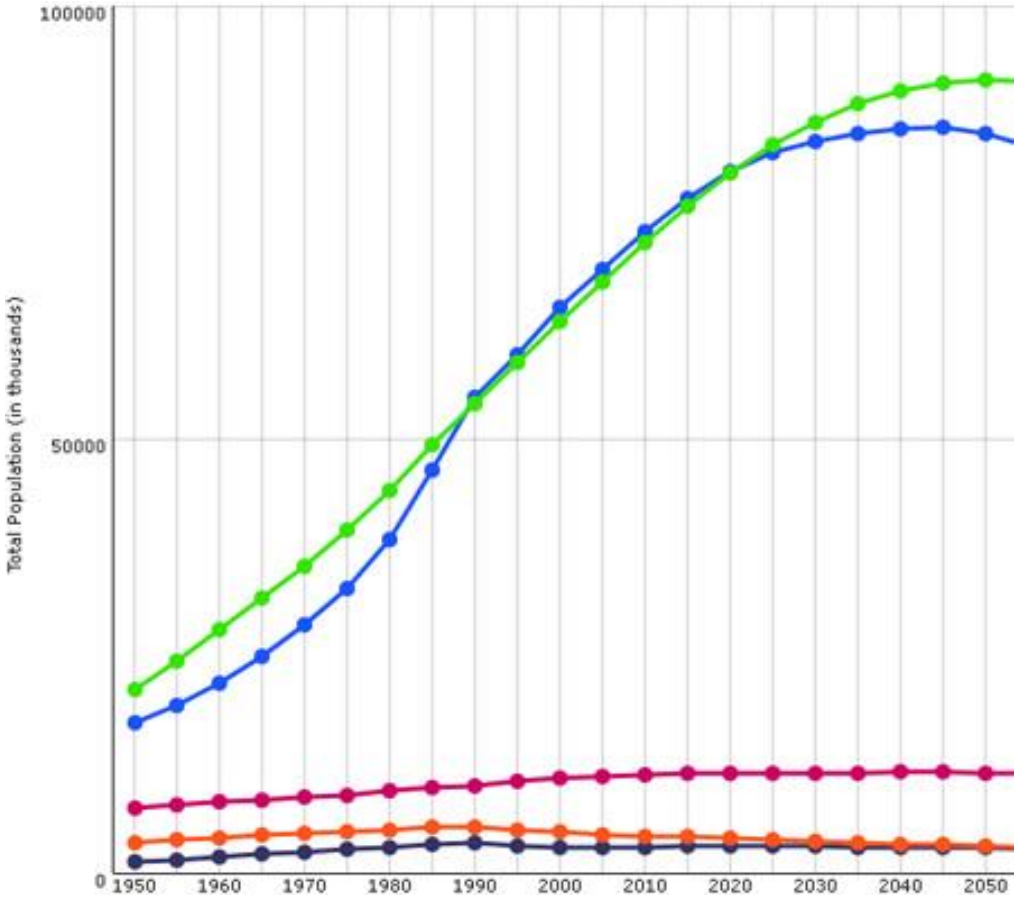
Demographics

	Turkey	Greece
Population	80,845,215 (July 2017 est.)	10,768,477 (July 2017 est.)
Age structure	**0-14 years:** 24.68% (male 10,209,284/female 9,745,057) **15-24 years:** 15.99% (male 6,601,471/female 6,324,277) **25-54 years:** 43.21% (male 17,691,703/female 17,243,428) **55-64 years:** 8.58% (male 3,448,232/female 3,492,199) **65 years and over:** 7.53% (male 2,712,323/female 3,377,241) (2017 est.)	**0-14 years:** 13.83% (male 767,245/female 722,313) **15-24 years:** 9.67% (male 532,179/female 509,487) **25-54 years:** 42.45% (male 2,275,984/female 2,295,082) **55-64 years:** 13.13% (male 692,420/female 721,641) **65 years and over:** 20.91% (male 986,816/female 1,265,310) (2017 est.)
Median age	**total:** 30.9 years **male:** 30.5 years **female:** 31.4 years (2017 est.)	**total:** 44.5 years **male:** 43.5 years **female:** 45.6 years (2017 est.)
Population growth rate	0.52% (2017 est.)	-0.06% (2017 est.)
Birth rate	15.7 births/1,000 population (2017 est.)	8.4 births/1,000 population (2017 est.)
Death rate	6 deaths/1,000 population (2017 est.)	11.3 deaths/1,000 population (2017 est.)
Net migration rate	-4.5 migrant(s)/1,000 population (2017 est.)	2.3 migrant(s)/1,000 population (2017 est.)
Sex ratio	**at birth:** 1.05 male(s)/female **0-14 years:** 1.05 male(s)/female **15-24 years:** 1.04 male(s)/female **25-54 years:** 1.03 male(s)/female **55-64 years:** 0.99 male(s)/female **65 years and over:** 0.8 male(s)/female **total population:** 1.01 male(s)/female (2016 est.)	**at birth:** 1.06 male(s)/female **0-14 years:** 1.06 male(s)/female **15-24 years:** 1.05 male(s)/female **25-54 years:** 0.99 male(s)/female **55-64 years:** 0.96 male(s)/female **65 years and over:** 0.78 male(s)/female **total population:** 0.95 male(s)/female (2016 est.)
Infant mortality rate	**total:** 17.6 deaths/1,000 live births **male:** 18.8 deaths/1,000 live births **female:** 16.3 deaths/1,000 live births (2017 est.)	**total:** 4.6 deaths/1,000 live births **male:** 5 deaths/1,000 live births **female:** 4.1 deaths/1,000 live births (2017 est.)

	Turkey	Greece
Life expectancy at birth	**total population:** 75 years **male:** 72.7 years **female:** 77.5 years (2017 est.)	**total population:** 80.7 years **male:** 78 years **female:** 83.4 years (2017 est.)
Total fertility rate	2.01 children born/woman (2017 est.)	1.43 children born/woman (2017 est.)

Source: Index mundi, 2019 [22]

Figure 26: **Population growth of Turkey vs neighbouring states**



Source: UN World Population Prospects 2010 Revision.

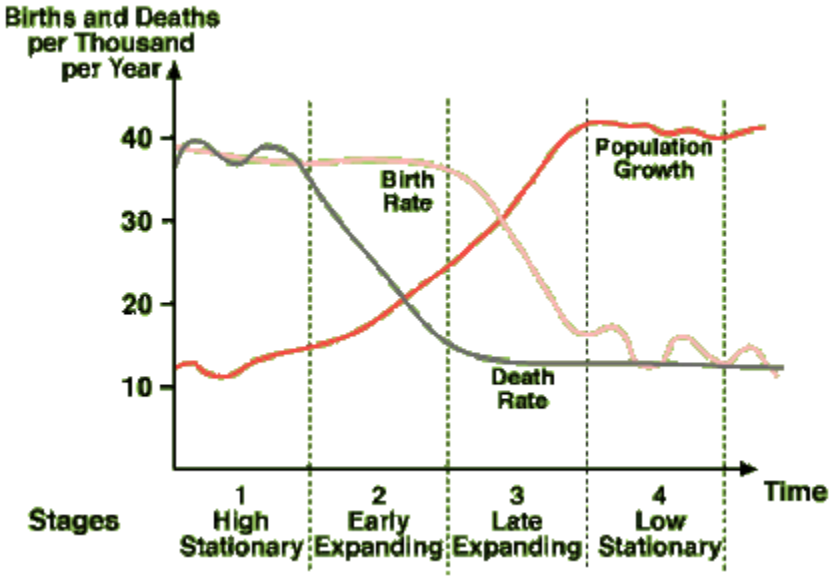
The above figure depicts the population growth rate of Turkey (green), Iran (blue), Greece (bordeaux), Georgia (orange), Armenia (black)

The figure paints an eloquent picture on the extreme differences of population dynamics between Greece and Turkey. While in the 1950's the population balance was almost 3 to 1 in favor of Turkey, in the 2020s it is expected to skyrocket to 11 to 1. This is a result of the fact that Turkey, unlike Greece, has not yet entered its "demographic transition", a term denoting the transition from high birth and death rates to lower birth and death rates as a country or

region develops from a pre-industrial to an industrialized economic system. As the societies of Turkey and Greece diverge in terms of adherence to cultural and religious values, the gap between the populations of the two countries continues to open at an exponential rate.

In general, Greece entered its demographic transition phase in the 1980's, in tandem with the increased standards of living brought about by policies of public expenditures and a socialist approach from the government. The public sector grew, along with the purchasing power of the Greek people who moved to the cities and abandoned the rural and agricultural life of the 1950's and 1960's. This paradigm shift has repercussions on birth rates, as they plummeted to just 1,43 children/woman, a level well below the 2,1 rate that is considered necessary for the renewal of population. It is worth noting that this birth rate also includes immigrants, which means that the actual birth rate of Greek women is even less than that.

Figure 27: **Demographic Transition Model**



Source: Greek Demographics, 2019 [23]

The increasing difference in population between the two countries has significant impact on Greece in a wide variety of terms. Firstly, since there is a shortage of people of young age, Greece's pension system and insurance coverage faces an ominous future, as the shrinking labor force is not able to support the social security costs which are growing as a result of the ageing population structure. The influx of immigrants, although provides a relief to some extent in terms of working capital, does not offer much to the social security system as many of them work in the "shadow economy", meaning that their employers do not pay social security contributions and therefore do not add to the stability of the system. To make matters worse, the difficult working conditions encountered and the different cultural background of the immigrant population tend to create incentives to some of them to resort to crime for subsistence.

On the contrary, Turkey being a country which has not yet entered its demographic transition, continues to expand dynamically. With a birth rate of 2.01 children/woman, it is 41% larger

than the respective Greek one, and will continue to be so for years to come. Especially now with the economic crisis hitting hard on Greece's economy , the continued shrinkage of the birth rate of Greek women will result to an even larger gap which cannot be covered.

A significant side effect of the low birth rates of Greek women which cannot be overlooked, is the diminished number of male conscripts of young age fit to serve in the military. Traditionally, Greece has maintained a mandatory conscription to the military for a duration ranging from 6 months to 3 years, depending on the period examined. The inverse pyramid age structure of modern Greece, having fewer people of young age in comparison to senior citizens, gradually leads to reduced numbers of young men fit for service. Military competence is one of the most important deterrence factors in the anarchic world political stage, so it is vital to the continuation of Greece's existence as an independent state to maintain military capability on par with its eastern neighbor. However, is this the case? The following chapter will examine the military expenditure and capabilities of Greece in relation to those of Turkey.

The military perspective

Both Greece and Turkey are members of the NATO alliance, which in principle means that a war between them is unthinkable. History however has demonstrated that the unthinkable in many occasions becomes possible, and therefore both countries have expended and continue to expend enormous resources in comparison to their respective sizes to ensure combat readiness and robust militaries.

The following table presents the military expenditure comparison between the two countries as of 2018

Figure 28: **Military expenditure comparison**

Source: Armedforces.eu, 2019

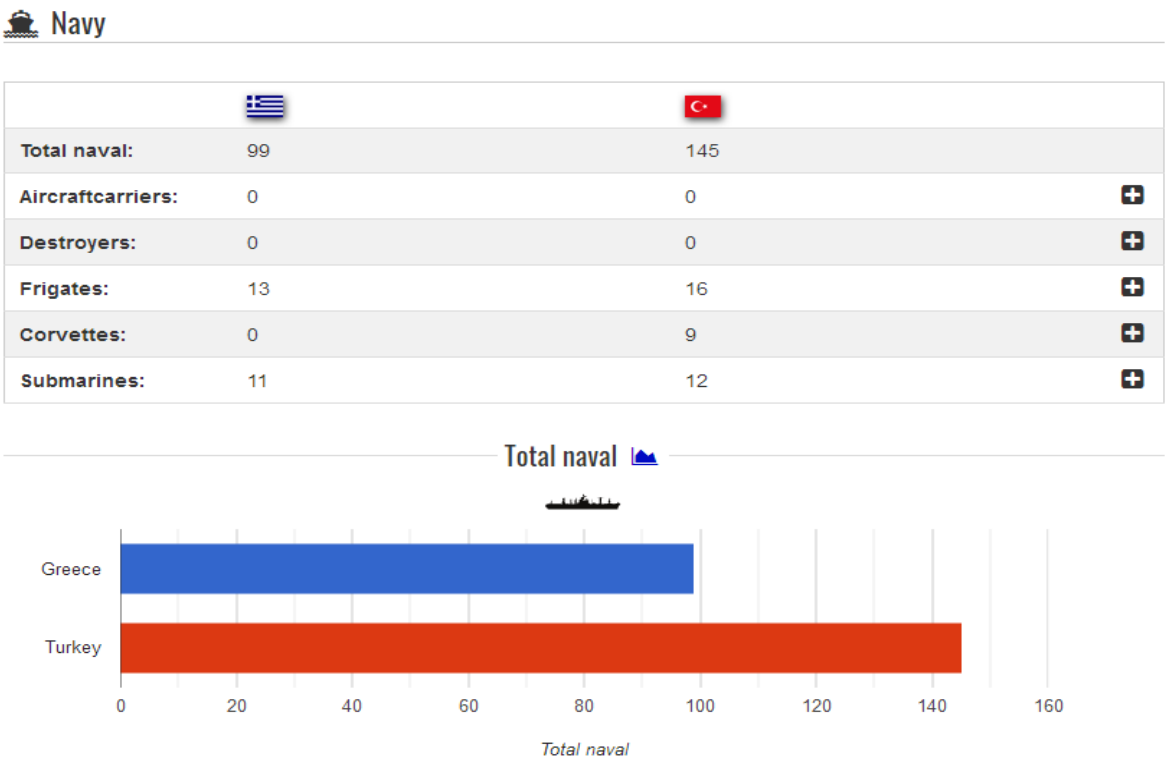
As can be seen, Greece spends significantly less in absolute numbers but roughly equal as a percentage of its GDP on its military. The figures however are only quantitative and not qualitative: It has been very long since the Hellenic Armed Forces underwent a serious modernization program, therefore a significant amount of this money goes to pensions and wages of its Armed Forces personnel. In addition, Greece continues to spend this amount of its GDP on weapons despite the fact that its economy is shrinking and has found itself amidst the economic crisis for the past 10 years, further exacerbating the dramatic state of its economy. The need for maintaining a strong military is bleeding Greece dry of financial resources, in a vicious cycle that seems unlikely to break in the foreseeable future.

On the contrary, Turkey has recently undergone massive modernization on every branch of its Armed Forces. Its Air Force is poised to acquire the F-35 Joint Strike Fighter aircraft, a stealth attack/fighter that is going to alter for good the perceived military balance in the Aegean and achieve air superiority for the Turkish side in the case of a conflict. Although

Turkey has distanced itself with the United States over the acquisition of S-400 Surface-to-Air missiles [24], as a co-producer of the F-35 it will sooner or later acquire this strategic weapon, or at least procure a similar one also capitalizing on the technological know-how acquired during its production.

Moreover, Turkey has embarked on an ambitious plan to modernize its Navy which has traditionally been regarded as its weak spot. As seen in the table below, Turkey already possesses a numerical advantage over naval assets, however this advantage is slowly translating to a qualitative one as well as Turkish navy is being modernized by leaps and bounds. Turkey plans to introduce 24 new naval assets to its fleet by 2023, among which are a light aircraft carrier, type 204 submarines and a significant number of new frigates and corvettes [25]. The picture painted for the Greek navy is ominous to that respect.

Figure 29: **Naval assets comparison**

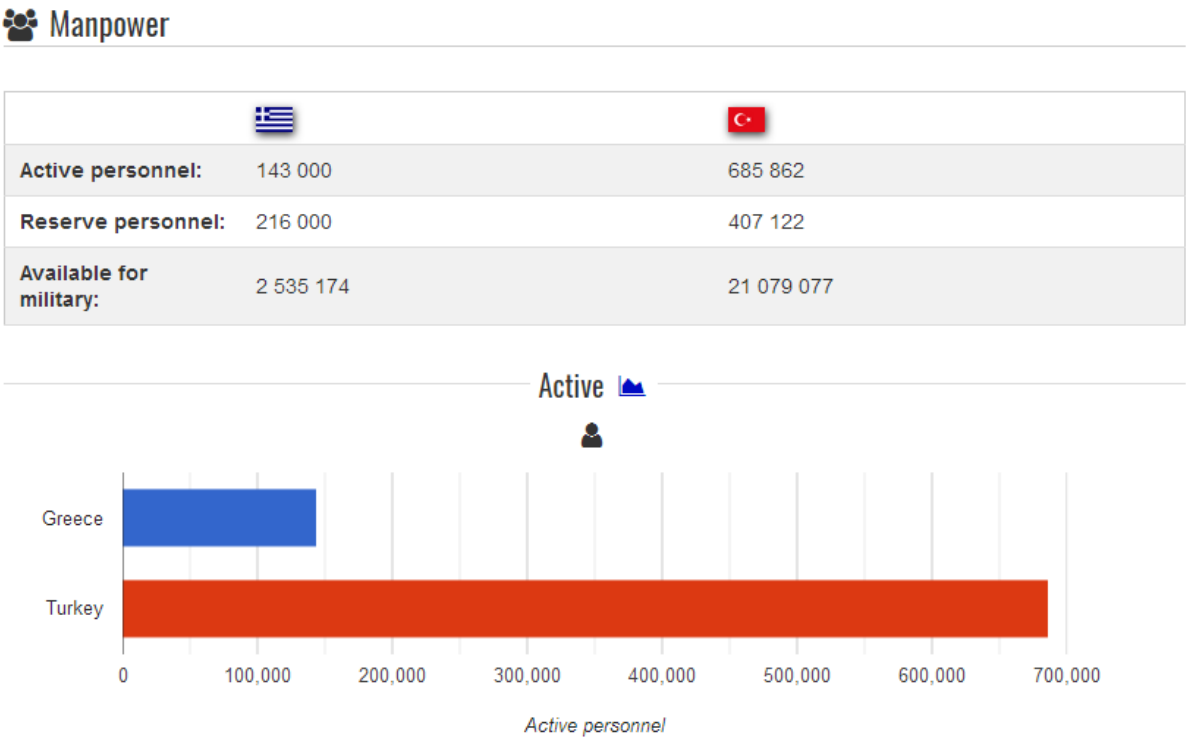


Source: Armedforces.eu, 2019

In terms of manpower, Turkey enjoys a vast numerical advantage. As per table below, Turkey maintains approximately 4,5 times more Active personnel on duty, while in a full scale mobilization it can amass a staggering 21 million, overshadowing Greece by a 1 to 8,5 ratio. Regardless of the fact that all this personnel could not possibly be deployed on the Thrace or Aegean front (both for logistical and political reasons related to Kurdish insurgency at the southeastern part of the country), it paints quite a clear picture on the gigantic task to be undertaken by Greece in the event of a prolonged conflict. Regardless of subjective views on combat readiness or chances of victory, the historic reality has proven that inexhaustible human resources prevail in a prolonged war even if the opponent maintains

a technological advantage, which in this case Greece does not. The Soviet Union during World War II utilized its vast manpower to bring Nazi Germany to submission, although Germany was far more industrialized and technologically advanced. Therefore, manpower will be in case of conflict a decisive factor in determining the winner, and as mentioned above the failing demographics of Greece will only make matters worse over time.

Figure 30: **Manpower comparison**



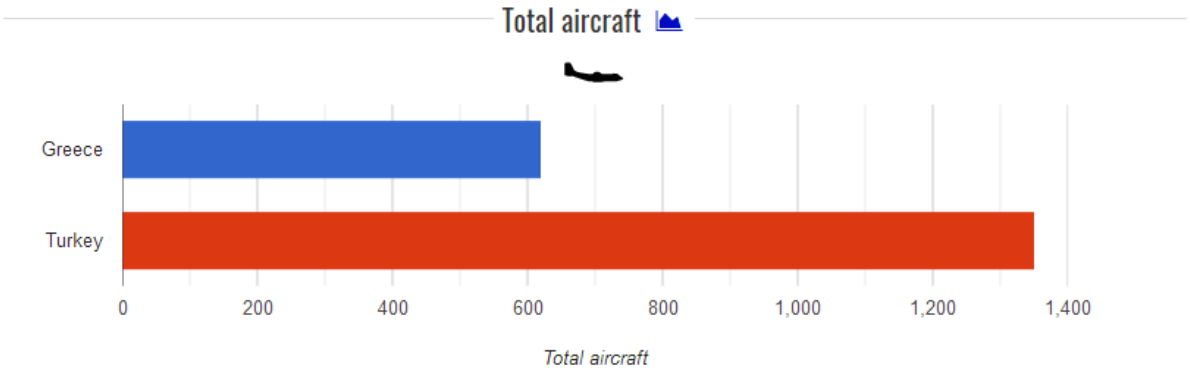
Source: Armedforces.eu, 2019

In terms of aircraft, there too Turkey enjoys an advantage. The following table presents the aircraft possessed by each nation

Figure 31: **Air assets comparison**

Air Forces

Total aircraft:	620	1 351
Fighter aircraft:	0	49
Multirole aircraf:	198	245
Attack aircraft:	0	0
Helicopters:	268	606



Source: Armedforces.eu, 2019

It is generally accepted that the Hellenic Air Force, although outnumbered, enjoys a qualitative advantage over its Turkish counterpart as a result of better training for its crew members [26]. Following the failed 2016 coup attempt against President Erdogan, the government has embarked on a McCarthy-like purge inside the civil and military structure against individuals perceived as threats [27], and the Turkish Armed Forces have been no exception. This fact has temporarily diminished the capabilities and readiness of the Armed Forces in general and the Air Force specifically. However this is a temporary effect; given time the now devoid of skilled pilots TAF will be reinforced by new and the qualitative advantage currently possessed by Greece will be diminished or eliminated altogether.

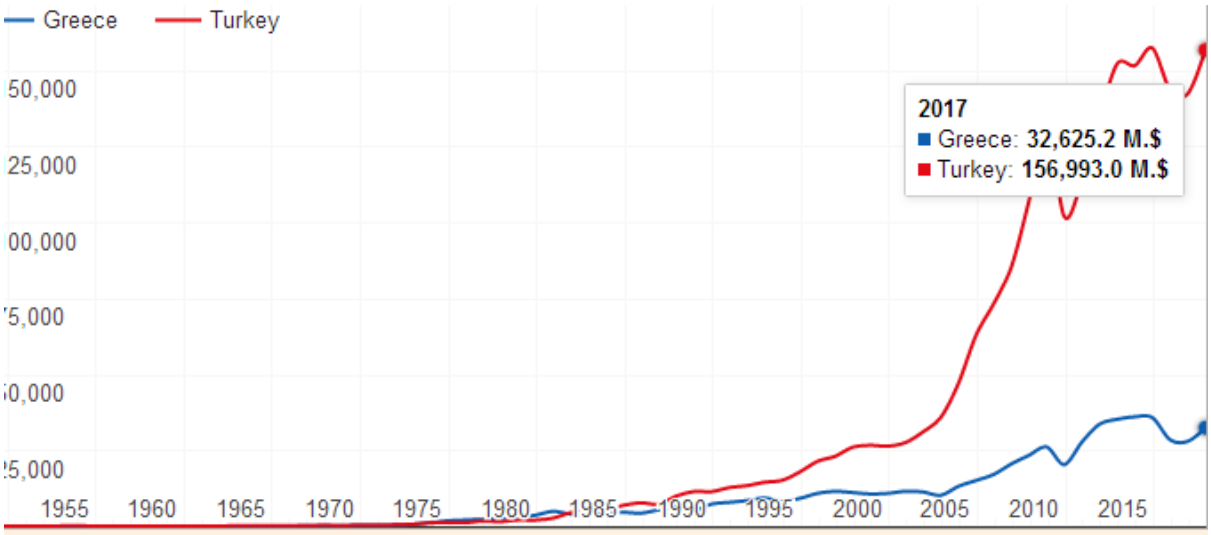
In addition, the future acquisition of 5th generation stealth aircraft by Turkey presents a monumental shift in the balance of aeronautical capabilities in the Aegean. Having stealth aircraft, Turkey will find itself tempted to attempt a decapitating first strike against Greek air defences and lay the groundwork for a full scale invasion of Eastern Aegean islands or Thrace. If this acquisition is combined with a strategic area-denial weapon as the S-400 or Patriot missile defence system, this will render the Eastern Aegean islands completely cut off from the mainland, with little hope of support or reinforcements in the eventuality of a conflict. It is obvious that conventional deterrence is hanging on a thread-Greece cannot follow the Turkish spending frenzy in high-tech weapons systems, so another form of hard deterrence needs to be established if Turkey is to restrain itself from attacking.

Comparison of economies

Greece and Turkey demonstrate a very different economic approach which greatly affects their macroeconomic indices. Turkey is largely a free-market economy that is driven by industry and service sectors, while the agricultural sector accounts for about a quarter of the country's employment. It has invested heavily on the automotive, defence, petrochemical and electronics industries, which have outgrown the textile and clothing sectors in Turkey's export mix. Following a severe financial crisis in 2001, Ankara adopted financial and fiscal reforms as part of an IMF program. The reforms strengthened the country's economic fundamentals and ushered in an era of strong growth averaging more than 6% annually until 2008. An aggressive privatization program also reduced state involvement in basic industry, banking, transport, power generation, and communication. The country's economy is export-oriented, with a significant amount of its GDP coming from exporting activities.

The following diagram shows the comparative exports of Greece and Turkey over time in millions of USD

Figure 32: **Exports (in US $) comparison, Greece and Turkey**



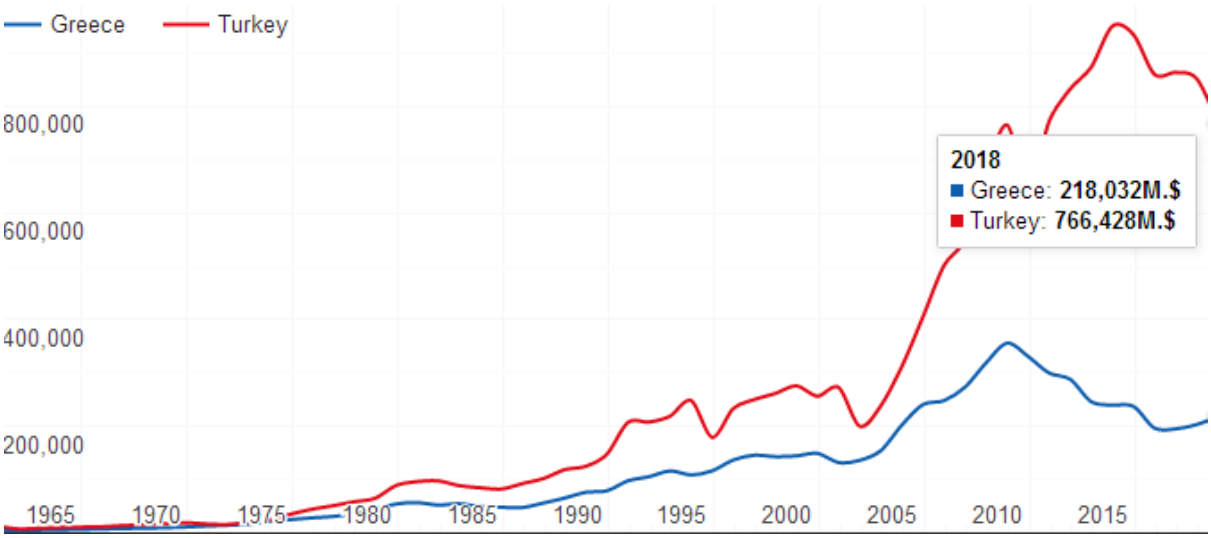
Source: Countryeconomy.com, 2017

As can be seen, following the year 2001 and the reforms undertaken by the Turkish government, exporting capability of Turkey exploded and reached 157.000 million from a mere 26.000 million $ in 2001. On the other hand, Greece could not keep up with the exporting capacity increase. It is worth noting that during the 90's Greece and Turkey demonstrated comparable exports in absolute terms, but since then the trend is largely developing in favour of Turkey.

On the other hand, Greece has a service-oriented economy which mainly revolves around tourism that brings in almost 20% of its GDP. Due to the lack of labour force given the demographics and the moving of people from rural areas to the cities, immigrants make up nearly one fifth of its work force, mainly in agricultural and unskilled jobs. A critical factor

affecting the size of Greek GDP is the size of its public sector, which accounts for almost 40% [28]. The following diagram demonstrates the evolution of Greek and Turkish GDP's over time

Figure 33: **GDP comparison, Greece and Turkey**

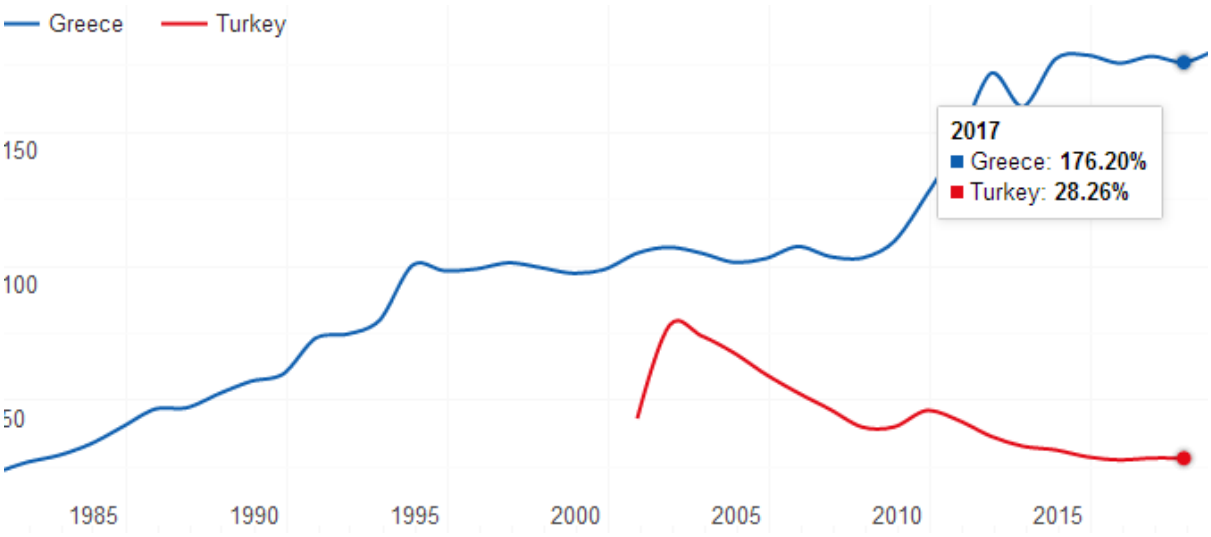


Source: Source: Countryeconomy.com, 2017

The above diagram demonstrates the dynamic increase of Turkish GDP in relation to the Greek, with the difference widely spreading following 2005. This can be attributed to the Greek financial crisis that hit the country from 2010 onwards, which is clearly visible on the downward trend of the GDP. However, the increased industrialization of Turkey and the robust export figures greatly contributed to the enlargement of the Turkish GDP also. It is worth noting that Turkey has embarked on a construction frenzy, with major projects being built in order to celebrate the 100 years from the establishment of the Turkish Republic in 2023. Turkey is building or planning to build projects [29] such as Istanbul's 3rd airport (cost 25,6 billion $), Sinop Nuclear Plant (22 billion $), Akkuyu Nuclear Plant (20 billion $), Istanbul-Izmir Highway (16 billion $), Osmangazi Bosporus Bridge (2 billion $), Istanbul Canal (15 billion $), Eurasia tunnel (1,3 billion $) etc. This public expenditure greatly contributes to the enlargement of the GDP.

The constantly growing GDP of Turkey also affects the debt percentage as a ratio of GDP. The following diagram depicts the GDP/Debt comparison of the two countries. It is obvious that from 2001 onwards Turkey has capitalized on its systemic reforms, increasing its GDP and reducing its debt/GDP ratio, while Greece has been showing a steady increasing trend which skyrocketed from 2010 onwards as a result of the economic crisis which greatly reduced its GDP, and by extension increased its debt/GDP ratio to almost 180 %

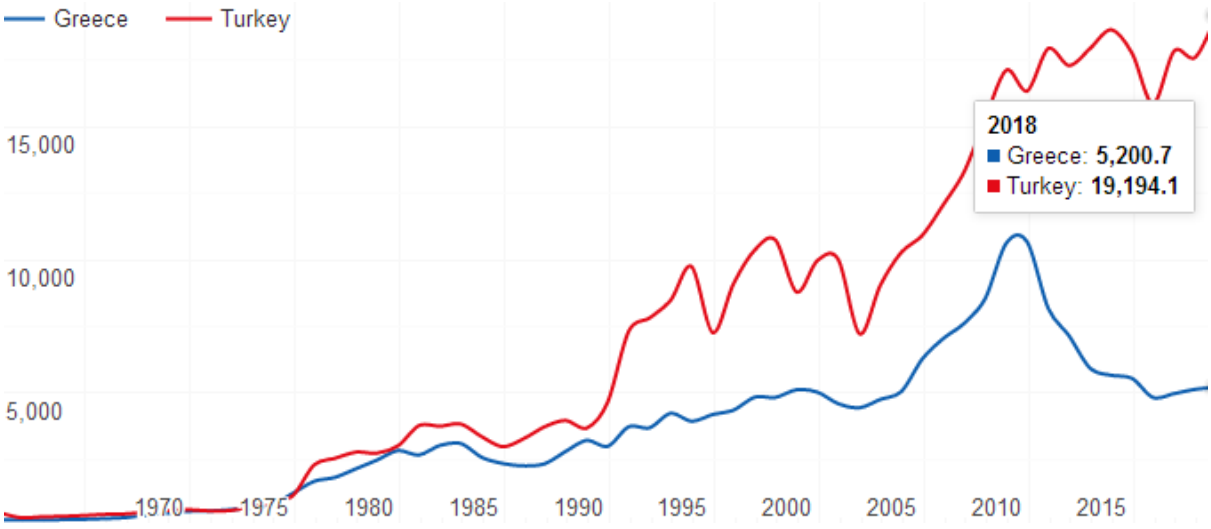
Figure 34: **Debt (% GDP) comparison, Greece and Turkey**



Source: Source: Countryeconomy.com, 2017

Another important factor to be examined is the defence expenditure of each country. The following diagram shows the evolution of actual defence budget of Greece and Turkey over time

Figure 35: **Defence expenditure comparison, Greece and Turkey**

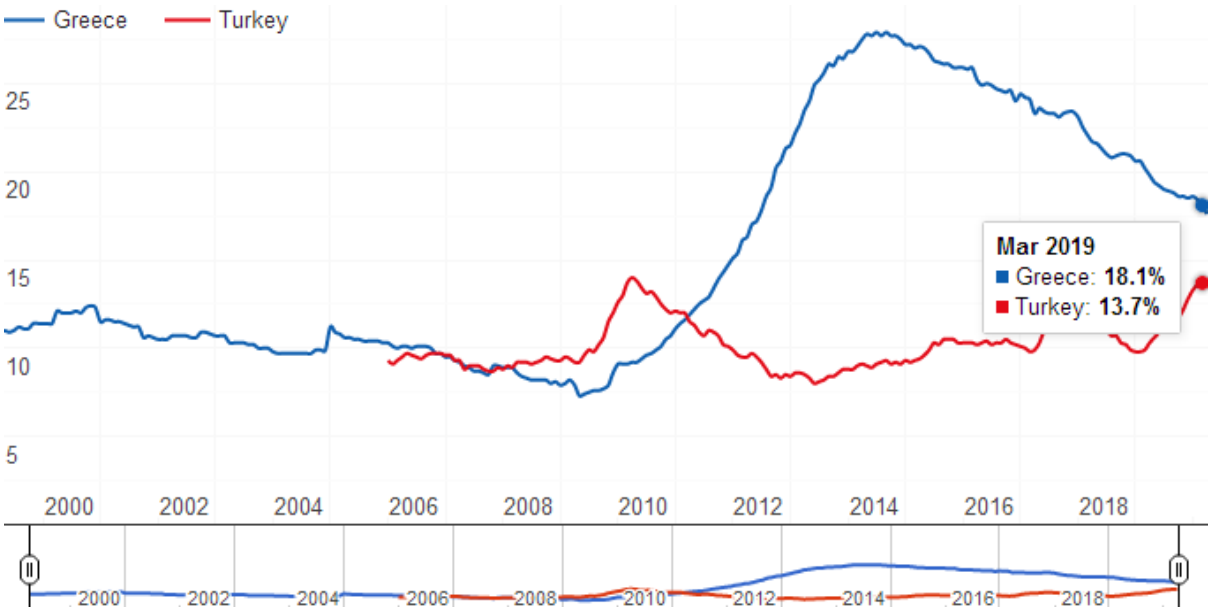


Source: Source: Countryeconomy.com, 2017

It is obvious that the gap between the defence expenditure of the two countries is getting wider over time. This is the result of many factors: On one hand, Greece following the 2010 economic crisis has dramatically reduced its defence budget in order to be able to achieve the fiscal targets imposed by the IMF and the EU. On the other hand, Turkey has been both experiencing exponential growth of its indigenous defence industry resulting in many orders, both for local use and exports [30], while also increasing its GDP and wealth which stimulates the enlargement of its armed forces. In fact, Turkey has laid out ambitious plans involving the construction of an aircraft carrier, the acquisition of S-400 strategic air defence system, the procurement 5th generation stealth aircraft, complete upgrade and renewal of its naval assets with new frigates and destroyers, production of Turkish helicopters and tanks. It has also invested heavily in local R&D for missile guidance systems, cyberwar capabilities, electronics and aviation industries. Apart from the quantitative, there is also a qualitative element to the comparison: Greece has been spending a large portion of its defence budget on pensions and salaries of its armed forces personnel, so the actual figure reserved for weapons upgrade and modernization is even less. The diminished defence budget cannot but affect the combat readiness and training of Greece's military structure, since costly exercises are being performed at a lesser rate than the past. An ever increasing military gap disturbs the perceived balance of power between the two countries, making a conflict a more likely scenario than when military parity between them was the case.

The next diagram examines the unemployment rate between the two countries

Figure 36: **Unemployment rate comparison, Greece and Turkey**

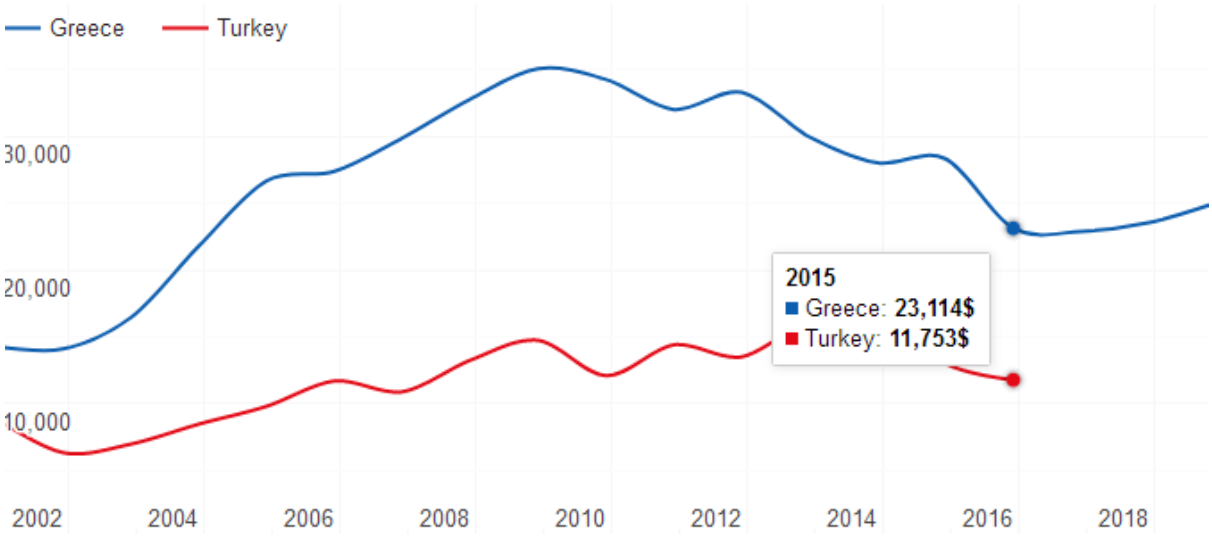


Source: Source: Countryeconomy.com, 2017

According to the official data, the unemployment rate between the two countries differs by about 5%. However, the way the official unemployment rate is calculated leaves room for

misinterpretations; seasonal employed persons do not count in the unemployment rate, self-employed persons also do not count in the calculation of the rate. Given that Greece's economy is mostly services-oriented with a high percentage of self-employed individuals, the actual unemployment rate is quite larger than the official. However, even so, Turkey still maintains an advantage in the utilization of its vast work-force which in general provides cheap labour. On one hand, the abundance of working force drives wages lower, as can be seen in Fig. 37, while the devalued Turkish lira provides good incentives to foreign investors to move their businesses in the country. On the other hand, Greece being a member of the Eurozone does not enjoy the fiscal freedom of currency devaluation, and therefore has to be competitive while not being able to manipulate its own currency.

Figure 37: **Average wage comparison, Greece and Turkey**



Source: Source: Countryeconomy.com, 2017

The overwhelming advantage of Turkey in terms of macroeconomic factors has led to an increased influx of Foreign Direct Investments. Greece on the other hand, especially after the 2010 financial crisis has not regained the trust of investors. Combined with the extensive de-industrialization after the 1990's and the transformation of its economy to service-oriented Greece is lagging behind and is doubtful whether it can catch up in the foreseeable future without strong political will.

Geography: A relentless parameter

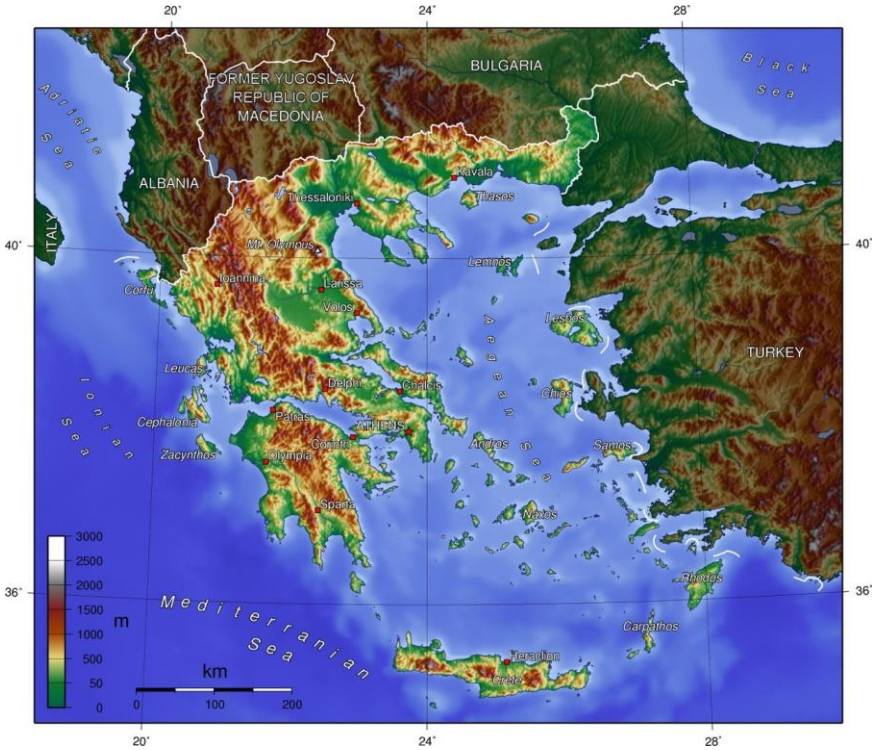
When examining the military perspective of the Greco-Turkish comparison, one cannot afford to overlook the strategic parameter of the geographical characteristics of the two adversaries. Greece and Turkey, albeit close to each other, present tremendous differences in relation to their geography, a fact that affects greatly the tactical situation of any future conflict.

The terrain of Greece

Greece is a country situated at the southernmost tip of the Balkan peninsula. It is bordered to the North by Albania, North Macedonia and Bulgaria, while Turkey borders it from the East. The country is surrounded to the east by the Aegean Sea, to the South by the Libyan Sea and to the west by the Ionian Sea. The coastline of the country is among the largest in Europe and the largest in the Mediterranean basin, reaching 13.676 km according to the CIA World Factbook.

The country consists of a mountainous and difficult to transverse terrain on its mainland, while it also has many islands of various sizes, both inhabited and uninhabited. According to the Hellenic Tourism Organization, Greece maintains possession over 6.000 islands, with 227 of them inhabited. The islands compose roughly 20% of the country's territory, and display great variations in terms of size.

Figure 38: **The geographic terrain of Greece**



By examining the above map, useful conclusions can be drawn in relation to the tactical situation in a possible conflict

- Greek territory is characterized by ***the lack of strategic depth.*** The country possesses a narrow strip of land in parallel to the Aegean Sea to the North, which at its widest point reaches approximately 90 km (excluding the Chalkidiki peninsula). From a

tactical standpoint, this is a major disadvantage as there is little room for the deployment of mechanized armored units, while the space restrictions of the defending Greek army make the encirclement by a strong land force being landed by sea or air behind Greek lines a possibility.

- The vast number of islands, and the great distances of some of them from the mainland means that they need to be self-reliant in terms of defensive capabilities, as the provision of reinforcements in times of conflict is difficult to execute. To this extent, Greece has armed the Eastern Aegean islands. It is worth noting that this has been done in violation of the Lausanne Treaty and the Paris treaty, which designate the islands as demilitarized [31]. However, the Cyprus conflict of 1974 raised concerns about their fate in a potential war between the two countries, therefore the Greek side embarked on a systematic rearmament of its islands to counter the Turkish threat. Nonetheless, since the islands are so many and the naval and air resources of the Greek side fixed, this means that ***some of them are indefensible***. A characteristic example is the island of ***Kastellorizo***, situated 130 km east of Rhodes and 570 km east of Athens.

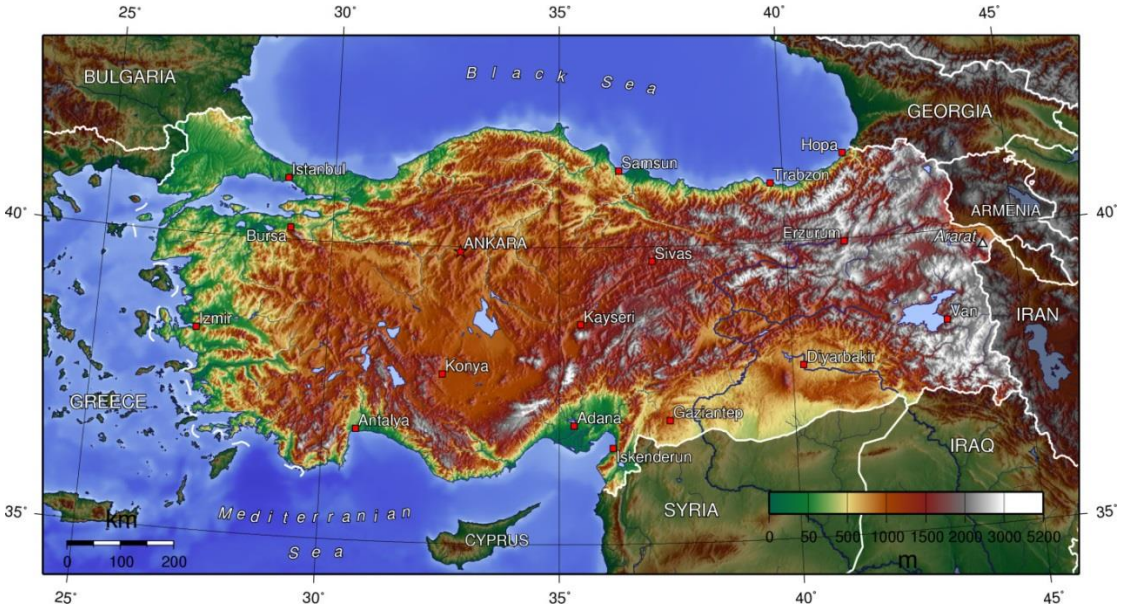
Therefore, the Turkish side maintains the tactical advantage since it can attack any island, at any time, utilize deceptive tactics and disperse the defensive Greek forces. In strategic terms, Turkey can **maintain the initiative** and achieve territorial gains at the expense of Greece much faster than Greece could capture Turkish ground. Since a conflict between the two countries is not expected to last long before the intervention of the Great Powers, ***the side holding enemy ground at the negotiation table will have the upper hand.***

The terrain of Turkey

Turkey is situated in Western Asia and partly, the Balkans. It is bordering Bulgaria, Greece and the Aegean Sea to the West, Georgia and Armenia to the East, Syria, Iraq and Iran to the South and the Black Sea to the North. The area of Turkey is roughly 784.000 km2, while its coastline reaches 7.200 km

The country extends more than 1.600 km from West to East and some 800 km from North to South. It maintains a small part in Europe, namely Eastern Thrace, while the rest of its landmass is part of Asia and more specifically the Anatolian peninsula.

Figure 39**: The geographic terrain of Turkey**



Contrary to Greece, Turkish mainland is characterized by a vast continuous land mass, mainly of a mountainous terrain with the exception of the plains of Eastern Thrace. This fact is a major advantage in terms of the strategic depth of the country. Turkish forces can handle and contain a foreign invasion, having the option of tactical withdrawal to attain more favourable conditions, a situation best exemplified in the Asia Minor campaign of the Greek Army during 1919-1922. The extended land mass and battle front meant that Greek forces needed to overstretch their supply lines to pursue the tactically retreating Turks, while at the same time being harassed behind their lines from irregular forces. As known, the Asia Minor campaign ended in a major catastrophe for the Greek side, although the Turks were not in the greatest of their military capabilities at that time, while the Greek Army was comprised of battle-hardened veterans fighting consecutively for over 10 years on various fronts. This fact is testament to the importance of geographical particularities that influence the outcome of military conflicts.

In addition, the continuum of the land mass also means that ground lost can be more easily regained, while the loss of an island is much more challenging to take back. Turkey does not hold sovereignty over many islands in the Aegean Sea, and those under her control are situated close to its mainland making their defence possible.

Geopolitics and the strategic importance of Turkey for the West

Greece and Turkey both joined NATO in 1952 as part of the strategic plan of the West to form a military alliance that would contain the spread of communism in the European continent and worldwide. Since then, many things have changed in the global political scenery: The Soviet Union collapsed, the Iron Curtain fell, Germany was reunited and communism no longer constitutes a threat for the West (namely the United States). Nonetheless the NATO alliance still stands with a renewed mission; to protect and advance

American interests under the guise of fighting terrorism. Although the Soviet Union no longer exists, primarily the Russian Federation and China constitute the upcoming adversaries of the US in the global arena.

The strategic importance of Greece for the West can be identified only in relation to that of Turkey. To that extent, a number of reasons exist that clearly demonstrate that Turkey is a much more valuable strategic asset for the US than Greece.

The favourable geographic location of Turkey

Both Greece and Turkey share the southerneast corner of the Mediterranean Sea, positioned in a favourable spot of the global sea routes that connect the European continent to the Indian Ocean through the Suez Canal. However, Turkey is bordering the USA's arch-adversary, Russia, while it also shares borders with major oil-producing countries that hold particular interest to the US, namely Syria, Iraq and Iran. The United States has capitalized on its close strategic embrace of Turkey, maintaining a number of military bases on its territory that provide an invaluable springboard for military and intelligence operations.

Figure 40: **US and NATO military bases in Turkey**

NATO Presence ■ U.S. Military Presence

1 Allied Land Command ● ■
2 Rapid Deployable Corps ● ■
3 Partnership for Peace Training Center ●
4 Center of Excellence–Defense Against Terrorism ●
5 U.S. Office of Defense Cooperation ■
6 **Kirsehir base.** Training Syrian fighters against ISIL ■
7 **Kurecik base.** Location of missile defense radar ● ■
8 **Malatya (Erhac) air base.** U.S.-led coalition "emergency use" against ISIL ■
9 Command center for missile defense radar ● ■
10 **Diyarbakir air base.** U.S.-led coalition use against ISIL ■
11 **Batman air base.** U.S.-led coalition "emergency use" against ISIL ■
12 NATO Patriot missile batteries (U.S.) ● ■
13 NATO Patriot missile batteries (Germany) ●
14 NATO Patriot missile battery (Spain) ●
15 **Incirlik air base.** Various uses, see text ■
16 Port used by U.S. military ■

Source: researchgate.net, 2018

In addition, the US has installed a number of strategic weapons in Turkish territory directly aiming the Russian Federation, both nuclear and conventional. The Turkish mainland houses a number of PATRIOT missile batteries and tactical/strategic nuclear bombs that serve NATO's plan of strategic encirclement of Russia, with the aim to coax it into yielding to diplomatic pressure.

Moreover, the close proximity of the country to the hostile to US interests Iran makes it a perfect location for the application of military pressure. Along with the US bases in Iraq, Turkey provides the opportunity to US forces to perform surgical aerial strikes to high value targets within enemy territory. On the contrary, Greece although maintaining a number of US and NATO bases of its own, is far away from the fields of American interest. Therefore, US presence in the country aims more at maintaining the status quo in the region, ensuring that Greece is bound to the Western alliance, rather than military exploitation.

Another important aspect of Turkey's importance as a function of its location is the fact that it holds the key to Russia's access to the Black Sea through the Dardanelles and Bosporus straits. One of Russia's main geopolitical problems is the lack of access to warm seas, meaning seas that do not freeze throughout the year, as is the case with its Northern Sea and Sea of Japan ports. Unhindered access to Black Sea ports is vital to Russia's commerce and exports, and throughout history Russia/Soviet Union has tried to establish a favourable status quo on the Dardanelles, the last being during the Turkish Straits crisis in 1946, a Cold war territorial conflict where the Soviet Union tried to impose a renegotiation of the Montreaux Treaty governing the status of the Straits.

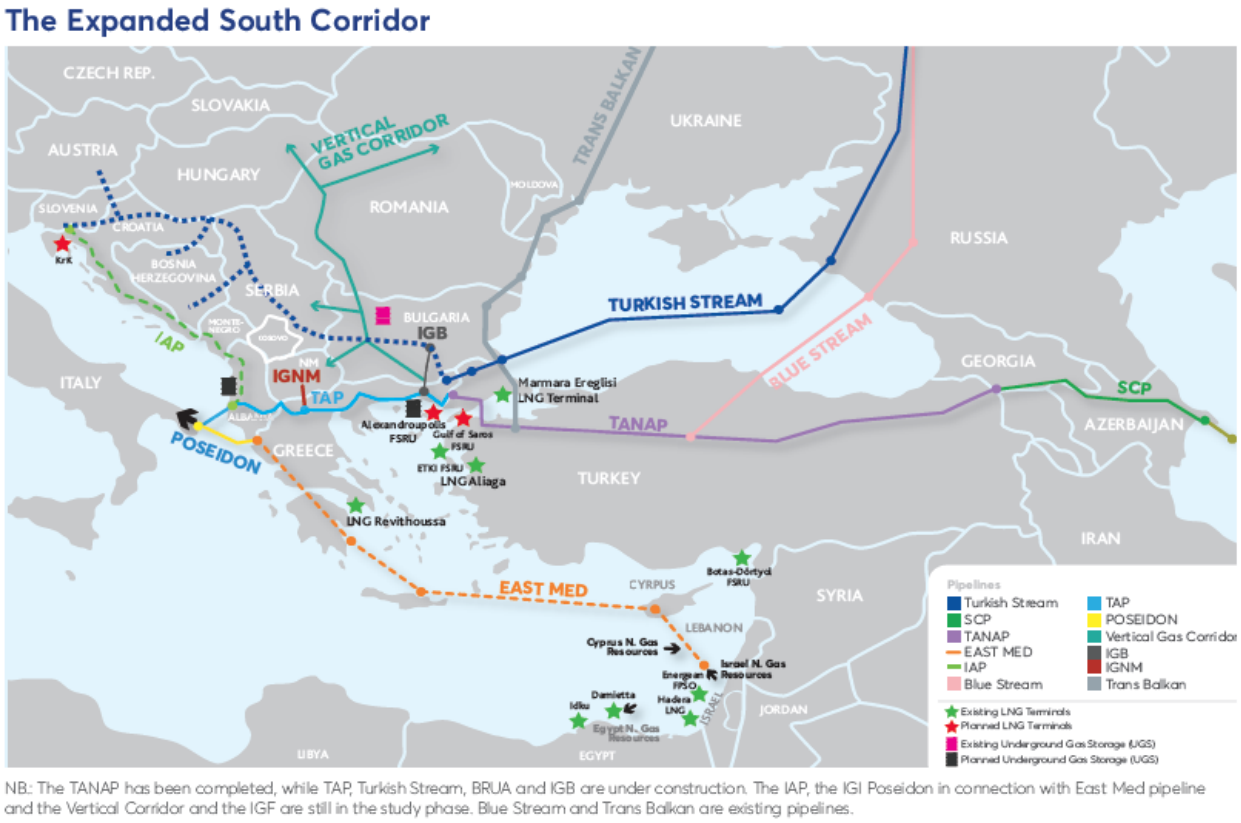
It is evident that because of the geographic position of Turkey, the country has the ability to exert considerable pressure to allies and adversaries alike. This fact has been recently exemplified with the open defiance of the US interests on behalf of Turkey, with the procurement of S-400 AAM batteries, the construction of Turkish and Blue Stream Natural Gas Routes, the continued trade with Iran, the invasion of Syria where it attacked Kurdish militias fighting alongside US against ISIS, the constantly deteriorating diplomatic relations with Israel, the provocative drilling for Natural Gas within Cypriot Exclusive Economic Zone etc.

The Natural Gas routes

Another important factor that weighs in on the relative significance of Turkey in comparison to that of Greece, is the fact that it is the country through which many major natural gas and oil pipelines have been constructed. These pipelines are vital to the energy security of the European continent, and therefore Turkey can hold a significant leverage to exert diplomatic pressure by playing this card.

The following picture depicts the existing and planned pipeline routes transversing Turkish soil to reach Europe

Figure 41: **The Natural Gas South Corridor**



NB.: The TANAP has been completed, while TAP, Turkish Stream, BRUA and IGB are under construction. The IAP, the IGI Poseidon in connection with East Med pipeline and the Vertical Corridor and the IGF are still in the study phase. Blue Stream and Trans Balkan are existing pipelines.

Source: IENE Fact Sheet #1: Gas markets in SE Europe (2019)

Turkey houses the Turkish Stream pipeline which is scheduled to gradually replace the Trans-Balkan pipeline crossing Ukraine. The tense relations between Russia and Ukraine have led to the underutilization of the Natural Gas pipelines crossing the country. This fact will increase significantly Turkey's importance to European interests, as the security of Natural Gas supply of many SE Europe countries will be relying upon Turkey's goodwill, and it is certain that Turkey will capitalize on this leverage in order to pursue its national interests at the expense of Greece.

Another major pipeline crossing Turkish soil is the Trans Anatolian Pipeline (TANAP) transferring Natural Gas from the enormous Shah Deniz gas field of the Caspian Sea, belonging to Azerbaijan. TANAP holds particular significance to Europe, since it provides an alternative route of supply directly competitive to Russian pipelines, thus contributing to supply diversification and safety. This pipeline is also important to Greece, as its extension, the Trans Adriatic Pipeline (TAP) is crossing Greek soil in its path to Italy, while it also accounts for a considerable percentage of the needs of the Greek market for Natural Gas.

In addition, Turkish Stream is also an important pipeline bringing in Russian Gas to Europe by crossing the Black Sea underwater and reaching Bulgaria through Eastern Thrace. Its future extensions towards Serbia, Hungary, Croatia and Austria will ensure their reliability of supply and enhance the regional sufficiency of resources.

Apart from pipelines, it is also noteworthy that through the Dardanelles and Bosporus straits almost 3% of the world's daily need in crude oil is being transported by means of tankers, bringing in oil from Russia and Kazakhstan [32]. Hence, Turkey maintains a major geopolitical tool that provides it to control the influx of resources to Europe, and therefore exert geopolitical pressure that puts Greece at a weak spot.

From the above analysis, it is clear that for Europe and the West in general, Turkey maintains increased significance in relation to Greece. The former has grown to be an increasingly independent, self-reliant and dynamic player in the South Eastern Mediterranean Region, trying to gradually release itself from the tight leash of the American control. On the other hand, Greece, with all its financial and political problems arising from the catastrophic decisions of 2015 has become extremely vulnerable to external pressure from allies and opponents alike. Greece is susceptible to diplomatic arm-twisting on the basis of its constant need to stay afloat economically, while the fate of its finances lies upon the good will of its European counterparties and of its military on the credit provided by Americans, Germans and French. Therefore, it is no wonder that Turkey weighs more in the geopolitical scale than Greece. This means that in the event of an armed conflict-no matter how short it might be-between the two countries, Western powers are more likely to advance Turkish interests by supporting the idea of concessions on behalf of Greece in exchange for a cease-fire. By default, Greece is in a tremendous disadvantage as it not only has to defend its territory with all the shortcomings detailed above, but at the same time it is very likely that it will be met by indifference, or even hostility, by its European and Western counterparties for the inevitable destabilization of the Region that will disrupt their vital interests.

The most effective way to tip the scale of the balance of power in this situation is to exercise **deterrence.** Deterrence theory suggests that an inferior force, as in the case of Greece, could hold back a more powerful adversary by virtue of the destructive power of its weapons. Up until recently, Greece was able to deter conventional attacks from Turkey based on its perceived parity of military forces and the ambiguity of the outcome of a possible conflict. A characteristic example of deterrence exercise was the Hora/Sismik incidents of 1976 and 1987, where Turkey withdrew its oceanographic vessels from the Aegean to prevent an armed response from the Greek side. However, as described above, the current situation is much different than it was 40 years ago. The gap in military capabilities and armed personnel is so large, that conventional deterrence is likely to collapse. Indeed, it is questionable whether Greece can maintain a prolonged conflict without territorial losses and with territorial gains. Therefore, a new form of deterrence is required, one that allows for weaker actors to counter stronger adversaries. Nuclear deterrence has been proven to be effective in quite a few cases throughout the global political arena, which will be described below

The case of North Korea

Perhaps the most characteristic example of a David vs Goliath situation is the communist dictatorship of North Korea. Following the 1950s conflict and the establishment of a fragile peace, North Korea was being protected from Western invasion by virtue of the military and nuclear arsenal of its closest allies, namely China and the USSR. However, the collapse of the communist motherland in the early 90s left North Korea facing a dire situation not only

financially, but also militarily. Although it still held a significant conventional force that can inflict heavy damage to neighboring South Korea and Japan, it was by no means a threat to the United States which would like to see the country falling under their sphere of influence. Hence, in 1993 North Korea announced its withdrawal from the **Nuclear Non-Proliferation Treaty** and started covertly the research and development of Nuclear Weapons. On 2006, North Korea conducted its first nuclear test, while on 2009 the International Atomic Energy Agency reported that North Korea had become a fully fledged nuclear power [33]. From that point on, the stakes were very high for the American side. An armed attempt to overthrow the North Korean regime, apart from a regional –and therefore contained- conflict, could result in a nuclear catastrophe for the closest allies of the United States Japan and South Korea. To make matters worse, the development of ballistic missile technology from North Korea provided it with the capability of reaching the Western territories of the United States, including Hawaii, thus making the possibility of a nuclear strike on American soil a credible threat. Up to this day, North Korea is considered to be a rogue state with nuclear capacity, and a leader that does not act as a rational player. These factors combined make nuclear deterrence credible, as the risks of an armed attempt to overthrow the regime on behalf of the Americans will come to an unimaginable cost, one that no democratically elected leader would ever undertake.

The case of Israel

Israel is another interesting example of a small state holding back larger forces. The state of Israel was established following the end of WW2 in 1947 and right from its very beginning of existence, was forced to fight continuous wars with its neighboring Arab States to secure the continuation of its existence. Israel fought in 1948 the Arab-Israeli War against the Arab League, a coalition of Arab states including Egypt, Jordan, Iraq, Syria, Lebanon, Saudi Arabia and Yemen. It also fought in 1967 the Six-Day War and in 1973 the Yom-Kippur War against the Arab States, which held the numerical advantage in terms of strength, while Israel was strongly disadvantaged in terms of strategic depth that it lacks. Right from the beginning of the state's existence, Israeli leader David Ben-Gurion set as a national objective the development of nuclear weapons in order to prevent the Holocaust from recurring. Recent history weighed significantly in the collective psyche of the Israeli nation, and consistent efforts towards the implementation of this goal were put forward, even at the cost of jeopardizing American-Israeli relations. It is known that American President J.F.Kennedy was deeply concerned about the possibility of introduction of nuclear weapons to the volatile region of the Middle East, and demanded inspections to the Israeli Nuclear reactors in order to halt the ongoing nuclear weapons program [34].

Today, the State of Israel is considered to be a nuclear power, although it maintains a policy of deliberate ambiguity with respect to its nuclear capabilities. It is believed to possess the ability to deliver nuclear warheads by means of several methods, including Submarine Launched Ballistic Missiles, Intercontinental Ballistic Missiles and aircraft. It also has refused to sign the Nuclear Non-Proliferation Treaty on the grounds of its contradiction to its national security interests. Israel is the only state in the Middle East possessing nuclear capability, which gives it a significant leverage over adversaries. Of course, this capability is

complemented by conventional armed capabilities, however the Israeli State views nuclear option as a last resort to safeguard its existence in case of overwhelming attack by its neighbors. Moreover, Israel has adopted the **Begin Doctrine**, a sustained attempt to deny other regional actors of the capability of acquiring nuclear weapons. In fact, the Israeli Air Force has destroyed the Iraqi and Syrian nuclear reactors in 1981 and 2007, while it is widely believed that the Stuxnet virus that damaged the Iranian nuclear facilities was developed by Israel.

The case of Pakistan

The adversarial relationship between Pakistan and India is another point of friction in the global political arena. India and Pakistan have been engaged in a long standing conflict with several engagements for the Jammu and Kashmir provinces. Since the 1950's, Pakistan has begun working on a nuclear program, with Pakistani Prime Minister Z.A. Bhutto advocating the nuclear option and famously said "if India builds the bomb, we will eat grass or leaves, even go hungry, but we will get one of our own."[35]. Pakistan was deeply concerned about the advancement of the Indian nuclear program during the 1960s, and in order to counter the Indian nuclear threat summoned its scientific and financial resources to the strategic aim of nuclear weapons development. This need was further exacerbated by the multiple Indo-Pakistani wars (1947,1965,1971 and 1999) which highlighted the need for effective deterrence in the face of overwhelming conventional Indian forces. Following the first successful Indian nuclear test named "Smiling Buddha" in 1974, and although its nuclear weapons development program began in 1972, Pakistan was able to perform its own nuclear test soon after acquired the capability to assemble a first-generation nuclear device on 1984 [36].

According to nti.org , in October 2015, Pakistan declared that it had developed tactical nuclear weapons. The Pakistani government has clarified that these would be used only in the event of a conflict with India. However, even though Pakistan had been suspected of building tactical nuclear weapons for many years, the official announcement has caused concern within the international community, especially in the United States. The weapons' small size and yield have ignited concern over their possible destabilizing effects in a potential conflict with India. Because of India's conventional military superiority, Pakistan maintains the ability to quickly escalate to the use of nuclear weapons in case of a conventional Indian military attack. [37]

Deterrence theory and the importance of nuclear weapons

As described in the examples above, nuclear weapons can effectively be a "game changer", allowing a militarily inferior state to "punch way above its weight" against a stronger adversary. With the dissolution of the former Soviet Union, nuclear information and equipment has become more easily accessible to multiple actors, and the possibility of nuclear proliferation is far from insignificant. Yet, there is a strong opposition from some military strategists to the development of nuclear weapons on the grounds of total destruction that these weapons can bring about, in case they are used. The assumption made in that case is that nuclear escalation will come about instantly, as a state might be tempted to make first

use in order to strike a decapitation blow or stop an enemy from overwhelming its defenses. This view is contrasted to the opinion of influential experts in the field of nuclear deterrence, as the American Herman Kahn. In his book "On escalation", Kahn proposes that nuclear escalation develops gradually, as a series of several rungs in the escalation ladder. During this escalation, the belligerents and external actors have the opportunity to contain the situation spiraling totally out of control by utilizing limited responses to nuclear use scenarios. Therefore, the use of nuclear weapons does not necessarily lead to total annihilation; hence the possession of nuclear arsenal makes a credible deterrence factor which in turn leads to less chances of war erupting. The significance of the limited escalation theory was best exemplified in the 1962 Cuban Missile Crisis, in which the United States under President John Kennedy opted for a limited response involving a naval blockade to the proposed bombing and invasion of Cuba which would certainly had led to an uncontrolled nuclear exchange. Consequently, the words of Arthur L. Herman "Strength prevents war; weakness invites it" best summarizes the importance of a nuclear arsenal to the stability of the world. One should not forget that, the only time where nuclear weapons were utilized was when one side enjoyed a monopoly of nuclear power. The possession of nuclear weapons makes it more difficult for a state actor to disturb the status quo, and this is something that Greek state officials and military strategists need to take into account in their grand strategy planning when dealing with a revisionary force like Turkey.

CONCLUSIONS

Following the collapse of the Soviet Union, the split of the world into two sides has given way to a multipolar global organization, with emerging powers challenging the dominance of the United States. The opportunity has presented itself to many nations to tap into the inexhaustible reserve of nuclear power, and the results of this proliferation reverberate throughout the world. The use of nuclear power as an energy source has reduced the reliance upon fossil fuels, reshaping the global energy landscape and the dependency dynamics of resource-challenged nations in relation to others. At the same time, the development of nuclear weapons by states other than the United States and Russia, has brought about new challenges regarding regional stability and geopolitical influence. It is within this fluid environment that Greece has to organize its future moves in an effort to secure its strategic interests, but most importantly, its continuous existence as an independent nation. It is not unfair to suggest that the current state of things paints an ominous picture for the future. The increased energy dependence of Greece, which is amplified by the forced outage of its only local resource, the lignite, in conjunction with the increased reliance upon imported natural gas which is mainly provided through pipelines crossing Turkey, poses risks with respect to its energy security. At the same time, the investment of Turkey into nuclear power development and know how presents a threat to Greece as it may find itself in the future confronted by a nuclear power, which no conventional military power can match. Thus, Greece is presented with a strategic dilemma which will shape its future relationship with Turkey. In case it is not willing, or unable to follow the nuclear path, Greece runs the risk of "Finlandization", falling prey to the constantly increasing power of Turkey. If, on the other

hand, Greece opts for the development of nuclear arms, it will certainly need to dedicate tremendous valuable resources, financial, diplomatic and others in this endeavor that will undoubtedly also bring it to a collision course with allies and enemies alike. It is however important to highlight the repercussions of this decision, so that no matter which course the country takes, the reader of the current thesis understands the significance of a call that will shape the country's future for generations to come.

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