Are fully electric vehicles a sustainable alternative for Greece? Or the world transition trend will actually harm the country if applied? Is there a solution?

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About

The present researches aim is to demonstrate an important element regarding Greece's future transport development.

I represent an individual engineering research team and my main focus is to present the hypothesis clearly. Personal influences may have affected the initiation of the research but the analysis, data presented and the conclusion are impartial.

The main purpose of the project is to be demonstrated to the key people of the Ministry of Transport of Greece and a number of important decision makers in the energy sector.

This wiki is created so anyone who is interested in energy production or transportation, can explore and read through the issue of electric vehicles introduced to Greece.

Summary

A global threat is the high presence of CO_2 in the atmosphere causing the well-known global warming. As part of Europe, the country of Greece is obligated to follow the 20-20-20 plan. In a few words, one target of that plan is to reduce 1990's CO_2 emissions by 20% by the year 2020 (Eurostat, 2016). In order to do that a number of profound solutions have been administrated.

The energy production in Greece can be classified as antiquated. On contrast, the percentage of renewable energy generated is above the European average. That bizarre phenomena is explained by the morphology of the country.

The transport sector is lacking the foundations for electric vehicle adaptation and in order to initiate that inevitable transition, firstly we must examine if it would be a sustainable alternative. A use of an extreme example will demonstrate for both liquid fuel vehicles and electric vehicles their CO_2 outputs.

The pressure to reduce CO_2 emissions is not just political but also an environmental necessity and it should neither be ignored nor postponed. But, another less regulated pollutant, sulfur dioxide, can permanently damage Greece's ecosystem.

Overview

2014	Επιβατικά - Passenger			Φορτηγα - Trucks			Λεωφορεία - Buses	Μοτοσυκλέτες - Motorcycles			
	Σύνολο Total	Ιδιωτικής Χρήσης Private use	Δημοσίας Χρήσεως Public use	Σύνολο Total	Ιδιωτικής Χρήσης Private use	Δημοσίας Χρήσεως Public use	Σύνολο Total	Σύνολο Total	Επιβατικές Passenger	Φορτηγές χρήσεως ιδιωτικής Freight private use	Φορτηγές χρήσεως δημοσίας Freight public use
ΣΥΝΟΛΟ ΕΛΛΑΔΟΣ	5,110,873	5,077,313	33,560	1,317,945	1,281,450	36,495	26,691	1,592,929	1,582,818	4,451	5,660

Data gathered from total number of registered vehicles. For full review: http://www.autogreeknews.gr/files/Diafora/A1106_SME18_TB_MM_00_2014_01_F_BI_0.xls

The total number of vehicles registered in 2014 in Greece is 8.038.597. In which 5.110.873 are cars, 1.281.450 are lightweight trucks or vans and 1.582.818 are motorcycles (Autogreeknews, 2015). Two main factors alternate the relation between register vehicle and its usage. Greece has a touristic season in which a great number of vehicles are used exclusively then and not during the winter. Also due to the economic crisis there is an increasing number of citizens that do not use their vehicle but it remains registered. Nevertheless, I will neglect those facts and analyze the assumption based on the fact that the economy of Greece is growing therefor there are no unused vehicles and the fraction of the increased usage during touristic season is absorbed as normal annual usage. That will allow the assumption to exhaust the limits of energy requirement and CO_2 emissions.

How many of them are electrical or hybrid?

Until 2014 where we have a clear number of total vehicles, only 6 are electric (Mpitsikokos K, 2015). A category named AFV which stands for Alternative Fuel Vehicles includes, fully electric cars, plug-in hybrids, Hydrogen and Natural gas (CNG). Conventional hybrid cars are not included in this category due to their dependency of an engine presence. This category has a total of 200 cars by early 2016 figures. Most of them are CNG powered and plug-in hybrids (Mandravelis V, 2016). Therefore the number of electric cars currently in usage is statistically irrelevant and will not be taken under consideration.

Peak scenario Introduction

The importance of the Peak scenario

In order to determine what the worst possibility is emission-wise, we have to stretch the data to its maximum usage limits and hypothesize it as the norm. It will clearly demonstrate the potential harm in the output if no action is taken. Also it will help us built a stronger governance foundations for the potential growth management. As the trends are showing, usage in transport is increasing. Having a theoretical stress test of a peak scenario is actually looking in the future.

Introduction

Based on government data (Ministry of Infrastructure, Transport and Networks, 2010), on each individual vehicle registered in Greece from the year 2002 up to the year 2010, Greenpeace has come up with an average rate of 200 grams of CO_2 per 1 Kilometer (Greenpeace, n.d). That figure seems high, and it is because a significant part of the fleet is by EURO 1 and 2 standards and are poorly maintained, all contributing to more CO_2 emissions. Also the examined scenario includes lightweight trucks.

The average driver in Greece drives 17,520 kilometers per year, data taken from insurance companies (Asfalisinet, 2016). That is an equivalent of 3.504 kilograms of CO_2 every year per driver. Assuming the highest usage scenario, that would be equivalent for 28,135,089.5 tons of CO_2 per year.

Of course, the true figures should be lower by my personal estimation by 30% because of the factors we named earlier. The study is not taking under consideration those attributes and concentrates only on the peak scenario.

Analysis

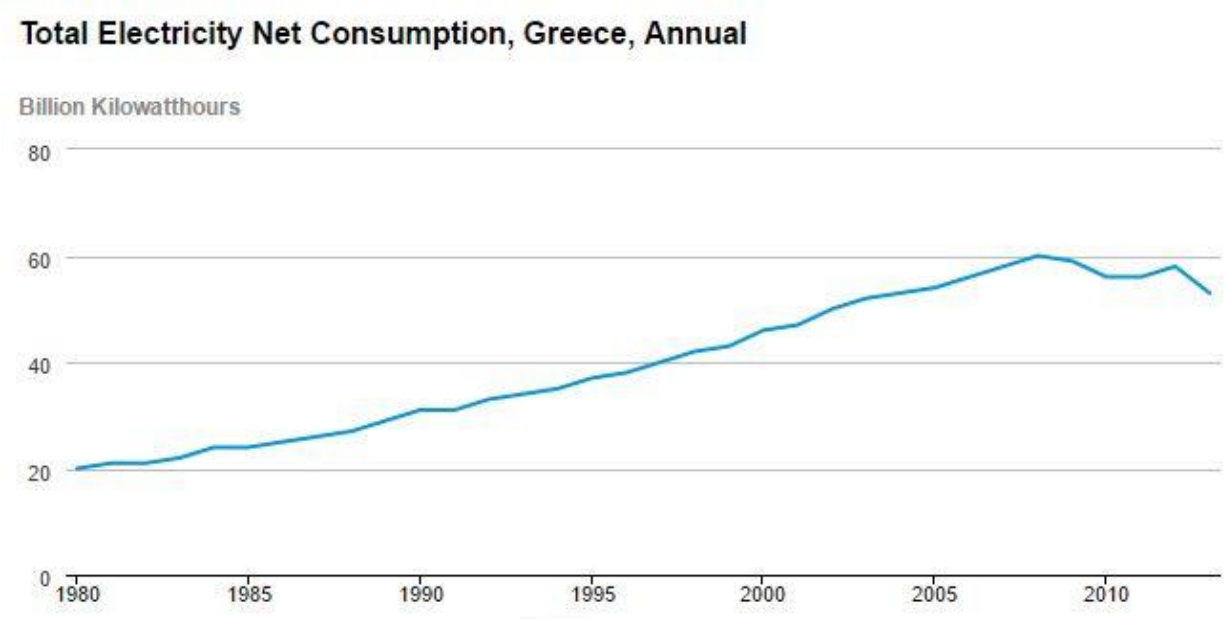


Diagram gathered from the U.S. Energy Information Association: https://www.eia.gov/opendata/qb.cfm?category=2134404&sdid=INTL.2-2-GRC-BKWH.A

In 2012 the national gross electricity consumption was 55TWh, while the gross electricity generation was 61TWh (Energypedia, 2015). It's worth mentioning the fact that the energy actually consumed in Greece is only 39% of the produced, while the rest 61% is imported from neighbor countries. The rest of the produced energy by Greece's power plants is exported. Still, conventional energy production mostly crude oil based and lignite burning power plants are responsible for approximately 83% of the total energy used. That is due to the unique morphology of the landscape. Mountainous mainland and 227 individual energy supplied islands. Gas pipelines, and water energy production is not even an option for most territories (Internal Energy Agency, 2014). Heating and powering households are mainly done through oil burning. 22% of the total energy is provided by renewable energy resources, mainly solar and wind (Energypedia, 2015). Although

solar energy is still promising based on the advantageous weather, political, social and geological troubles are preventing it from further expansion. Land pollution is considered the biggest obstacle. Installing wind farms or solar panels requires land space. A great amount of potential land is part of a touristic landscape and installing renewable energy equipment will damage or even ruin the touristic industry of the region. Although, numerous mountainous regions that are not classified as touristic safeguarding areas and there are not inhibited, are perfect candidates for future instalments.

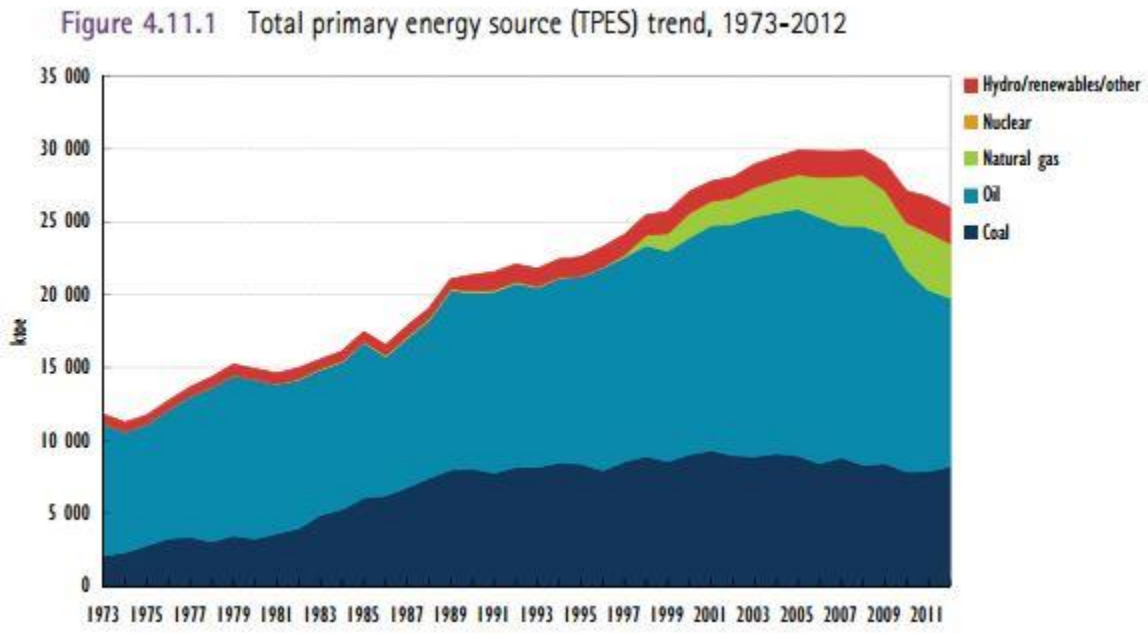


Diagram showing the total energy sources in Greece. Taken from the International Energy Agency: https://www.iea.org/media/freepublications/security/EnergySupplySecurity2014_Greece.pdf

Total CO_2 emission from Greece are 76 million metric tons (Global Carbon Atlas, n.d).

The total CO_2 emissions from electricity and heat production is 45.55 million metric tons (Knoema, n.d).

We can clearly observe that the estimated 28 million tons of CO_2 from vehicle usage we calculated before, cannot be a representative figure. The actual emissions from transport are 19.5 million tons (Knoema, n.d). And that includes aircraft and marine emissions, estimated to have a 16% and 20% respectively (IMO, 2015) (Psaraki V, Pagoni I, 2008).

Diagram showing the measured CO_2 emissions from transport in million metric tons. Gathered from the TradingEconomics: http://www.tradingeconomics.com/greece/co2-emissions-from-transport-million-metric-tons-wb-data.html

In order to determine if an electric car is less pollutant, we have to calculate how many grams of CO_2 are emitted per 1 Wh generated. We are analyzing the peak scenario and not taking in to the current calculations the real data given.

45 550 000 000 000 Grams of CO_2 / 61 000 000 000 000 Wh = 0.7457

1 Wh = 0.75 Grams of CO_2

For every produced WattHour, 0.75 grams of CO_2 are emitted.

The official real-use measured energy consumption of a popular electric car is 38 KWh/100 miles (Fuel Economy, n.d).

That means that is 380 Wh / 1 Mile which equals to 236 Wh / 1 Km.

Now, the estimated average driver is driving 17,520 Km per year, which means the total energy needed for one car would be 4,134,720 Wh per year.

For all vehicles that would be (4,134,720 * 8,038,597 vehicles) 33,237,347,787,840 Wh. (33.2 TWh)

That is equivalent for 24,928,010,840,880 grams of CO_2 (24,9 million metric tons)

It is less considering the total carbon output, but is it sustainable?

Financial Implications of Emission Reduction

Considering the real estimated CO_2 emission from transport (19.55 tons) from which the 64% are from vehicle cars. That means that the total CO_2 emission from them are 12.5 million tons.

Comparing the two figures of the peak scenario we can clearly see that electric cars are less pollutant by 3.1 million metric tons of CO_2. Or 12% less CO_2 emission. Assuming that this pattern of reduction will also follow the real figures that could mean that the transport emissions may set at 11 million tons.

It is a reduction but many sectors could argue that it is a fraction that is not worth the transition just yet. The transformation of the fleet from liquid fuel based to electric requires a strong power network upgrade. On top of that, electric cars are not competitive pricewise. Financial grants and other measures need to be implied for the public to buy them. That is a huge cost just to reduce 1.5 million tons of CO_2. It is not worth it at this period of time. A bigger percentage of energy produced in Greece should be coming from RES and the efficiency of electric cars should progress. Europe's 2020 targets are set to increase by 2020 the energy efficiency by 20%, includes electric car efficiency. If by year 2020 the efficiency has increased by only half that amount, 10%, it is still beneficial.

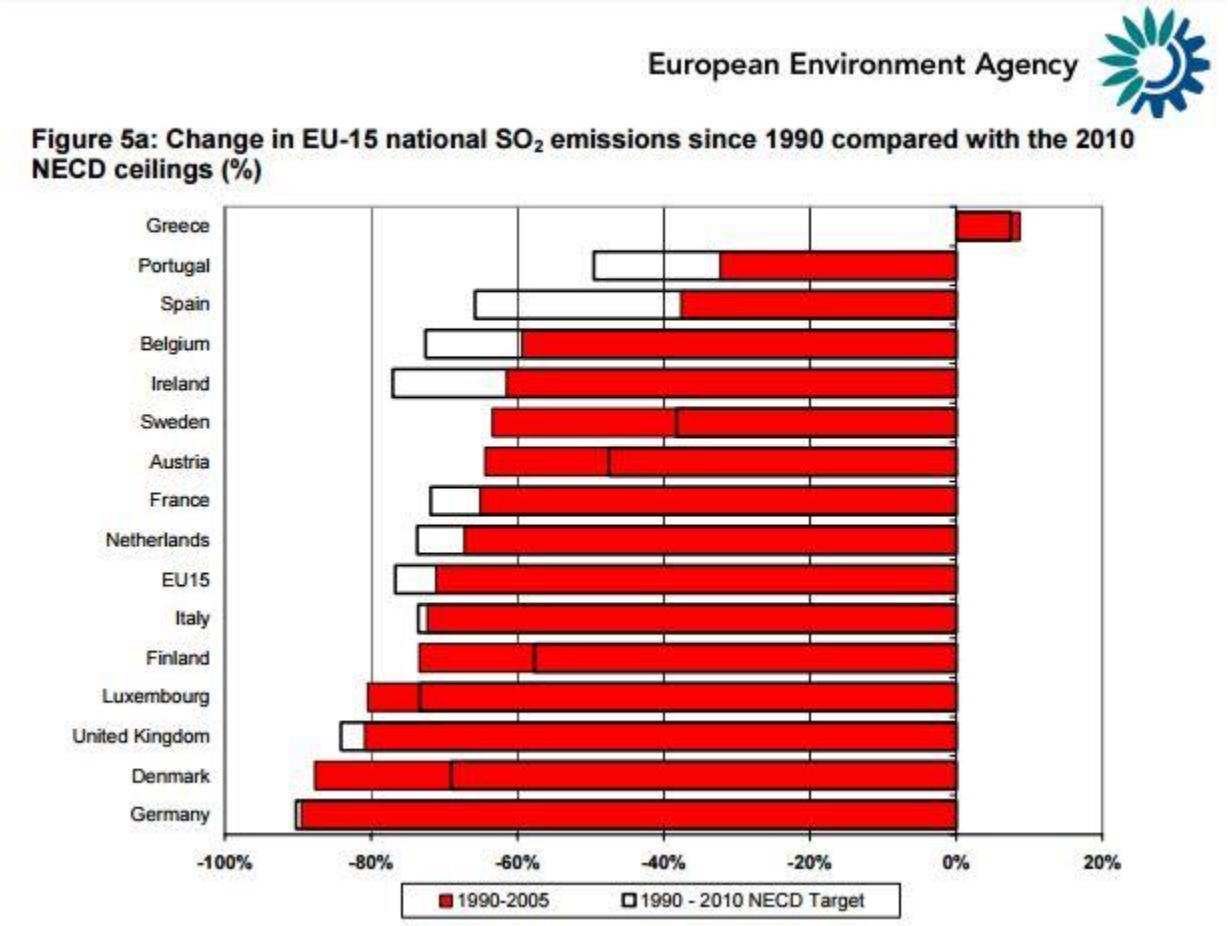
In order to compare that with today's figures we have to increase the distance an electric car travels with the same amount of energy used (10% more efficient). From 236 Wh / 1 Km to 236 Wh / 1.1 km.

That equals to 212.4 Wh / 1 km.

That would give us a total of 22,435,209,756,792 CO_2 (22.4 million tons) for the peak scenario and it is equivalent with 25% decrease from liquid fuel based. Assuming the pattern will also follow the real figures that could mean that the transport emissions may set at 9.4 million tons of CO_2. A difference of 3.1 million tons.

Sulphur Dioxide Pollution

Referring once again to the outdated but unfortunately one-way of lignite burning and petroleum burning power plants. Lignite reserves in Greece are high. It's cheap and very accessible. It is sensible that the energy production was based on this particular fuel in the previous years. To this day, lignite mining remains at high levels, 54 million metric tons were mined in 2013 (Wikipedia, 2016). An incredibly large amount to a small country with a population of approximately 11 million people. Compared to similar energy production countries like Turkey or Poland which they have in the same year 63 and 66 million tons respectively (Wikipedia, 2016). Those countries are also more than 4 times larger.



Graph showing that Greece had an increase in sulfur dioxide emissions in the 1990 - 2015 period despite the obvious declining trend. Taken from the European Environment Agency: http://www.eea.europa.eu/data-and-maps/indicators/emission-trends-of-sulphur-dioxide-so2/emission-trends-of-sulfur-dioxide-so2

As we can observe from the graph above, the target of Greece was the only one set in the positive region.

That excessive lignite use has some very negative effects on the environment. It is responsible for acidic rain. A chain reaction over the years has ruined lakes and entire ecosystems around the power plants. All because of the continuous sulfur dioxide emissions (Cleantrust, 1999).

Unfortunately we are not able to replace immediately those power plants, we are restricting their use slowly. So it is certain that the extra demand for electric energy will come partially from lignite burning sources.

Alternative Views

It is difficult to pinpoint a different or alternative view on a hypothesis. Electric vehicles are considered to be the only viable solution for the future. The time of the application could be worth debating for the case of Greece but that includes mostly micro-political discussion. The main body of this research is to focus either electric vehicles can be a sustainable replacement and not if they are financially, individually or politically favorable.

Despite that, a different form of electric vehicles arises. Hydrogen powered vehicles are the main alternative with some instant advantages.

These vehicles use liquid hydrogen as fuel and they generate electricity through hydrogen cell technology. They are by principal electric vehicles consisting of a purely electric motor. The big difference between the conventional electric vehicles is replenishment. Liquid hydrogen is the fuel and is stored in a tank inside the vehicle, therefore the car operates just like a liquid fuel one. It does not require any sort of charging. Also its range is significantly more, it will cover more distance than the equivalent battery stored electric one.

Those arguments can set an opposite view and make strong arguments in to abandoning in part the research for battery technology development and focus on liquid hydrogen production. It is fairly known that the process is not efficient and not enough resources are developing this technology. It could be the ultimate alternative due to the fact that liquid hydrogen vehicles emit only water. No air pollution from transport usage.

One more less meaningful disadvantage of electric cars, is the environmental imprint of their production. Electric motors and batteries have seen a spike in demand in the recent years due to that fact. And lithium is a crucial component and a hazardous material. It's a material that goes under heavy procedures and releasing pollutant by-products in the environment as it progresses (Anderson M, 2013).

Of course Greece does not have an industrial battery production factory so that danger can't be listed here, but overall is one more addition of environmental pollutants.

Viable Solution

To form a solution we have to take under consideration the current economic status of the country. It is fairly impossible to expect from a decadent economy to transform the energy layout. Minor investment, not just financial but also academic, in the development of some specific technologies can be proven vital for the future.

European emission regulations are strict and the government has to follow them. And history has shown that the easiest solution to just manipulate the data will be preferred. Manipulating independent measurements is impossible. But, manipulating the market by grants, loans and tax-cuts to boost electric vehicles sales is already visible. Because it is an extremely small amount of the vehicle market (there is not even official measured data), it is not visible in the emission footprint. An expansion of that financial boost for electric vehicles is going to achieve a statistically record-able, yet misleading CO_2 emission cut, at a cost of permanently damaged ecosystems.

One viable solution that might work is:

- Prevent the financial granting of electric cars. At this period of time is a clear political maneuver with a large economic loss.
- Part of that money or all if possible should be dedicated to develop and expand technologies related to AC motor efficiency, energy storage, RES, hydrogen production and still developing internal combustion engines.
- Invest in to more RES to be part of the national energy network
- Re-evaluate that criteria in the near future with the most recent data in order to determine further action.

Supporting the third proposition, there is a huge increase in RES consumption in Greece.

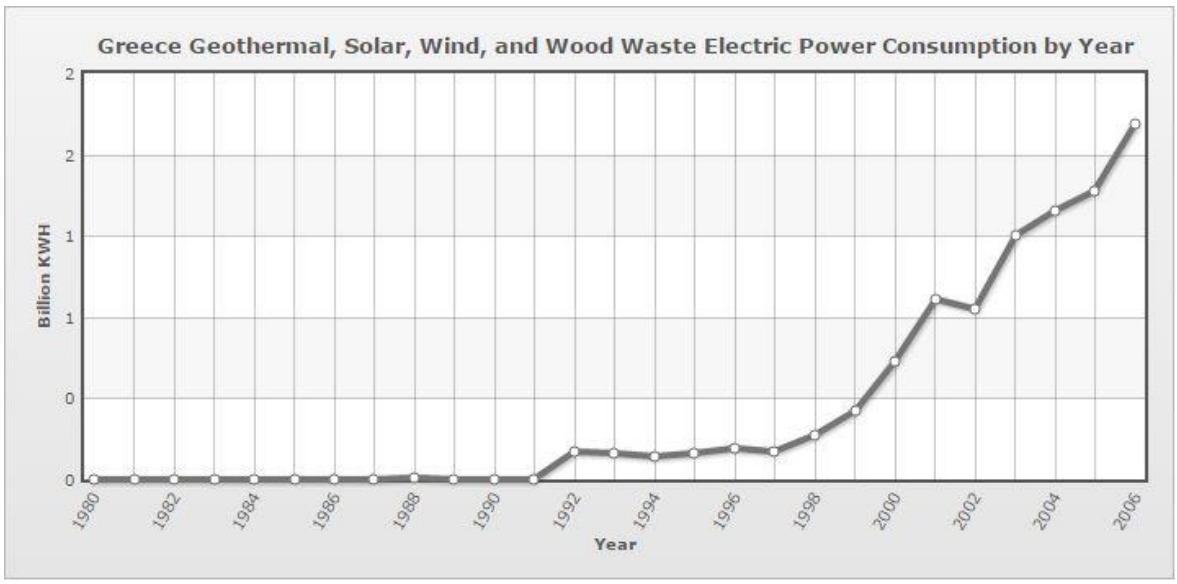


Diagram showing the consumption of energy from renewable resources. Taken from IndexMundi: http://www.indexmundi.com/energy/?country=gr&product=other&graph=consumption

Of course these quantities can be characterized as negligible, although they are rapidly rising. Maybe they could not contribute directly to the greater amount of energy needed. Surely, they will contribute indirectly by alleviating the network in low usage areas, thus decreasing the total need of lignite burning energy production.

Conclusion

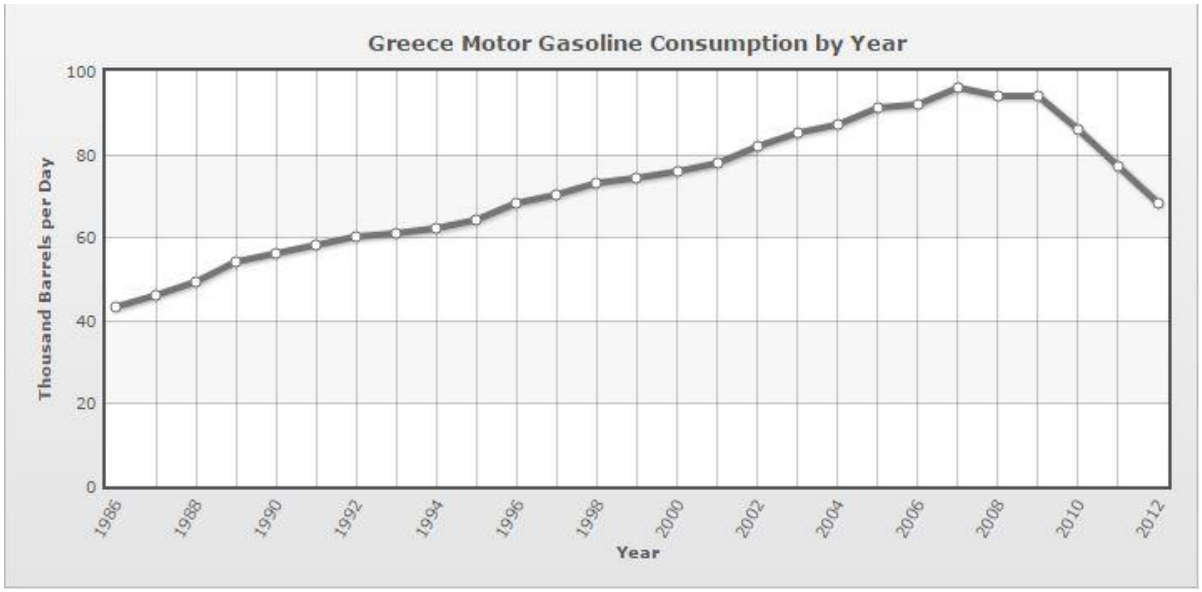


Diagram showing the total Gasoline consumption for transport purposes. Taken from IndexMundi: http://www.indexmundi.com/energy/?country=gr&product=gasoline&graph=consumption

Diagram showing the total CO_2 emissions in million metric tons from transport in Greece. Taken from TradingEconomics: http://www.tradingeconomics.com/greece/co2-

emissions-from-transport-million-metric-tons-wb-data.html

The hypothesis was to eliminate the above diagrams by retaining the existing standard and levels of vehicle use by substituting them with electric powered vehicles. The total energy demand is relatively decreased. Is lower ranging from 12% to 25% considering the case but, it is all transferred to the electricity production network of the country as an additional demand. After analyzing all the aspects we can have a moderately safe conclusion.

Currently electric cars are not a sustainable alternative for Greece. Emissions of CO_2 will decrease but with a huge financial cost and with unknown impacts from other factors like waste pollution. Due to the overload of the electric power plants where the majority are lignite burning and petroleum burning, the waste output will be elevated. Regardless the CO_2 emissions, sulfur dioxide presence is dangerously high in territories around power plants and in some cases already over the hazard limits. More sulfur dioxide emissions are unacceptable therefore a significant increase in energy production is not considered a sustainable alternative. In the future when more energy will be generated from RES and most importantly the efficiency will increase, only then Greece should begin the aggressive transition to electric vehicles. The near existent danger is ruining a vital part of the ecosystem from sulfur dioxide trying to reduce CO_2 emissions. The most constructive plan is to invest financial and research resources to develop further technologies related to energy efficiency and renewable energy resources.

Additional Links

http://www.mma.gob.cl/retc_ingles/1316/w3-article-51518.html (Explains further the effects of sulfur dioxide pollution)

https://en.wikipedia.org/wiki/Fuel_cell (An overview of how hydrogel fuel cell technology works)

http://americanhistory.si.edu/fuelcells/basics.htm (An overview of how hydrogel fuel cell technology works)

http://shrinkthatfootprint.com/electric-cars-green (A different explanation for why electric cars are more sustainable in the long term)

http://www.environmentalleader.com/2013/07/05/electric-cars-actually-dirtier-than-gasoline-cars/ (An opposing view to the fact that electric cars are less pollutant)

http://energytransition.de/2016/02/lignite-in-the-greek-energy-system-facts-and-challenges/ (Additional information about lignite energy production in Greece and the history of it)

https://euracoal.eu/info/country-profiles/greece/ (Additional information about lignite usage in Greece)

http://energytransition.de/2016/06/the-evolution-of-renewable-energy-sources-res-in-greece-a-synopsis-of-the-legal-framework/ (Information about RES evolution in Greece)

https://www.theguardian.com/world/2016/apr/28/germany-subsidy-boost-electric-car-sales (An example of financial grants for electric car usage, regarding the cost of the transition hypothesis)

http://www.europarl.europa.eu/document/activities/cont/201106/20110629ATT22885/20110629ATT22885EN.pdf (A research from the European Parliament about the financial implications of the electric cars market)

https://en.wikipedia.org/wiki/Lithium (Information about Lithium)

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