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ABBREVIATIONS AND ACRONYMS

- Organizations and Policy Keywords

AEC -- Algerian Energy Company.

APRUE -- National Agency for promoting and rationalizing of energy usage. (L'Agence Nationale pour la Promotion et la Rationalisation de l'Utilisation de l'Energie)

CDER -- Center of renewable energy development. Centre de Développement des Energies.

CRNA -- Algiers Nuclear Research Center.

FNER-- National funds for renewable energy. (Fonds National des Energies Renouvelables)

FNME -- National Funds for Energy Efficiency. (Fonds National de la Maitrise de l'Energie)

IEA -- International Energy Agency.

NEAL -- New Energy Algeria

OPEC -- Organization of the Petroleum Exporting Countries.

PNME -- Programme National de Maîtrise de l'Energie

RE -- Renewable Energy

SGTE --Algerian company of networking electricity transportation.(Société Algérienne de Gestion du Réseau de Transport de l'Electricité)

Sonatrach -- National Society for Electricity and Gas (*Société Nationale de l'Electricité et du Gaz*)

Sonelgaz -- National company for mining, production, transportation and commercialization of hydrocarbons. (*Société Nationale pour la Recherche, la Production, le Transport, la Transformation, et la Commercialisation des Hydrocarbures s.p.a.*)

SPE -- Algerian company of electricity production. (Société Algérienne de Production de l'Electricité)

Abstract

This report was researched and written to prove that Algeria is capable of being one of leading countries in the energy supply business. Not just that, but for it to easily operate completely on green energy using renewable and alternative resources for energy extraction. This promise can be achieved if proper work and decisions are made into the matter. Algeria provides 100% energy access to its citizens. As from late 2010 it was measured at 98.6%. Algeria's Total Final Consumption in 2013 was measured at around 38,543 ktoe and has been steadily increasing in response to the improvements of the social life and economical life in Algeria.¹ The question is whether it's in the capability for Algeria to achieve such coverage of energy through the use of renewable resources for energy production. The table below shows the measures of the energy consumption according with the sectors, measured at ktoe:²

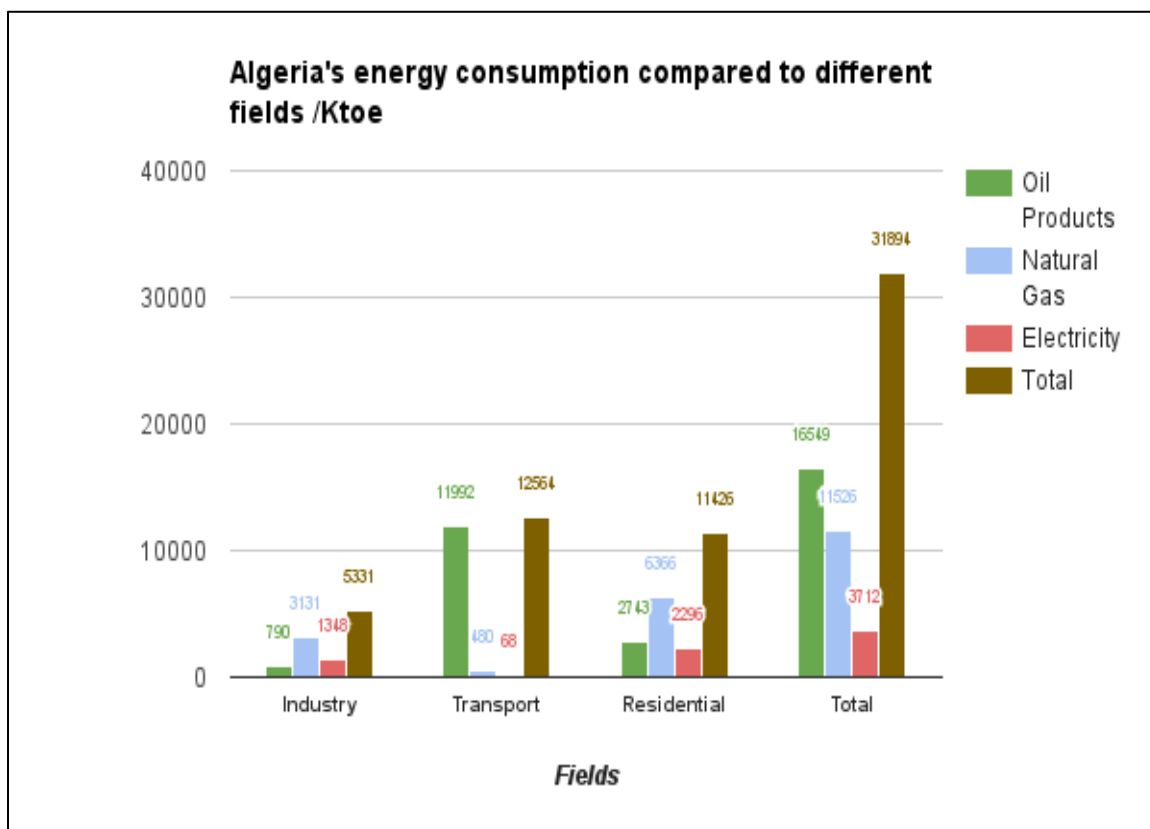


Figure 1 - Algeria's Energy Consumption, 2012³

Source: International Energy Agency

¹"Statistics." Statistics. 2013. Accessed February 15, 2016.

²"Statistics." Statistics. 2013. Accessed February 15, 2016.

³ Author, based on "Statistics." Statistics. 2013. Accessed February 15, 2016

In 2012, Algeria produced about 53.99 kWh in electricity. That is a low number if we consider the possibilities. Crude oil production in Algeria maintains a high rate at a 1.42 bbl/day, out of this number about 1,1 bbl/day gets exported to several countries. Natural gas produced in Algeria is the main source at a rate of 79.65 billion cu m , with proven reserves of 4.505 trillion cu m which is a pretty high reserve for a country with such low population. ⁴

⁴ "The World Factbook: Algeria." *Central Intelligence Agency*. Central Intelligence Agency, 2016. Web. Mar. 2016.

1. Overview

1.1 Introduction

The People's Democratic Republic of Algeria, or Djazair (Islands in Arabic) is mostly known among the Arab nations as the country of the million martyrs. Throughout its history, Algeria had to spare the lives of innocent people whose only purpose was to defend their homeland and religion. It took the people and the land more than a century to abolish the French Colonial forces and more than 2 million people died for this cause in the process. French language comes second after Arabic, as the official languages used nationwide.



Figure 2 - Algeria's Map #1⁵
Source: Natural Earth Data

Now Algerian citizens can pay back the land, by limiting the exploitations of the land resources and finding alternative methods to save the future generations some land, goods and resources. Algerian has advantages over other countries, such as :

- Algeria's borderlines exceed 6,000 miles connecting with seven countries. Not just that, but it maintains a significant connection with Europe through the Mediterranean Sea. This connection gives Algeria a strong opportunity to strengthen its economy.
- Algeria is the largest African and Arabic country with an area wider than 900,000 square miles. That's more than five times the area of California. About four-fifths

⁵ Author based on shapefiles from, "Features | Natural Earth." Natural Earth RSS. Accessed March 2016.

of this area is desert so that use of this warm desert region can create the ultimate environment for most efficient energy yield through the PV Cells.

- The population of Algeria compared to its surface area is low, which offers the opportunity to invest a portion of the nation's budget in energy and operate in a fully sustainable way.



Figure 3- Algeria's Map #2⁶⁺
Source: World and City Maps

1.2. Transmission Grids:

Thanks to a steady approach in the energy economy, Algeria is providing people with electricity throughout the country, feeding 100% of the population with energy. Achieving this isn't as simple as it seems – it requires well equipped instruments and pipelines to transfer or transport the energy across the land. In order to acquire a stable production and consumption cycle of hydrocarbons, you have to provide an elegant system for the raw materials from and to the refineries and so on. Lack of research and resources can cause a malfunction in the energy associated aspect of a country.

⁶ "World and City Maps." Google Maps World Gazetteer Google Route Planner Africa Comments. Accessed March 2016.

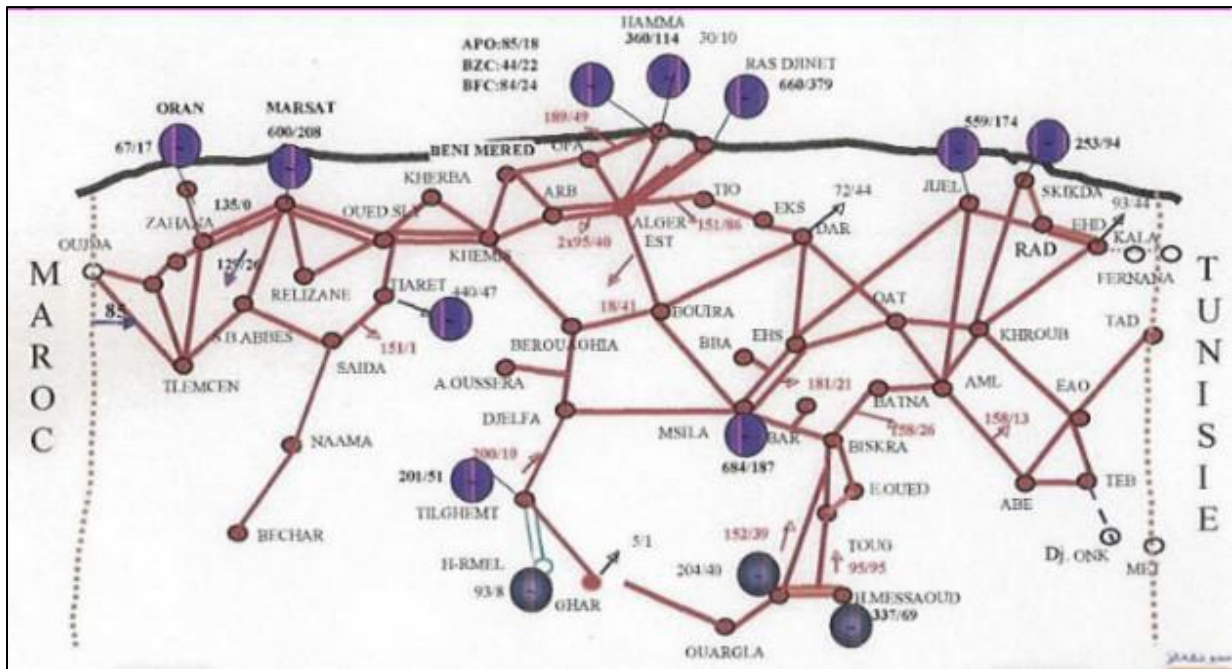


Figure 4- Algeria's national Transmission grid ⁷
Source: GENI

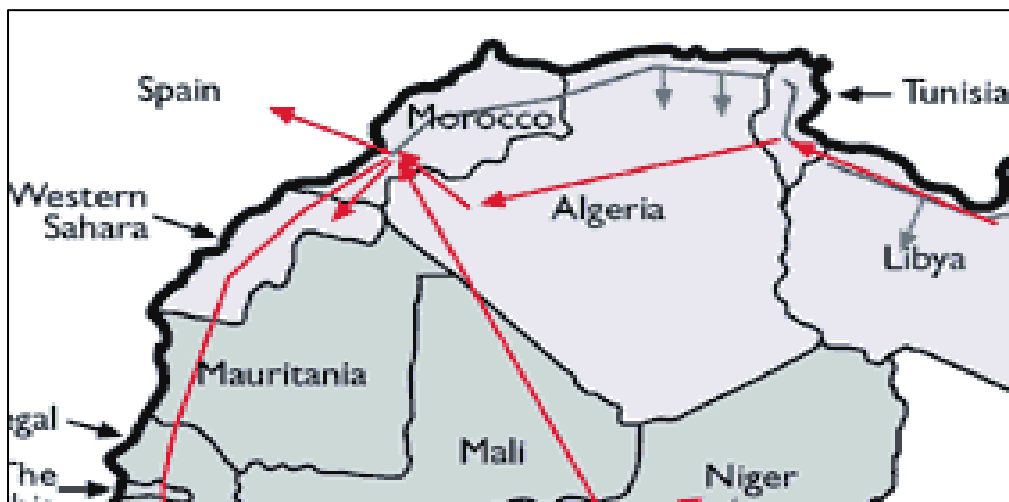


Figure 5- Algeria's International Transmission grid ⁸
Source: GENI

As seen in Figure 4, most of the Algeria wilayas (States) are well connected throughout the transmission grid, guaranteeing electric connectivity amongst the citizens. Not just that, but plenty of the grids stretch out to the rest of African or European countries, filling up other countries gaps in electricity or other sources of energy.

⁷"Map of Algerian Electricity Grid - Algeria - National Energy Grids - Library - GENI - Global Energy Network Institute." Map of Algerian Electricity Grid - Algeria - National Energy Grids - Library - GENI - Global Energy Network Institute. Accessed March 2016.

⁸"Map of Algerian Electricity Grid - Algeria - National Energy Grids - Library - GENI - Global Energy Network Institute." Map of Algerian Electricity Grid - Algeria - National Energy Grids - Library - GENI - Global Energy Network Institute. Accessed March 2016.

1.3. Energy-related Economy

Algeria's economy is based mainly on the revenues coming from hydrocarbon manufacturing and trades. Petroleum products in Algeria represent 30% of the country's gross domestic product (GDP), 95 % of export earnings and 60% from budget revenues.

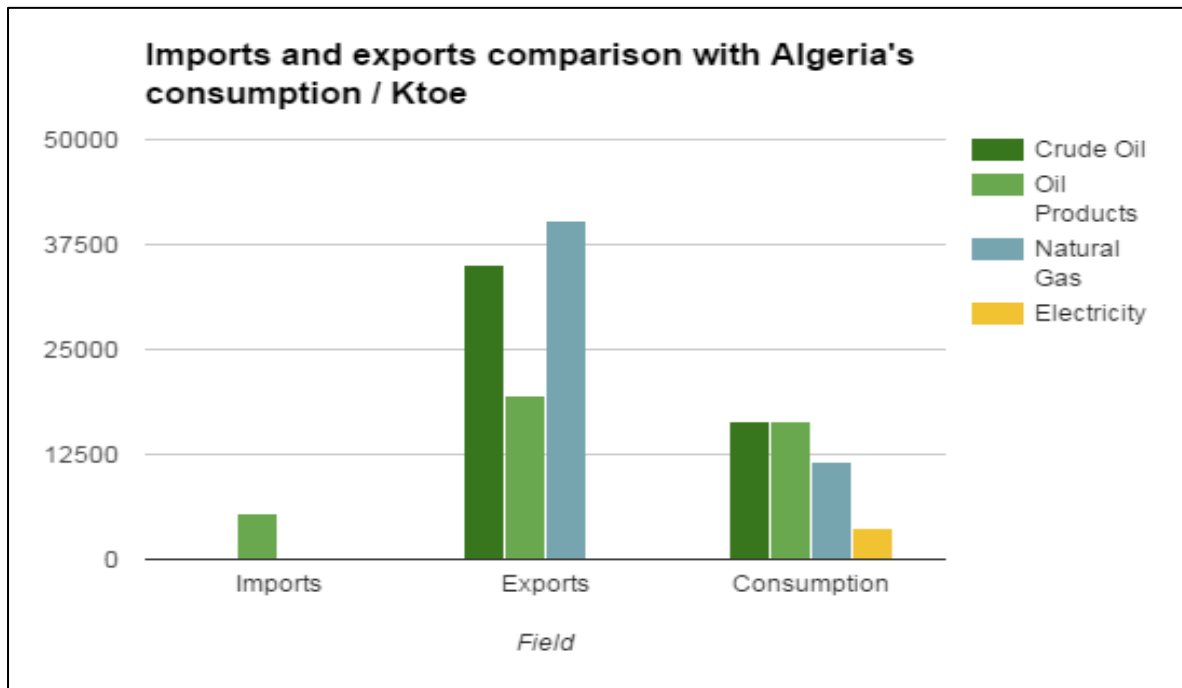


Figure 6- Imports and exports comparison with local consumption ⁹

Source: International Energy Agency

Mainly, Algeria supports its economy through exports, as there are significant amounts of energy resources available. Compared to imports, exports are believed to be about nine (9) times the imports amount. Algeria imports more than 5,000 ktoe, of mainly oil products. While on the other hand, exports are peaking at a range of 46,000 ktoe, mostly crude oil and natural gas.¹⁰

⁹ Author, based on "Statistics." Statistics. 2013. Accessed February 15, 2016

¹⁰ "Statistics." Statistics. 2013. Accessed February 15, 2016.

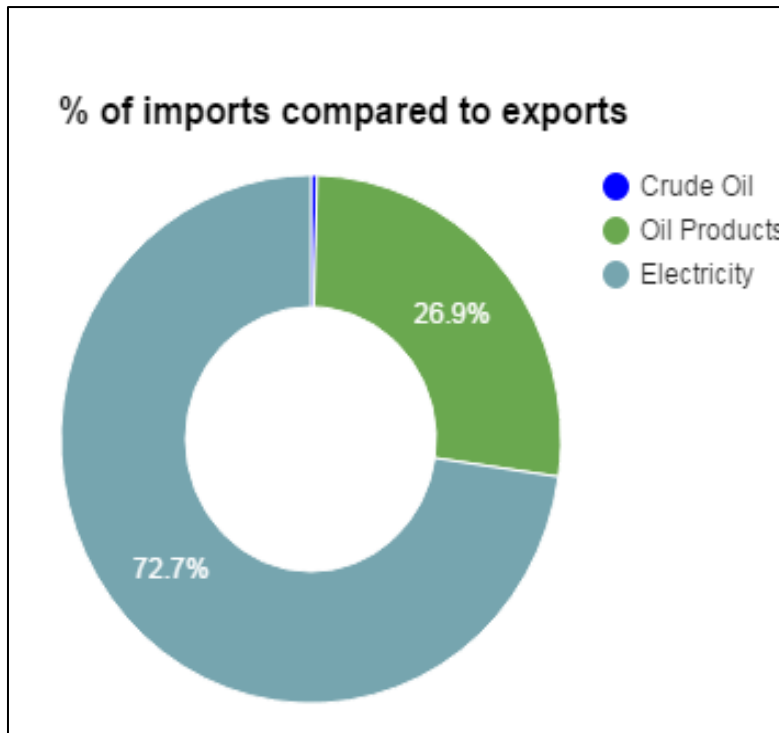


Figure 7- Percentage of Imports compared to exports..¹¹
 Source: International Energy Agency

1.4. CO₂ Emissions

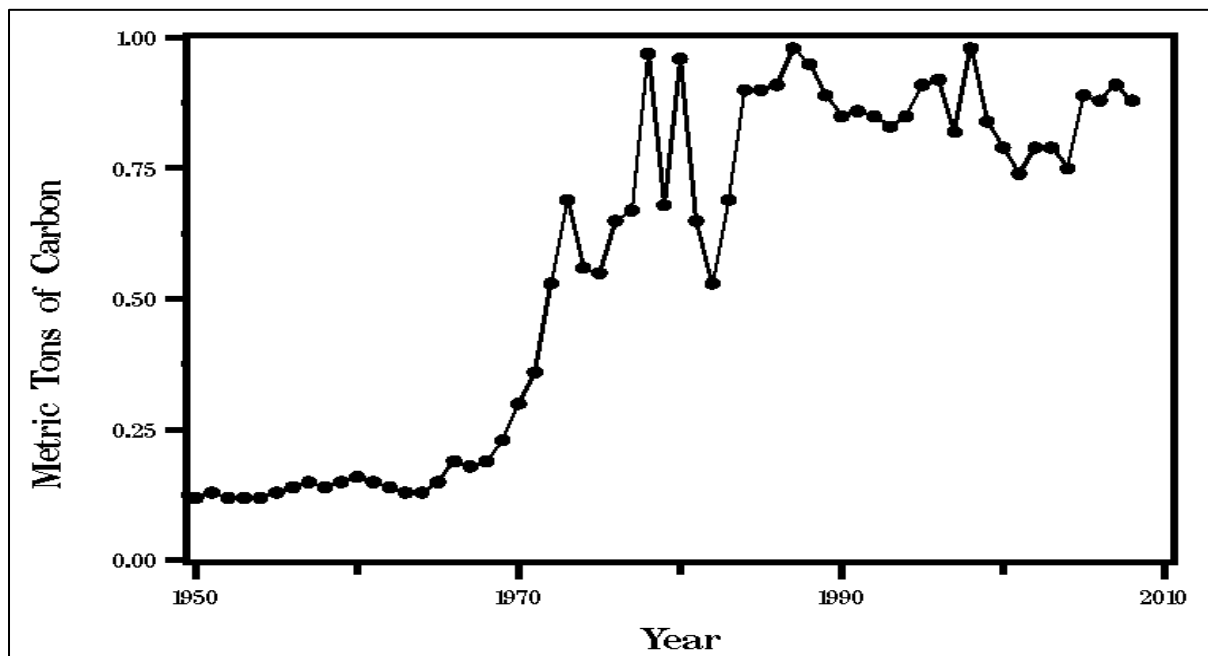


Figure 8- CO₂ Emissions, per metric ton..¹²
 Source: International Energy Agency

¹¹ Author, based on "Statistics." Statistics. 2013. Accessed February 15, 2016

¹² "Fossil-Fuel CO₂ Emissions from Algeria." Fossil-Fuel CO₂ Emissions. Accessed March 2016.

The main issue of CO₂ emissions has been increasing dramatically all over the world, due to the extreme usage of resources and the high standards of living in the developed countries that must be met. Algeria had a clean sheet with CO₂ discharges until the country joined the OPEC. Fossil fuels were richly found when experts first searched for resources, this was one of the all-embracing news stories the country had since the Independence .

Algeria now ranks as the **38th** country with CO₂ emissions exceeding 140,000 kt, as measured in 2013 and the rate is still increasing.¹³ This increase could be avoided if sustainable improvements were made into each sector accordingly with the levels of CO₂ emitted.

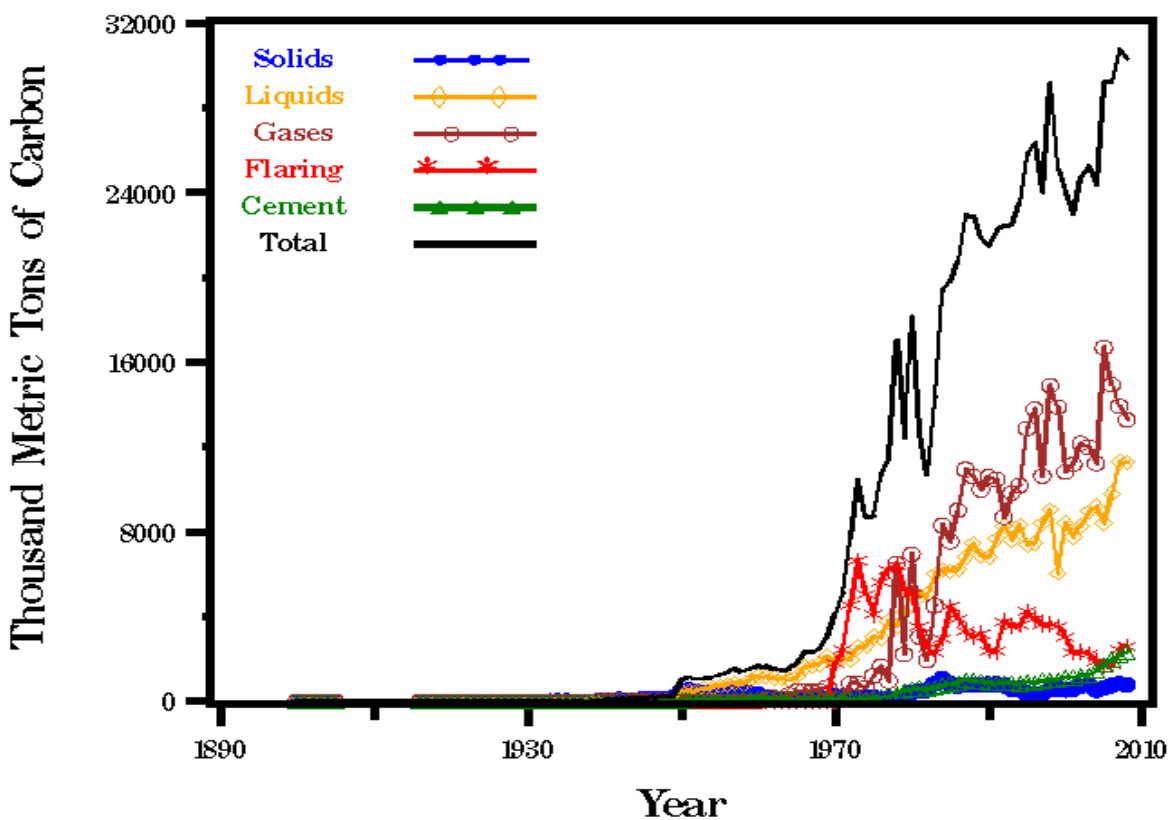


Figure 9- CO₂ Emissions, by each source.¹⁴
 Source: Carbon Dioxide Information Analysis Center

¹³ "Fossil-Fuel CO₂ Emissions from Algeria." Fossil-Fuel CO₂ Emissions. Accessed March 2016. <http://cdiac.ornl.gov/trends/emis/alg.html>.

¹⁴ "Fossil-Fuel CO₂ Emissions from Algeria." Fossil-Fuel CO₂ Emissions. Accessed March 2016. <http://cdiac.ornl.gov/trends/emis/alg.html>.

2. Non-Renewable Energy Situation in Algeria

2.1. Oil and Petroleum (Crude Oil)

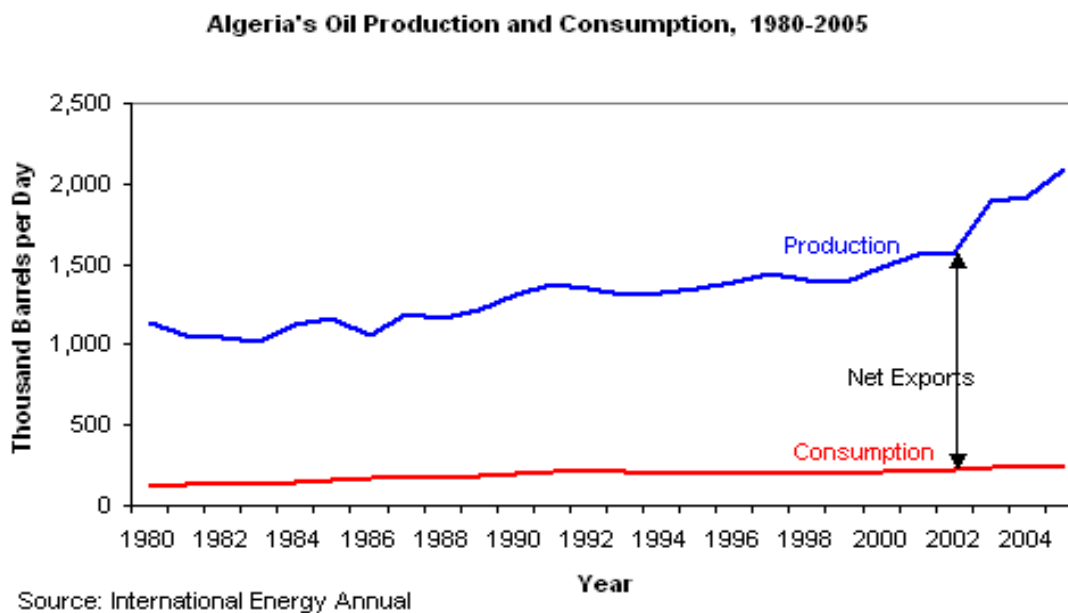


Figure 10- Algeria's Oil Production and Consumption, 1980-2005.¹⁵
Source: International Energy Agency

Both the Algerian economy and infrastructure are strongly influenced by the supply of crude oil. Difference between the consumption and production, represents the amount of crude oil that is exported to the neighboring countries, in Europe or even the Maghreb countries.

The amount of crude oil produced in 2013 in Algeria was 68.7 Mtoe, making it the **18th** top country that produces oil. The country goes up to 33 in the ranking of the top countries in energy consumption, which gives us a notion of the major imbalance between the production and consumption.¹⁶

¹⁵ "Statistics." Statistics. 2013. Accessed March , 2016.

¹⁶ "Statistics." Statistics. 2013. Accessed March , 2016.



Figure 11- Algeria's Pipelines Map .¹⁷
Source: International Energy Agency

The colored lines in the map above show the path of the pipelines that transport the crude oil to the outlying areas and regions. As we can see, the destinations of these lines mostly are on the European side, such as Spain, Portugal, etc. But still there are a couple of pipelines that stay on the African side and move to countries like Tunisia, Morocco, Mali, etc.

2.2. Natural Gas

Natural gas can be considered the major source of power that Algeria depends on and it is the most efficient among all the fossil fuels. A total of 98% of all the power generated in Algeria, is through natural gas resources. This means that Algeria ranks the **eleventh** most country with natural gas reserves and the third for the amount of recoverable shale gas resources.¹⁸

¹⁷ "Statistics." Statistics. 2013. Accessed March , 2016.

¹⁸ "U.S. Energy Information Administration - EIA - Independent Statistics and Analysis." Algeria. Accessed April 2016.

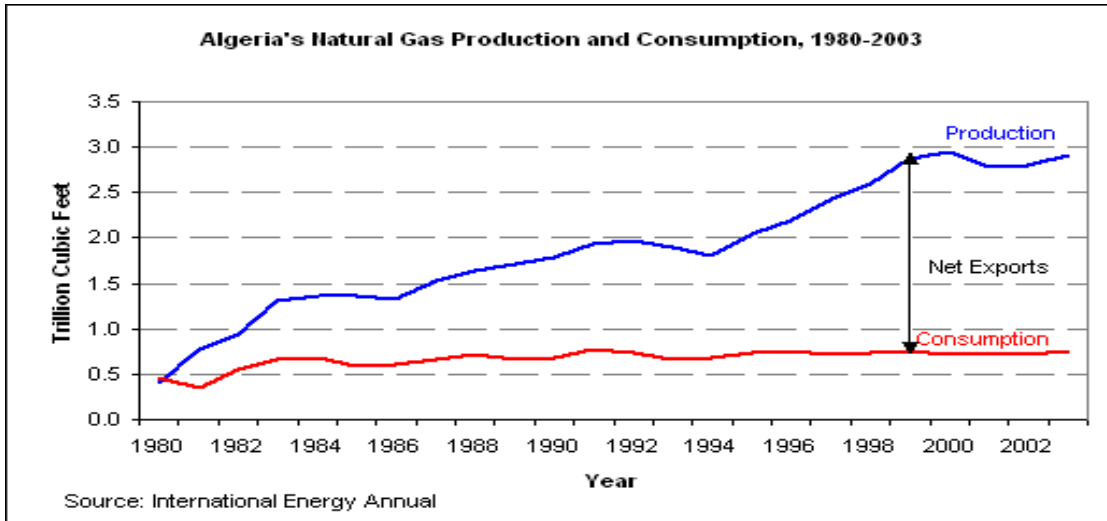


Figure 12- Algeria's Natural gas Production and Consumption, 1980-2003.¹⁹
Source: International Energy Agency

In 1980, Algeria's gas production was at the same rate as the country's consumption. Later on, steady increase in the consumption is reflected by increased difference with the production through time thus creating a huge gap between production and consumption calls for an increased exports rate.

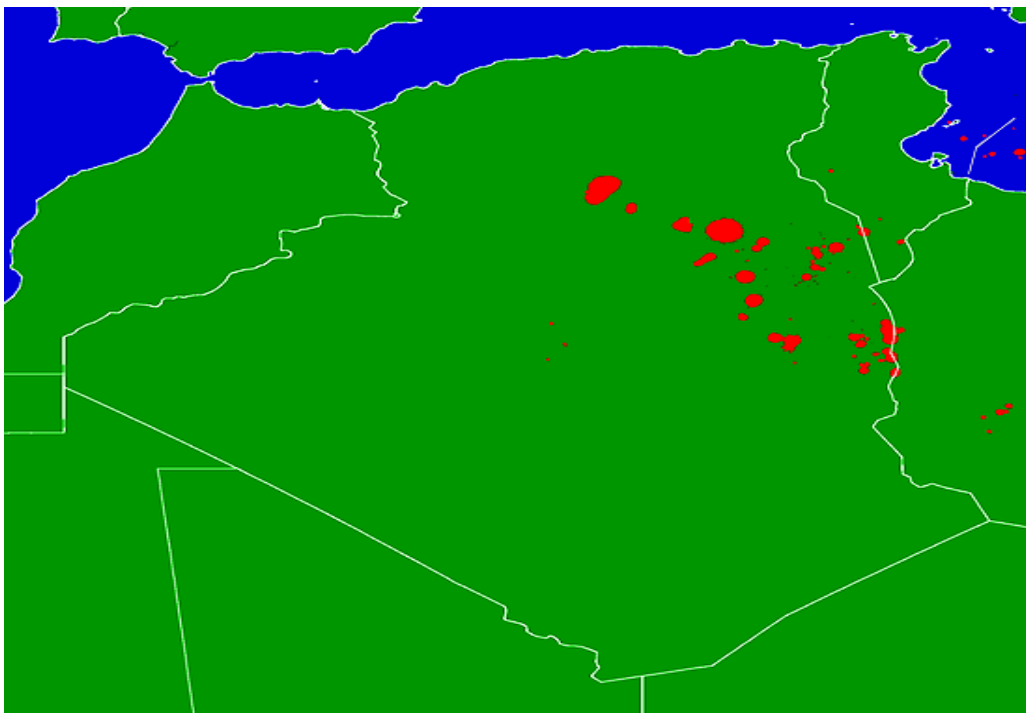


Figure 13: - Algeria's map marked with gas flares locations.²⁰
Source: International Energy Agency

¹⁹ "Statistics." Statistics. 2013. Accessed April , 2016.

²⁰ "Statistics." Statistics. 2013. Accessed April , 2016.

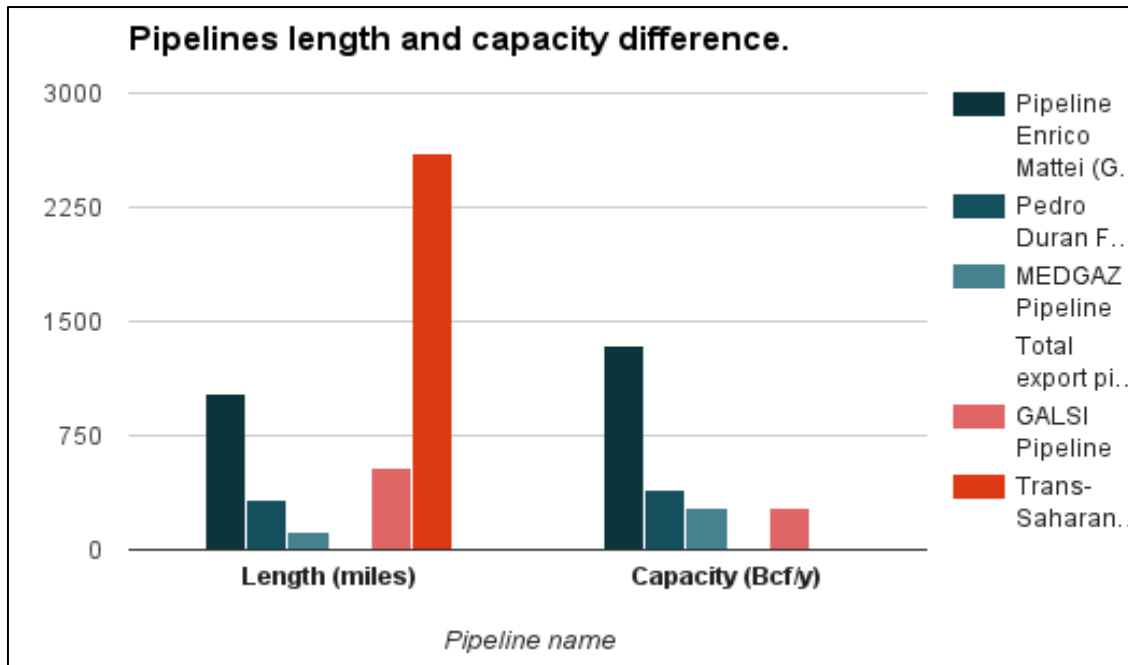


Figure 14: Algeria’s Natural gas pipelines comparison. ²¹
 Source: U.S Energy Information Agency

This chart shows the pipelines responsible of transporting natural gas around the country. Most of these pipelines originate from the southern parts of Algeria and then stretch its way up to Europe. The pipeline represented by a blue shade exists and is fully functional. While the shaded red represents the upcoming and recommended pipelines for duty.

²¹ Author based on information from, "U.S. Energy Information Administration - EIA - Independent Statistics and Analysis." Algeria. Accessed April 2016.

2.3. Electricity:

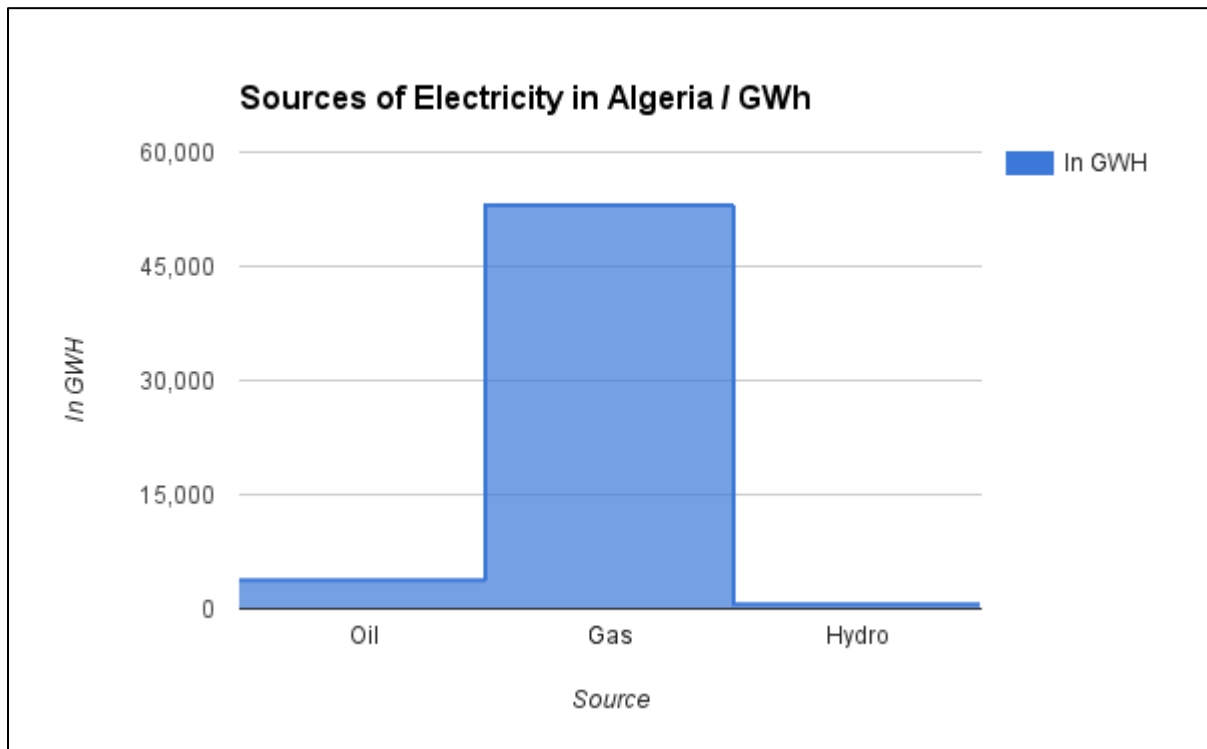


Figure 15- Algeria's sources of power, for Electric generation.²²
Source: International Energy Agency

According to Sonelgaz, the energy demand has been increasing on an average of 8 % annually in Algeria. Between 2001 and 2013, electricity production rose from 26,250 GWh to 57,397 GWh.²³ The powering sources varied for generation processes, like Oil represents 6.49 % of the total, Gas represents 92.42 % and lastly Hydro means generate just 1.08 % of the total. Natural Gas isn't just needed to improve the economy but to provide full electricity access to citizens and transport it to them. This increase in demand has to be responded with an increased rate in the production amount, and this likely would require billions of dollars' worth of investments in new generating capacity, plus transmission and distribution infrastructure.

2.4. Nuclear Energy:

Algeria doesn't have any nuclear weapons, biological or chemical, but it was one of the first African countries to sign the "Treaty of Pelindaba". In the 1960's, France was

²² "Algeria: For 2013." IEA. Accessed April 2016.

²³ "Sonelgaz" Sonelgaz. Accessed April 2016.

experimenting its nuclear weaponry on Algerian lands, as they carried out seventeen nuclear weapons tests in the Algerian desert (4 atmospheric tests and 13 underground tests).

However, Algeria was interested in developing a nuclear power civilian project. Other than that, Algeria is still in the process of exploiting its Uranium sources, as it was predicted that about 26,000 tons of uranium are reserved in the Southern Sahara desert.²⁴

Draria Nuclear Complex: (CRND)

- NUR reactor: 1 MW used for training and research purposes for reactor engineering.
- UDEC(nuclear fuel development unit)

Birine Nuclear Complex: (CRBD)

- Es-salem reactor: 15 MW used for isotope production and materials testing.



Figure 16- Birine nuclear research site.²⁵
Source: International Atomic Energy Agency

²⁴MEFTAH, B. "Algerian Nuclear Power Program and Related I&C Activities." Iaea.org. May 2013. Accessed April 2016.

²⁵MEFTAH, B. "Algerian Nuclear Power Program and Related I&C Activities." Iaea.org. May 2013. Accessed April 2016.

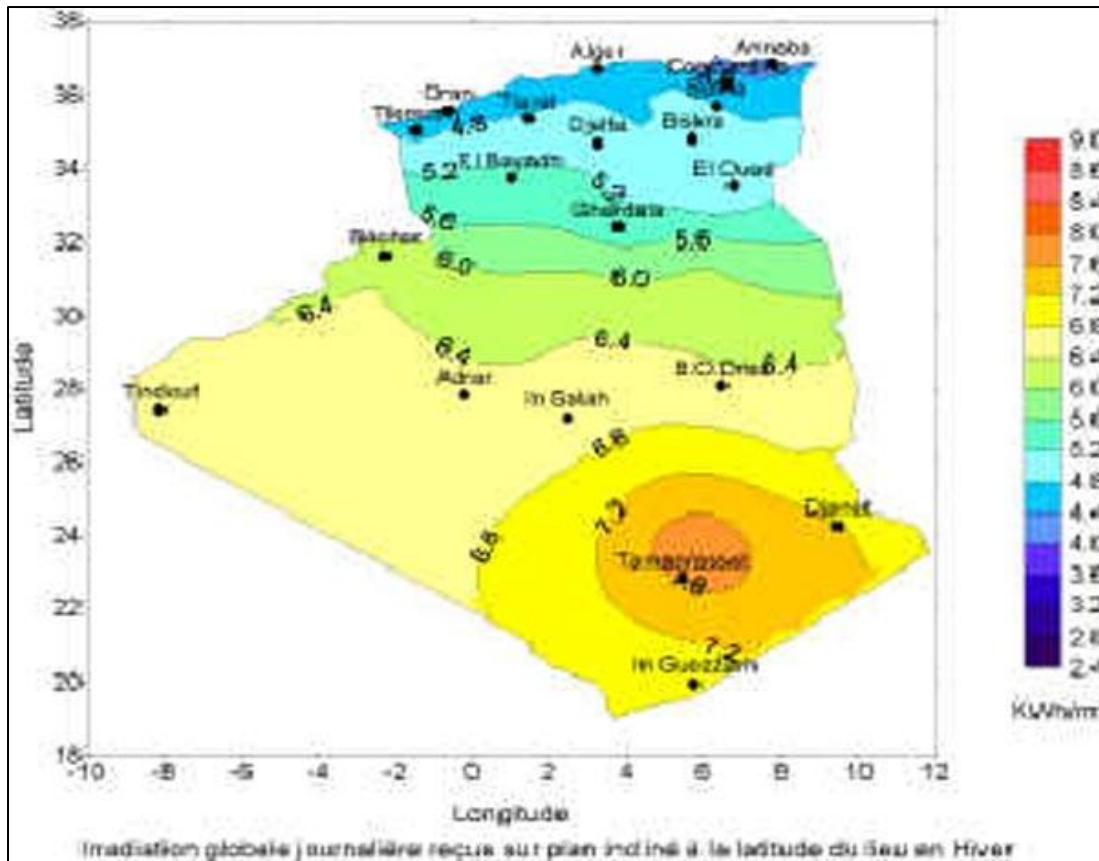


Figure 18- Algeria’s daily global irradiation on inclined plane received in winter.²⁷
 Source: Renewable Energy Development Center Algeria

3.2. Biomass Fuel

To generate fuel through biological processes may require a couple of restrictions. To succeed in generating biofuel, you have to have vast areas of Greenland and not just that, but also to be ready to use them in your generation process. Luckily, Algeria has plenty of agricultural lands and a high quality of unpolluted soil fully rich with minerals, making it a good call to plant soybeans, corn and wheat..etc. for energy purposes. “To each his own biofuel feedstock” - that is what Nakheel, an Algerian biotech company must have thought when it took decision to research and invest in bioethanol production using dates from the abundantly growing palm trees in North Africa and the Near East as a raw material.

The Deglet Nour date originally comes from Algeria, which is still the world's largest producer of Deglet Nour dates. It is grown predominantly in the **Biskra** province of Algeria, in the oases of **Tolga** and **M'Chouneche**. Biofuel also is based on animals’ waste, as their

²⁷“Renewable Energy Development Center Algeria”. Accessed May 2016.

waste usually is responsible for many pollution problems, but can be solved through the generation of renewable energy out of it. Animal or plants waste eventually can be turned into high-calorie energy source.²⁸



Figure 19- Palm trees crop waste, mostly seen in Southeastern region.
Source: Renewable Energy Development Center Algeria

3.3. Wind Energy

Wind power usually ranges from a topographic area to another, also it depends on the climate too. Algeria's climate ranges greatly between the northern and the southern halves of Algeria. Northern half, is unique because it acquires an ideal location on the Mediterranean, it has the Atlas Mountains and other high plains. But the northern winds aren't as strong as the southern ones. The southern winds speeds range from 4m/s - 6m/s, but most southern lands are lower in latitude than the northern region, whereas desert represents more the 70% of the total Algerian surface area. Adrar is considered to be the most suitable place as it's famous for operating, and providing strong winds. Having strong winds around a high hill or ridge can provide a good power plant.

²⁸ A. B. Stambouli, Z. Khiat, S. Flazi, Y. Kitamura, "A review on the renewable energy development in Algeria: Current perspective, energy scenario and sustainability issues", *Renewable and Sustainable Energy Reviews*, vol. 16, pp.4445-4460, 2012.

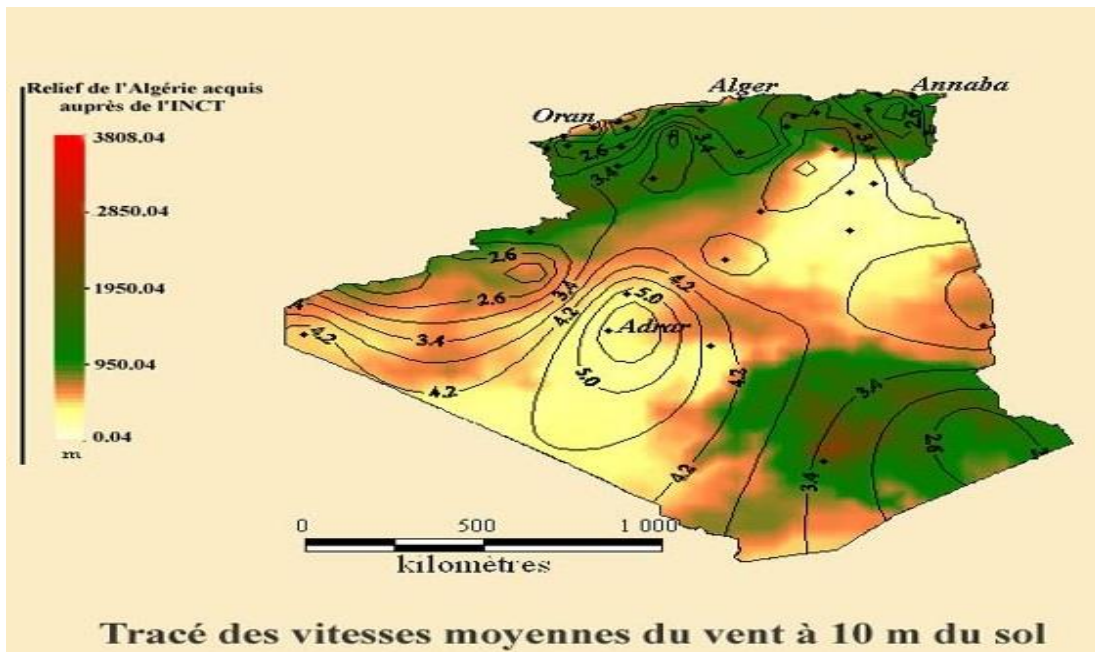


Figure 20- Algeria’s average wind speeds to 10 m above ground.²⁹
 Source: Renewable Energy Development Center Algeria

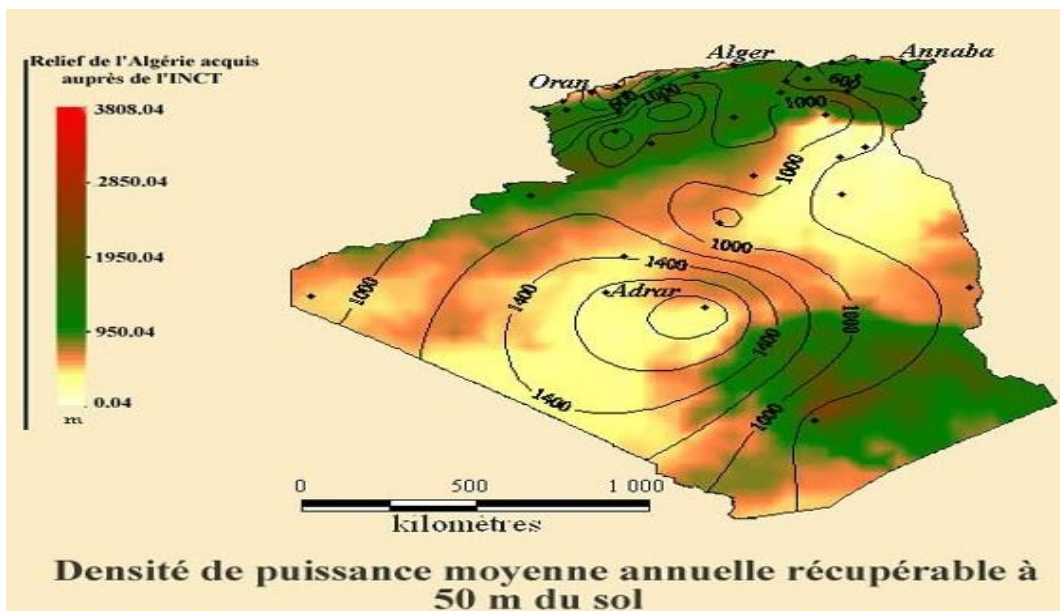


Figure 21- Algeria’s average wind speeds to 50 m above ground.³⁰
 Source: Renewable Energy Development Center Algeria

²⁹ “Renewable Energy Development Center Algeria”. Accessed May 2016.

³⁰ “Renewable Energy Development Center Algeria”. Accessed May 2016.

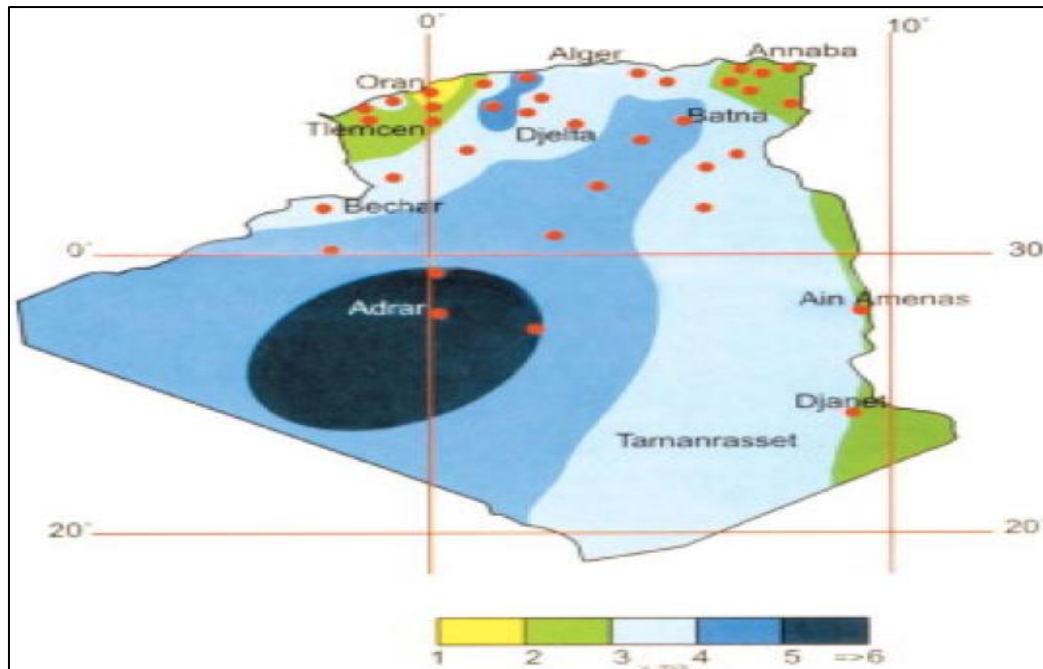


Figure 22- Algeria’s average wind speeds by area.³¹
Source: Renewable Energy Development Center Algeria

3.4. Geothermal Energy

Algeria is famous for its cluster of hot springs, as there exists, more than 200 hot springs all around the country. They been used mostly for leisure and therapeutic purposes, widely recognized by locals. With such amount of hot springs in a country, it can be taken into consideration to take use of the pressurized heat and make useful work out of it.



Figure 23- Hammam Meskoutine hot springs, Guelma, Algeria.
Source: Renewable Energy Development Center Algeria

This type of energy can be easily figured out, as there is no need for further use of any fossil fuels in the process. This method should be enhanced and made into action, for an example:

³¹“Renewable Energy Development Center Algeria”. Accessed May 2016

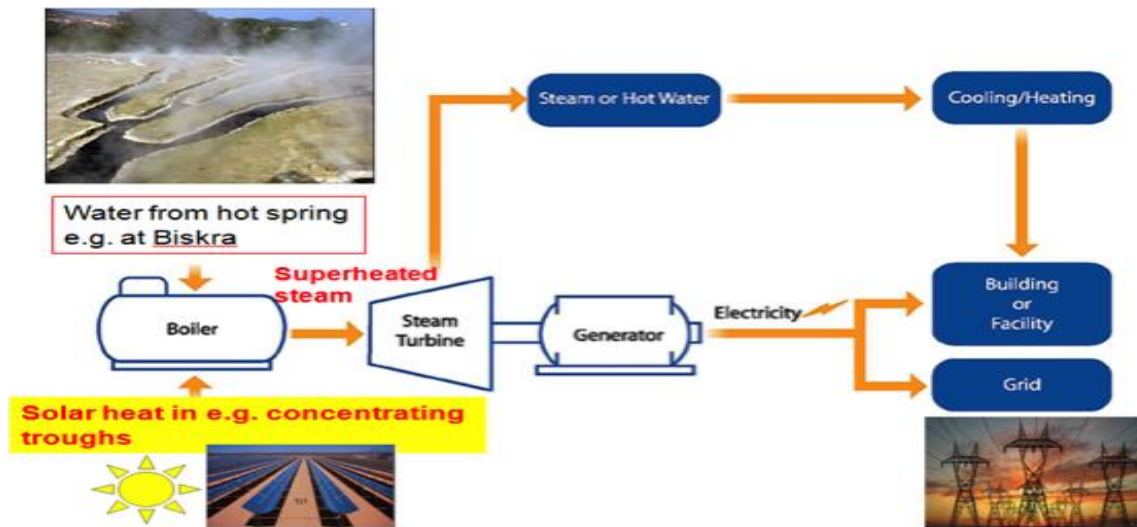


Figure 24- Process of generating geothermal energy.³²

Source: Algerian renewable energy assessment: the challenge of sustainability

3.5. Hydroelectric Energy

One of the main forms of energy comes after oil and natural gas in terms of popularity and business in Algeria, by generating 5% of the total energy consumed . Ever since, Algeria has managed to generate itself a considerable amount of hydroelectric energy through the making of power plants.



Figure 25- Ain Defla Dam, Algeria.

³² A. B. Stambouli, "Algerian renewable energy assessment: the challenge of sustainability", Energy Policy, Vol. 39 (8), pp.4507-4519, 2011.

These are usually built into large bodies of water, such as lakes, rivers,. .etc.. Hydroelectric is one of the most efficient sources of energy, at about 90% effectiveness. Algeria uses mostly the traditional hydropower method, which is suited only to large dams. While the new technology, is the concentrated reduced flow of water, but it's most effective in the generation process.

4. Algeria's Energy Policy Framework

4.1. Laws and Policies;

Renewable Energy National Renewable Energy Program

In 2011, one of the first steps into sustainability was taken by Algeria, by encouraging a potential for renewable energy sources. This could diversify the sources of energy used in Algeria.

- By installing 22,000 Mw of power generating capacity, between years 2011 and 2030.
- This plan should meet 20% of electric generation from renewable resources.
- Such massive project should be capable of providing new job opportunities for the public, also supply the region with energy needed.

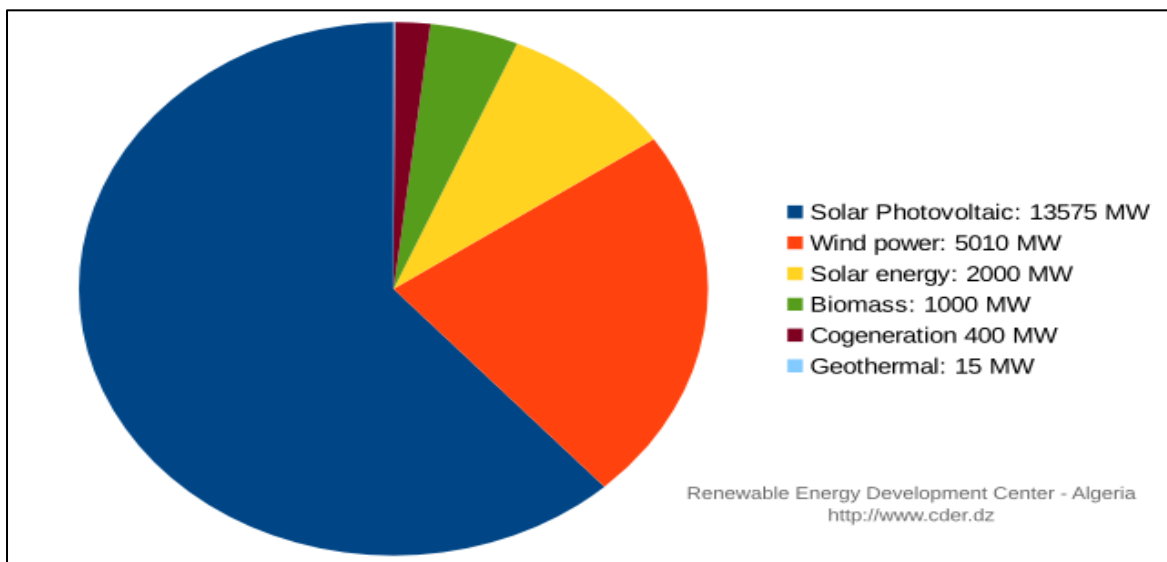


Figure 26- Division of program by technology sector.
Source: Renewable Energy Development Center Algeria

Feed-in Tariff for PV-Solar (FIT)

This program acts as supportive plan for sustainable improvements and the power plants being set up. This program will keep paying a fee for power plants throughout a 20 year period. The program breaks down the funding into two phases depending on the power plant size:-

- Phase 1 : Paid through 5 years with a limited number of functional hours.
- Phase 2 : Paid through next 15 years.

*To be able to apply this law upon your private power plant, a power plant has to generate a minimum of 1 Mw.³³

Renewable Energy National Fund (RENF)

Created in 2009 as a financial support for actions taken within renewable energy plans and strategies these funds are generated by 0.5 percent tax on oil revenues.³⁴

Renewable Energy Promotion in Framework of Sustainable Development.

This plan was developed and approved 2004, to handle three main aspects of renewable energy:

- Complete certification to at least the source of energy technology, so it can be promoted nationally and internationally.
- A national observatory for promotion of renewable energy.
- Financial incentive framework to benefit activities promoting the advancement of renewable energy techniques.³⁵

Law 99-09 on the Management of Energy

This law was passed in 1999, promoting energy efficiency awareness by .

- Establishing a general framework for rational use of energy.
- Developing energy conservation and energy efficiency techniques.
- Developing renewable energy and environment protection through the reduction of carbon dioxide and monoxide emissions, and prevent air pollution.

³³ "Ministère De L'Énergie - Algérie - Les Entreprises Du Secteur." Ministère De L'Énergie - Algérie - Les Entreprises Du Secteur. Accessed May 2016.

³⁴ "Ministère De L'Énergie - Algérie - Les Entreprises Du Secteur." Ministère De L'Énergie - Algérie - Les Entreprises Du Secteur. Accessed May 2016.

³⁵ "Ministère De L'Énergie - Algérie - Les Entreprises Du Secteur." Ministère De L'Énergie - Algérie - Les Entreprises Du Secteur. Accessed May 2016.

Ministry of Energy and Mines



Figure 27- Ministry of Energy and Mines Circle, list of companies³⁶
 Source: Renewable Energy Development Center Algeria

The Minister of Energy and Mines includes

- **Sonatrach** is the Algerian government-owned company formed to be in charge of exploiting the hydrocarbons of the country. Under Sonatrach, there is a range of other companies whose importance ranges widely, may be for transportation means or even for other exploiting forces of fossil fuels.³⁷
- **Sonelgaz:** On the other hand, Sonelgaz is the national company responsible of producing electricity, transportation of gas and electricity, infrastructure planning, and many other.³⁸



³⁶ "Ministère De L'Énergie - Algérie - Les Entreprises Du Secteur." Ministère De L'Énergie - Algérie - Les Entreprises Du Secteur. Accessed May 2016.

³⁷ "SONATRACH." SONATRACH. Accessed May 2016.

³⁸ "SONELGAZ." SONELGAZ. Accessed May 2016.

- **CDER** (Renewable Energies Development Center) , carries scientific activities in renewable energies field. Not just that, but also apply technologies and researches onto real-time problems concerning our ability to shift our focus from fossil fuels, to finding alternative eco-friendly solutions.³⁹



- **NAFTEC** is a subsidiary to the government-owned Sonatrach for the purpose of :

- Operating oil refineries around Algeria.
- Management of refineries.
- Upgrade and expand the refinery in order to cope with the requirements of the local and the international market.⁴⁰



- **NAFTAL** is founded in 1982, as a subsidiary to **Sonatrach**, and it's main mission is to distribute and market the petroleum products and Timber in the domestic market. The company is even responsible of a number of pipelines responsible of transporting hydrocarbon.⁴¹



³⁹ "Renewable Energy Development Center Algeria". Accessed May 2016

⁴⁰"SONATRACH – NAFTEC SpA." Major Projects | INDUSTRONIC® Industrie-Electronic GmbH & Co. KG. Accessed May 2016. <http://www.industronic.com/northamerica/english/projects/major-projects/projects/sonatrach-naftec-spa/>.

⁴¹ "NAFTAL." NAFTAL. Accessed May 2016.

5. Conclusion

Algeria has a strong potential for renewable-energy. If the geographical pattern is studied thoroughly, many potential renewable energy sources can be navigated. Winds concentration can be found around the south-western region, reaching speeds of up to 6 m/s. Solar energy can be of huge success in the southern Sahara, with a solar radiation exceeding 2300 kWh/m² around the year. On the other hand, the highest underground temperatures can be detected all around the northern half which can be of great geothermal use, as it's one of the oldest energy assembly methods used. With hot spots all around the country ranging from 60-90°C.

Algeria's potential to reach 100% energy sustainability may be hard to achieve by 2030, but it is not impossible. Let's say we use 130,000 km² of the Saharan desert and install solar panels all around, that would give us enough energy to power all of Europe and North Africa. Algeria managed to establish a strong transmission system for the fossil fuels, yet at this current pace Algeria would take some time to switch to renewable resources. But if we can find a way to switch the pressurized demand on fossil fuels and calibrate it with more innovative environmentally-friendly energy resources, then it should reach the goal of 100% sustainable energy use gradually through time.

Power Terminology

GWh – GigaWatt hour: The gigawatt is equal to one billion (10⁹) watts or 1 gigawatt = 1000 megawatts.

kV – kiloVolt

KW – Kilowatt

kWh – kiloWatt hour

kWh/m – Kilowatt hours per meter squared

kWp – Kilowatt peak Mtoe – Megatons of Oil equivalent: One megaton is a value based on the amount of energy released by burning one ton of crude oil or 6.6 – actual barrels of oil to produce 11.63 MWh of electricity.

MV –MegaVolt: A megavolt is 1 million volts in electronics and physics.

MW – MegaWatt: a megawatt is equal to one million watts

MWe – MegaWatt electrical

MWt – Megawatt thermal

km - Kilometers

PV – Photovoltaic

TPES – Total primary energy supply – the total amount of energy to meet the country's basic utility needs

TWh – Terawatt hours: one terawatt is equal to one trillion watts

Bcf/y- Billion cubic feet per year.

m/s - Meter per second.

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