

# The Energy Demand Pattern of Algeria: Review of Evolution and Sustainable Development

Louafi Chahrazed  
Constantine 2 University  
Constantine, Algeria  
[Louafi\\_dz@yahoo.fr](mailto:Louafi_dz@yahoo.fr)

**Abstract-**This paper aims to analyze the Algerian energy consumption from 1965 to 2013; And to highlight the change in the structure of sources toward a sustainable development. We have relied on World Bank data, and local data that have been published by specialized institutions. It became clear that within the stability of the current production and the increase in the domestic demand in order to ensure a sustainable path of development, this situation affects, the exportations as well as the increase in energy intensity. Therefore it saliently shows the need to reconcile between supply and demand and maintain the share from natural resources for the future generations, through a persisting requirement to accelerate the process of embracing the different policies and strategies to control the use of energy.

**Keywords:** Energy Consumption; Energy Fossil; Renewable Energy; Energy Intensity.

## I. INTRODUCTION

The interest in sustainable development, which presents one of the most important modern ideas, is growing within the international community. This calls up for the need to balancely combine between economic growth and environment preservation, especially that all economic activities in all sectors, have close relationship to energy where the demand is increasing for various sources.

However, most of current patterns of energy supply and use are unsustainable [1] and affect our environment in many different ways, some of them have a greater impact than others[2] and led to the emergence of environmental problems at all levels: local, regional and global, and with the emerging of global warming and climate changes. With this three-dimensional challenge that we face: development, energy, and the environment[3], it becomes necessary to look for opportunities to develop strategies and policies and treat appropriately these problems.

Algeria like the rest of the world faces this challenge and the government is trying to relaunch the economy through programs within a social cope of development. Algeria is set on track towards urbanization where the population growth exceeds 3%, and will attain 45,4 million in 2030 according to estimations[4], and therefore is claiming more access to high level of energy, in order to improve the life-style, which contributes significantly in the recovery programs, especially the supplementary one[5], according

to statistics about the increasing levels of energy demand, especially of electricity that is produced essentially using oil and natural gas, which are not unlimited and are slowly being exhausted.

In order to ensure a sustainable path of development, the Algerian government shows great interest in renewable energies. It is necessary to find a way to reconcile between production and consumption. It should focus on the transfer of cleaner and more efficient technologies, their development and implementation in the sector of energy. Algeria has known high intensity curve of energy.

We have to learn from the experiences of developed countries, and make the necessary transition towards sustainable management of natural resources. In most parts of the economy, the Algerian government continues to adopt political reforms that aim to enhancing transparency and economic efficiency.

## II. THE ALGERIAN ENERGY SITUATION

Algeria's primary energy sources include oil, natural gas, electric power, with the remainder either being oil or hydroelectric, this latter constitute a very small proportion in the balance of energy; because of the lack of availability of watersheds necessary to generate electricity. Oil and natural gas are the major source of primary energy in Algeria with about 99.8 % in 2015 according to national office statistics, its economy is heavily relies on the hydrocarbons Sector .

According to british petroleum data, Algeria had 0.7% of the total of the oil proved reserves the end of 2015, that place the country in the largest fourth position in Africa, and the tenth position in OPEC countries. The strategic geographical location of Algeria offers many advantages for the extensive use of the renewable energy sources and enable the boosting of investment potential, in particularly the foreign investment - for products of exportation - that may stimulate the economic activities and make it a pioneer in the Mediterranean region.

### A. Fossil energy

#### 1) Oil

The proven oil reserves were estimated around 12.2 thousand million barrels at the end of 2015 [6] where the extraction was hold onshore, since there had been limited offshore exploration. The government recently approved

amendments of Algeria's hydrocarbon law that included fiscal incentives for foreign companies to invest in untapped exploration areas, in particularly the offshore, and in areas believed to contain unconventional resources [7].

Oil consumption has been increasing rapidly as the economy and population grow (about 7% per year). Fossil fuel consumption subsidies are most prevalent in Algeria around 50.7% [8]. Energy price subsidies causes an inefficiency, distortions in the market and the result is an over-consumption of energy, that discourages investment in renewable energy which encourages widely smuggling. In addition, a substantial amount of petroleum products is also smuggled to neighbor-countries, because they are much cheaper [9]. the consumption trend is expected to continue in an unsustainable manner [10].

### 2) *Natural Gas*

There is an impressive amount of reserves of natural gas in Algeria. The known reserves are about 2.4% of the world's total proven reserves. Therefore, Algeria has a huge potential for gas industry development and could be a major natural gas exporter as well. The average of gross annual production has been around 9,8% since the nationalization.

The Production has steadily declined since 2005 as the countries large and mature fields have been depleted. There is a host of new projects planned to come on line, but they have repeatedly been delayed, where some of them depend on the construction of new infrastructure [7].

The expansion of the distribution system of natural gas and the networks of transportation, under the programs of public distribution, is one of the major policies for sustainable development in the country. The pipeline distribution system for domestic and industrial uses has been extended to 1476 localities against 13 in 1962 [11]. In 2015, the natural gas counts 62.4% of Algeria's total energy consumption and the government plans to replace the consumption of oil products by natural gas in household and industrial sectors in the coming years.

### 3) *Electricity*

The production of electricity is in progress, where 17% produced by steam-powered units, 31% by gas turbines, 49% by combined cycles, 1% by hydroelectricity, 2% by hybrid power plants, and 1% by diesel[12]. The park of electricity production was strengthened in 2011 by putting in service a capacity of 1470 MW, and require more additionnal capacity mainly gas turbines and diesel groups To face the considerable evolution of the demand 8,5%.

### B. *Renewable Energy*

Renewable energy consumption is much smaller around 0.1 %, it represents the first experience of the promotion and the use of thermal solar energy, at an industrial scale, which encompassed the realization, in 2011, of a power plant with a capacity of 150MW at Hassi R'Mel. It will be naturally followed by the realization of numerous projects. According to the Algerian program of Renewable Energy and Energy

Efficiency (P.E.N.R.E.E), Algeria aims to install, by 2030, renewable energy plants with a capacity of 22000 MW [13]; equal to 40% of the production of electricity for domestic consumption.

To reach this target, The investment will be realized by both public and private sectors, as well as by foreign partners. However, Algeria begins to adopt an economic and ecological solution by investing in renewable energies with its ambitious P.E.N.R.E.E program. The Algerian Ministry of Energy and Mines paves the way to become a dynamic leader in green energy.

#### 1) *Wind Energy*

The Wind potential has been studied and was found in almost half of the country. It reaches a moderate speed of 2 to 6 m/s, which is ideal for water pumping especially in the high plains [14], and an important potential for electricity generation in many far distanced areas in southwest regions that are not provided with electricity. In spite the low wind energy potential, the program of renewable energy does not exclude it, as it constitutes the second axis of development which will embrace the 3 % of electricity production in 2030 [13]. So the Algerian program of renewable energy plans at first, between 2011 and 2013, the installation of the first wind farm with a power of 10 MW situated in Kabertene, of the city of Adrar, covering 30 hectares. The ministry has projected to install other 7 wind farms with a total power of 260 MW within the middle term [15]. Several studies are being set to detect the favorable locations to realize other projects over the period 2016-2030 for a power of about 1700 MW.

#### 2) *Biomass Energy*

Algeria has relatively a low potential of energy extracted from biomass. Algeria does not neglect the chance of producing and using it, in fact, it is been planned to implement pilot projects to address another source of renewable energy [13], where the CDER is responsible. The forms of biomass in Algeria are mainly: solid wastes, crop wastes, and forestry residues, where the solid waste represents the best source of biomass potential in the country.

According to the National Cadastre the generating of Solid Waste of the municipalities in Algeria is, annually, more than 10 million tons [16]. Furthermore Recoverable potential is around 3.7 million Toe\* which can be acquired through forest reserves. The current recovery is around 10%, to mention that about 1.33millions tep/year through urban and agriculture waste are not recycled [17]. A very little work has just started to make biomass usage cost-effective energy source [18].

#### 3) *Energy Solar*

By its geographical situation, Algeria has one of the highest solar fields in the world. The daily average solar energy obtained on a horizontal surface of 1m<sup>2</sup> is about of 5 KWh over the major part of the national territory, and The insolation time over the quasi-totality of he national territory

exceeds 2000 hours annually and may reach 3900 hours (high plains and Sahara). The daily energy on a horizontal surface of 1m<sup>2</sup> is of 5 KWh over the major part of the national territory, or about 1700 KWh/ m<sup>2</sup> / year for the North and 2263 KWh / m<sup>2</sup> / year for the South of the country.

The average number of sunshine hours exceeds 2000 h/year and may reach 3900hours per year in high plains and Sahara [19]. The first project has been nevertheless started recently it concerns a hybrid photovoltaic power plant with a capacity of 15 megawatts (35% of this capacity is provided by solar panels) located in Hassi R'Mel.

### III. THE PRODUCTION AND CONSUMPTION IN THE ENERGY SECTOR

The Algeria's primary energy includes oil, natural gas, and hydroelectricity. The primary energy consumption increases rapidly as the economy and population grow, as shown in figure 1.

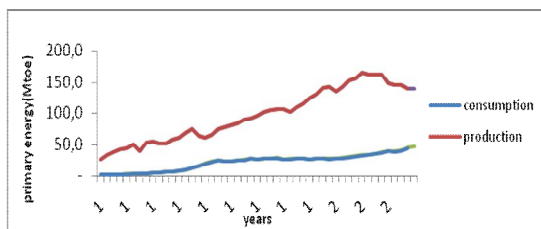


Fig. 1: Algerian Primary Energy Production and Consumption

This trend would continue unless the techniques of energy conservation are used in some areas. The energy demand is dominated by petroleum products and natural gas (99.9%). Hydroelectricity has a subordinate role and figure 2 shows the pattern of energy demand in Algeria. The consumption of primary energy has been increasing in the last half-century at an annual average of 7%. the energy consumption per capita increased from 0.18 toe in 1967 to 1.2 in 2013, We find that the structure of the consumption has grown the products benefit of the gaseous products which recorded the Gas exportation shows that petroleum products consumption has been continuously increasing since 1980, as is shown in figure 2. The trend of consumption is explained by the regular increase since 1980. Since the formation of National Oil Company Sonatrach, the government has been heavily subsidizing the price of petroleum product in order to provide a cheap source of energy for the industrialization process adopted after the independence.

A large amount of waste has occurred in the consumption of petroleum product reflects the inefficiency in utilization. The sector of transportation is the second important consumer of energy, which petroleum products are mostly consumed in road transportation with 95,4% in 2013[20]. The average of growth rate is 3.64% a year during the period from 1980 to 2008 while the highest average is 19,5% during 2009-2013, because of several factors:

- Increased use of means of transport, whether measured by the number of passengers, the number of vehicles and goods in the national slowdown in

the adoption of policies that will improve the performance of the sector due to low levels of oil prices; Algeria occupies the ninth position among the 10 countries where the fuel is the least expensive in the world [21]

- Increase growth in international trade, and increasing the volume of goods transported by freight, which has led to increased demand for different fuels.

And is one of the energy-intensive sectors , and one of the factors that influence the quality of vehicles used an increase in other gas sector final consumption, which is due to the increase in vehicles that use liquefied natural gas is observed. The consumption of natural gas in household and commercial sectors has been growing rapidly as the distribution pipeline extends into different areas. Natural gas is used for water and space heating and cooking in the domestic sector. Natural gas is also used in refineries for water heating, steam and electricity production. Gas has become an increasingly popular option for electricity generation in recent years since gas is relatively cheap as compared to oil price. The combined cycle gas turbines are very efficient and are used in all new power plant stations.

The consumption of natural gas is negligible in agriculture and transport sectors. Gas burning technology has enormous potential and is certainly becoming commonly used.

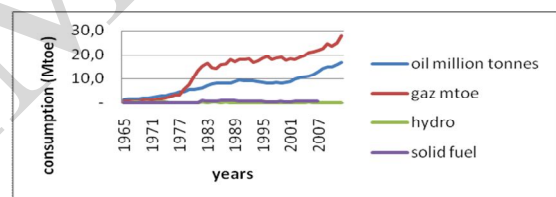


Fig. 2: Algeria's Energy Consumption

There is a change in the composition of final consumption sector, according to sources , Before it was most of the final consumption sector dominant petroleum products and other gases has become both electricity and gas constitute the lion's share in the composition of sources, the most consumed , due to the expansion of distribution networks for electricity and gas, the embodiment of the national energy policy live up to the program achievement important in the field of lighting and rural general distribution of gas that allowed the lifting of coverage in terms of the delivery of electricity to more than 99% and a penetration rate of gas to more than 50%. In addition to lower gas prices , which encourages the use of force against petroleum products and other gases The share of natural gas in the household sector consumption of primary energy has exceeded that of oil products since 1998.

The economic and environmental benefits of natural gas and uncertainty in oil export provide impetus to increase its share in the household sector. Currently, more than half of Algeria's total energy consumption comes from natural gas. The government plans billions of dinars of further investment

in the coming years to increase the share of natural gas in domestic energy consumption in Continuous of development programs already launched under the National Gas Program, the five-year program 2010-2014 provides the connection of natural gas by more than one million homes. In addition to the National Gas Program, the development plan of GRTG network integrates decided in the context of development studies network gas transportation and supply natural gas and electric power investment studies planned investments GRTG speaks for security of supply and those related to the connection of new industrial customers.

The development plan includes the work structuring GG2 48" in diameter, with a length of 437 km, which will strengthen the supply of natural gas from the central region. The first tranche of this pipeline (section Hassi R'Mel - Gréo, 314 km) is required for 2016 and the estimated amount is 31milliards dinars. Natural gas consumption has increased in household and commercial, industry, power plant by 58,93%, 122,12 respectively from 2000 to 2011 [22]. The consumption of natural gas in the sector of household and commerce has been growing rapidly as the distribution pipeline extends into different areas. Natural gas is used for water and space heating and cooking in the domestic sector.

Natural gas is also used in refineries for water heating, steam and electricity production. Gas has become increasingly a popular option for electricity generating in recent years, since gas is relatively cheap compared to oil. The combined cycle (gas turbines) are very efficient and used in all new power plants. The consumption of natural gas is negligible in agriculture and transportation sectors. Gas burning technology has enormous potential and is certainly becoming commonly used. The total electricity generating was about 56,2 TWh in 2013. The installed power has reached 15,1 GW [23] with a growth rate of 10,7% since the beginning of the 21th century, and an increase of 6% from 1985 to 2013.

According to the Ministry of Energy and Mines, to cover the market needs, 28 GW electricity should be added to the present generation capacity, in order to meet electricity demand in the next decade. It is planned to generate 8 GW from hydroelectric power plants and 22 GW from thermal and combined cycle power plants. Sonelgaz has anticipated that by increasing its production to double, in order to achieve, in five years, an equal capacity to the one currently installed. To secure a sustainable distribution of power during summer, a substantial reserve of power was integrated to the interconnected network, with a capacity of 12,000 megawatts: 3000 megawatts during 2013-2015 and 9000 MW during 2016-2017, which 60% will be produced by combined cycle and 40% by gas turbines [24] .

The residential, commercial, and industrial sectors count respectively around 54%, 27%, and 19% of electricity consumption [25]. The total electricity consumption was about 51798 GW h in 2012, this includes the power produced by independent producers in the industrial sectors which comes to around 46,47%. Electricity consumption in Algeria increased to 1366,7 GW h/person in 2012. A main attention

should be given to household use. Buildings and appliances use one third of the total of electric energy. The maximum use of energy in household sector is for space heating (51%), cooking (30%) [26] And lighting (32% of electricity) [27] . The rise of consumption is due to the use of air conditioning equipment.

**IV. PATTERN OF ENERGY USE AND DEVELOPMENT**

There is generally a close correlation between the rate of economic growth and the demand for energy. Government policy, and the way it affects the direction of the economical growth, had an important influence on the demand for energy. Fossil fuels have a dominant role in the pattern of energy use in Algeria. Table1 shows the energy intensity (the ratio of energy consumption to GDP growth rate) for four distinct periods in Algeria.

Table I: The Growth Rate of Gnp and Energy Demand

Years	Gross rate of domestic product (GDP) %	Energy consumption growth rate %	Energy Intensity
1970–1980	6.36	14.18	2.23
1980–1990	2.80	7.41	2.65
1990–2000	1.71	2.04	1.19
2000–2013	3.76	4.15	1.10

*The period 1970–1980* coincides with the choice of the development of the industrializing industry adopted since the independence as a strategic option for a genuine development including: iron and steel, mechanics, and other industries that rely intensively on energy, which led to a strong consumption of energy, in consequence. The energy intensity was about 2.23 which was far from the one recorded in the industrial countries. This indicated a rapid economic progress and an immense utilization of energy resources. In this period, the population and the industrial growth rate increased consequently compared to the period that had preceded the nationalization of hydrocarbons sector (1971).

The Oil revenue has increased and the economic growth rate began to increase at the end of the period. There were a strong interference of the state in the economic life and huge investments were launched that led to positive rates and an increase in the investment spending, financed by the oil revenues that constituted the most important part, especially after a sudden increase in the price of oil. In this period most of the total foreign exchange requirement came from oil revenues, and made the economic progress. The consumption share by analogy to production has doubled. Natural gas rose to an average of 17,9% during the same period.

*The period 1980–1989* coincides with the decline of oil prices; which led to a severe economic crisis: a decline in exports and imports, and a serious reduction of the GDP. This crisis had a great impact on the contribution of industry of extraction sector in the composition of GDP. We ought to note that if the decline of the oil price reaches 1\$ it causes the public treasure a loss of 30 billion dinars [28]. The share of energy production reached its lowest level compared to



previous decade as shown in fig 1, created a deficit in the balance of payments and diminished the solvability before the international and professional institutions. Therefore the government had to reconsider its policy of expenditure by reducing public spending and rationalizing the consumption.

In the 70's and the 90's, Algeria, as many developing countries, is on track to reduce the global energy intensities with moderate rates.

*The period 1989–1999* was marked by a political instability. It was an extension to a previous phase that coincided with the beginning of the second Gulf War. Its first manifestation was a reduction of oil revenues which caused a decline of the economic growth. Algerian economy knew difficult times. This situation opened the way for the IMF to reschedule the Algerian debts and was compelled to change its policy to managing the economy and reduce its dependency to energy rent and adopt the oil reform Act of 1992. Algeria has worked in the framework of structural adjustment programs, imposed by the IMF.

The second half of the nineties knew perturbations in the public budget because of fluctuations in the oil prices. The industrial sector was more affected by the economic crisis with the shut-down of many public institutions due to mismanagement and bankruptcy, and the inability of the government to bear the losses ;except for the hydrocarbon sector that is why the energy intensity was about 2.6.

*During 2000-2012*, the public revenue knew a remarkable development led to an improvement of the financial situation, a result of the substantial rise of oil prices that reached the peak in 2005, and to the change of the economic policy that resulted to the expansion of public spending, in order to get out of the crisis spillover, exhibited by the general decline of GDP. The government adopted plans for the economic recovery: the program of support during 2001-2004, and the complementary program of support during 2005-2009, shown by some indicators, which boosted the economic activity recording higher rates of growth . Due to the fact that prices had an indirect impact on the volume of imports and affected the cost of production, the imported products were more expensive.

The Direct foreign investments has been attracted to set up industries that were naturally petroleum based and most of the total foreign exchange requirement came from oil revenues. The energy intensity was 1,1 this performance has been achieved through foreign partnership and technology transfer [29], and specially from the structural changes that occurred in the global economy despite the new policies adopted that would gear the improvement of efficiency in all sectors. Export volumes grew strongly more toward the gaseous products.

It is of prime importance to sustain and increase the crude oil exportation capacity. At the present, the local energy consumption is increasing at the expense of exports, however the production capacity of oil has stagned since 2005 and the gas reserves since 1999. The annual average of

discoveries, made during 2001-2012, was about 16, which is significant and superior to what has been achieved since the nationalization of hydrocarbons. It led to a steady increase in the potential of production due to the strong investment of foreign companies; creating favorable conditions for more funding of oil projects.

To sustain its production capacity Algeria adopted the solution of gas injection as secondary recovery method. Thus, valuable amounts of gas must be used to maintain the productivity of oil fields, and has established a national policy to conserve energy in all sectors, according to the Law No. 99-09 of 28 July 1999[30] about "the control of energy", that defines the conditions and means of supervision. The instruments provided by the government for the implementation of this policy are:

- Agency for the Promotion and Rationalization of Energy Use (APRUE).
- The National Fund for Energy Conservation (FNME).
- The National Program for Energy Conservation (PNME).
- The Inter-sectoral Committee of Energy Management (ICEM).

The adoption of National program Energy Management as instrument of government action for the application of the law by Executive Decree No. 04-149 [31], contains a five-year program of government:

- Defining the framework and prospects for energy efficiency,
- The assessment of potential and the definition of objectives in terms of energy efficiency,
- Actions to be taken in the context of these objectives in short, medium, and long terms.

The energy efficiency program obeys to the will of the government in order to promote a more responsible use of energy and to explore all ways to conserve the resources and rationalize the consumption. The objective of energy efficiency is to produce the same goods and services, by using the least possible energy. This program contains actions that favor the use of most suitable energy forms for different uses that require changing the consumer's behavior and improving equipment. In addition to that, several R&D projects in the solar heating, hydroelectric power, and wind power sectors are launched.

## V. CONCLUSION

Energy sector have long been the backbone of the economy and plays a central role in the world energy markets as it is a major producer and exporter. Algeria's energy mix was exclusively based on fossil fuels, especially natural gas. Energy consumption per capita has steadily increased from 1 to 6.0 barrels per person per year. Transport and household sectors are major users of petroleum products.

The strategies adopted by the Algerian government realized through plans for economic and social development begin with industrialization, economic growth, expansion of the national distribution, urbanization and improving living standards greatly contributed to the augmentations of energy demand . The rate of growth of domestic demand for energy is high it is currently 33 % of production while it was 19,7% in 1980. Almost Algeria's energy demand is put by fossil fuel which affects environment problems. The government wants to reduce this dependence attempting to firstly by adopting public distribution program public gas cleaner combustion They reflect the commitment of public authorities to promote sustainable development and represent a vector of socio-economic development. by Introducing renewable energy into the local power market. Oil revenues is very important for the economic growth of Algeria; to maintain the oil revenues the share of non-oil exports of foreign exchange earnings must be increased in any plan for sustainable development , the intensity energy is growth due to non atteigement stage saturation It is clearly that the current Algerian energy model is unsustainable. It is time to change the pattern of consumption for the benefit of future generations.

However, the country has enormous renewable energy potential, mainly solar, which the government is trying to harness by launching an ambitious Renewable Energy and Energy Efficiency Program. We must make the necessary transition to a sustainable management of natural resources. It is also necessary to effectively support the transfer of clean energy technologies in developing countries in a global movement towards sustainable development. The transition of developing countries in the post -industrial economy is the most important to do a global attempt to economy steady state and structure of consumption worldwide problem.

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