The Algerian Challenge between the Dependence on Fossil Fuels and its Huge Potential in Renewable Energy

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Received: 13.06.2012 Accepted:06.07.2012

Abstract- Algeria plays a very important role in world energy markets, both as a significant hydrocarbon producer and as an exporter, as well as a key participant in the renewable energy market. Due to its geographical location, Algeria holds one of the highest solar potentials in the world. This paper present the currently situation of the renewable energy and assesses present and future potential of renewable energy sources (RESs) in Algeria and also discusses the trends and expectation in solar systems applications and the aspects of future implementation of renewable energies in the Europe, Middle East and North Africa (EU-MENA) region status. The problem related to the use of RES and polices to enhance the use of these sources are also investigated. The co-importance of both policy and technology investments for the future Algerian markets of RES and competitiveness of the solar/wind/biomass approach is highlighted. An example of policy significantly impacting Algerian project are reviewed (The DESERTEC project).

Keywords- renewable energy, hydrocarbons, Algeria, solar power, wind energy, efficiency program, potential resources

1. Introduction

The current situation of energy in Algeria begins to have an important trend in its future politics to be interested in the exploitation of its resources of the renewable energies and especially the enormous potential in solar energy. The current evaluation translates a blatant disparity where the branch of industry leans completely on hydrocarbons. In 2010, Algeria's energy mix is almost exclusively based on hydrocarbons, mainly natural gas (93%). The small share of renewable energy (2%) is currently dominated by hydraulic power. [4]

Beyond its hydrocarbon resources, Algeria has a high potential of renewable energy which it has the ambition to develop with foreign partners. The development of these potential, in particular huge reserves of solar energy would have several positive consequences for Algeria, its partners and the world community in general. The promotion of the electricity produced starting from the renewable energy sources is in the forefront of the priorities of Algeria for reasons of energy supply diversification, for reasons of environmental protection and for reasons related to economic and social cohesion.

With its ambitious "Renewable Energy and Energy Efficiency Program" of March 2011, the Algerian ministry of energy and mines paves the way for Algeria to become a dynamic leader of green energy.

22.000 MW of power generating capacity shall be installed from renewable sources between 2011 and 2030 with [13]:

- 12,000 MW to meet the domestic electricity demand.
- 10,000 MW for export.

Through 2030, 40 % of the production of electricity for domestic consumption will be from renewable sources. To reach these targets, Algeria needs to invest up to **120** billion US Dollars in renewable energy between now and 2030. The investment will come from both the public and private

sector, as well as from foreign partners. The new energy policy will be supported by the development of a local subcontracting industry, which is expected to creat around 100,000 new jobs.

Algeria aims to be a major actor in the production of electricity from solar photovoltaic and solar power as it considers this source of energy as an opportunity and a lever for economic and social development, particularly through the establishment of wealth and job-creating industries. In addition, several wind farm development projects will be launched. Experimental projects in biomass and geothermal energy shall be implemented. The Renewable Energy and Energy Efficiency Program provides for the development by 2020 of about sixty solar photovoltaic and concentrating solar power plants, wind farms as well as hybrid power plants.

Sonelgaz, already running a project to develop a hybrid (gas-solar) power station at Hassi R'mel with a 150 MW capacity and a separate 10 MW wind farm at Adrar, will take charge of completing several renewable energy projects (Desertec). Investments are planned to take off between 2015 and 2030, with electricity production rising to 22,000 MW, double the current generating capacity. Most of this will come from natural gas, saving around 600 thousand million cubic metres of gas over 25 years. Half of the saved gas will be stored with the rest exported, earning the country an additional 200 billion US Dollars over the period. Electricity consumption is expected to reach 75 to 80 TWh in 2020 and 130 to 150 TWh in 2030. The massive integration of renewable sources in the energy mix represents a major challenge for preserving fossil resources, diversifying electricity production systems and contributing to sustainable development.

2. The Algerian Energy Sector

Algeria is one of the most important oil and gas producers and exporters in the world. Algeria also is a member of OPEC and with a 25 % share of the European gas market a very important energy source for Europe. In the year 2000 the petrochemical industry contributed a 40.8 % gdp share. 97.1 % of the Algerian export goods consisted of petrochemical products in 2000.

2.1. Oil and Oil Production

Despite the fact that Algeria first discovered oil back in 1956, the National Council of Energy believes that the country still contains vast hydrocarbon potential. Algeria is considered to be under-explored. Over the last few years, significant oil and gas discoveries have been made by Sonatrach in cooperation with foreign companies, who now hope to increase Algeria's crude oil production capacity significantly over the next few years.

Algeria's proven oil reserves remain at 9.2 billion barrels, but are expected to be revised upward in coming years. Algeria should also see a sharp increase in crude oil exports over the next few years due to a rapid shift towards domestic natural gas consumption and planned increases in oil production. Algeria's Saharan Blend oil is among the best in the world.

2.2. Natural Gas

Algeria has 160 trillion cubic feet of proven natural gas reserves, ranking it in the top 10 worldwide. Several contracts with hundreds of millions of dollars are going to be concluded for investments in the gas industry. Feasibility studies are on the way to build a new gas pipeline linking Algeria directly to Europe via Spain. Algeria was the second largest exporter of LNG in 1998, with 22% of the world's total. After a complete renovation of its LNG facilities, however, Algeria's LNG production capacity will become even higher.

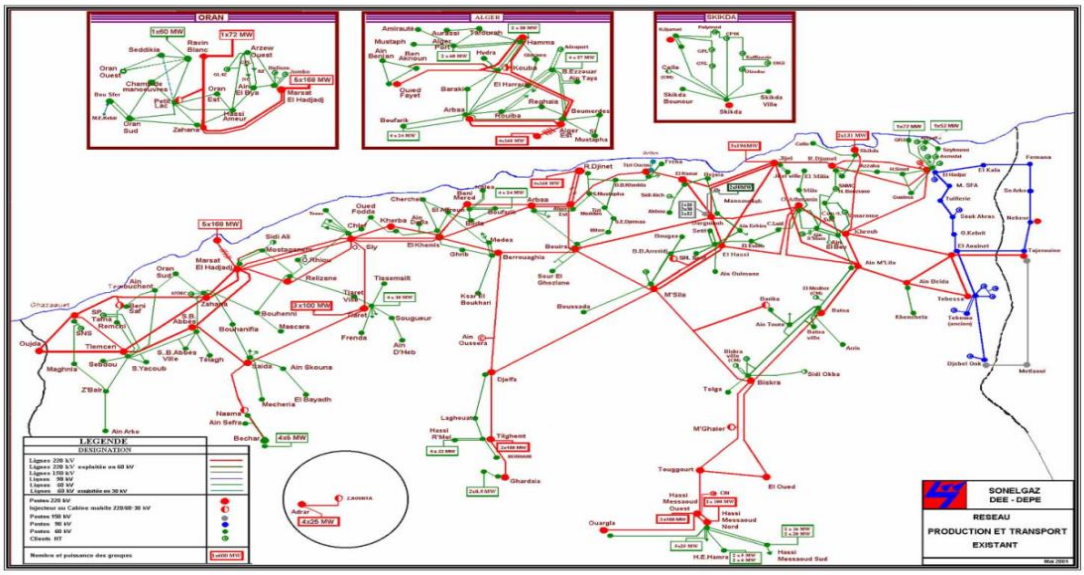


Fig. 1. Map of Algerian electrical power networks. 2011 by MEM [5]

2.3. Mining

Algeria's mining industry makes raw materials available to industry. The increasing need for energy and raw materials calls for reliably and precise prospecting and exploration procedures as well as the necessary equipment. With more than 30 different raw materials, mining activities in Algeria are very diversified. Besides ancient deposits of iron, selenium, zinc, lead, barium and marble, vast deposits of gold, tungsten, tin, silver, diamonds, mercury, raw earths, raw metals, precious stones and semi-precious stones have been discovered in recently conducted research efforts.

2.4. Electricity

Algeria's electricity demand is growing at a rapid, 5%-7% annual rate, and will, according to Sonelgaz, require significant additional capacity -- possibly 8,000 MW by 2010 ,in coming years.

Currently, Algeria has around 6,000 MW of installed power generating capacity, but this has not been sufficient to reach demand during peak cooling periods in the summer. In July 2003, power and water shortages led to rioting and demonstrations in the country. Currently, the Algerian government is pushing power conservation measures. In the longer-term, however, Algeria's power sector will need to grow. This will require billions of dollars worth of investments in new generating capacity, plus transmission and distribution infrastructure (i.e., lines and sub-stations).

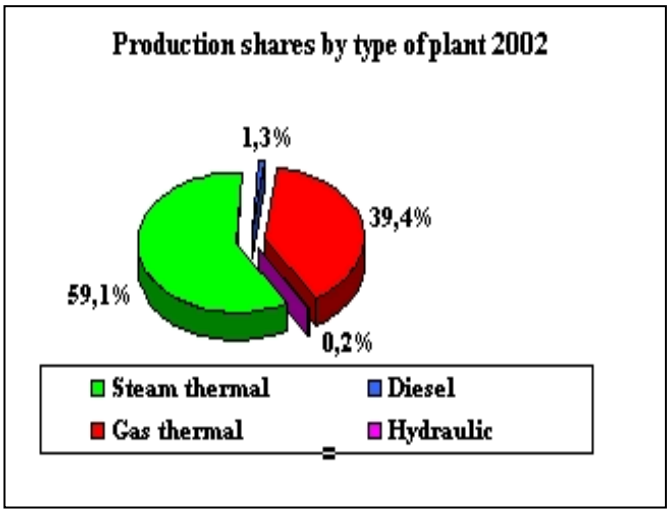


Fig. 2. Production shares by type of plant in Algeria [1]

Sonelgaz is the sole, state owned generation, transmission and distribution utility. Sonelgaz also distributes gas throughout the country. Recent legislation has, however, opened the door for independent power producers to enter the market. The majority of installed capacity is thermally fired (95.3%) with the remainder hydro powered.

As of December 31st, 2003, Sonelgaz operated 6345 MW of which:

- 6039 MW for the network inter-connected
- 306 MW for the networks isolated from the South.

The electric power network operates at 50, 345, 220, 90 and 60 kV. The transmission system consists of around 11 000 km of line and 115 transmission substations. There are international transmission links with Morocco and Tunisia.

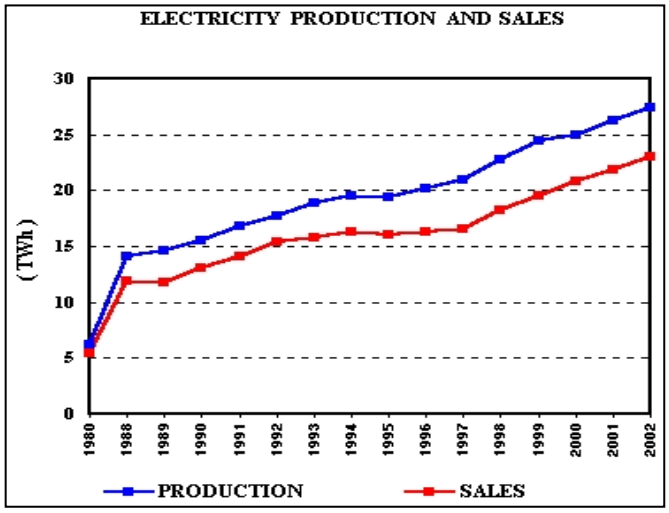


Fig. 3. Electricity production and sales in Algeria [1]

3. Renewable Energy Potentials in Algeria

The assessment of potential is based on two different types of sources: assessments of the Algerian Government (also used in UbiFrance 2009) and the in-depth studies conducted by the German Aerospace Center (DLR). DLR calculated data mainly from satellite imaging and further processing to derive technical and eventually economic potentials. Tab. 1 summarizes solar, wind, geothermal and biomass potentials for electricity generation.

In addition to the DLR study, assessments by Algerian institutions have to be analyzed. The Center for the Development of Renewable Energies (CDER) surveyed different types of renewable energies. Data are gathered in the "Guidelines to Renewable Energies" report by the Ministry of Energy and Mines (MEM 2007). Algeria's MEM concludes that "the biggest potential in Algeria is solar" (MEM 2007)

Table 1. Data on solar radiation in Algeria. MEM 2007[5]

Region	Coastal	Highlands	Sahara
Average sun hours per year	2650	3000	3500
energy received Kwh/m²/a	1700	1900	2650

The data presented by the MEM (2007) is supported by data compiled by the World Energy Council that stay in the same range: Annual average insolation for Algeria is rated at 2,000 hours while the high plateaus receive about 3,900 hours. This results in an average solar energy potential of 2,400 kWh/m2/an (figure 4).

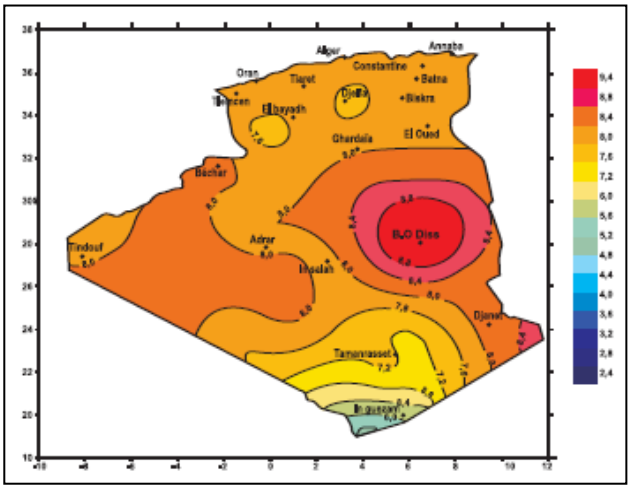


Fig. 4. Average Daily Sun of Direct normal [10]

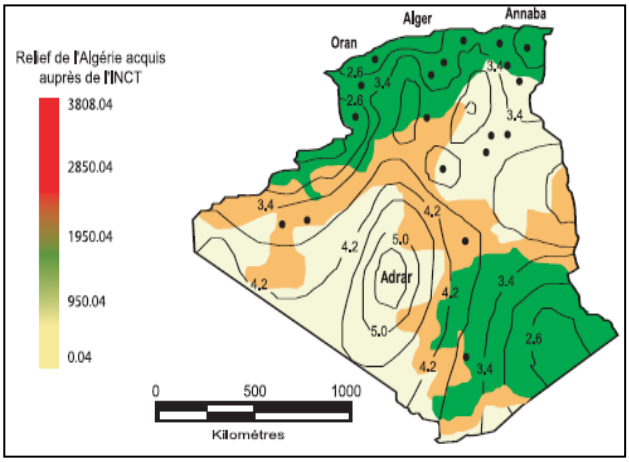


Fig. 5. Wind map showing onshore potential by CDER

National onshore wind energy potential is rated as being low (MEM 2007). However according to an analysis comparing wind data from 75 locations in Algeria (published in 2000), there are several promising wind power locations (Hamane/Khellaf 2000), see Fig. 5. Offshore data were not available.

According to the Ministry of Energy and Mines, Algeria has potential for low-temperature geothermal applications (hot springs) in the range of 700 MW (MEM 2007).

4. Renewable Energy: a priority in Algeria

Algeria has created a green momentum by launching an ambitious program to develop renewable energies and promote energy efficiency. This program leans on a strategy focussed on developing and expanding the use of inexhaustible resources, such as solar energy in order to diversify energy sources and prepares Algeria of tomorrow. Through combining initiatives and the acquisition of knowledge, Algeria is engaged in a new age of sustainable energy use. The program consists of installing up to 22 000 MW of power generating capacity from renewable sources between 2011 and 2030, of which 12 000 MW will be intended to meet the domestic electricity demand and 10 000 MW destined for export. This last option depends on the availability of a demand that is ensured on the long term by reliable partners as well as on attractive external funding.

In this program, renewable energies are at the heart of Algeria's energy and economic policies: It is expected that about 40% of electricity produced for domestic consumption will be from renewable energy sources by 2030. Algeria is indeed aiming to be a major actor in the production of electricity from solar photovoltaic and solar power, which will be drivers of sustainable economic development to promote a new model of growth. The national potential for renewable energy is strongly dominated by solar energy. Algeria considers this source of energy as an opportunity and a lever for economic and social development, particularly through the establishment of wealth and job-creating industries. The potential for wind, biomass, geothermal and hydropower energies is comparatively very small. This does not, however, preclude the launch of several wind farm development projects and the implementation of experimental projects in biomass and geothermal energy.

4.1. Program and perspectives of the Renewable Energy in Algeria

The renewable energy and energy efficiency program is organized in five chapters:

- Capacities to install by field of energy activity
- Energy efficiency program
- Industrial capacities to build in order to back up the program.
- Research and development.
- Incentives and regulatory measures.

The program provides for the development by 2020 of about sixty solar photovoltaic and concentrating solar power plants, wind farms as well as hybrid power plants.

These phases are a part of Algeria's strategy, which is aimed at developing a genuine solar industry along with a training and capitalization program that will ultimately enable the use of local engineering and establish efficient know-how, including in the fields of engineering and project management. The renewable energy program to meet domestic needs in electricity will generate several thousand of direct and indirect jobs.

Today, Algeria's energy needs are met almost exclusively by hydrocarbons, mainly natural gas. The other forms of energy are mobilized only when natural gas cannot be used. The long term extension of the national energy consumption pattern can affect the existing supply-demand balance for this energy source. The level of natural gas volumes, produced of the domestic market would be 45 billions m3 in 2020 and 55 billions m3 in 2030. Other volumes of natural gas are intended for export to help finance national economy. Electricity consumption is expected to reach 75 to 80 TWh in 2020 and 130 to 150 TWh in 2030. The massive integration of renewable sources in the energy mix represents a major challenge for preserving fossil resources, diversifying electricity production systems and contributing to sustainable development.

The energy efficiency program consists mainly in the achievement of the following:

- Improving heat insulation of buildings;
- Developing solar water heating;
- Spreading the use of low energy consumption lamps;
- Substituting all mercury lamps by sodium lamps;
- Promoting LPG and NG fuels;
- Promoting co-generation;
- Conversing simple cycle power plants to combined cycle power plants, wherever possible;
- Developing solar cooling systems;

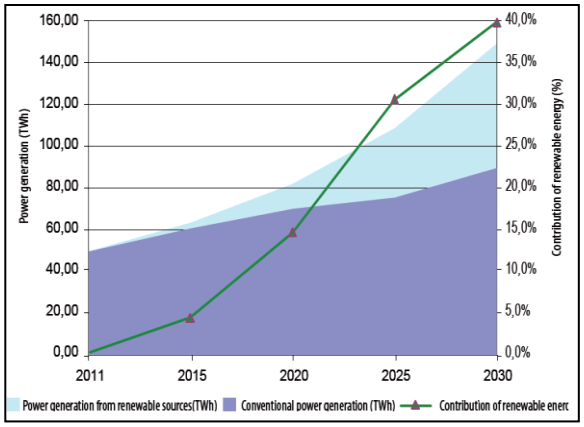


Fig. 6. Contribution of renewable energies for power generation in Algeria

The renewable energy program is defined through different phases:

- Installation of a total power capacity of 110 MW by 2013
- Installed power capacity to reach 650 MW by 2015
- Installed power capacity to reach about 2600 MW by 2020 and a possibility of export of 2000 MW
- An additional capacity of about 12000MW is expected to be installed by 2030 and a possibility of export up to 10 000 MW.

The program, by sector of energy production in Algeria, is summarized as follows:

4.2. Photovoltaic Energy

Photovoltaic solar energy refers to the energy recovered from sunlight and transformed directly into electricity through photovoltaic panels. It results from direct photon-to-electron conversion in a semiconductor. In addition to the advantages related to the fact that photovoltaic systems do need low cost maintenance, this energy fully meets the needs of facilities in remote areas where connection to the grid is too expensive. Photovoltaic solar energy is a non-polluting source of energy. The modularity of the photovoltaic solar system allows for innovative and aesthetic use of its components in architecture.

The energy strategy of Algeria is based on the acceleration of the development of solar energy. The government plans launching several solar photovoltaic projects with a total capacity of 800 MWp by 2020. Other projects with an annual capacity of 200 MWp are to be achieved over the 2021-2030 period.

4.3. Solar thermal energy

The direct solar radiation is concentrated by a collector on an absorber where it is transferred into a fluid that is either sprayed directly or drives the heat to a steam generator. All solar energy systems have a number of elements in common: a collector that concentrates the heat, a liquid or gas that transfers the heat to an extraction point, an evaporator, a turbine and a generator. More commonly known as « Concentrating Solar Power » (CSP) system, the solar thermal energy technology can meet demand in electricity 24 hours a day if it is coupled with a thermal storage system or if production is Renewable Energy and Energy Efficiency Program combined with other energies like natural gas.

Pilot projects for the construction of two solar power plants with storage of a total capacity of about 150 MW each, will be launched during the 2011-2013 period. These will be in addition to the hybrid power plant project of Hassi R'Mel with a total power capacity of 150 MW, including 25 MW in solar.

4.4. Wind energy

By definition, wind energy is the energy produced by wind. It is the result of the action of wind turbines, wind-driven electrical machines and whose function is to produce electricity. Blades pulled in rotation by the strength of the wind allow the mechanical or electric power production in any sufficiently windy site. The energy that the mill rotating pulls out of the wind drives the rotor which converts mechanical energy into electrical energy through a generator.

The amount of energy produced by a wind turbine depends primarily on the speed of wind but also on the area swept by the blades and the air density.

The first wind farm of a power of 10 MW in Adrar between 2014 and 2015, two wind farms with a capacity of 20 MW each are to be developed. Studies will be led to detect suitable sites to realize the other projects during the period 2016-2030 for a power of about 1 700 MW.

5. Algeria and North Africa are the Source Electric Power for Europe

In the subsequent year, the German Aerospace Center released a follow-up study, TRANS-CSP (DLR 2006), which investigates the HVDC transmission of CSP-generated solar electricity from North Africa to Europe in greater detail, the HVDC supply network is proposed for the transcontinental transfer of bulk electricity from renewable sources Fig.7.

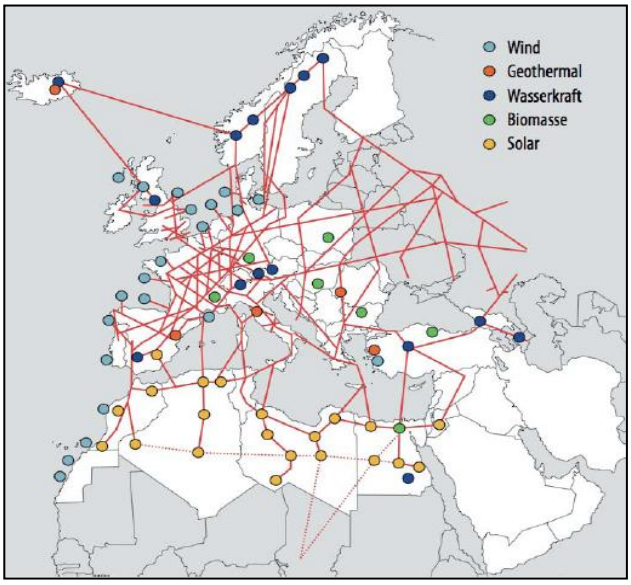
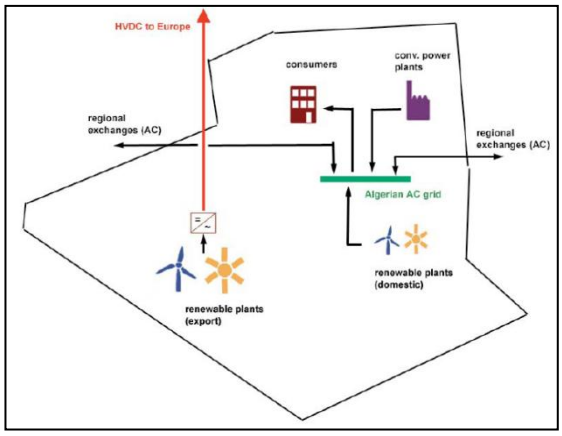


Fig. 7. HVDC backbone grid integrating different types of renewable energies [5]

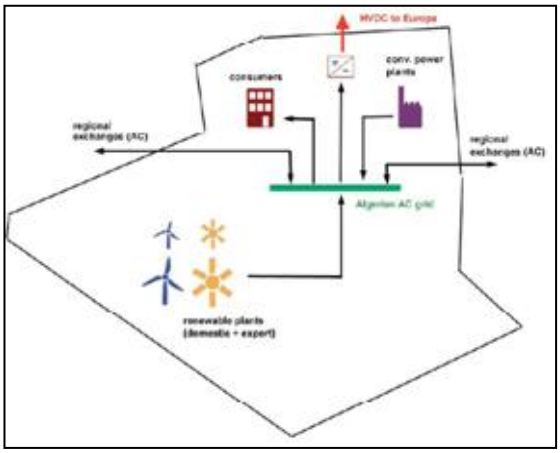
The study outlines a scenario in which MENA-based CSP plants would supply around 700 TWh/y of solar electricity to Europe by 2050, thereby covering more than 15 percent of the continent's electricity demand. 20 power lines of 5 GW capacity each would be needed for electricity transfer, requiring investments of €45 billion in addition to the €350 billion that would be needed for the CSP plants. For Algeria, one of the proposed 5 GW lines would start at Tindouf, and follow along a 3,100 km track to final destinations in France and Western Germany. *Desertec*. The study outlines a scenario in which MENA-based CSP plants would supply around 700 TWh/y of solar electricity to Europe by 2050, thereby covering more than 15 percent of the continent's electricity demand. 20 power lines of 5 GW capacity each would be needed for electricity transfer, requiring investments of €45 billion in addition to the €350 billion that would be needed for the CSP plants. The levelised electricity costs (including the transport) are estimated even lower than in the MED-CSP study.

The greatest energy resource technically available on the planet is available in desert areas around the equator. The DESERTEC concept was designed to deserts and technology for enhanced security in the field of energy, water and climate. For this purpose, Desertec proposes that Europe, the Middle East (Middle East) and North Africa (EU-MENA) begin to cooperate in the production of electricity and desalinated water using solar thermal energy concentration and wind turbines in the deserts of MENA.

These technologies can meet the increased demand for electricity and desalination of sea water in the MENA region, and produce clean electricity that can be exported by transmission lines high voltage direct current (HVDC or HVDC) with low losses to Europe (10-15%) Gerhard Knies's work led to the Desertec project, which aims by 2050 to produce 15% of the electricity consumed by Europe, via a large network of solar parks and wind across the Mediterranean, connecting continental Europe countries of North Africa and the Middle East (MENA English) by high-voltage cables. The total cost of this project is estimated at 400 billion Euros.



(a)



(b)

Fig. 8. First (a) and Second (b) Scenario for renewable energy exported by HVDC to Europe DESERTEC, [4]

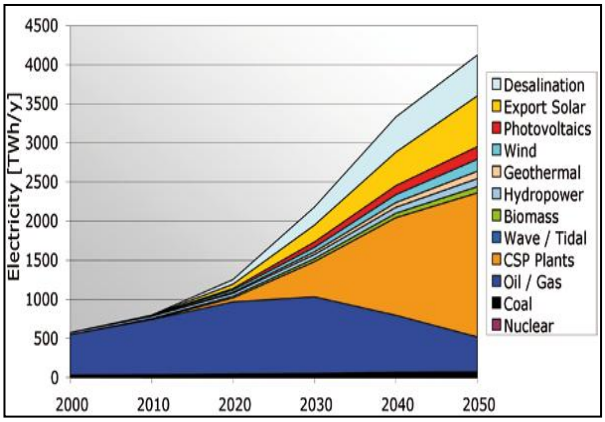


Fig. 9. Perspectives of Electricity generated for regional demand using the different forms of primary energy available in Algeria and MENA [10]

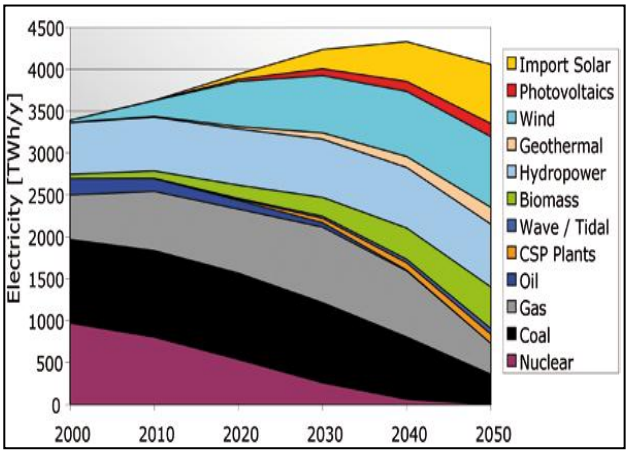
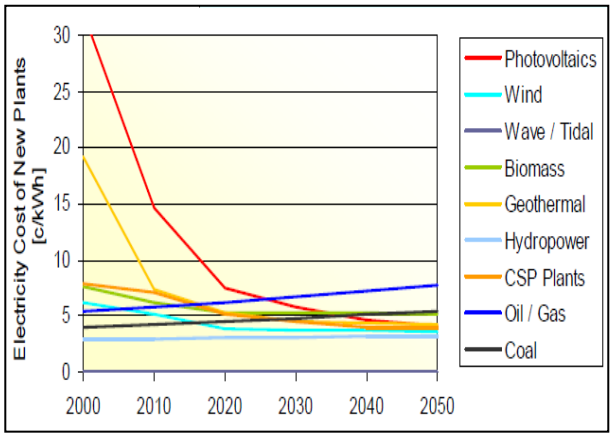


Fig. 10. Perspectives of Electricity generated for regional demand using the different forms of primary energy available in Europe [10]



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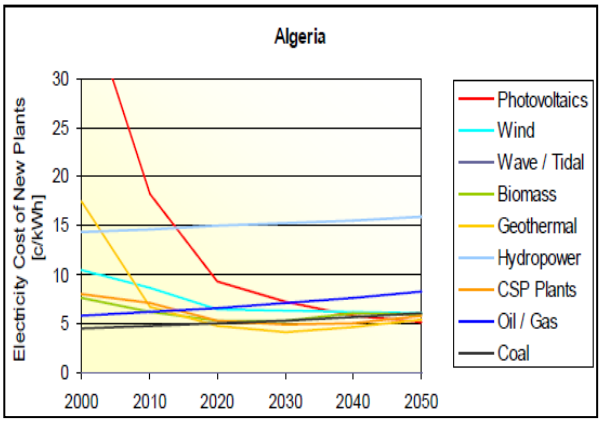

(b)

Fig. 11. Objective to accomplish in 2050 of average cost Electricity in EU-MENA (a) and in Algeria(b) DESERTEC strategy [11]

6. Conclusion

Taking advantage of this program of renewable energy development, Algeria:

- Place renewable energy at the heart of its energy and economic policies.
- Detach from the oil-gas resources.
- In positioning itself as a major actor in the production of electricity from solar photovoltaic and solar thermal energy which will drive a sustainable economic development.
- Consider this energy as a lever for economic and social development, particularly through the company of industries that create wealth and jobs .
- Is given the opportunity to sustain as an actor in the energy market.

Acknowledgements

We have pleasure to present our sincere thanks to all members of the organizing committee and the referees of 3rd NURER (The III. International Conference on Nuclear and Renewable Energy Resources will be held on the 20-23rd May 2012 in Istanbul, Turkey) who gave us the opportunity to present in very good conditions of this present paper and to select and publish it in IJRER.

Abbreviations

DLR:	German Aerospace Center
NERC:	National Energy Research Center
CNRST :	National center of scientific and technical research
NEAL:	New Energy Algeria
MED-CSP:	Concentrating Solar Power for the Mediterranean Region
TREC:	Trans-Mediterranean Renewable Energy Cooperation),
EU-MENA:	Europe, Middle East and North Africa
MEM :	Ministry of energies end mines
kWh:	kilowatt-hour (unit of energy)
HVDC:	High Voltage Direct Current transmission of Electricity

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