

Selection Strategy of Rational Zones for Installation of Photovoltaic Solar Panels in Algeria

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Abstract

This study concerns the preliminary phase of the project to installation solar panels in Algeria. The sites enjoy one of the most sunshine in the world, the Saharan region must be the spearhead in the development of energy which, moreover, with an abundant potential still under-exploited, photovoltaics constitute a formidable opportunity for the economic development of the region. In the perspective of a transition to "green energy" and in order to promote the emergence of solar energy in Algeria, a reflection on the development strategies of this energy must be combined with the strong challenges of the region, namely, the preservation of biodiversity, ecological continuities, as well as landscapes, the maintenance of agricultural land and forest areas and the fight against climate change. In this context, the contribution envisaged with this work is to contribute to the identification of a set of sites with high solar potential that can accommodate solar power plants.

Keywords: Renewable Energy, Photovoltaic, Zone, Strategy, Algeria.

Introduction

Recently, solar energy has proven to be one of the alternatives to our dependence on fossil fuels, this clean, inexhaustible energy provides ten thousand times more energy than that consumed by the entire world population Funk [1]. As a result, developing this sector remains a priority for many countries in order to achieve a sustainable development on these three dimensions: economic, social and environmental.

The rise of developing countries, as well as the increase in the world's population and the increase in average per capita income, leading to a steady increase in energy needs. Fossil fuels today maintain a dominant position in meeting energy demand, but poses environmental problems.

According to [2], renewable energy is particularly important, especially solar photovoltaics. In this scenario, renewable energy accounts for almost half of the increase in global electricity production until 2035 and intermittent sources, namely photovoltaic solar and wind, account for 45% of the growth of renewable energies. The energy context, focusing on the place of electricity from photovoltaic (PV) in the global energy mix, continues to grow rapidly. With about 38.4 GW of PV capacity installed in 2013 worldwide to reach a total PV capacity of 138.9 GW, as reported in the 2014 report of [3].

The market for solar power generation has been growing exponentially over the last decade. However, from an energy and

financial point of view, it is the amount of energy delivered, depending on the location and the implementation of the modules that matters. African countries have important untapped resources in the form of solar radiation energy that neither political leaders nor public opinion seem to be giving the interest that might be expected. It was indeed the "intertropical regions", and in particular Africa, that the pioneers of renewable energy focused on their innovations. These characteristics were, according to [4], the major assets. In return, they probably burdened the two great initial foundations of solar energy development: namely, on the one hand, the availability of energy source in these regions and, on the other, the project of solar energy economic and human development of these same regions.

Energy consumption is linked to economic development. It must be noted that, both in terms of production and in terms of consumption, Africa today remains, above all, a land in energy crisis representing a real obstacle to its development. With 14% of the world's population, Africa represents only 3. About 20% of global primary energy consumption [5]; Lucas et al.[6]. Although Algeria is a weak greenhouse gas emitter (United Nations Framework Convention on Climate Change in 2015), it has already made heavy investments to adapt to the effects of climate change and mitigation greenhouse gas (GHG).

As a result, the need for new energy sources around the world has become essential to reduce greenhouse gas (GHG) emissions

and limit temperature rise to 2°C by 2100 [7]. Several countries have begun to strengthen their energy transition policies aimed at adopting these clean and inexhaustible sources of a large part of the energy mix. In this regard, Algeria has embarked on the path of renewable energy by launching an ambitious programme to reach 22000 MW by 2030, 62% of which will be devoted to solar energy Ministry of Energy [8].

This strategic choice is motivated by the immense solar potential of the country. To reverse the trend, Algeria intends to focus on renewable energy. With a period of sunshine of 2000 to 3900 hours per year and daily radiation of 3000 to 6000 Wh / M² (equivalent to 10 times global consumption), Algeria has enormous renewable energy potential.

Solar energy thus appears to be the most available, the most efficient and the most competitive to develop. In this context, this energy could therefore be the social and economic lever for the country by participating in the creation of several jobs and wealth positions. In terms of solar energy, Algeria is very privileged. The country has a huge Saharan land mass and a small population, which is a considerable source.

Algeria is starting a green energy dynamic by launching an ambitious programme for renewable energy development and energy efficiency. This vision of the Algerian government is based on a strategy focused on the development of inexhaustible resources such as solar. The updated renewable energy programme consists of installing a renewable power of around 22,000 MW by 2030 for the domestic market, with the maintenance of the export option as a strategic objective, if market authorities permit. Large-scale projects to exploit renewable resources, particularly solar energy, are already underway; for example, the Solar Power Plant of Oued Nechou (20 km north of Ghardaïa) with a production capacity of 1.1 (MW) to generate solar electricity, and the Hansi R'Mel solar thermal power plant (100 km north of Ghardaïa) which uses CSP technology with a capacity of 150 (MW) which has been operational since July 2011 [9].

The use of renewable energy is imperative in the country like Algeria, which has a large solar field and a favourable climate for the development and expansion of the renewable energy sector, including the installation of photovoltaic systems. The development of the photovoltaic sector is one of the elements of energy policy and commitment to the sustainable development of our country.

In this way, our work revolves around the following: Firstly a characterization of the solar potential in Algeria and a brief overview on the legal, administrative and financial aspects necessary for the installation of photovoltaic panels.

Secondly, we will propose possible guidelines through a methodological approach to the choice of solar panel implementation strategy.

The Diagnosis of Energy Performance The Average Solar Deposit Available in Algeria

Algeria is the largest country in Africa since the 2, 381,741 km²

area of Sudan. The desert part (Sahara) covers more than 84% of the area, or about 2 million km². Due to its geographical location, Algeria is ranked as one of the best solar resource countries in the world and has a Mediterranean basin (Fig. 1); 169,000TWh/year for solar thermal, and 13.9 TWh/year for photovoltaic solar [10].

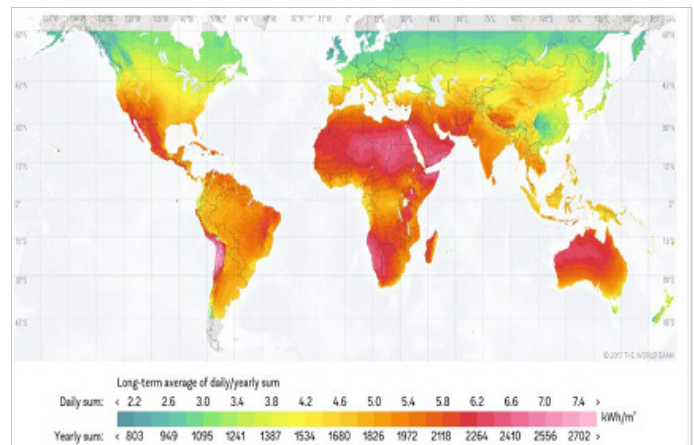


Figure 1: The Global Solar Atlas

Source: Department of Energy: <http://www.energy.gov.dz>, accessed September 12, 2018.

Algeria has a large solar deposit that exceeds 5 billion GW/h per year with a duration of sunstroke over almost the entire national territory exceeding 2000 hours annually and can reach 3900 hours in the highlands and in the Sahara [11] Figure. 2.

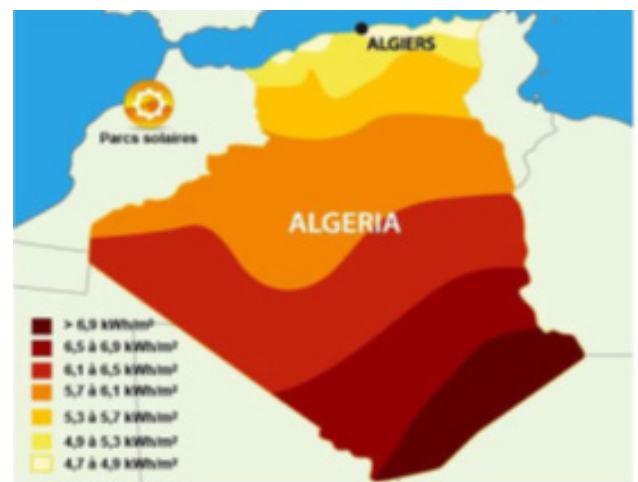


Figure 2: Variation of sunshine in Algeria (Ministry of Energy, 2018).

Source: Department of Energy: <http://www.energy.gov.dz>, accessed: September 12, 2018.

The energy received daily on a horizontal surface of 1m² is in the order of 5 kwh over most of the country, nearly 1700 kwh/m²/year in the north and 2263 kwh/m²/year in the south of the country ,Ministry of Energy [12].

Table 1 above shows that the largest solar potential, covering

86% of the territory, is located in the south of the country. Previous studies have already confirmed the great capacity of the desert to receive energy, including the study conducted by the German physicist Gérard Knies which shows that six hours of sunshine from the Sahara would store electricity for the entire human race for an entire year. Moreover, another study men-

tioned by an Algerian economist, Bachir Messaitfa, in his book Algeria 2030 “Prospective Vision”, ensures the ability of the Algerian South to meet the global demand for electric energy on average four times, while respecting the energy security standard.

Table 1: Solar potential in Algeria by region (Ministry of Energy, 2018).

Region	Coastal Regions	Highlands	Sahara
Area (%)	4	10	86
Average duration of sunshine (Hours/year)	2650	3000	3500
Average energy received (kwh/m ² /year)	1700	1900	2650

Regulation (Legislative Framework) and Financial Aid in Algeria

Once the strategic decision is made, appropriate policy means must be defined to achieve the objectives set. Political and legal instruments define how projects can take root in the territory. We distinguish between legal (legislative and regulatory) and financial policy instruments (tariff and incentive mechanisms) relating to the dissemination of projects:

The legislative framework is designed to encourage investment in renewable energy and energy efficiency, and to protect the environment. Law 99-09 of 2009, still in force, was the first to define the regulatory framework and the objectives of energy management policy. This law aims to rationalize endogenous energy consumption, promote electricity generation from ER sources (solar energy, geothermal and wind, hydropower) and combat greenhouse gas emissions in residential areas, with a view to preserving energy and public health; For Algeria, the promotion of RE (renewable energy) is the key factor in achieving sustainable development. In this context, Law 04-09 clearly defined the objectives to be achieved, to adopt the comprehensive strategy to promote renewable energy and energy efficiency. To achieve this, a set of practical measures was put in place Act 09-09 of 2009, such as the creation of the National Renewable Energy Fund (NFRE), and consecrate 0.5% of oil royalties to its financing. The government increased its financial stake to 1% of oil royalties. Similarly, Law 14-10 announced the closure of the National Energy Control Fund, with the transfer of its functions to the NFREC.

Later, Executive Order No.13-218 of 2013 adopted identified incentives to be taken to stimulate renewable electricity generation. For example, the government has committed to provide premiums for the costs of diversifying electricity generation from ER sources on the one hand and, on the other hand, to purchase all renewable electricity, produced by both the public and private companies, at a price higher than the total cost of production. Finally, in 2017, Executive Order 17-98 and Executive Order No. 17-204 were approved.

In order to achieve the INDC (Intended Nationally Determined Contribution) electricity target, the Algerian government updated the Algerian Renewable Energy and Energy Efficiency Development Plan in 2015, envisioning the installation of 22,000 MW of RE by 2030, 4525 MW should be installed by 2020,

with the rest during the 2021–30 periods. The main RE source to generate electricity is programmed to be photovoltaic. The share of the solar photovoltaic in RE electricity production should be at least 61.70% by 2030.

The Methodologies for Impact Assessment

The environmental impact assessment of the project was based on the identification and mapping of solar deposits and all constraints in the study area.

Technical Presentation of the Project

In order to consider development options, a number of technical criteria are to be studied in order to verify the feasibility conditions of the project. The implementation of a photovoltaic project can only be conceived through the analysis of its compatibility with the stakes of the territory that welcomes it. These, of various natures (technical, environmental, social), lead to the identification of criteria of acceptability.

Strategic choices must be made and take into account the main parameters for the installation and maintenance of photovoltaic generators. The areas have optimal technical characteristics for the installation of photovoltaic panels (sunshine, orientation, topography, accessibility, etc.).

Environmental and social impact assessments must also be carried out in the early stages of project planning, and action should be taken to mitigate potential adverse impacts.

Introduction to site selection

A searched site has a favourable local climate, a good solar resource (sunshine) and the absence of serious environmental or social concerns associated with the development of a PV project. The solar energy resource depends on the solar radiation of the geographic area, as well as local elements such as the presence of shadows. First, the assessment of the solar resource can be carried out from satellite data or It may be wise to use mapping tools the Geographic Information System (GIS) to facilitate the process of selecting a site, by assessing multiple constraints and determining the total area of suitable land available for the development of a solar PV project.

Site Selection Criteria

Reasons for Choosing the Project

Selecting an appropriate site is a crucial element in the develop-

ment of a viable solar PV project. In general, the site selection process must take into account the constraints and the impact that the site will have on the cost of the electricity generated.

The sites to house the different PV in the regions will be chosen, based on the following criteria:

-High potential for sunshine. However, the southern regions benefit from extremely favourable sunshine conditions and have vast open spaces that can accommodate large electricity generation capacity.

1. The land likely to host the photovoltaic solar power plant project. An accessible land, quite large and in one piece, easily amenable.
2. The installation of photovoltaic panels must meet the planning provisions applicable to the chosen site area in accordance with the planning regulations.

Impact of Climate Factors on the Electrical Performance of PV Modules

The external parameters that influence the behavior of modules that require the installation of outdoor platforms to take them into account. Module performance may differ due to weather factors such as low illumination, temperature, solar spectrum, radiation angle of impact, partial shading.

Climate Constraints

The weather events to consider are:

1. Flooding that can damage electrical equipment mounted on or near ground level. There is also an increased risk of erosion of the support structure and foundations, depending on geotechnical conditions.
2. Strong winds
3. Local industrial air pollution can reduce sunlight.
4. A sector that is not subject to extreme events

Topography

The terrain is a discriminating criterion for operators who favour flat areas to minimize development costs. Ideally, the site should be located on a flat area or a slight south-facing slope in the northern hemisphere or northward in the southern hemisphere. This topography makes the installation simpler and reduces the cost of the technical modifications necessary to adjust the installation to the ripples of the terrain. The topography causing technical constraints (areas for which the terrain was not compatible with the project's implementation were excluded: steep and/or north exposed areas).

In terms of the impact on topography and soils, it is minimized by an early reflection of the land to be developed, free of slope and geological characteristics compatible with the project. The constraint of the ground movements is taken into account.

Environmental and Social Considerations Impacts and measures on natural spaces

Biodiversity

The location of PV solar power plants leads to the destruction of existing habitats and disturbs the fauna and flora. Facilities should be located away from ecologically sensitive areas, such as protected areas, wetlands, natural forests and major wildlife

corridors. The impact on flora and fauna will involve creating shaded areas under rows of modules can have a beneficial effect for some species and hinder others. Biodiversity can occasionally be promoted, especially in arid regions, by contributing to water retention in the surface parts of the soil when it is in the shade. Ideally, PV solar power plants should be built on open or sterile sites (such as deserts or semi-desert areas).

Currently, the project grounds are clearly marked by human activity. The project will lead to the transformation of agricultural land into a much more developed but relatively quiet area. No protected or inventoried natural area is affected by the installation of photovoltaic panels.

Environmental and Social Issues

The area must be well adapted to the implementation of solar projects, and all the proposed areas are usable for the definition of projects. The sites are located on unoccupied and unused land, relatively far from the dwellings. The areas likely to receive the photovoltaic modules, the main issues to be taken into account in the project definition are:

1. The presence of water basins that should be conserved as much as possible to limit and collect the effects of storm water runoff at the site.
2. These conditions allow rainwater to fall on all the land and run freely. The risk of groundwater pollution is minimized by the choice of site and the very characteristics of the project.
3. The site's hunting reserve status, hence a hunting ban,
4. The need to improve access roads to the site (stability, quality, slope, turns).

Landscape and Heritage

The open installation area, characterized by the absence of natural physical barriers, located on a flat area. The site is far from the dwellings, which will greatly limit the impacts and potential nuisances. It is not very frequented for pastoral activity. No historical or archaeological heritage is recorded approximately the site. Avoiding impacts on cultural heritage, sites should be selected as to avoid proximity to inhabited areas, to avoid affecting cultural heritage (such as cemeteries, sacred sites) and avoid or minimize negative impacts on agricultural land.

Geotechnical Considerations

It is recommended that a geotechnical study of the site be carried out before the final selection. Its objective is to assess soil conditions in order to inform the design approach and the right of way to ensure that the foundations of the support structures are well designed. Potential impacts on the soil are:

1. Soil waterproofing: At the site level, geology and local geotechnical features must be conducive to the installation of solar field structures.
2. Land movements: Slide, fall of blocs, Landslide, Collapse; nevertheless, the project's implementation area must be outside the risk areas.

Module Sullyng

Another parameter to take into account when predicting a PV project is the influence of dirt or dust deposits on PV modules

that obscure incident light and thus decrease the production of PV modules. As highlighted [13] that trace the evolution of studies conducted on the analysis of losses of PV modules due to dirt deposits. Another study conducted in Phoenix [14] shows that the cleanliness of a PV module can become economically attractive, that it can recover 1% of its power when it rains, and that dirt deposition effects are greater when the angle of radiation incidence increases.

The efficiency of the solar installation could be greatly reduced if the modules are covered with particles and dust. The criteria to be considered should include local weather, environment, human and wildlife factors to determine the relevance of a site for a solar PV installation. The soiling of the modules will require maintenance and cleaning plan.

Water Availability

The water is an indispensable commodity for cleaning the modules. A main supply of water, groundwater, stored water or access to a portable water tank may be required; In arid environments near communities, attention should be paid to local people's dependence on present groundwater and the impact (if any) of proposed groundwater extraction on local water sources. This is particularly important when there are several solar developments nearby, namely when there may be cumulative effects on water availability that could negatively affect local populations.

Socio-Economic Impact of Solar Energy Projects

Solar technologies have many economic advantages. First, solar radiation is completely free. One of the main advantages of photovoltaic solar panels is their flexibility. They can be installed almost anywhere and generate electricity where the demand is. Owners of solar installations are therefore protected from increases in electricity, biogas or biomass (wood or pellet) tariffs. The economic impact of the solar photovoltaic plant project in Algeria is determined by the main factors, namely:

1. The creation of tens of thousands of direct and indirect jobs.
2. Participation in improving the quality of life through the coverage of national electricity demand.
3. Reducing poverty

The best way to properly integrate these projects into the environment is to have a territorial-scale approach that allows the best matchings between local energy resources and the needs of the territory, while ensuring the participation of local actors.

The Development of an Impact Grid Assessment

To assess and analyze the perceived level of risk prior to the choice of the implementation strategy for each case studied one of the methods proposed by the matrix of [15] to shed light on the role of contextual specificities.

This grid allows establishing the sensitivities of the territory concerned by the impact of the project according to all the factors identified as follows:

1. The technical factors relate to the conditions of installation of solar power plants, depending on the proximity of the connection network and the terrain.

2. Geological and hydrogeological factors aggregate the territory's vulnerabilities in terms of natural hazards and water protection.
3. Factors related to urban planning, landscape and heritage.
4. Factors related to the preservation of biodiversity, protected or preserved spaces.

Conclusion

Algeria is a country that enjoys a relatively enviable position in terms of energy therefore has enormous renewable energy potential. In this respect, solar radiation is an alternative energy source that is experiencing a real revolution around the world since it has many advantages. One of the goals of photovoltaic solar is to reduce the demand for fossil fuels in order to reduce greenhouse gas emissions. In addition, solar radiation is a form of energy that is complementary to electricity. The energy management strategy should be implemented should strengthen the role of solar radiation as a tool in achieving energy efficiency targets and alternative energy production. The effects would be positive both on the region's economy and on the reduction of air pollution on a continental scale. The great-uncharted potential of solar energy is therefore an exceptional opportunity for Algeria. This energy is abundant, free and renewable.

The energy transition to a green model based on the transition from the current energy system using non-renewable resources to an energy mix based on renewable resources. This transition necessarily involves diversifying energy sources through the promotion of an "energy mix" and the exploitation of primary energies. These energies constitute a saving wealth for many regions in loss of attractiveness, especially in pre-Saharan and Saharan areas. The growth of its exploitation would have positive effects on the environment, the economy and the social, while respecting and supporting the application of the principles of sustainable development.

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