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Research Article

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Solar Energy in Tunisia: Literature Review

Chtioui S.[1], Ben Mariem S.[2*]

[1]Faculty of science of Tunis, University of Tunis El Manar, Tunis 2092, Tunisia
[2*]National research Institute of rural engineering, Water and Forests (INRGREF), University of Carthage, Ariana 2080, Tunisia

Abstract: Solar energy holds immense potential for Tunisia, a country blessed with abundant sunshine. With an average of over 3,000 hours of sunlight annually, Tunisia is ideally positioned to harness solar power to meet its energy demands sustainably. The importance of solar energy in Tunisia lies in its ability to address energy security, promote economic development, and combat climate change. Solar energy also contributes to Tunisia's economic development. Expanding the solar energy sector creates job opportunities in manufacturing, installation, maintenance, and research. It attracts foreign investments, particularly in large-scale solar projects like photovoltaic (PV) farms and concentrated solar power (CSP) plants. Additionally, solar energy reduces electricity costs in the long run, benefiting households and businesses alike.

Keywords: Solar Energy, Tunisia

1. Introduction

Water has always been an essential human need. Without water, no organism, whether plant or animal, can live. Indeed, the first concern of any community has always been to find easy access to this resource and to provide the energy needed to pump it [1]. The muscular energy of man or draught animals has been used since ancient times to raise and distribute water. In most cases, however, these techniques are extremely expensive because of their low efficiency [2].

With the industrial revolution, diesel or electric motors are likely to be used more and more in the longer term. But with the rise in oil and electricity prices, it has become necessary to develop other sources of energy, to power irrigation pumps that are less dependent on petroleum products or electricity [3]. Today, renewable energies have become one of the main resources for producing electricity [4].

This literature review describes the basic concepts of solar energy and the production of electricity using the photovoltaic effect in the case of Tunisia. The main elements of the photovoltaic system are studied and an overview of the different types of photovoltaic systems is given. The various fields of application of solar energy are then presented, with particular emphasis on photovoltaic water pumping for crop irrigation.

2. The Sun: Source of Energy

Energy from the Sun accounts for almost all the energy available on Earth. In addition to its direct contribution in the form of light and heat, it is the source of biomass (photosynthesis), the water cycle, winds, ocean currents and, in the form stored for millions of years, our gas, oil and coal reserves [5].

The Sun emits electromagnetic radiation in a wavelength range from 0.22 to 10 microns (µm). Figure 1 shows the variation in spectral energy distribution. The energy associated with this solar radiation breaks down roughly as follows:

- 9% in the ultraviolet band (<0.4 µm),
- 47% in the visible band (0.4 to 0.8 µm),
- 44% in the infrared band (>0.8 µm).

The Earth's atmosphere receives this radiation at an average power of 1.37 kilowatts per square metre (kW/m²), plus or minus 3%, depending on whether the Earth is moving away from or towards the Sun as it rotates around it. However, the atmosphere absorbs some of it, so the amount of energy reaching the Earth's surface rarely exceeds 1.2kW/m^2 (1200W/m²). The Earth's rotation and tilt also means that the energy available at a given point varies according to latitude, time of day and season. Finally, clouds, fog, atmospheric particles and various other meteorological phenomena cause hourly and daily variations that sometimes increase and sometimes decrease solar radiation, making it diffuse [6].

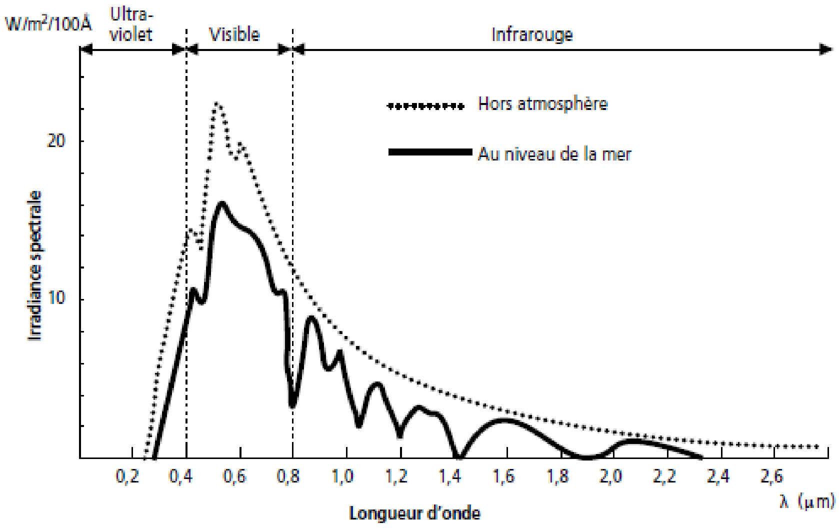

Figure 1: Spectral analysis of solar radiation

Solar radiation (G) is the intensity of solar radiation received on a plane at a given time. It is usually expressed in watts per square metre (W/m²), and varies from zero, at sunrise, to its maximum value, typically at solar noon [7].

Solar radiation can also be expressed as the amount of solar energy captured on a plane during a given interval. It is usually expressed in kilowatt hours per square metre (kWh/m²), in 'maximum hours of sunshine'.

Daily sunshine values are usually presented as monthly averages for different latitudes and inclinations at specific locations (to reflect the effect of different weather conditions). Sunshine is most often expressed in terms of 'maximum hours of sunshine', i.e. the equivalent number of hours per day when illuminance averages 1000W/m² [8].

The hours of maximum sunlight are a useful index for sizing photovoltaic systems.

There are four types of radiation:

• Direct radiation is the radiation received directly from the Sun. It can be measured using a pyrheliometer.

• Diffuse radiation is due to the absorption and diffusion of part of the sun's rays by the atmosphere and their reflection by clouds. It can be measured by a pyranometer.

• Reflected solar radiation or ground albedo is the radiation reflected by the ground or by objects on its surface. This albedo can be high when the ground is particularly reflective (water, snow).

• Global radiation is the sum of all radiation received, including radiation reflected by the ground and objects on its surface.

The majority of the world's population lives in areas where the level of solar irradiation is between 150 and 300 W/m2, or 3.5 to 7.0 kWh/m2 per day.

The average distribution of solar energy received at ground level on Earth is shown in Figure 2.

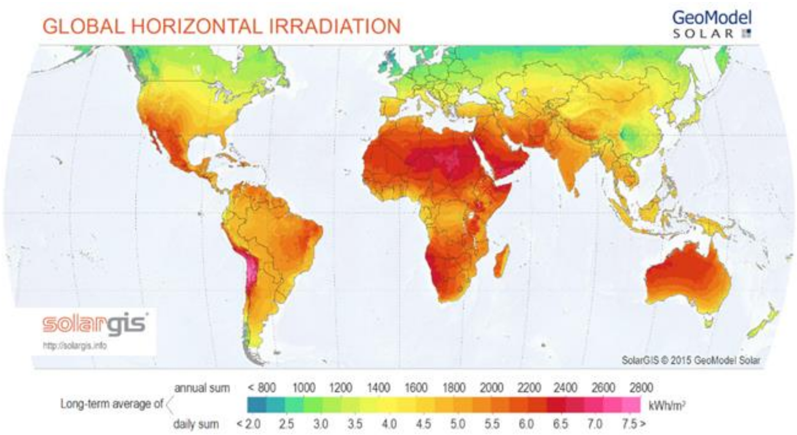

Figure 2: Average distribution of global solar irradiation.
(Image: SolarGIS © 2016 GeoModel Solar/Creative Commons)

3. Solar Energy in Tunisia

Solar energy has great potential on the African continent. On average, Tunisia has solar resources of over 3,000 hours/year, with some regions enjoying more sunshine than others. Most regions in the south of the country have more than 3,200 hours of sunshine a year, with peaks of 3,400 hours a year in the Gulf of Gabès (south-east). On the other hand, the minimum insolation period in the northern regions is between 2,500 and 3,000 equivalent hours of full sun. Solar irradiation varies from 1,800 Kilowatt-hours (kWh)/m²/year in the north to 2,600 kWh/m²/year in the south [9].

The distribution of solar irradiation and solar electricity potential by region in Tunisia is shown on the map in Figure 3.

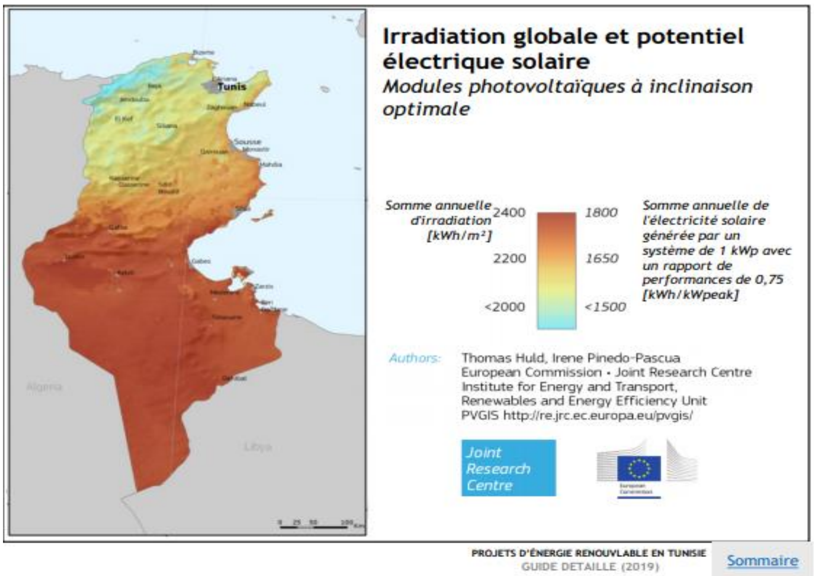

Figure 3: Sunshine rate and solar electricity potential by region in Tunisia

Despite the importance of these resources, the exploitation of solar energy remains limited in Tunisia and has so far concentrated on relatively small (kW) residential installations. Medium-sized (up to 1 MW) and large-scale (1 MW and more) solar PV plants have not yet been installed.

In 2010, the Tunisian government set up the Prosol-Elecprogramme to support the development of LV grid-connected solar PV in the residential sector. By the end of 2018, the programme had enabled the installation of around 22,000 solar installations with a total capacity of around 55 MWp as part of self-consumption projects (Figure 4).

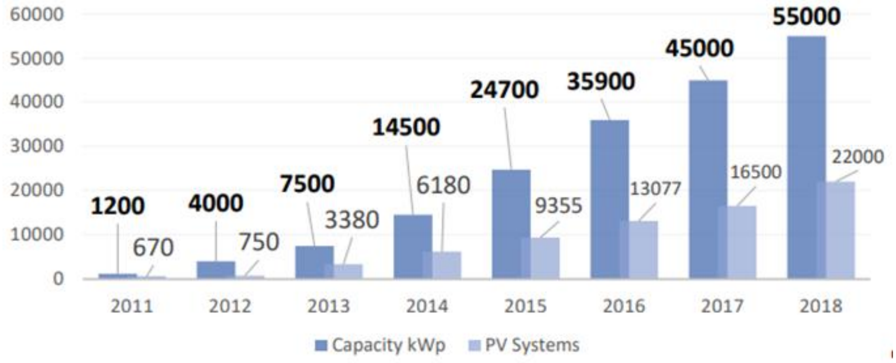

Figure 4: Capacities installed as part of solar PV self-consumption projects (Parasol-Elecprogramme) (Renewable energy projects in Tunisia detailed guide version May 2019)

The applications for energy obtained from photovoltaic generators are extremely varied. We have some solar energy infrastructures, but they are not up to the task.

- Achievements in the field of solar electrification

The very first photovoltaic installation, at HammamBiadha (Siliana governorate), dates back to 1980, with a capacity of 30kWp. Subsequently, a 2MWp photovoltaic park was created to electrify certain rural areas. The Tunisian government is encouraging investment in the photovoltaic sector by covering 30% of the investment costs. In addition, STEG buys the surplus electricity produced.

Currently, the British group NurEnergie (Figure 5) is planning to build the 4.5 GW TuNur solar power project in the governorate of Kebili, an integrated solar energy project linking Tunisia's sunny desert to European electricity markets.

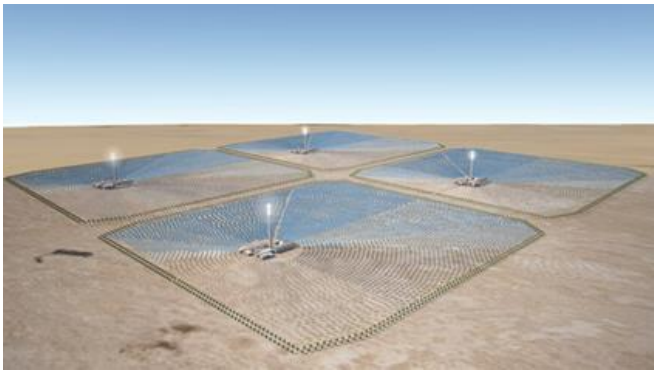

Figure 5: TuNur, a solar power plant project in the Tunisian desert

- Using solar energy to desalinate water

Water desalination using solar energy can be seen as a highly attractive alternative for producing drinking water. Within the framework of cooperation with the Japanese government, the project to desalinate brackish water using photovoltaic energy in Ben Guerdane has been selected at a cost of 20 million DT. The project involves the construction of a desalination plant with a capacity of 1800 m3/d, using energy from photovoltaic cells (200 Kwc).

As part of the drive to improve the living conditions of the rural population, the project to build 45 desalination plants with a combined capacity of 200m3/d in the governorates of Medenine, Tataouine and Kebili is planned by the National Energy Management Agency in collaboration with the Ministry of Agriculture, Water Resources and Fisheries.

- Using solar energy to pump water

Tunisia has been using this type of technology since the end of the 1970s (HendiZitoun photovoltaic pump at the CRGR), following the 1st oil crisis. The HammamBiadha solar village experiment also used this type of pumping, but without much success.

With the creation of ANME, various experiments and pilot installations were carried out, often as part of technical cooperation initiatives, particularly with Germany. These installations are often intended for human and animal drinking water consumption. These include:

- The project to install a photovoltaic pump in Douz (Kebili governorate) as part of Spanish cooperation, with an installed power of 4.5 kW for a flow rate of 20 m3/d and a HMT of 165 m; the cost of the installation is 80,000 TD.
- The project to install 14 photovoltaic pumps with GTZ (Germany) in the governorates of Kairouan (7), Tataouine (3), Mednine (2) and Kebili (2).
- The power installed is a few kW (from 1.2 to 3.5 kW), the flow rate is a few m3/d (from 7m3/d to 35m3/d) and the HMT is a few dozen metres (from 26 m to 165 m). The cost of the installations varies from 15,000 DT to 45,000 DT.
- The MEDA project to install 13 photovoltaic pumps with the EEC in the governorates of Kebili (2), Gabès (3), Mednine (2), Tataouine (2) and Siliana (4). The power installed is a few kWp (from 1.6 to 8.5 kW), the flow is a few m3/d (from 6 m3/d to 50m3/d) and the HMT is a few tens of metres (from 20.5m to 254 m).

4. Conclusion

The applications of solar energy in Tunisia are diverse. Solar PV systems are increasingly installed in residential, commercial, and industrial settings to generate electricity. Large-scale solar farms, such as the Tozeur photovoltaic plant, feed into the national grid, enhancing energy availability[10]. Solar water heating systems are popular in households and hotels, reducing reliance on conventional energy sources. Moreover, off-grid solar solutions provide electricity to remote areas, improving rural livelihoods and access to essential services.Solar energy is vital for Tunisia's energy future. It offers a sustainable, cost-effective solution to energy challenges, fosters economic growth, and supports environmental preservation. By capitalizing on its solar potential, Tunisia can pave the way for a greener and more resilient energy landscape.

References

[1]. Ingrao, C., Strippoli, R., Lagioia, G. &Huisingh, D. (2023). Water scarcity in agriculture: An overview of causes, impacts and approaches for reducing the risks. Heliyon 9, e18507.

[2]. Wang, J. &Azam, W. (2024). Natural resource scarcity, fossil fuel energy consumption, and total greenhouse gas emissions in top emitting countries. Geoscience Frontiers 15, 101757.

[3]. Majeed, Y., Khan, M.U., Waseem, M., Zahid, U., Mahmood, F., Majeed, F., Sultan, M. &Raza, A. (2023). Renewable energy as an alternative source for energy management in agriculture. Energy Reports 10, 344–359.

[4]. Ang, T.-Z., Salem, M., Kamarol, M., Das, H.S., Nazari, M.A. &Prabaharan, N. (2022). A comprehensive study of renewable energy sources: Classifications, challenges and suggestions. Energy Strategy Reviews 43, 100939.

[5]. Akram, M.W. &Hasanuzzaman, M. (2022). Chapter 1 - Fundamentals of thermal energy and solar system integration, in: Hasanuzzaman, M. (Ed.), Technologies for Solar Thermal Energy. Academic Press, pp. 1–24.

[6]. Mridha, R.H. &Hasanuzzaman, M. (2022). Chapter 3 - Heat exchanger for solar thermal energy, in: Hasanuzzaman, M. (Ed.), Technologies for Solar Thermal Energy. Academic Press, pp. 55–91.

[7]. AlamEmon, Md.S.&Ahmad, M.U., Hasanuzzaman, M. (2022). Chapter 2 - Solar thermal energy conversion, in: Hasanuzzaman, M. (Ed.), Technologies for Solar Thermal Energy. Academic Press, pp. 25–54.

[8]. Al Tanjil, H. &Hasanuzzaman, M. (2022). Chapter 11 - Environmental impact assessment of solar thermal energy, in: Hasanuzzaman, M. (Ed.), Technologies for Solar Thermal Energy. Academic Press, pp. 323–360.

[9]. Saidi, L. &Fnaiech, F. (2014). Experiences in renewable energy and energy efficiency in Tunisia: Case study of a developing country. Renewable and Sustainable Energy Reviews 32, 729–738.

[10]. Rekik, S. & El Alimi, S. (2024). A GIS based MCDM modelling approach for evaluating large-scale solar PV installation in Tunisia. Energy Reports 11, 580–596.