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PV Energy Generation Assessment based Si-crystalline and CIS Technologies under Algerian Climatic Conditions

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Abstract – *As in the whole world, renewable energies in Algeria, including photovoltaic energy, are attracting more and more attention in recent years. The integration of distributed generation (DG) into the power grid using renewable energy sources, such as PV, FC and wind, has important advantages such as low distribution losses, better continuity and power quality, and high system reliability. This paper is about a simulation study to analyze the energy assessment of a grid-connected photovoltaic system (GCPVS). The system with 1 MW capacity is simulated and analyzed based on solar resource, tilt and azimuth angles for each area and using Si-crystalline and CIS technologies under different weathers conditions in Algeria (Algiers, Chlef, Tlemcen, Tamanrasset and El Oued). The system configuration is simulated using the new version of PVGIS to account for PV plant energy output assessment. The obtained simulation results were discussed as per monthly and yearly values based on PV cell technologies and optimized tilt and azimuth angle.*

Keywords: *Solar energy, PV energy assessment, PV grid-connected, PV cells Technologies, PVGIS tool*.

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I. Introduction

Today, power systems based renewable energy (PSRE) are becoming increasingly popular due to the increasing demand for energy and concerns about greenhouse gas (GHG) emissions that will cause environmental problems, i.e. global warming and climate change [1].

The demand for electricity increases due to population growth and industrialization, renewable energy sources are being used more and more, while fossil fuel sources are decreasing [2]. Algeria is promoting the renewable energy program to minimize greenhouse gas emissions and protect its fossil fuel resources, like many other nations around the world and due to the energetic setting characterized by the progressive depletion of fossil fuels and global warming. In order to achieve this, the Ministry of Energy and Mines introduced an extensive renewable energy initiative in 2011 [3]. This program is mainly based on photovoltaic solar energy. The target to be reached by 2030 is that about 40% of the electricity generation for domestic consumption comes from renewable energy sources (RES).

Over the past decades, solar PV has grown steadily at about 40% per year through its use in grid-connected PV power plant [4]. Due to its vast accessibility, solar energy is one of the most promising renewable energy sources. The annual installed capacity of solar PV rose by at least 50% to at least 75 GW in 2016, bringing the total installed capacity to 303 GW globally [5]. Because the technological advances have drastically reduced the cost of solar photovoltaic modules, by about 80% between the years 2008 and 2015 [6]. The conversion of solar energy into other useful energy can be achieved by many techniques [7]. One of them, the solar photovoltaic system, is used to produce electricity based on the photovoltaic effect. The solar PV system can be used in two ways, for isolated application and/or grid connected mode [8,9]. Most recently installed solar systems nowadays are wired into the utility grid [10].

In 2020, the world's cumulative solar PV capacity was 773.2 Giga-watts, with 138 Giga-watts of new PV capacity installed that year [11]. The statistical data show that PV systems are now developing in three main categories: - Small photovoltaic systems (1-5 kW) used in residential application and private homes. - Medium PV systems used in industrial, commercial, and office buildings (usually 10-250 kW). - Centralized PV power plants or large-scale grid connected system ranging (100 kW up to 5 MW). The large-scale grid connected PV systems with the rated capacity ranging from 1 MWp to hundreds of megawatts or even more are generally connected to the utility grid on the medium (20 kV/35 kV) or high-voltage side (110 kV). The primary purposes of renewable energy resources integration are environmental advantages using free sources of energy. As well, in order to remove the necessity of high-voltage transmission lines, they can be used close to the consumption centers. Also, because distribution lines cause significant losses, distributed generation (DG) come with some advantages like: better power quality, low distribution losses and high system reliability [2,10].

In this study, we provide the evaluation and the performance assessment of a mega scale grid connected PV system for some areas in Algeria which is Algiers, Tamanrasset, Chlef, Tlemcen and El Oued

II. Renewable Energy Statue in Algeria

As mentioned in the introduction section, the Algerian government is now seeking to reduce the economy's dependence on hydrocarbons, which account for 98% of the country's currency income [12].

Table 1. Solar potential in Algeria

Areas	Coastal	High plains	Sahara
Surface (%)	4	10	86
Area (km^2)	95.270	238.174	2,048,279
Mean daily sunshine duration (h)	7.26	8.22	9.59
Average duration (h/y)	2650	3000	3500
Average energy ($kWh/m^2/y$)	1700	1900	2650
Solar daily energy density (kWh/m^2)	4.66	5.21	7.26
Potential daily energy (TWh)	443.96	1240.89	14,780.63

Due to Algeria's year-round abundance of sunshine, particularly in the Sahara (total potential daily energy of 16,555.48 TWh). According to the World Energy Council (WEC) [13] and other sources and as indicated in Table 1, the climate in Algeria is conducive to the growth of renewable energies, particularly solar energy [14–18]. To meet the aim of 40% of power generation by 2030, as indicated in Figure 1, the overall percentage of renewable energies RE, which are growing more and more important, is anticipated to increase annually [19]. From the year 2011 to 2030, the programmer of energy production is summarized in Figure 2.

Assessing and prediction the possible energy production from PV power plant is an important criteria which has to be focused in this study. The purpose of this work is to provide a general overview of the feasibility and production of photovoltaic systems in some regions of Algeria, which can help the government, researchers and energy investors to make decisions for the exploitation and utilization of photovoltaic systems for the electricity generation.

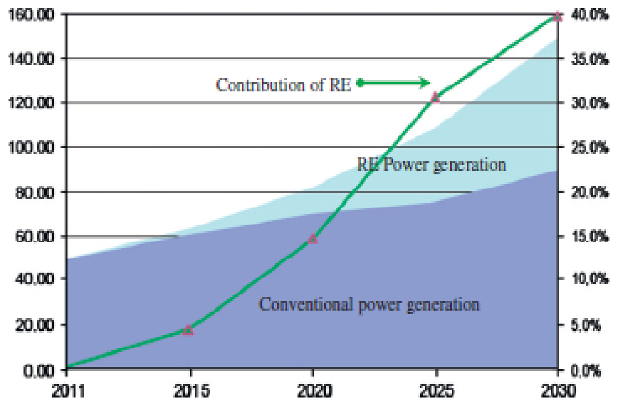


Figure 1. Contribution of RE for power generation

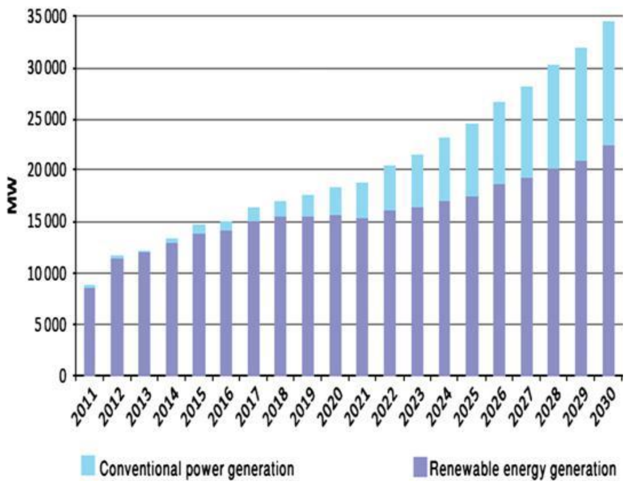


Figure 2. Structure of the national power generation in MW [19]

III. Proposed Case Study

This study provides the evaluation and the performance assessment of a mega scale grid connected PV system for some areas in Algeria which is Algiers, Tamanrasset, Chlef, Tlemcen and El Oued. Author in [20] used the monthly average clearness index parameter to define the different climatic zones as shown in Figure 3. Four zones are for different climatic conditions in Algeria which are bound in the following limits [21].

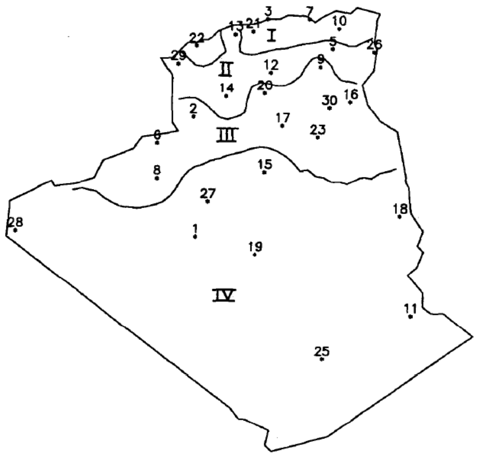


Figure 3. Algerian climatic regions classification [22]

Zone I : $K_{tm} \leq 0.548$

Zone II : $0.548 < K_{tm} \leq 0.609$

Zone III : $0.609 < K_{tm} \leq 0.671$

Zone IV : $K_{tm} > 0.671$

Where; K_{tm} is the monthly average clearness index.

The geographical data and the distribution of climatic zones for the five selected sites located in Algeria are presented in the Table 2. As can be seen in this table, the selected locations are distributed over various latitudes and have different climatic conditions. Figure 4 shows the locations of five selected areas in Algeria.

Table 2. Geographical data and climatic zones for the selected sites [21,23]

Name of site	Lati (°)	Long (°)	L. a. m (m)	Climatic zones
Algiers	36.3	3.15 E	25	I
Tlemcen	34.5	1.19 E	810	II
Chlef	36.08	1.17 E	112	II
El Oued	33.21	6.5 E	84	III
Tamanrasset	22.4	5.31 E	1378	IV

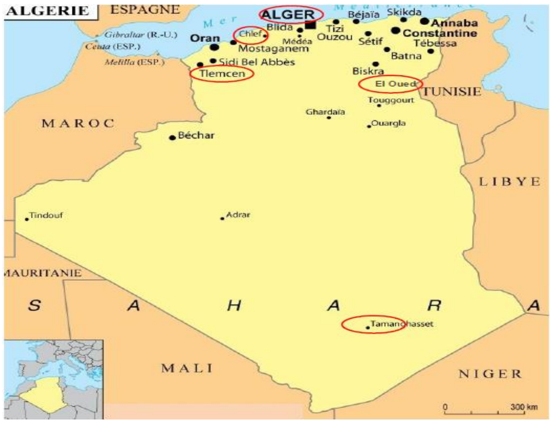


Figure 4. Sites locations in Algeria maps

III.1. PV Grid Connected System

Figure 5 shows the schematic view of the components of a grid connected photovoltaic system, consisting of PV modules, a DC/AC converter, and the electrical grid [24]. The photovoltaic effect is a physical phenomenon specific to certain materials called semiconductors that generate electricity when exposed to the sunlight. These PV materials include several types of solar PV cells such as Cadmium Telluride (CdTe) or copper-indium gallium-selenide (CIGS)), thin films (amorphous silicon (a-Si), and crystalline silicon (mono-crystalline and polycrystalline) [25].

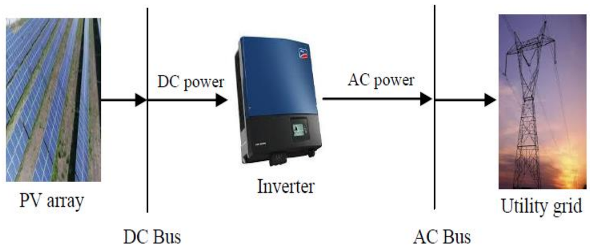


Figure 5. PV Grid connected system scheme

In this paper, a grid connected PV system based on Si-crystalline and CIS technologies is simulated and the results are discussed and analyzed. The available solar radiation and ambient temperature of the location have major impact on the output power of the PV array. Where the PV array output has a directly proportional relationship with the solar irradiation and inverse proportional relationship with the ambient temperature.

Equation (1) shows the array's instantaneous output power [26,27].

$$P_{pv}(t) = P_{peak}\left(\frac{G(t)}{G_{St}}\right) - \alpha_T\left[T_c(t) - T_{St}\right] \times \eta_{inv} \times \eta_{wire} \quad (1)$$

Where; the standard testing conditions of solar radiation and ambient temperature are displayed as G_{St} and T_{St}, respectively. P_{peak} is the rated power of PV array, Tc and T_{St} are the temperature of the PV cell and the temperature of the PV solar cell under standard test conditions (25 °C), respectively [28].

T_c represents the temperature of the PV cell, which can be calculate from equation (2).

$$T_c(t) - T_{ambient} = \frac{T_{standard}}{800} G(t) \quad (2)$$

$$E_{dc,d} = \sum_{t=1}^{t=T_{rp}} V_{dc} \times I_{dc} \times T_r \quad (3)$$

Where; Tr is the recording time interval, Trp is the reporting period, and N is the number of operating days of plant in a month. The monthly DC energy generated by the PV system is given by equation (4).

$$E_{dc,m} = \sum_{d=1}^{N} E_{dc,d} \quad (4)$$

The total daily AC energy generated by the PV system (E_{ac}) which is fed into the utility grid is given by equation (5).

$$E_{ac,d} = \sum_{t=1}^{t=T_{rp}} V_{ac} \times I_{ac} \times T_r \quad (5)$$

The monthly AC energy generated by the PV system is given by equation (6).

$$E_{ac,m} = \sum_{d=1}^{N} E_{ac,d} \quad (6)$$

The inverter efficiency is given by equation (7).

$$\eta_{inv} = \frac{P_{ac}}{P_{dc}} \quad (7)$$

Where; P_{ac} and P_{dc} are respectively the power output delivered by the inverters and power output delivered by the photovoltaic modules [29].

III.2. Simulation Procedure

Computer based simulation were more advanced and useful tools for hybrid renewable power systems analysis and the operation performance assessment under varying climates and capacities [30,31]. Based on the literature review, the authors conducted studies for the performance analysis of photovoltaic systems for different sites worldwide by using various available simulation tools as well as through experimental analysis. Several commercial software tools are available to study both grid-connected and off-grid renewable energy systems, as well as hybrid energy systems. As: HOMER, System Advisor Model (SAM), PVSYST, RETscreen, Solar Pro, PVWATT, and PVGIS, this last one is used in this paper [32].

Photovoltaic Geographic Information System (PVGIS), a simulation tool from the European Commission, is adopted in this paper for the assessment study of the proposed 1 MW photovoltaic grid connected power plant. PVGIS, is one of the main and most used tools for solar irradiation estimation, PV energy production and economic parameters analysis.

This software allows the calculation of monthly and annual electricity production for grid connected photovoltaic systems and isolated sites in Africa, Europe and now in America and Asia. Figure 6 shows the screen shot of the PVGIS software.

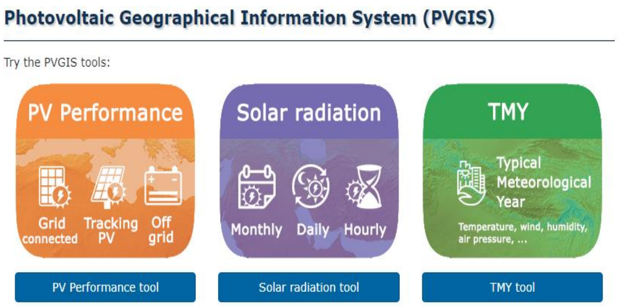


Figure 6. PVGIS software interface

The PVGIS simulation methodology adopted for the performance analysis of the proposed system is shown as in Figure 7.

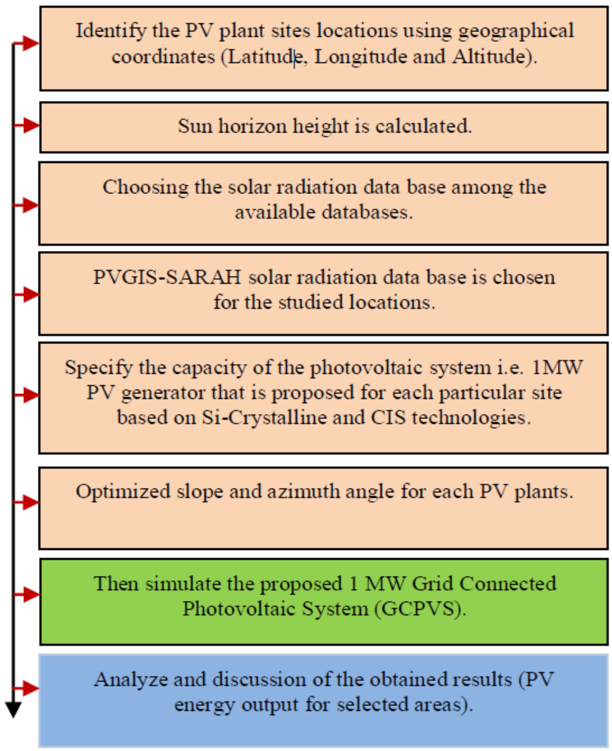


Figure 7. Simulation methodology of 1MW grid connected PV system

IV. Results and Discussions

The simulation results and performance analysis of the studied 1 MW grid connected PV system were presented taking into account the monthly and annual solar radiation, PV cell technologies, PV system capacity and optimized tilt and azimuth angle as input data of the system.

IV.1. Optimal Tilts Angles and Orientations

One of the main difficulties of electricity production by means of a PV power plant is its randomness, which is dependent on many other variables. Indeed, many technical parameters such as the geographical location, weather conditions, inclination and orientation of PV modules, for a given system can provide very different results. The tilt angle is optimized and chosen in such a way that maximum potentials of solar energy can be harvested as shown in Table 3.

Table 3. Optimal orientation and inclination angles

Locations	Optimal Inclination Angle (°)	Optimal Azimuth Angle (°)
Algiers	30	-7
Tamanrasset	24	-10
Tlemcen	32	-12
Chlef	32	-4
El Oued	32	-5

IV.2. Monthly Solar Irradiation on a Fixed Plan

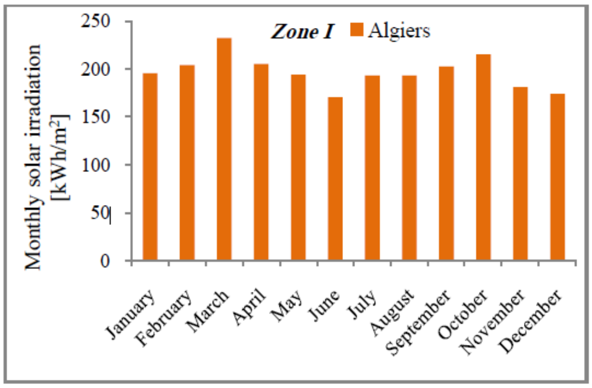
The monthly solar irradiance data in [kWh/m^2] relative to the optimal tilt angles for the four zones that include considered areas are analyzed. Figure 8 clearly represents the monthly variation in solar irradiance for the selected locations.

In Zone I (Algiers): The highest solar irradiation is possible in the March month and the lowest irradiation is seen in June. An average annual solar irradiation is about 2358 kWh/m^2 Figure 8(a).

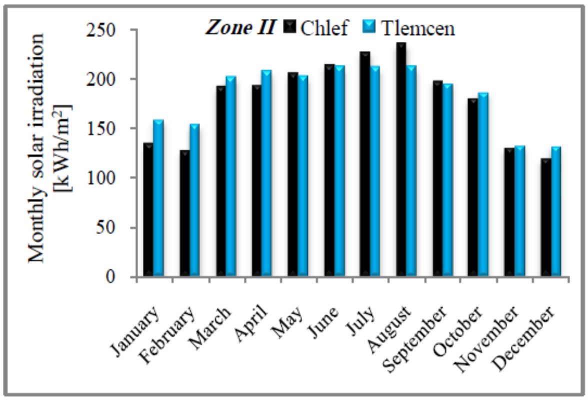
In Zone II (Chlef and Tlemcen): The highest solar irradiation is possible for the months of July and August and the lowest solar irradiation is observed for the months of November and December, as shown in Figure 8(b). The amount of solar irradiation is higher in Tlemcen that in Chlef with an average annual solar irradiation, i.e. 2157 kWh/m^2 and 2203 kWh/m^2 for the sites of Chlef and Tlemcen, respectively.

In zone III (El Oued) and zone IV (Tamanrasset): the highest irradiation is possible during the months of March, July and August and the lowest irradiation is observed during the months of November and December.

As shown in Figure 8(c), the amount of solar irradiation in Tamanrasset is higher than in the El Oued area. The average annual solar irradiation is about 2370 kWh/m^2.



(a)



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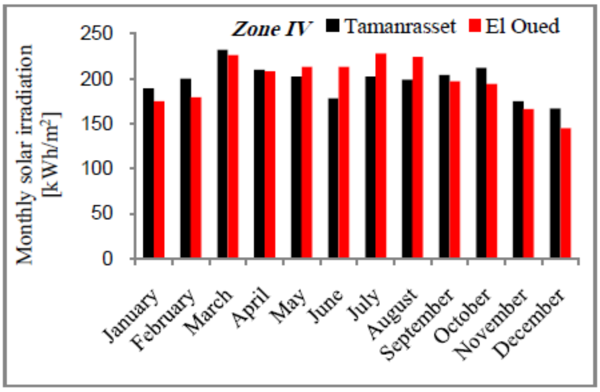

(c)

Figure 8. Monthly solar irradiation for each zone at optimal tilt angle, zone I (a), zone II (b), zone IV (c)

IV.3. Monthly Energy Production

The electrical energy generation is an important measure for the feasibility and performance analysis of the solar PV system. The electricity generation of the 1 MW photovoltaic power plant using CIS and crystalline silicon technologies on a monthly basis is shown in Figure 9 and Figure 10, respectively.

It should be noted that there are variations in the amount of generated electricity during the year, which may be due to the effect of local weather conditions. From January to April and from September to December, Tamanrasset have the highest energy production followed respectively by El Oued, Tlemcen, Chlef and Algiers, and this is for the tow PV cell technologies. The amount of AC energy produced in Tamanrasset during November is the lowest when using CIS technology (143000 kWh) and 144000 kWh when using Si-crystalline.

From May to August, the sites of Algiers and Chlef have the largest amount of energy that is injected into the grid, which is higher than the other areas, this is due to high temperatures in those regions.

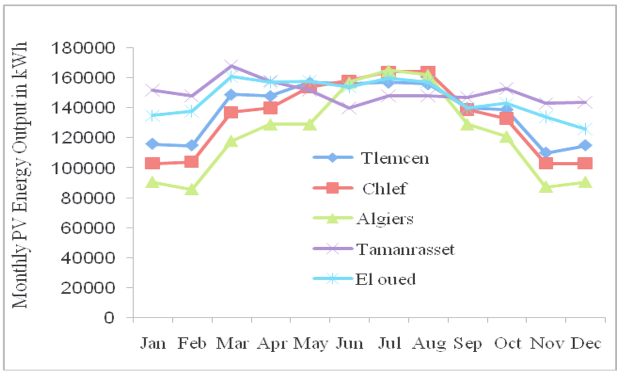

Figure 9. PV electrical energy production for studied areas using CIS technology.

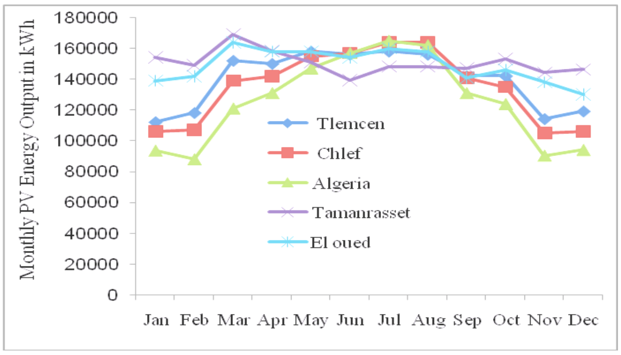

Figure 10. PV electrical energy production for studied areas using Si-crystalline

At the first zone location (Algiers), maximum energy outputs are seen in the month of Jun, July And August i.e. 157000, 165000 and 162000 kWh respectively. When using CIS modules, an average monthly energy output of 138166 kWh, 133500 kWh, 122016 kWh, 150083 kWh and 146916 kWh respectively for Tlemcen, Chlef, Algiers, Tamanrasset and El Oued. An average monthly energy output of 139750 kWh, 135083 kWh, 125358 kWh, 150500 kWh and 149000 kWh respectively for Tlemcen, Chlef, Algiers, Tamanrasset and El Oued when Si-crystalline is used.

The energy generation in the summer period is observed to be about twice the production in the winter period. The low energy production in winter is due to low solar radiation and short solar duration values. The temperature plays a major role in photovoltaic conversion, high temperatures lead to a decrease in the performance of PV modules and energy production (see the case of Tamanrasset).

IV.1. Annual PV Energy Output

Finally, as a comparison between Si-crystalline and CIS technology, Figure 11 shows the energy production fed into the grid on an annual basis for the regions studied.

As a summary and from this figure, among the tow PV technologies, Si-crystalline technology seem to be performed well for (Tamanrasset, El Oued, Tlemcen and Algeria) followed by CIS PV cell, while CIS is better than Si-crystalline for the site of Chlef.

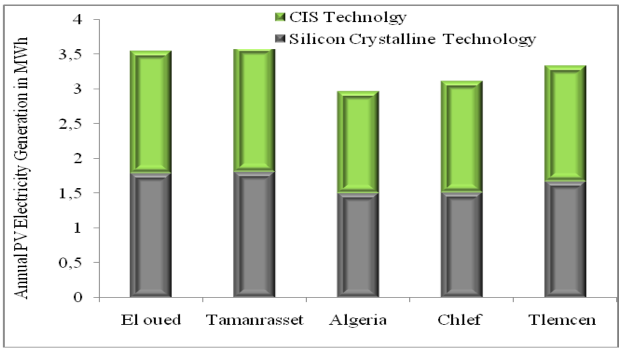

Figure 11. Annual PV energy output for selected areas using Si-crystalline and CIS technology

V. Discussion

The results obtained in this study indicate that grid-connected photovoltaic system is technically feasible for power generation and could play an important role in the future energy mix of the country.

The solar PV system can be used in many different applications such as in hybrid systems [33, 34], wastewater treatment plants [35], solar air conditioning [36], solar water heating system [37], solar concentrator application [38], and rural electrification [39].

As a future perspective, the study can be carried out using the various PV module technologies with appropriate installation methods (sun tracking system) for PV system performance improvement.

VI. Conclusion

In response to worsening environmental problems and the diminishing long-term viability of fossil fuels, renewable energies, including solar photovoltaic, are receiving a great deal of international attention. The simulation study of 1 MW PV system is presented in this paper, focusing on the assessment of the energy productions and its variations for five regions in Algeria. The annual AC energy is predicted using two different photovoltaic modules (standard crystalline silicon and CIS technology) based on optimal orientation and tilt angle is carried out using the new version of PVGIS tool. Based on this study, the following conclusions were drawn:

- Based on the monthly energy output, an average energy output of 139750 kWh, 135083 kWh, 125358 kWh, 150500 kWh and 149000 kWh respectively for Tlemcen, Chlef, Algiers, Tamanrasset, and El Oued when Si-crystalline is used.
- The difference in the monthly average production between the two photovoltaic modules is 1584 kWh, 3000 kWh, 417 kWh and 2084 kWh respectively for Tlemcen, Algiers, Tamanrasset and El Oued, noted that Si-crystalline modules recorded the highest performance. Except in the region of Chlef, when CIS PV module is better than Si-crystalline, the difference is 1583 kWh in terms of average monthly output.
- From this study, it can be concluded that the feasibility studies are necessary before proceeding with the practical installation, the tilt angle and azimuth should be accounted as they are among the influencing factors as well as the effect of temperature.

Declaration

- The authors declare that they have no known financial or non-financial competing interests in any material discussed in this paper.
- The authors declare that this article has not been published before and is not in the process of being published in any other journal.
- The authors confirmed that the paper was free of plagiarism.

References

[1] C. M. Hong, C. H. Chen, “Intelligent control of a grid-connected wind-photovoltaic hybrid power systems”, International Journal of Electrical Power & Energy Systems, vol. 55, pp. 554-561, 2014. https://doi.org/10.1016/j.ijepes.2013.10.024

[2] S. A. Nowdeh, A. R. Ghahnavieh, H. Shojaei, “Reliable designing of stand-alone PV/FC hybrid system”, Majlesi Journal of Electrical Engineering, vol. 7(2), pp. 41-47, 2013.

[3] Ministry of Energy and Mines (MEM), “Program for Renewable Energy and Energy Efficiency”, March 2011.

[4] M. Chikh, S. Berkane, A. Mahrane, “Performance analysis of a grid connected micro-amorphous silicon PV pilot plant after eight months monitoring”, IEEE, 2015.

[5] REN21, “Renewable 2017 Global Status Report. Paris”, http://www.ren21.net/status-of-renewables/global-status-report/, accessed on 2022/01/10.

[6] IEA, “Next generation wind and solar power: from cost to value”, International Energy Agency (IEA), Paris, 2016.

[7] K. A. Soteris, “Solar energy engineering: processes and systems”, Amsterdam, Netherlands, Elsevier, 2014.

[8] A. El Fathi, L. Nkhaili, A. Bennouna, A. Outzourhit, “Performance parameters of a standalone PV plant,” Energy Conversion and Management, vol. 86, pp. 490-500, 2014. https://doi.org/10.1016/j.enconman.2014.05.045

[9] R. Rahul, S. C. Kaushik, L. Ravita, “A review on modeling, design methodology and size optimization of photovoltaic based water pumping, standalone and grid connected system,” Renewable and Sustainable Energy Reviews, vol. 57, pp. 1506-19, 2016. https://doi.org/10.1016/j.rser.2015.12.228

[10] M. Castro, A. Delgado, F. J. Argul, A. Colmenar, F. Yeves, J. Peire, “Grid-connected PV buildings analysis of future scenarios with an example of Southern Spain”, Solar Energy, vol. 79, pp. 86-95, 2005.

[11] Statistas. https://fr.statista.com/, accessed on 2022/02/20.

[12] B. A. Stambouli, Z. Khiat, S.Flaz, Y. Kitamura, “A review on the renewable energy development in Algeria: current perspective, energy scenario and sustainability issues”, Renewable and Sustainable Energy Reviews, vol. 16, pp. 4445-4460, 2012.

[13] World Energy Council, http://www.worldenergy.orgS. 2011.

[14] CDER Algeria, http://www.cder.dzS, accessed on 2022/01/10.

[15] S. A. Boudghene, “Algerian renewable energy assessment: the challenge of sustainability”, Energy Policy, vol. 39, pp. 4507-19, 2011.

[16] S. H. Muller, “Renewable energies in the MENA region: potential for sustainable energy provision and export to Europe”, Institute of Technical Thermodynamics German Aerospace Centre (DLR,2010), 2010.

[17] PVGIS, http://www.rensmart.com/Weather/PVGISSolarS, accessed on 2022/01/11.

[18] German Aerospace Centre (DLR), https://www.dlr.deS, 2005.

[19] CDER, “Renewable Energy and Energy Efficiency Program. Portail des énergies renouvelables”, CDER, https://www.cder.dzS, 2011.

[20] A. Hadj Arab, B. Ait Driss, R. Amimeur, E. Lorenzo, “Photovoltaic systems sizing for Algeria, ” Solar Energy vol. 54(2), pp. 99-104, 1995.

[21] S. Kebaïli, H. Benalla, “Optimal sizing of a stand-alone photovoltaic systems under various weather conditions in Algeria”, Revue des Energies Renouvelables, vol. 18(2), pp. 179-191, 2015.

[22] S. Semaoui, A. Hadj Arab, S. Bacha, B. Azoui, “The new strategy of energy management for a photovoltaic system without extra intended for remote-housing,” Solar Energy vol. 94, pp. 71-85, 2013. https://doi.org/10.1016/j.solener.2013.04.029

[23] A. Mellit, S. A. Kalogirou, S. Shaari, A. Hadj Arab, “Methodology for predicting sequences of mean monthly clearness index and daily solar radiation data in remote areas: application for sizing a standalone PV system”, Renewable Energy, vol. 33(7), pp. 1570-1590, 2008.

[24] S. Yilmaz, H. R. Ozcalik, “Performance analysis of a 500-kwp grid-connected solar photovoltaic power plant in kahramanmaras”, Turkish Journal of Electrical Engineering & Computer Sciences, vol. 23, pp. 1946-1957 2015.

[25] International Energy Agency (IEA), “Technology roadmap solar photovoltaic energy, https://www.iea.org, IEA 2014.

[26] LAZARD'S, “levelized cost of energy analysis”, https://www.lazard.com/), accessed on 2022/02/18.

[27] H. A. Kazem, M. T. Chaichan, “Effect of humidity on PV performance based on experimental study”, International Journal of Applied Engineering Research, vol. 10(23), pp. 43572-43577, 2015.

[28] R. M. Patel, “Wind and solar energy”, CRC Press LLC, 1999.

[29] A. Raghoebarsing, A. Kalpoe, “Performance and economic analysis of a 27 kW grid-connected photovoltaic system in Suriname”, IET Renewable Power Generation, vol. 11(12), pp. 1545-1554, 2017. DOI: 10.1049/iet-rpg.2017.0204

[30] D. Connolly, H. Lund, B. V. Mathiesen, M. Leahy, “A review of computer tools for analyzing the integration of renewable energy into various energy systems”, Applied Energy, vol. 87(4), pp. 1059-1082, 2010. https://doi.org/10.1016/j.apenergy.2009.09.026

[31] S. Sinha, S. S. Chandel, “Review of software tools for hybrid renewable energy systems”, Renewable and Sustainable Energy Reviews, vol. 32, pp. 192-205, 2014.

[32] A. Haffaf, F. Lakdja, D. Ould Abdeslam, R. Meziane, “Monitoring, measured and simulated performance analysis of a 2.4 kWp grid-connected PV system installed on the Mulhouse campus, France”, Energy for Sustainable Development, vol. 62, pp. 44-55, 2021. https://doi.org/10.1016/j.esd.2021.03.006

[33] S. Ebrahimi, M. Jahangiri, H. A. Raiesi, A. R. Ariae, “Optimal planning of on-grid hybrid microgrid for remote island using HOMER software, Kish in Iran”, International Journal of Energetica, vol. 3(2), pp. 13-21, 2018. http://dx.doi.org/10.47238/ijeca.v3i2.77

[34] A. Haffaf, F. Lakdja, R. Meziane, D. Ould Abdeslam, “Study of economic and sustainable energy supply for water irrigation system (WIS) ”, Sustainable Energy, Grids and Networks, 100412. doi:10.1016/j.segan.2020.100412.

[35] A. Khechekhouche, F. Bouchemal, Z. Kaddour, K. Salim, A. Miloudi, “Performance of a wastewater treatment plant in south-eastern Algeria”, International Journal of Energetica, vol. 5(2), pp. 47-51, 2020. http://dx.doi.org/10.47238/ijeca.v5i2.139

[36] A. Haffaf, F. Lakdja, D. Ould Abdeslam, R. Meziane, “Solar energy for air conditioning of an office building in a case study: Techno-economic feasibility assessment”, Renewable Energy Focus, vol. 39, pp. 148-162, 2021. https://doi.org/10.1016/j.ref.2021.09.002

[37] M. Ghodbane, D. Benmenine, A. Khechekhouche, B. Boumeddane, “Brief on solar concentrators: Differences and applications”, Instrumentation Mesure Métrologie, vol. 19(5), pp. 371-378, 2020. https://doi.org/10.18280/i2m.190507

[38] D. Benmenine, M. Ghodbane, M. E. Soudani, H. Abdelouahed, A. Massiv, N. Elsharif, “A small parabolic trough collector as a solar water heater: an experimental study in Ouargla region, Algeria”, International Journal of Energetica, vol. 5(2), pp. 01-06, 2020. http://dx.doi.org/10.47238/ijeca.v5i2.141

[39] A. Haffaf, F. Lakdja, D. Ould Abdeslam, “Electrification d'une charge isolée d'agriculture par hybridation énergétique”, Revue des Energies Renouvelables, vol. 22(1), pp. 1-17, 2019.