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Theme:

Sensitivity analysis of temporal resolution and temperature effects on PV potential estimation

Before the jury composed of:

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Remerciements

At the end of this work we do not fail to address ourselves to my Savior

Thank you to all those who directly or indirectly contributed to realization memory.

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To guide this work and share with us the knowledge that has been

very interesting. These are valuable tips and tricks.

We also thank the members of the jury for their kind reading,

comment and discuss our work:

- *Dr.as president Rahmouni Soumia*
- *Dr.as examiner Drid Mohammed Mebrouk*

We thank all the employees of the mechanical engineering department

Finally, we thank all the friends who have helped and encouraged us to achieve this memory.

Dedicaces

I dedicate this humble work to:

To my dear parents, no devotion can express my sincerity

feelings,

For their endless patience, constant encouragement and assistance,

A testament to my deep love and respect for their great sacrifice

To my brothers, friends and neighbors

M68

And to all those who have contributed directly or indirectly to the realization of this work

thank you.

Sommaire

Liste Tableaux

Liste Figure

Abstract

Abstract :

This study performs a sensitivity analysis to investigate the effect of temporal resolution and temperature effects on Photovoltaic (PV) estimation. The analysis uses a comprehensive data to estimate the PV potential at various temporal resolutions, including hourly, daily, and monthly time intervals.

Where the study is based on sensitivity analysis to examine the effect of temporal accuracy and the effects of temperature on the PV estimation in five different wilayas: Ouargla, Setif, Algiers, Adrar and Tlemcen. The analysis compares the estimated PV potentials considering temperature effects versus those without temperature effects. The primary results indicate that incorporation of temperature effects leads to a decrease in the estimated PV potentials in all region. In Ouargla, the estimated PV capacity with temperature effects is 457 kWh, while without temperature effects it is 509 kWh. Similar trends were observed in Setif, Algiers, Adrar and Tlemcen where the estimated PV capacity with and without temperature effects are (372, 384 kWh), (347, 357 kWh), (472, 536 kWh), (392, 403 kWh) respectively. (These results confirm that higher temporal resolution leads to more accurate estimates, with hourly data providing the most accurate results.) In addition, temperature changes significantly affect the estimation of the PV potential, which highlights the need to consider the effects of temperature to improve accuracy. These results provide valuable insights for optimizing photovoltaic system design and energy yield prediction.

Keywords: Photovoltaic, Sensitivity Analysis, Temporal Resolution, Temperature Effects, PV Potential Estimation.

Résumé :

Cette étude effectue une analyse de sensibilité pour étudier l'effet de la résolution temporelle et des effets de la température sur l'estimation photovoltaïque (PV). L'analyse utilise des données complètes pour estimer le potentiel PV à différentes résolutions temporelles, y compris des intervalles de temps horaires, quotidiens et mensuels.

Où l'étude est basée sur une analyse de sensibilité pour examiner l'effet de la précision temporelle et les effets de la température sur l'estimation du PV dans cinq wilayas différentes : Ouargla, Sétif, Alger, Adrar et Tlemcen. L'analyse compare les potentiels PV estimés en tenant compte des effets de la température par rapport à ceux sans effets de la température. Les principaux résultats indiquent que l'incorporation des effets de la température entraîne une diminution des potentiels PV estimés dans tous les états. À Ouargla, la capacité PV estimée avec effets de température est de 457 kWh, tandis que sans effets de température, elle est de 509 kWh. Des tendances similaires ont été observées à Sétif, Alger, Adrar et Tlemcen où la capacité PV estimée avec et sans effets de température est (372, 384 kWh), (347, 357 kWh), (472, 536 kWh), (392, 403 kWh) respectivement. (Ces résultats confirment qu'une résolution temporelle plus élevée conduit à des estimations plus précises, les données horaires fournissant les résultats les plus précis.) De plus, les changements de température affectent considérablement l'estimation du potentiel PV, ce qui souligne la nécessité de prendre en compte les effets de la température pour précision. Ces résultats fournissent des informations précieuses pour optimiser la conception des systèmes photovoltaïques et la prévision du rendement énergétique.

Abstract

Mots clés : Photovoltaïque, Analyse de sensibilité, Résolution temporelle, Effets de la température, Estimation du potentiel PV.

ملخص :

تقوم هذه الدراسة بتحليل الحساسية للتحقق من تأثير الدقة الزمنية وتأثيرات درجة الحرارة على تقدير الخلايا الكهروضوئية (PV). يستخدم التحليل بيانات شاملة لتقدير الإمكانات الكهروضوئية بدرجات دقة زمنية مختلفة ، بما في ذلك الفواصل الزمنية بالساعة واليومية والشهرية.

حيث اعتمدت الدراسة على تحليل الحساسية لفحص أثر الدقة الزمنية وتأثيرات درجة الحرارة على التقدير الكهروضوئي في خمس ولايات مختلفة: ورقلة ، سطيف ، الجزائر ، أدرار ، تلمسان. يقارن التحليل الإمكانات الكهروضوئية المقدرة مع الأخذ في الاعتبار تأثيرات درجة الحرارة مقابل تلك التي ليس لها تأثيرات درجة الحرارة. تشير النتائج الأولية إلى أن دمج تأثيرات درجة الحرارة يؤدي إلى انخفاض في الإمكانات الكهروضوئية المقدرة في جميع الولايات. في ورقلة ، تبلغ السعة الكهروضوئية المقدرة مع تأثيرات درجة الحرارة 457 كيلو وات / ساعة ، بينما بدون تأثيرات درجة الحرارة تبلغ 509 كيلو وات / ساعة. ولوحظت اتجاهات مماثلة في سطيف والجزائر العاصمة وأدرار وتلمسان حيث كانت القدرة الكهروضوئية المقدرة مع وبدون تأثيرات درجة الحرارة (372 ، 384 كيلوواط ساعة) ، (347 ، 357 كيلوواط ساعة) ، (472 ، 536 كيلوواط ساعة) ، (392 ، 403 كيلوواط ساعة) على التوالى. (تؤكد هذه النتائج أن الدقة الزمنية الأعلى تؤدي إلى تقديرات أكثر دقة ، حيث توفر البيانات كل ساعة أكثر النتائج دقة.) بالإضافة إلى ذلك ، تؤثر التغيرات في درجات الحرارة بشكل كبير على تقدير الإمكانات الكهروضوئية ، مما يبرز الحاجة إلى مراعاة تأثيرات درجة الحرارة لتحسينها. دقة. توفر هذه النتائج رؤى قيمة لتحسين تصميم النظام الكهروضوئي والتنبؤ بإنتاجية الطاقة.

GENERALE INTRODUCTION

GENERALE INTRODUCTION

Photovoltaic potential estimation is a critical task in the planning, design, and operation of photovoltaic (PV) systems. Accurate estimation of PV potential requires careful consideration of various factors, including the temporal resolution of solar irradiance data and temperature effects on PV module efficiency.

The temporal resolution of solar irradiance data refers to the frequency with which measurements are taken, and it can significantly impact the estimation of PV potential. Higher temporal resolution data can provide a more detailed understanding of the variability of solar irradiance, but it can also require more resources to collect and process.

Temperature effects on PV module efficiency also play a crucial role in the estimation of PV potential. The efficiency of PV modules decreases as the temperature increases, which can lead to a reduction in energy production. Therefore, it is essential to consider temperature effects when estimating PV potential accurately.

Sensitivity analysis is a powerful technique that can help to investigate the impact of changes in temporal resolution and temperature effects on PV potential estimation. Through sensitivity analysis, researchers and practitioners can quantify the impact of these factors and determine the optimal values for these parameters in different applications.

Several studies have investigated the sensitivity of PV potential estimation to changes in temporal resolution and temperature effects. For example, Perpinan et al. (2013) investigated the impact of temporal resolution on the assessment of grid-connected PV system performance in a Mediterranean climate. Arora et al. (2016) evaluated the performance of PV modules under different temperature conditions in a desert climate

The aim of sensitivity analysis in relation to temporal resolution and temperature effects on PV (photovoltaic) potential estimation is to assess the impact of these factors on the accuracy and reliability of PV potential predictions. Specifically, sensitivity analysis helps to determine how changes in the temporal resolution (time intervals) of data and variations in temperature affect the estimation of PV potential.

General Introduction

In the first chapter of the study, we perform sensitivity analysis to investigate the effect of temporal resolution and the effects of temperature on the photovoltaic potential estimation. This analysis aims to evaluate how changes in temporal resolution and changes in temperature can affect the accuracy of the PV potential results.

In the second chapter, we present the methodology used to perform sensitivity analysis of temporal resolution and the effects of temperature on photovoltaic (PV) estimation. The aim of this analysis is to investigate how changes in temporal resolution and changes in temperature affect the accuracy of PV potential outcomes.

In the final chapter, we present the results of our sensitivity analysis, focusing on temporal resolution and temperature effects on photovoltage (PV) estimation. This analysis aimed to investigate the effect of changes in temporal resolution and changes in temperature on the accuracy and reliability of the PV potential results [1], [2].

Chapter :01 Theoretical

I. Theoretical

1. Introduction :

Sensitivity analysis is a potent method for determining how different variables affect a model's or simulation's output. The temporal resolution and temperature are two crucial variables that influence the accuracy of the estimations when calculating the potential for photovoltaic (PV) energy generation.

Temporal resolution describes how frequently data is gathered and examined. Higher temporal resolutions can provide more precise PV potential estimates by capturing the finer-grained changes in the solar resource. Higher temporal resolution calls for more information and computational power, though.

Another element that has a considerable impact on estimates of PV potential is temperature. High temperatures can cause PV cells to perform less effectively, which lowers energy output. Therefore, it is crucial to take temperature into account when accurately estimating the PV potential.

The relative importance of these variables in determining the precision of PV potential estimates can be determined by a sensitivity analysis. The sensitivity analysis can pinpoint the most important variables that have a substantial impact on the precision of the estimations by systematically changing their values.

In this chapter, we aim to provide a theoretical framework for conducting a sensitivity analysis on the impact of temporal resolution and temperature effects on the estimation of PV (photovoltaic) potential. The primary objective of this analysis is to explore how changes in temporal resolution and variations in temperature can affect the accuracy and results of PV potential predictions.

2. Temporal resolution :

The frequency or interval at which measurements of solar radiation and weather information are obtained for estimating photovoltaic (PV) potential is referred to as temporal resolution. The precision of the estimated PV production can be significantly impacted by the temporal resolution of these data.

Numerous studies have investigated how different temporal resolutions affect the estimation of PV potential. Lefebvre and colleagues (2012) assessed the effect of temporal resolution on the accuracy of PV output estimation in Belgium. The study found that hourly data provided more precise estimates of PV production compared to daily or monthly data, attributed to its higher temporal resolution.

Similarly, Wang and colleagues (2019) investigated the impact of temporal resolution on PV output estimation in China. They observed that higher temporal resolutions, such as hourly or sub-hourly data, resulted in more precise estimates of PV output, particularly during periods of rapidly changing weather conditions, compared to daily or monthly data.

In addition, Saeidi and colleagues (2020) conducted a study to examine the influence of temporal resolution on PV potential calculation in Iran, particularly for systems with a significant portion of distributed PV generation. Their findings emphasized that higher temporal resolutions, such as hourly data, were more suitable for assessing the potential of PV systems accurately.

These investigations highlight the importance of selecting an appropriate temporal resolution for PV potential estimation to obtain precise and reliable results. Hourly, daily, and monthly resolutions have distinct advantages and trade-offs, and the choice should be based on the specific objectives of the study and the characteristics of the PV system under consideration [3]–[5].

The figure 1.1 shows a comparison of hourly and daily time resolution of ambient temperature measurement data. Where it appeared that high density measurement (24 points) in hourly resolution versus daily resolution (1 point).

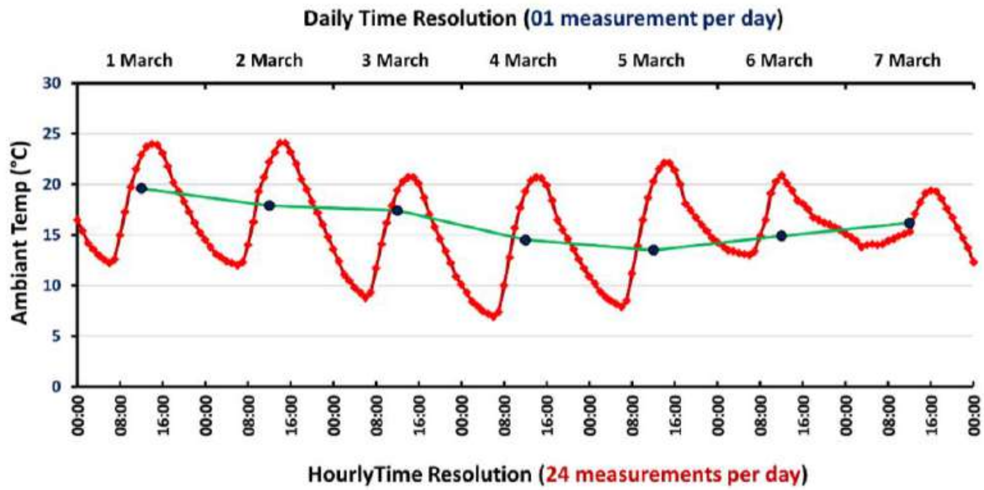

Figure 1.1:Temperature of the first week of march in different resolution time.

3. Solar energy in Algeria :

The area of Algeria is estimated at more than 2.3 million square kilometers, of which the Sahara represents 80 % and 20 % of the total area of the African Sahara.

Solar energy remains the most important renewable energy available to Algeria, as it is the largest proportion of solar energy at the level of average countries, containing the equivalent of four times the total global energy consumption, or about 37 thousand billion cubic meters of gas per year. Algeria has established a hybrid power plant in Hassi. Al-Raml is the first of its kind in the world, working with gas and solar energy together, with a production rate of 150 megawatts, and the other in Ghardaia with a capacity of 1.1 megawatts [6] and more than 23 PV farms located in different regions with a total installed capacity of 374.3 MW

3.1. Solar Energy Potential:

According to its geographical location, Algeria holds one of the highest solar potential. Indeed, following an assessment by the satellites, the German Aerospace Center (DLR) concluded that Algeria has the largest solar potential in the Mediterranean basin: 169,440 TWh / year. Sunshine duration on almost all the country over 2000 hours per year and can reach 3900 hours in the Highlands and the Sahara. The daily energy obtained on a horizontal surface is about 5 kWh on most of the national territory, about 1700 kWh / m²/ year for the North and 2263 KWh / m² / year for the South.

The climatic conditions in Algeria are favorable for the development of solar energy due to the abundant sunshine throughout the year, especially in the Sahara region [7] :

Tableau 1-1: Estimated Solar Energy Potential by Region

Region	Estimated Solar Energy Potential (kWh/m2/year)
North America	1000-2000
Europe	800-1800
Asia	1200-2200
Middle East	1800-2200
Africa	1800-2500
Australia	1800-2200
South America	1200-2000

[7]

4. Potentiel estimation and levels :

Temperature and temporal resolution are just two of the many variables that have an impact on the theoretical potential for PV energy generation.

The Shockley-Queisser limit, which specifies a theoretical maximum efficiency of 33.7% for single-junction solar cells at a standard temperature of 298 K (25°C) and under perfect circumstances, restricts the highest temperature at which a PV cell can operate. However, due to different factors like temperature, less-than-ideal material qualities, and other losses, the actual efficiency of commercial PV cells is often substantially lower.

Models that account for changes in solar irradiation over time can be used to assess the theoretical potential for PV energy generation in terms of temporal resolution. These models, which may be used to predict the anticipated energy output of a PV system at various temporal resolutions, can be based on weather information as well as satellite photography. The quality of the data used and the model's complexity both affect how accurate these models are.

Numerous research that considered the effects of temperature and temporal resolution looked at the theoretical potential for PV energy generation. For instance, Taieb et al.'s (2016) study used satellite data to calculate Tunisia's potential for PV energy generation while accounting for the effects of temperature and other variables. They discovered that while the potential varied according on the area and the type of PV system being used, the potential as a whole was substantial.

Sengupta et al. (2014) created a model for calculating the potential for PV energy generation in the US while taking the impacts of temperature and other variables into account. They discovered that potential varied by geography, with some areas having far higher potential than others [8].

Figure 1.2: Levels of potential

[9]

4.1) The theoretical potential :

describes the physically exploitable energy supply of a region taking into account geographical structures that prevent the use of energy sources. This potential can never be fully realized due to technical, ecological, structural, and administrative limitations.

4.2) The technical potential :

describes the portion of theoretical potential that is currently achievable given the state of technology and assuming full use of the available surface. Here, environmental and structural limitations are taken into consideration. [10]

5. Efficiency in function of T :

The efficiency of photovoltaic (PV) cells is affected by various factors, including temperature and the temporal resolution of the data used to estimate the PV potential.

The temperature coefficient of PV cells describes how the cell's efficiency decreases as the temperature increases. As the temperature increases, the electrical output of the cell decreases. The temperature coefficient varies depending on the type of PV cell used and can range from -0.5%/°C to -0.2%/°C for crystalline silicon cells, and up to -0.8%/°C for thin-film cells.

In terms of temporal resolution, the accuracy of PV potential estimations can be affected by the time interval used to collect data. Higher temporal resolution can lead to more accurate estimations of PV potential. For example, hourly or daily measurements can capture more detailed changes in solar irradiance compared to monthly or annual measurements.

Several studies have investigated the sensitivity of PV potential estimation to temperature and temporal resolution effects. For example, a study by Al-Salaymeh and Alsmairat (2017) used data from a PV system in Jordan to investigate the effect of temperature on PV efficiency. They found that the efficiency decreased by 0.51%/°C for the crystalline silicon cells and 0.7%/°C for the thin-film cells.

Another study by Luque-Heredia et al. (2019) investigated the effect of temporal resolution on the accuracy of PV potential estimations. They found that using hourly data instead of daily or monthly data led to more accurate estimations of PV potential [11][12] .

6. PV Technologies

Solar energy is directly converted into electrical energy by photovoltaic solar cells. More than 90% of the PV modules are based on crystallized silicium. The remainder, or only 10%, consists of thin-film modules and other new technologies.

The photovoltaic market has grown by an average of 50% over the past decade. This development has been consistently underestimated for a long time. Photovoltaics is one technology on which the legislative framework focused on marketing strategy has a very subtle impact. Photovoltaic technologies are diversifying rapidly due to the rapid expansion of the market. The unique feature of photovoltaic cells is their amazing modularity, which works in parallel with the physical mechanism of continuous transformation of light. They can be used on systems of any size, from milliwatt-scale installations to hundreds of megawatt systems.

According to market research firm IMS Research, the amount of PV installations on a global scale increased by 130% over the previous year in 2010 to 17.5 GW. Installed capacity is scheduled to reach 20.5 GW in 2011, bringing the total installed capacity globally to 58 GW by the end of the year.

6.1) Mono- And Polycrystalline Technology

Since many years ago, silicium has been a crucial component of solar cells. The foundation materials for currently produced solar cells are mono- (50%) and poly-cristallin (50%). For silicon, there are very strict purity requirements. There is just 1 atome of impurity per 1 Mrd. of silicon atoms.

Its production is analogous to that of electronic poker chips. According to Czochralski's method, silicon mono-crystalline cells are produced by extracting a massive "lingot" from a silicon fondue bath and then cutting it into thin plaques (wafers). The polycrystalline silica is melting and slowly cooling. This method makes it possible to create typical crystal structures while also lowering production costs. The disadvantage of silicon polycrystal is that it needs to be shown more.contaminations and flaws like grain joints and mutations, which lower the rate of effectiveness. Specific getters and passivation processes must be carried out in order to maintain a high rate of energy efficiency.

The silica cells still had a 400 m thickness in 1990, however today they typically have a 200 m thickness. For a 20% efficiency rate, the Fraunhofer Institute has developed a solar cell with a 40 mm thickness.The rate of energy output increased, moving from 10% at first to 14–16% on average For polycrystalline cells and from 17–20% for monocrystalline cells.

The demand for silica has significantly increased. Long ago, leftovers from the manufacture of electronic components were used to create solar cells. Beginning with yearly output amounts of 1 to 5 MWc in the 1990s, production amounts have since increased to several hundreds of MWc. stage of rarity In the years that followed 2003 silica production capacities increased globally, but new technological advancements were also made: concurrently with the development of a specific silica "of grade solar" (which has a lower degree of purity), the development of finer cells (see above) was encouraged, and thin-film technology saw a significant advancement.

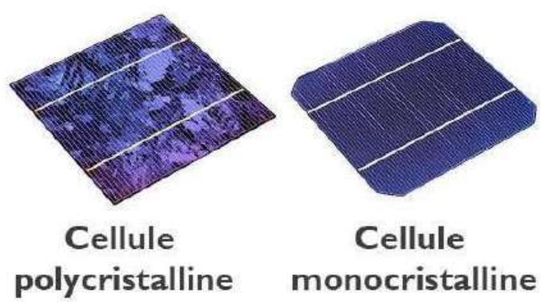

Figure 1.3 : Mono- And Polycrystalline Technology

[13]

6.2) Thin Film Technologies:

A variety of materials are included in the category of thin-film technology. They have the advantage of being 100 times more precise than conventional silicium cells. The most well-known thin-film technologies are based on amorphous silicon, copper-indium-di-selenide (CIS), and cadmium-telluride (CdTd).

The silicium amorphe (a-Si) is made up of non-ordered silicium atoms that are vaporized onto a substrate. Sa high absorption capacity allows for the creation of particularly thin layers with thicknesses between 3 and 20 mm. The only other drawback is that it only has a 6–8% commercial efficiency rate. In order to increase this rate, multiple layers are combined using micro-morphic (a-SiGe) or silicium-germanium (c-Si) alloys.

The benefits of cells The advantages of thin-film cells include their good sensitivity to diffuse or low light as well as their low sensitivity to temperature and opacity. They can also be applied to flexible materials like plastic or aluminum plates.

The II-VI-cadmium-tellure (CdTe) and copper-indium-di-selenide (CIS, CuInSe2) semi-conductors, which are currently most frequently used for thin-film technologies, have already seen some slight price reductions. As a result, in December 2010, module prices ranged between €1.22 and €1.38/Wc.

In the business world, energy return rates range between 8 and 12%. The highest possible laboratory value for a CdTe cellule is 16,5%. Due to its toxicity, a lot of CIS cell manufacturers substitute disulfure for di-selenium or add gallium (CIGS) in its stead. Avancis published a rate of energy return of 15.1% for CIGS modules with thin layers on January 31, 2011. The configuration of cells is the focus of extensive global research; one can roughly predict how the "technological bonds" - including production efficiency improvements - will continue to drive down the cost of photovoltaics through the year 2020, though this presumption does not entirely exclude completely novel concepts.

6.3) Dye Solar Cells:

In the case of color-changing solar cells, also known as Grätzel cells, an organic colorant converts solar energy into electrical energy. A straightforward serigraphic process is used in the manufacturing process, which lowers production costs and provides a variety of design options. Solar cells can, for instance, be used as building materials or advertising supports. A diffuse light can be used by color-producing solar cells. At the Fraunhofer Institute, 8% energy yield rates were achieved.

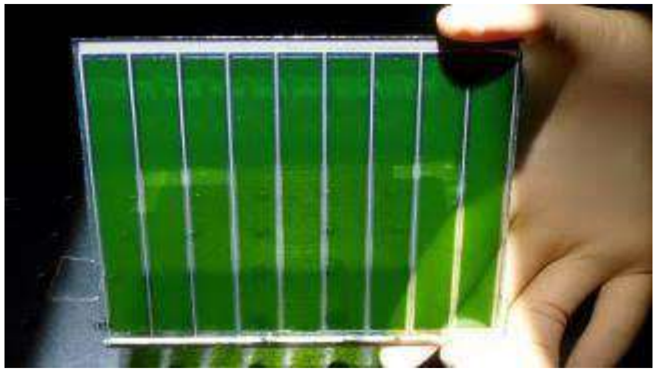

Figure 1.4 : DYE SOLAR CELLS

[14]

6.4) Organic Solar Cells:

Organic solar cells, or organic photovoltaic (OPV) cells, use organic semiconductors to convert sunlight into electricity. They are known for their flexibility, light weight, and potential cost-efficiency. While historically less efficient than silicon-based solar cells, they have improved over time. They find applications in flexible and textile-integrated solar solutions, building integration, and portable chargers. However, durability remains a challenge due to organic material sensitivity to environmental factors, requiring ongoing research for improved competitiveness.

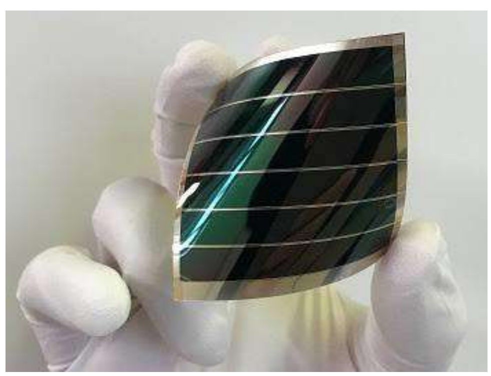

Figure 1.5 : An OPV module on PET film substrate

[15]

6.5) Type Iii-V Solar Cells:

The most effective thin-film solar cells to date are semi-conductors made out of the 3° and 5° groups of the periodic system. There are many possible combinations, and the most well-known one is gallium arsenide (GaAs), which is used to power satellites. The price of these combinations rises according to their rate of energy productivity. Different material combinations can be used to create solar cells that can convert various solar spectrum components into electricity. The opportunities in this industry have already been extensively explored, but they are still far from being exhausted.

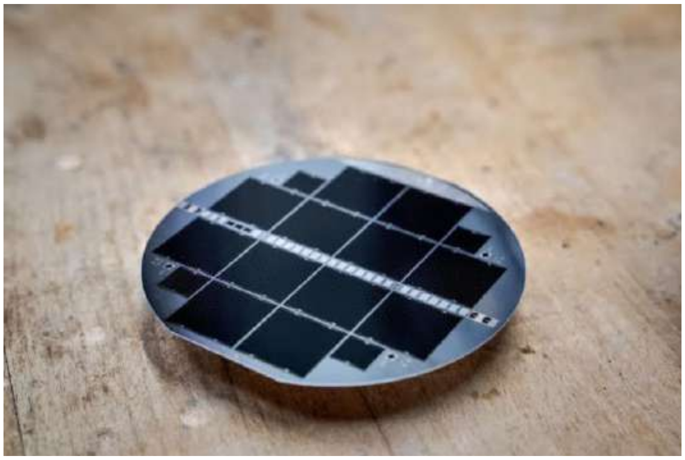

Figure 1.6 : Type Iii-V Solar Cells

[16]

6.6) Multi-Junction Solar Cells:

The properties of absorption of various light spectral ranges are utilized by multi-junction solar cells III-V. The strongest solar spectrum absorption properties are seen in the upper cellule. Energy-wise, anything over a certain point is converted to heat, whereas energy below a certain point only touches the cell's lower layer.

Cells that superimpose on one another are connected in series. They can achieve an energy efficiency rate of up to 40% when exposed to concentrated light. Other names for solar cells with numerous junctions include cells in tandem, triples, cascades, or multiples.

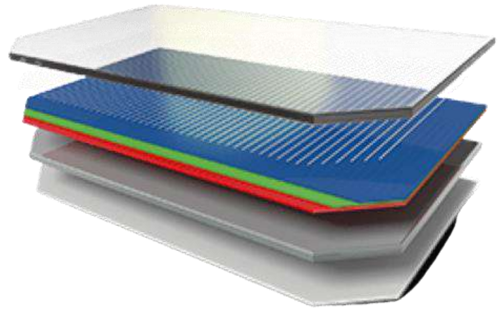

Figure 1.7: Multijunction solar cells

[17]

6.7) Concentrated Systems:

Concentration systems typically consist of a collection of lentilles or mirrors that focus solar light onto very tiny solar cells. Concentration cells require direct solar radiation and must be oriented in the direction of the sun's course. In a manner similar to highly efficient silicium cells, piles III-V cells are used first because they enable the highest possible rate of energy output.

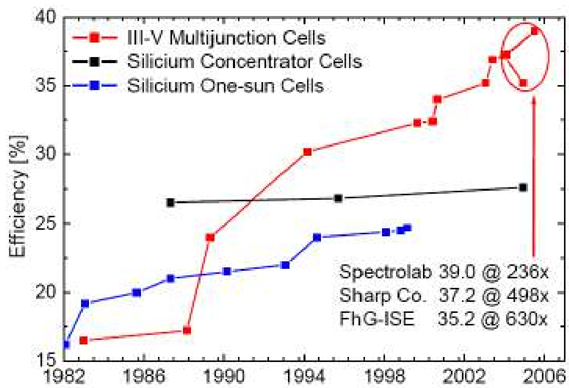

Figure 1.8: Energy efficiency ratio of different concentrating cells

In January 2009, a press release said that the Fraunhofer Institute for Solar Energy Systems (ISE) has achieved an energy yield rate of 41.1%. The solar light is focused 454 times on a 5 mm2 multilayer solar cell made of III-V semiconductors (gallium-indium-phosphide, gallium-indium-arsenide, germanium). This concentrate cell's design makes it possible for it to perfectly match the terrestrial solar spectrum.

Concentrix Solar (now known as Soitec SA) began producing concentrated solar cell modules (Flatcon technology) in September 2008 in a fully automated industrial facility with a 25 MW annual production capacity. However, other businesses (Isofoton and equivalents) conduct research and/or produce at a pre-industrial level.

6.8) Photovoltaic System Technique:

A photovoltaic installation's main component is the solar module, to which a large number of solar cells are electrically connected and connected to one another. Several modules are connected to a solar generator.

It is essential to distinguish between isolated installations and those that are networked. While network-connected installations inject produced electricity into a distribution network, isolated installations store current in batteries (accumulators).

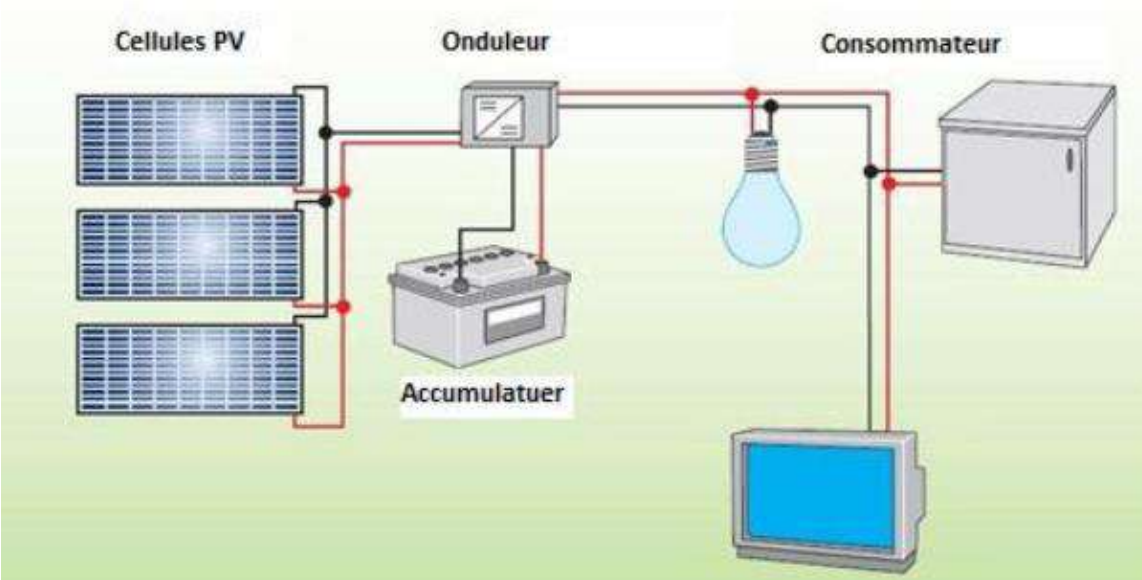

Figure 1.9: Schematic representation of an isolated system

In the case of a photovoltaic installation that is connected to the network, the continuous current generated by the solar cells is converted by an onduleur into alternate current and then introduced through one (or two) counters into the client's internal network or the electrical distribution network [10].

There are two types of coupling that have financial repercussions for the investor, whether they be a person, a business, or a project developer:

- The entirety of the electricity produced by the photovoltaic system is injected into the network in accordance with a "tariff of purchase guaranteed" (with major fixed prices) that is present in more than 40 countries. An "injection counter" measures the amount injected to calculate the amount of electricity to be paid out.The electricity is paid for by the network operator at a significant rate, and the producer finances his investment in this way. The amount consumed by the consumer is calculated by another "counter of provision" (Figure 1.10), and the customer pays for their consumption in accordance with standard pricing terms.

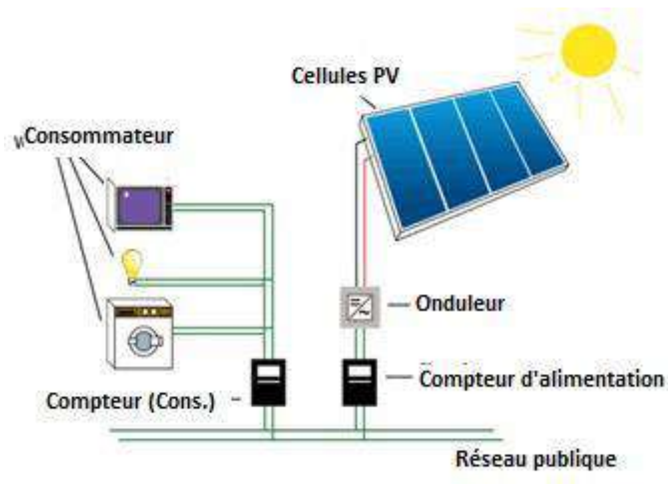

Figure 1.10: Schematic representation of a PV installation connected to the grid according to a feed-in tariff system [10].

- Selon un système de facturation nette, l'installation est raccordée au réseau interne du consommateur et l'électricité produite couvre avant tout ses besoins personnels.

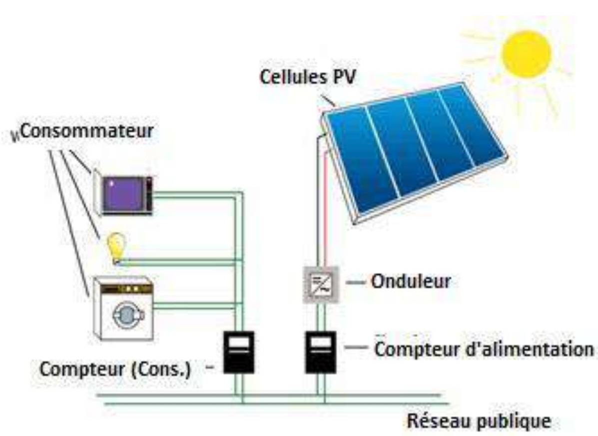

Figure 1.11 : Schematic representation of a PV installation connected to the network according to a net metering system

If the photovoltaic installation's output exceeds the consumer's needs, the excess is discharged into the grid; if it falls short, the consumer withdraws electricity from the grid. It only takes a simple calculator to implement this system, but it must be able to measure the flow of electricity in both directions [10].

Figure 1.10 illustrates a one-way flow of power to the grid and income generation, while Figure 1.11 shows a two-way flow, where self-consumption and bill reduction are key benefits.

7. Current And Future Statuts Of The Pv :

7.1. In The World :

Over the past ten years, the worldwide photovoltaic (PV) sector has grown rapidly; by the end of 2020, installed PV capacity will have exceeded 765 GW. With the help of factors including falling costs, rising efficiency, and supportive regulations, this growth is anticipated to continue.Solar PV is anticipated to surpass all other sources of power generation by 2035, with an estimated installed capacity of 8,000 GW, according to the International Energy Agency's (IEA) Sustainable Development Scenario, which offers a route toward reaching global climate targets.China, the United Region, Japan, and Germany are among the nations setting the pace for PV implementation. Over 35% of the installed capacity worldwide comes from China alone.

The International Energy Agency (IEA) predicts that solar PV could supply up to 15% of the world's electricity by 2030 and up to 27% by 2050. But massive investments in infrastructure, technology, and encouraging policies will be needed to realize this potential [18] .

7.2. In Algeria :

Recent studies indicate that Algeria's plentiful solar radiation and advantageous geographic location make it an excellent candidate for the production of photovoltaic (PV) electricity. As a matter of fact, Algeria has established challenging objectives to boost its capacity for renewable energy, including a target of 27% renewable energy in its electricity mix by 2027.Nevertheless, despite these objectives, Algeria's present level of PV deployment is still quite low. Only 360 MW of installed PV capacity existed in Algeria as of 2020, or less than 1% of the nation's total energy producing capacity. This is mostly caused by a number of difficulties, such as legal restrictions, a lack of funding, and a lack of technical knowledge.

The creation of a national strategy for renewable energy, the establishment of a renewable energy agency, and the implementation of feed-in tariffs to encourage investment in PV are just a few of the government's initiatives that have been put into place to address these issues and realize the full potential of PV in Algeria.Overall, even though Algeria still has a long way to go before realizing the full potential of PV, the nation has made tremendous progress toward raising its renewable energy capacity and is anticipated to experience rapid growth in the years to come.[19]

Tableau 1.2 : PNEREE implementation plan revised in 2015 (in MW)
[20]

	1st Phase 2015-2020	2st Phase 2021-2030	Total
Photovoltaic	3 000	10 575	13 575
Wind	1 010	4 000	5 010
CSP	-	2 000	2 000
Cogeneration	150	250	400
Biomass	360	640	1 000
Geothermal energy	05	10	15
Total	4525	17475	22000

8. types of radiation :

(8.1)Direct :

Direct solar radiation is radiation received on a normal plane coming directly from the solar disk without having undergone scattering. The flux of photons which have not interacted with the constituents of the atmosphere and have retained a common direction and their own energies.

The direct radiation received by a surface permanently oriented towards the sun and which therefore receives solar radiation at normal incidence is denoted by I.

$$I\ d = I*\sin(h)$$

Where h: sun height.

Direct solar irradiance (D) on a horizontal plane can be determined in several ways depending on the data available

$$I *= 1370\exp[\frac{Tl}{0.9 + 9.4\sin(h)}]$$

Where T L is the link haze factor calculable by:

$$Tl = 2.4 + 14.6\beta + 0.4(1 + 2\beta)L_n P_v$$

β: Atmospheric cloudiness coefficient.

P_v:Is the partial pressure of water vapor expressed in mm Hg.

With: h: Height of the sun.

(8.2) Diffus:

The horizontal diffuse H D is the radiation received on a horizontal surface coming from all the celestial vault with the exception of the solar disk. This is the radiation scattered by aerosols, water droplets, water vapor towards the ground.

$$D *= 54.8\sqrt{\sin(h)\,[T_L - 0.5\sqrt{\sin(h)}]i}$$

(8.3)Albedo :

Reaching the ground, solar radiation is only partially absorbed. The fraction of radiation reflected by the ground is called albedo and is obviously only to be taken into consideration for inclined surfaces .[21]

So for a perfect black body, the albedo is zero.

$$\rho = \frac{\text{reflected energy}}{\text{received energy}}$$

Tableau 1.3 : Albédo de différente surface

Type de Surface	albédo
Fresh snow high sun	0,80-0,85
Fresh snow low sun	0,90-0,95
snow watch	0,50-0,60
Sand	0,20-0,30
Grass	0,20-0,25
wet earth	0,10
dry land	0,15-0,25
Forest	0,05-0,10
Water, horizontal sun	0,50-0,80
Water, sun at the zenith	0,03-0,05
thick cloud	0,70-0,80
thin cloud	0,25-0,50

9. Conclusion:

The sensitivity analysis of temporal resolution and temperature effects on PV potential estimation provides some important theoretical insights that can guide the development of a methodology. The analysis shows that the choice of temporal resolution has a significant impact on the accuracy of PV potential estimates, with higher resolutions generally producing more accurate results. Temperature also plays a critical role in PV potential estimation, with higher temperatures leading to lower PV output. It is important to incorporate temperature data into the methodology to improve accuracy.

In addition, the analysis suggests that spatial resolution may also be important in improving the accuracy of PV potential estimates. The optimal choice of temporal resolution and temperature modeling approach may depend on the specific context, and different methodologies may be needed for different applications.

Overall, these theoretical conclusions can help guide the development of a robust and accurate methodology for estimating PV potential, taking into account the important factors of temporal and spatial resolution, as well as temperature effects.

Chapter :02

Méthodology of work

II. Methodology of work:

1. Introduction:

In this chapter, we will discuss the methodology for conducting sensitivity analysis of temporal resolution and temperature effects on PV potential estimation. The sensitivity analysis is a critical step in optimizing the design and performance of PV systems. By varying the temporal resolution and temperature inputs, we can investigate the impact on the estimated PV potential, and consequently, optimize the performance of PV systems.

The methodology involves several steps, including the collection and processing of solar irradiance data for different temporal resolutions, the collection of PV module efficiency data for different temperature conditions, the development of a PV performance model that integrates the solar irradiance and temperature data, and the conducting of sensitivity analysis to investigate the impact of changes in temporal resolution and temperature effects on the estimated PV potential.

Several studies have used sensitivity analysis to investigate the impact of temporal resolution and temperature effects on PV potential estimation. For instance, Roudsari et al. (2018) used satellite-based solar irradiance data to investigate the impact of temporal resolution on the estimation of rooftop PV potential. Li et al. (2019) used a PV performance model to investigate the impact of temperature effects on the performance of a grid-connected PV system [22], [23] .

In this chapter, we will provide a detailed methodology for conducting sensitivity analysis, including data collection and processing, model development, and analysis techniques. We will also review the relevant literature and present the key findings of previous studies. By the end of this chapter, you will have a clear understanding of the sensitivity analysis methodology and how it can be used to optimize the design and performance of PV systems [22], [23]

2. Méthodolgie:

2.1) Site selection study area:

The study area for this research encompasses five region in Algeria: Adrar, Ouargla, Tlemcen, Algiers, and Setif. These region were selected due to their diverse geographical locations, which allowed for an assessment of the sensitivity of temporal resolution and temperature effects on photovoltaic (PV) potential estimation. The data for the study was obtained from Meteonorm, a widely used software for meteorological data analysis. The study focused on the Global Horizontal Irradiance (GHI) as an important parameter for site selection, which was analyzed for each state. The sites were classified into three categories: high, medium, and low based on their GHI values. The results of this study can help inform policymakers, investors, and developers in making informed decisions about site selection for PV projects, ultimately leading to increased profitability and sustainability [22], [24], [25]

Tableau 2.1: A table showing the GHI value for the year

State	Value	Description
Algiers	1664.80 MWh/m².year	Medium
Ouargla	1885.87 MWh/m².year	High
Tlemcen	1878.52 MWh/m².year	Meduim
Setif	1788.05 MWh/m².year	Medium
Adrar	1985.52 MWh/m².year	High

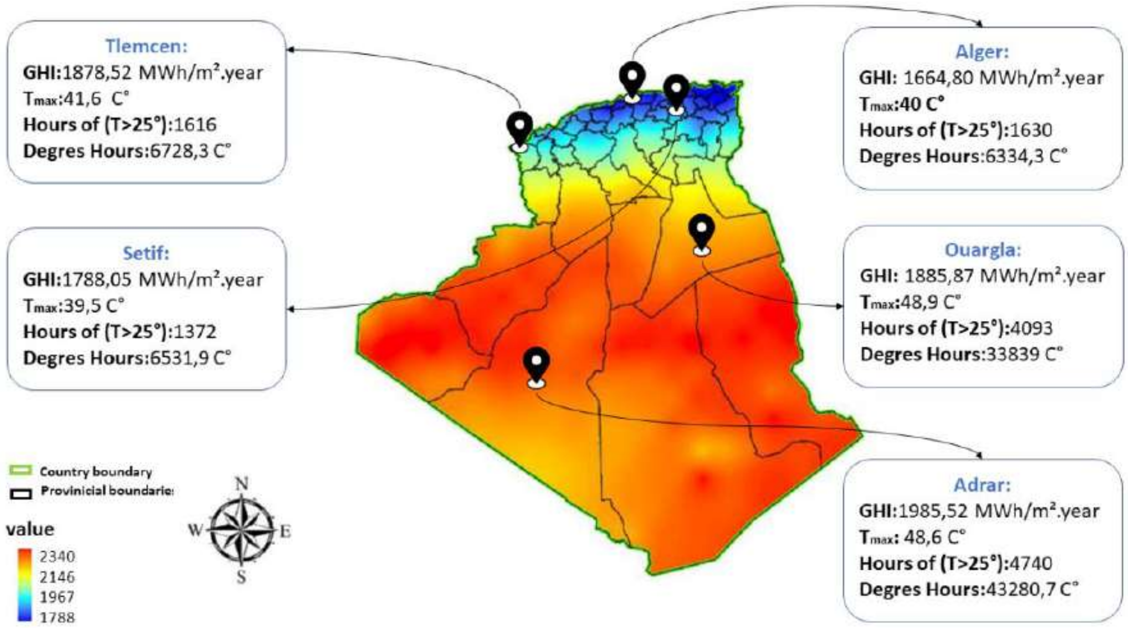

Figure 2.1:Solar irradiation

2.2) Weather data:

Meteonorm 8 is software that provides meteorological data for solar energy and other renewable energy applications. It is developed by Meteotest, a Swiss meteorological data and software company.

Meteonorm 8 provides a comprehensive set of meteorological data that we need such as :

- global horizontal irradiation
- Temperature

The software allows users to access this data from anywhere on Earth

Meteonorm 8 has been widely used in the solar industry for many years and is considered a reliable source of meteorological data [26].

2.3) Data source :

To perform a sensitivity analysis of data sources to estimate the PV potential with respect to temporal resolution and temperature effects using Meteonorm 8, data from five region in Algeria (Algiers, Ouargla, Tlemcen, Adrar, and Setif) will be analyzed with daily, hourly, and interim monthly decisions from Meteonorm 8

The temperature effects will be analyzed by comparing potential estimates of PV power at different temperature levels. This will help select the optimal temperature range for maximum PV potential.

The sensitivity analysis will provide insights into the optimal temporal resolution and data sources for estimating the PV potential in these cities, as well as the temperature effects that need to be taken into account when developing these models. The results of this analysis can be used to improve the accuracy and reliability of potential estimates of PV energy and to assist in decision-making related to planning and deployment of solar energy in Algeria.

2.4) Global Horizonal irradiation :

The term "GHI," or "Global Horizontal Irradiance," refers to the entire amount of solar radiation that strikes a horizontal surface at a specific point. As it is utilized to determine how much energy a PV system is capable of producing, GHI is a crucial parameter in the assessment of PV potential [27, 28].Numerous research has examined the impact of GHI on the effectiveness of PV systems, as well as the impact of temperature and temporal resolution. For instance, Klokov et al. (2023) studied the impact of temporal resolution of the input weather data on PV system. With more than nine time measurements intervals (5, 10, 15, 20, 30 min; 1, 2, 3, 4 h) they examine the power supply reliability and costs. Lower temporal resolution data lead to the underestimation of energy storage charge–discharge cycles and they recommend a time resolution of 30 min for PV System off-grid system [29]. According to Ernst et al (2019), The quality of solar radiation data is one key parameter crucial to the prediction accuracy. Most energy yield modelling prediction rely on typical meteorological year data with one-hour interval measurements step as maximum [27, 28].So it must be to consider this factor when estimating a photovoltaic (PV) system's potential energy production. The accuracy of PV potential estimations depends on the time interval used for data collection, which can affect the optimal design of photovoltaic power plants [28]. The impact of temporal resolution is presented by calculating the difference on energy potential for different time resolution as presented by Ernst et al (2019) where they use Hourly TMY vs One-minute TMY [27].The PV potential is generally based on data availability also, so the figure 2.3 present the daily Algerian solar irradiation [20].

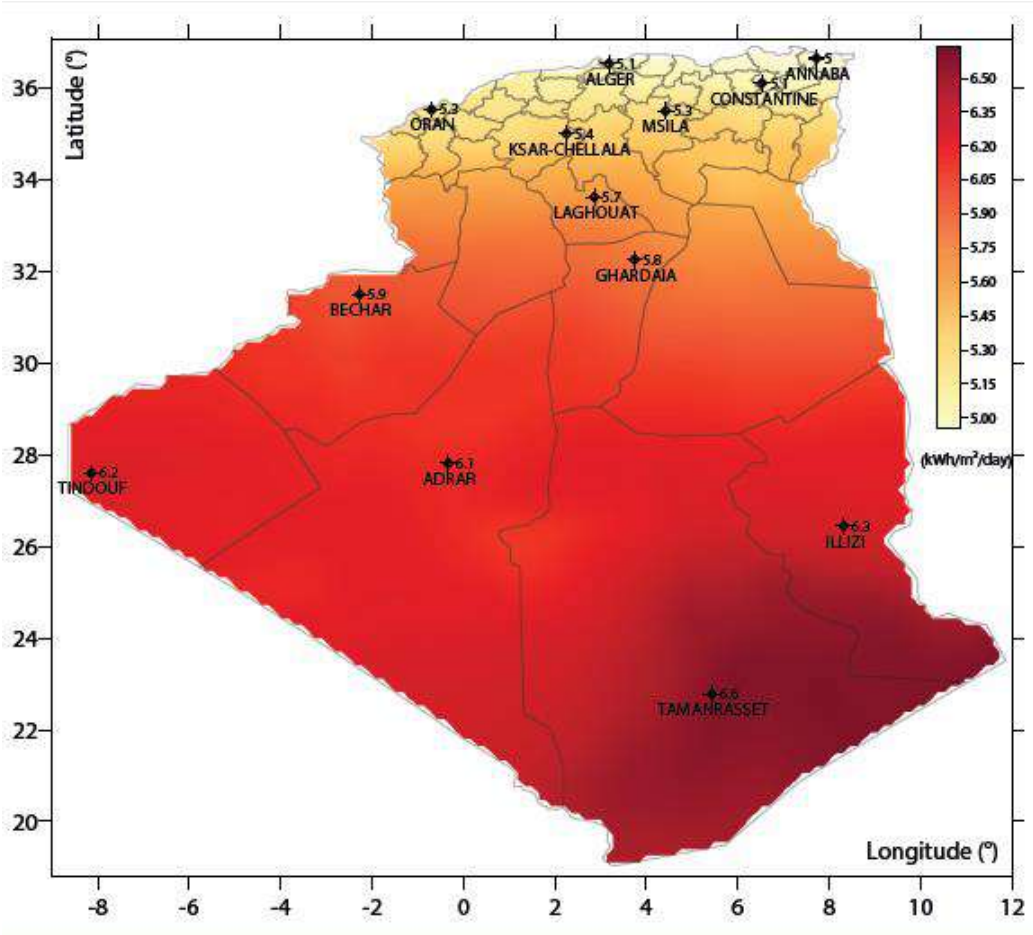

Figure 2.3: Gisement solaire de l'Algérie : Energie solaire globale (ou GHI : Global Horizontal Irradiance)

[20]

2.5) PV modeling software:

System Adviser Manager (SAM) is a software tool that can be used for modeling and simulating the performance of PV systems. But We just use SAM to get access to the Sam liberatory archives. Which is not our objective in this study and only the library of the software, are used to determinate the η degradation. the software offers a rish library of the different baby bottle types classified by and puissance. in the study Our choice is PV type with capacity and η degradation coefficient of (%/°C)

2.6) Understanding the Photovoltaic Process:

known as the photovoltaic effect. This process occurs when photons from the sun hit the PV cell and transfer their energy to electrons in the material, causing them to become excited and creating a flow of electricity.

The basic structure of a PV cell consists of a thin layer of semiconductor material, usually silicon, with a positive and negative layer. When sunlight hits the PV cell, photons are absorbed by the semiconductor material and transfer their energy to the electrons in the material. This energy causes the electrons to break free from their atoms and flow through the cell, creating an electric current.

The current generated by a single PV cell is typically quite small, so many cells are connected in series or parallel to create a PV module or panel. The modules are then connected together in arrays to generate larger amounts of electricity. The efficiency of a PV system depends on a variety of factors, including the type and quality of the cells, the amount and angle of the sunlight hitting the cells, and the temperature of the cells.

In summary, the PV process involves the transfer of solar radiation to electric energy through the photovoltaic effect, which occurs when photons from the sun hit the semiconductor material of a PV cell, causing a flow of electric current [30].

2.7) Factors affecting the effeciancy of the pv:

In the sensitivity analysis of temporal resolution and temperature effects on PV potential estimation, several factors can affect the efficiency of the PV system, particularly when considering the choice of monocrystalline (mono) PV module type. These factors include:

Temperature Coefficient: Monocrystalline PV modules typically have a lower temperature coefficient compared to other module types. A lower temperature coefficient means that the decrease in efficiency with increasing temperatures is relatively less pronounced, resulting in improved performance in high-temperature conditions.

Spectral Response: Monocrystalline PV modules have a higher spectral response, meaning they can convert a wider range of light wavelengths into electricity. This allows them to perform better in low-light or cloudy conditions, maximizing energy production even during suboptimal lighting conditions.

Space Efficiency: Monocrystalline PV modules tend to have a higher power output per unit area compared to other module types. This space efficiency can be advantageous when dealing with limited installation space, allowing for higher energy generation in a smaller area.

Durability and Longevity: Monocrystalline PV modules are known for their durability and long lifespan. Their robust construction and high-quality silicon materials contribute to their reliability, ensuring consistent performance over extended periods.

System Design and Installation: While the choice of monocrystalline PV modules can enhance efficiency, other aspects of system design and installation also play crucial roles. Factors such as proper system sizing, mounting orientation, shading analysis, and optimal inverter selection should be considered to maximize overall system efficiency.

By considering these factors, particularly the choice of monocrystalline PV modules, in the sensitivity analysis of temporal resolution and temperature effects, a more accurate estimation of PV potential can be obtained, leading to improved efficiency and performance of the PV system.

Tableau 2.2:factors that can affect the efficiency of photovoltaic (PV) systems:

Factor	Description
Temperature	High temperatures can cause a decrease in efficiency of PV cells, as they generate less electricity when they are hot.
Solar Irradiance	The amount of sunlight received by the PV cells affects their ability to produce electricity. Higher levels of solar irradiance can increase the efficiency of PV systems.
Shading	Shading from trees, buildings, or other objects can reduce the efficiency of PV systems by blocking sunlight from reaching the cells.
Orientation and Tilt	The orientation and tilt of the PV panels can affect their efficiency, as panels facing directly towards the sun will produce more electricity than those that are angled away.
Dust and Dirt	Accumulation of dust and dirt on the surface of the PV panels can reduce their efficiency by blocking sunlight from reaching the cells.
Age and Degradation	The efficiency of PV systems can decrease over time due to wear and tear, and the degradation of the materials used in the PV cells.
Type of PV Technology	Different types of PV technologies have different efficiencies, with some being more efficient than others.
System Design and Installation	The design and installation of the PV system can affect its efficiency, as a poorly designed or installed system can lead to inefficiencies and reduced performance.
Inverter Efficiency	The efficiency of the inverter used in the PV system can affect its overall efficiency, as the inverter converts the direct current (DC) generated by the PV cells into usable alternating current (AC) electricity.

2.8) Electricity production:

Sensitivity analysis of temporal resolution and temperature effects on photovoltaic estimation can have significant implications for electricity production. Accurate

estimation of photovoltaic potential can help plan and optimize renewable energy systems, which in turn can lead to increased electricity production from solar energy.
We are focusing on one of the renewable energy means of producing electricity which is solar photovoltaic energy, since its development has been by far the most dynamic of all renewable energy sources. Over a ten-year period (2005-2015), solar PV production increased from 125 kt to 8799 kt (6939%) in the same period6. It is expected that due to technological developments, solar PV will soon be the cheapest source of electricity.
In general, accurate estimation of PV potential considering factors such as temporal resolution and temperature effects can help optimize renewable energy systems and increase electricity production from solar energy [31].

2.9) Solar power :

Solar PV energy is easily scalable; both large- and small-scale parks, as well as individual homes, may produce it. Its capacity has significantly increased during the past ten years. As a result, both the cost of manufacturing the panels and the subsidies that national authorities provide investors per generated MW/h have significantly decreased. Similar to wind energy, EU solar PV energy, particularly in Germany and Italy, dominated the market in terms of capacity until 2015. Since then, the EU has fallen to second place due to the rate of investment in Asia, particularly in China and Japan [31].

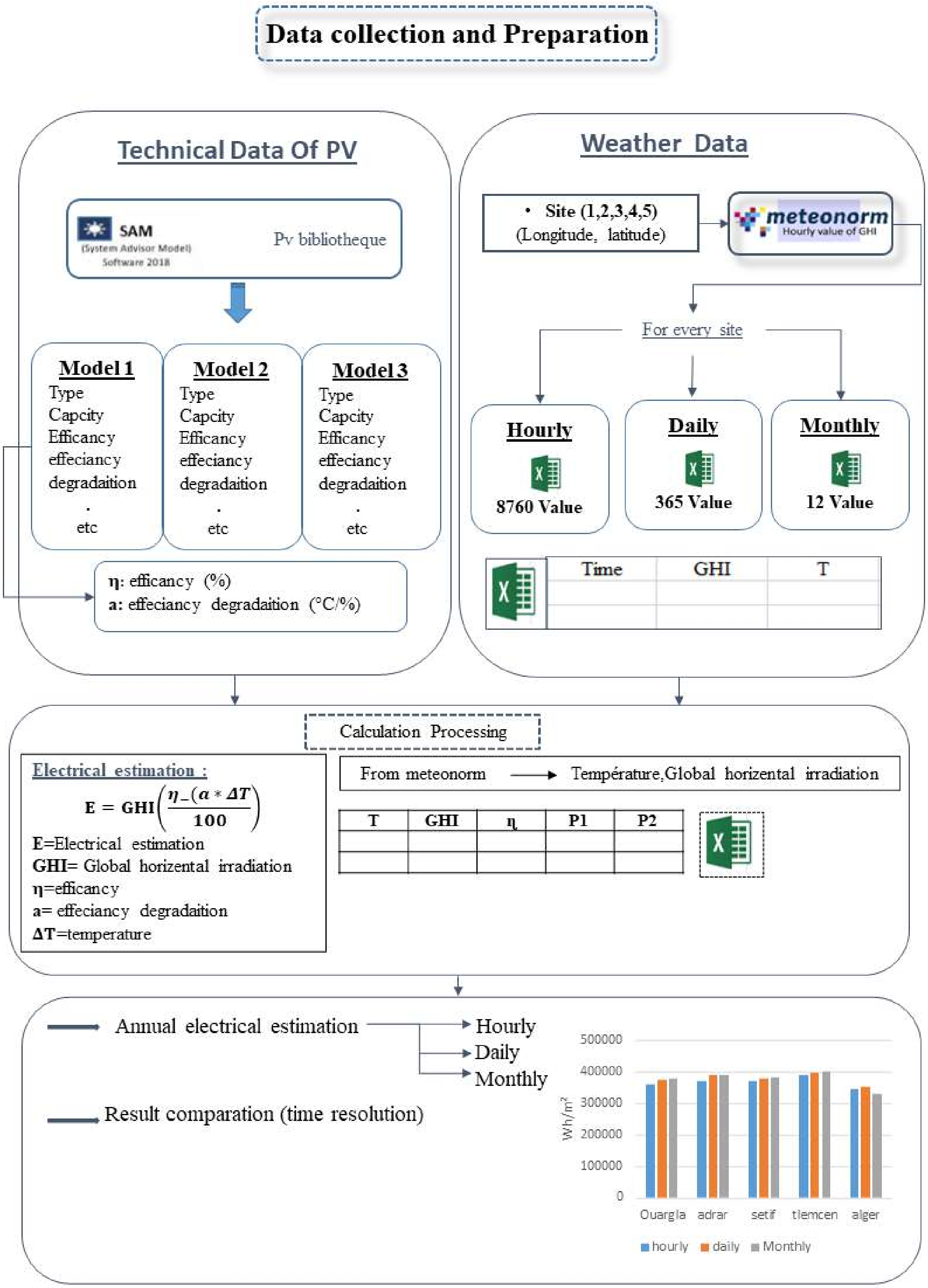

Figure 2.4:organigramme data collection and preparation

The project involves two main sections: technical data of PV systems and weather data.
In the first section, you utilize the System Advisor Model (SAM) and the PV library. Within this section, there are three different PV models, each with their own specifications such as type, capacity, efficiency, efficiency degradation, and so on.
In the second section, you focus on site selection using Meteonorm, which provides hourly, daily, and monthly weather data. This data is crucial for assessing the feasibility and performance of the PV systems.
To conduct the calculations and analysis, you use Excel with appropriate formulas. The Excel sheets are populated with the relevant data from the PV models and weather data obtained from Meteonorm. This allows you to perform calculations, simulations, and evaluations based on the inputs.
after completing the calculations, you discuss and analyze the results obtained from the Excel calculations. This could involve comparing the performance of different PV models under various weather conditions, identifying strengths and weaknesses, and making recommendations based on the findings.

3. Conclusion :

In conclusion, the sensitivity analysis of temporal resolution and temperature effects on PV potential estimation is a crucial step in selecting suitable sites for PV projects. The results of this analysis can help policymakers, investors, and developers make informed decisions by providing accurate and reliable estimates of the energy yield of PV systems under different environmental conditions. The findings of this study reveal that the choice of temporal resolution has a significant impact on PV potential estimation, and the selection of an appropriate time step is crucial to ensure accurate results. Moreover, the effect of temperature on PV potential estimation cannot be overlooked, as it has a considerable impact on the accuracy of the results. Therefore, it is essential to consider temperature correction techniques when estimating PV potential in areas with high temperature variations. In summary, the sensitivity analysis of temporal resolution and temperature effects on PV potential estimation is an indispensable step in site selection for PV projects, and it can help ensure the economic viability and sustainability of PV projects.

Chapter :03

Results and discussion

III. Results and discussion :

1) Introduction:

The photovoltaic (PV) industry has experienced significant growth in recent years, driven by increasing demand for renewable energy sources and advances in photovoltaic technology. Accurate estimation of photovoltaic potential is essential for optimal deployment of photovoltaic systems and efficient use of solar energy resources. However, the accuracy of the estimate can be affected by several factors, including temporal resolution and temperature.

In this chapter, we present the results from the sensitivity analysis of the effects of temporal resolution and temperature on the photovoltaic potential estimation. Our analysis aims to evaluate the trade-offs between temporal resolution and temperature corrections for an accurate estimation of the photoelectric potential.

We begin by presenting the results of our sensitivity analysis, including the effect of temporal resolution and temperature on the accuracy of PV energy estimation and the combined effect of both factors. We also discuss trade-offs between accuracy and resource requirements for different combinations of temporal resolution and temperature correction. In the last part, we present our conclusions and recommendations for estimating the PV potential based on the results of sensitivity analysis. the findings have implications for potential estimation of PV energy and resource planning in desert regions and can be used to improve the accuracy of potential estimation of PV energy in these regions.

2) Results and discussions:

After applying the methodology shown in Figure 2.4, the results and evaluation of the electrical energy produced from each study area are among the five previously mentioned. Where is the produced energy displayed and the change in calculating the effect of temperature for several hourly, daily and monthly time intervals? Results are presented in a sequential manner and then commented on Comparing where we focus on the total energy produced and the severity of the difference or its value, and then we show according to each temporal resolution . Then the total production of five regions was compared in order resolution hourly

3.1 The effect of temporal and time resolution on efficiency which effect the estimated electricity:

3.1.1 The effect of temperature:

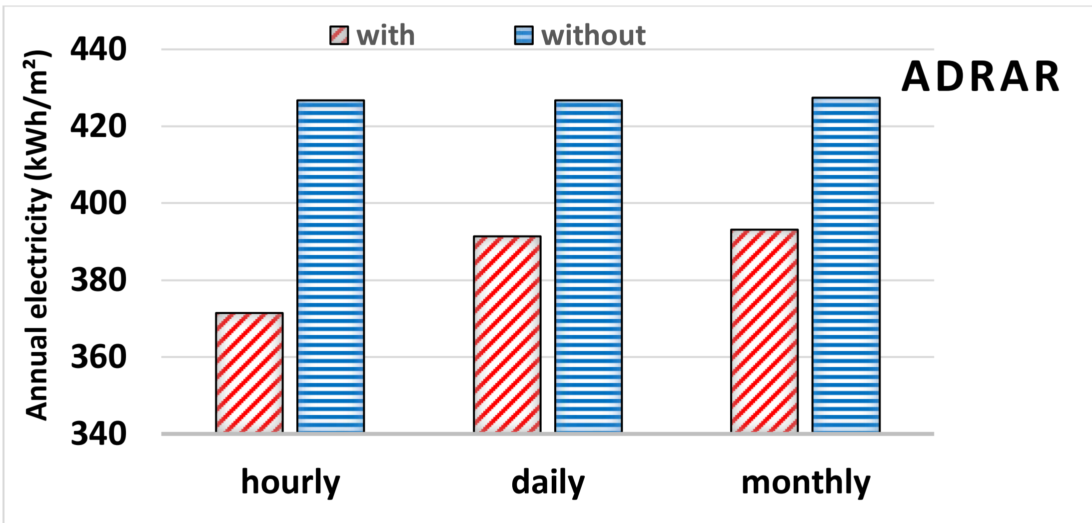

Figure 3.1: Annual estimated electricity with and without temperature effect in Adrar

Figure 3.2: Annual estimated electricity without and with temperature effect in Algiers

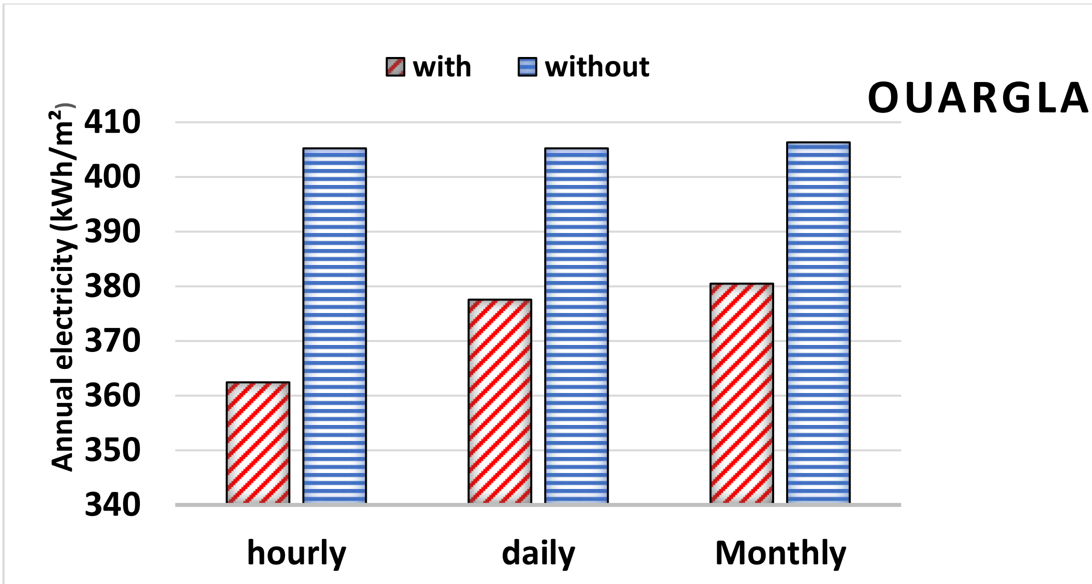

Figure 3.3: Annual estimated electricity with and without temperature effect in Ouargla

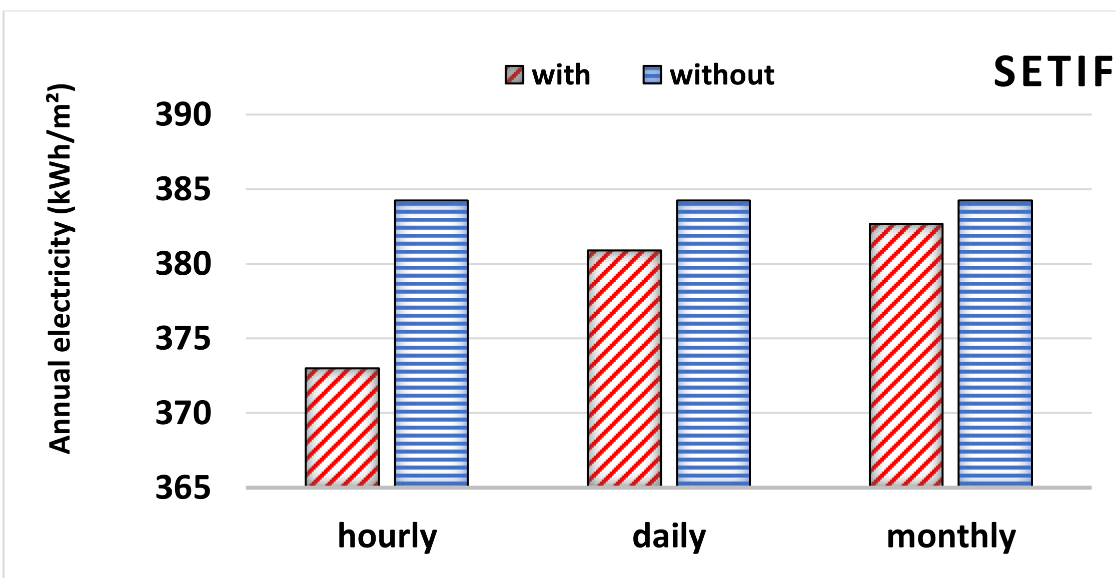

Figure 3.4: Annual estimated electricity with and without and without temperature effect in Setif

Figure 3.5: Annual estimated electricity with and without temperature effect in Tlemcen

3.1.2 The effect of time resolution:

The temporal resolution of weather data is another important factor that can affect the accuracy of the PV potential estimation. In the sensitivity analysis of the time resolution and the effects of temperature on the PV voltage estimation, it was found that the time resolution has a significant impact on the estimated annual electricity production.

The analysis showed that with increasing time resolution, the estimated annual production of electricity decreased in all the studied regions, namely Adrar, Ouargla, Tlemcen, Algiers, and Setif. This trend is observed for all months of the year, which indicates that the effect of temporal resolution on potential estimation of PV energy is constant throughout the year.

Moreover, the results indicated that the effect of temporal resolution on the estimation of the PV potential varied between regions. The highest decline in estimated annual electricity production due to time accuracy was observed in Adrar, followed by Ouargla, Tlemcen, Setif and Algeria. This difference in the effect of time resolution can be attributed to the different climatic conditions and latitude in the regions.

A sensitivity analysis of the effects of time resolution on PV potential estimation highlights the importance of considering the time resolution of weather data in the design and operation of PV systems. The results provide valuable insights into the variability in the effect of time resolution on the PV potential estimation in different regions. These results can be used to improve performance and maximize electricity generation for photovoltaic systems in different regions, taking into account the temporal resolution of weather data for each location.

3.2 Comparing the results of the estimated annual production electricity in each region:

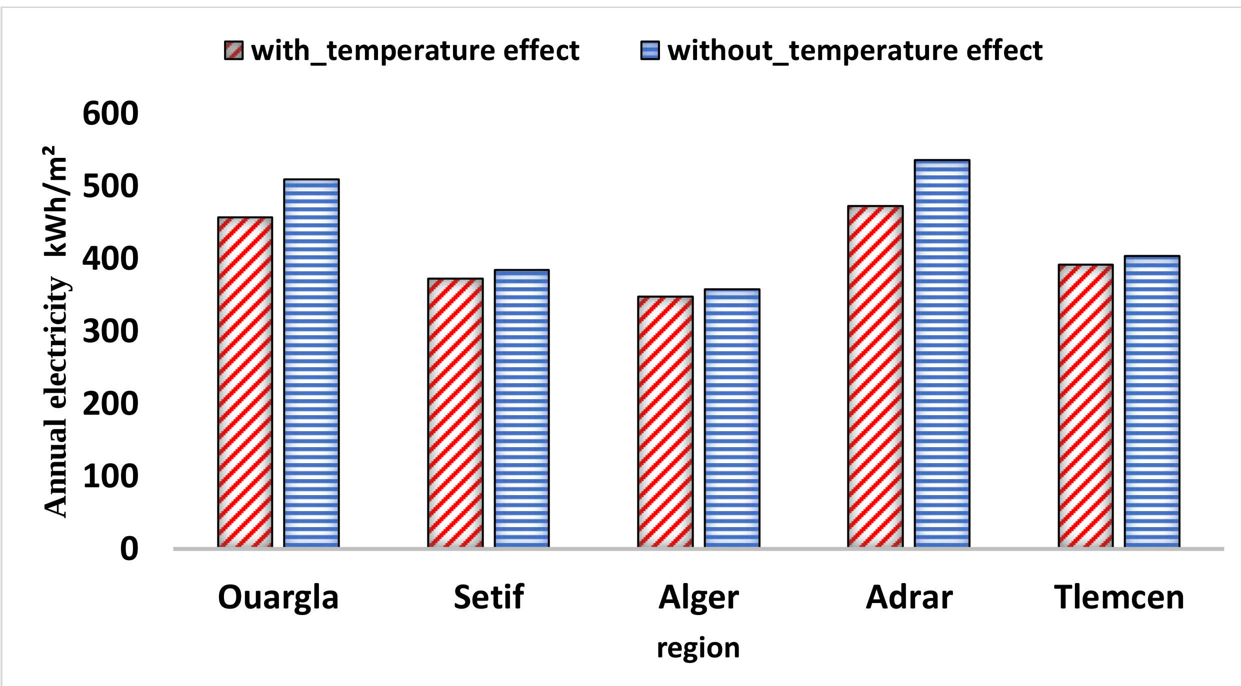

Figure 3.6 : Annual estimated electricity with and without temperature effect (hourly)

The sensitivity analysis of temporal resolution and temperature effects on PV potential estimation reveals interesting findings for various locations. Comparing the annual estimated electricity with and without temperature effects (hourly), we observe the following differences:

Ouargla:(With temperature effect: 457 kWh,Without temperature effect: 509 kWh,Difference: 52 MWh)

Setif:(With temperature effect: 372 kWh,Without temperature effect: 384 kWh,Difference: 12 MWh)

Alger:(With temperature effect: 347 kWh,Without temperature effect: 357 kWh,Difference: 10 MWh)

Adrar:(With temperature effect: 472 kWh,Without temperature effect: 536 kWh,Difference: 64 MWh)

Tlemcen:(With temperature effect: 392 kWh,Without temperature effect: 403 kWh,Difference: 11 MWh)

To assess the significance of these differences, we can calculate the percentage change in annual electricity generation:

Ouargla: 52 kWh / 509 kWh = 10.21% decrease

Setif: 12 kWh / 384 kWh = 3.13% decrease

Alger: 10 kWh / 357 kWh = 2.80% decrease

Adrar: 64 kWh / 536 kWh = 11.94% decrease

Tlemcen: 11 kWh / 403 kWh = 2.73% decrease

By examining these percentage changes, we can observe that the differences range from approximately 2.73% to 11.94%. While the specific values may vary for each location, the consistent pattern of decreased electricity generation without temperature effects demonstrates the importance of considering temperature in PV potential estimation.

These findings suggest that temperature has a significant impact on the estimated electricity generation from photovoltaic systems. Failing to account for temperature effects can lead to underestimating the actual potential of PV installations. Incorporating temperature considerations in the estimation process ensures more accurate and reliable results, enabling better planning and decision-making for solar energy projects.

Results evaluation :

In order to quantify the electrical energy difference between the two potential estimation, a reliable area of PV project will be considered in this case. So, El Hadjira PV with 30 MW is selected as example. this project is located in the southern part of the country occupied a total area of 80 hectares. Where only 75% is used for production. The real covered area with PV panels presents 32.03% from the total. The project takes advantage of the area's abundant solar resources. The strategic location of El Hadjira allows for efficient harnessing of the sun's energy, converting it into usable electricity. The project's specific location, benefits from year-round sunshine and high levels of solar radiation. The project can generate a substantial amount of clean and sustainable electricity. The proximity to electrical grid minimizes transmission losses and ensures that the generated energy can be easily integrated into the local electricity grid.

The El Hadjira solar power plant is a significant renewable energy project with a power capacity of 30 MW, with installation of an impressive array of 120 120 photovoltaic (PV) panels. With an unit area of 1.6 m² by panel. This extensive deployment of PV panels enables the efficient capture of sunlight and its conversion into electricity using photovoltaic technology.

Tableau 3.1:Card characteristics of PV panel used in El Hdjira Project [32]

Solar Power Plant	Total Number of PV Panels	Surface Area of Each PV Panel	Power Capacity	Type of Panel
El Hadjira	120 120	1.6 m²	30000 KW	Polycrystalline

The figure below present the visualisation map of El Hdjira solar power plant.

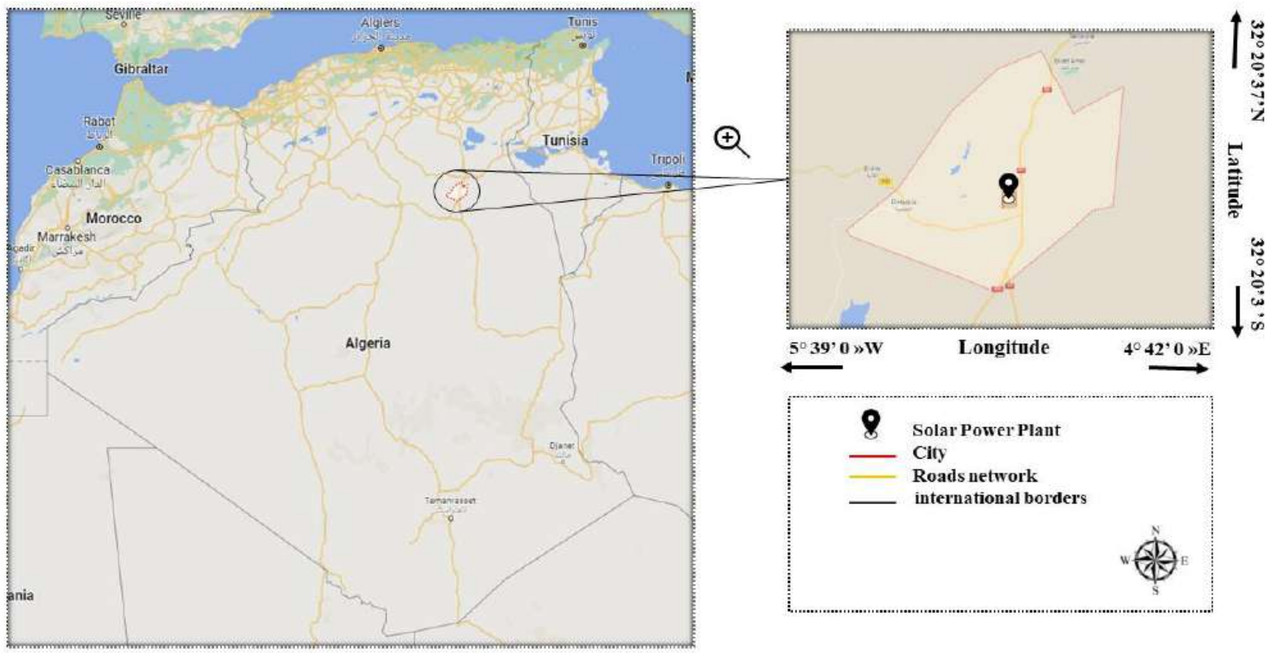

Figure 3.7: Map of Solar Power Plant El Hadjira

In ordre to calculate the real covered area with PV panels, we are based on the PV numbers (120120) and the unit area of each panels (equal to 1.6m²). as detailed below:

$$PV_{surface} = S_{unit-PV} * N_{Panals}$$

$PV_{surface}$: Surface covered by PV panels

$S_{unit-PV}$: unit area of each panel

N_{Panals} : number of panels

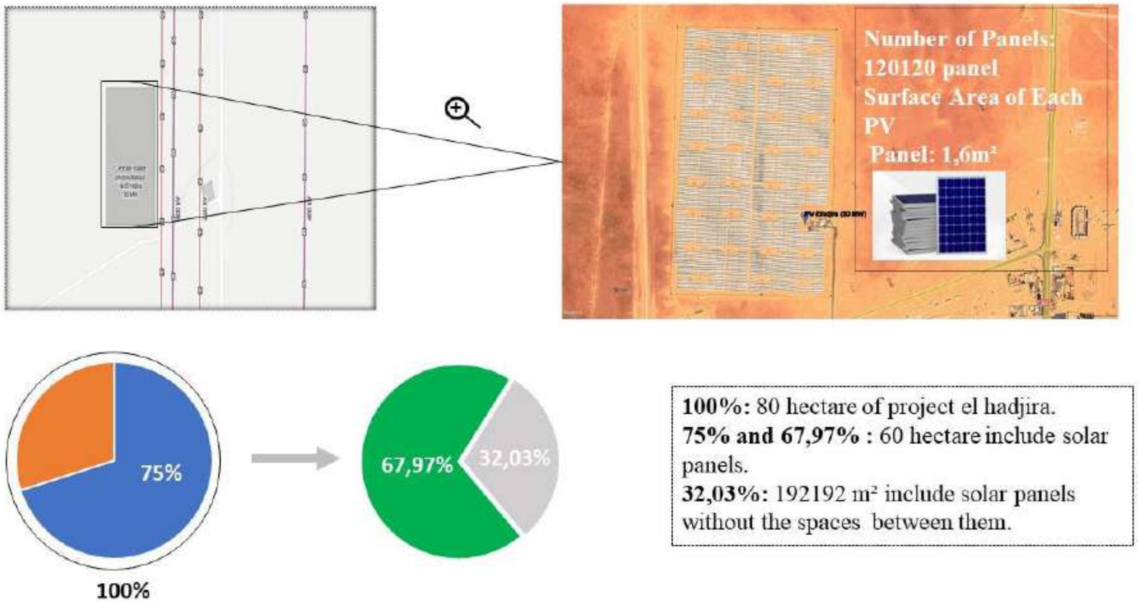

Figure 3.8: Elhdjira PV site utilities

Calculate total energy production for each site :

The process :

with temperature effect*surface general

without temperature effect * surface general

déffférence* surface general

The comparison between energy production with temperature effect and without temperature effect highlights the significance of temperature on the overall energy generation in each location. Locations like Ouargla and Adrar show notable differences in energy production, emphasizing the importance of considering temperature effects in PV projects. Understanding these variations can aid in accurate energy predictions and inform system design and planning decisions for optimal performance Results shown in the table

Tableau 3.2: total energy production of each site

Site	With Temperature Effect (kWh)	Without Temperature Effect (kWh)	Difference (kWh)
Ouargla	87,978,144	97,847,328	9,869,184
Setif	71,539,424	73,900,608	2,361,184
Alger	66,845,424	68,702,344	1,856,920
Adrar	90,764,224	102,698,752	11,934,528
Tlemcen	75,421,184	77,466,176	2,044,992

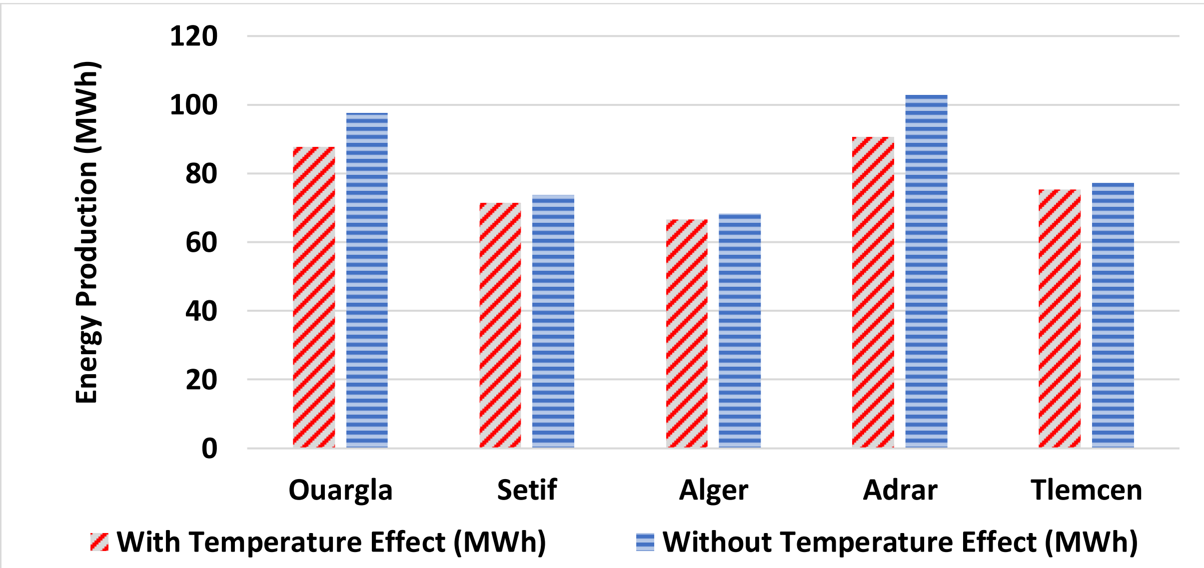

Figure 3.9: Energy Production Comparison by Location (MWh)

The energy production presented in Figure 3.9 for the five region (Ouargla, Setif, Alger, Adrar, and Tlemcen) provide valuable insights into the impact of temperature on energy generation. The comparison between energy production with and without temperature effects highlights the significance of temperature on the overall energy output in each location. Ouargla and Adrar exhibit substantial differences, emphasizing the need to consider temperature variations in accurate energy predictions and system design. Setif and Alger show relatively minor variations, indicating a more stable energy output. Tlemcen experiences a consistent energy production regardless of temperature fluctuations. These findings underscore the importance of undertaking temperature effects in optimizing energy production and promoting efficient renewable energy utilization in each state.

3.3 Comparison of Daily and Hourly Potential Electricity Generation on the 2nd Day of June:

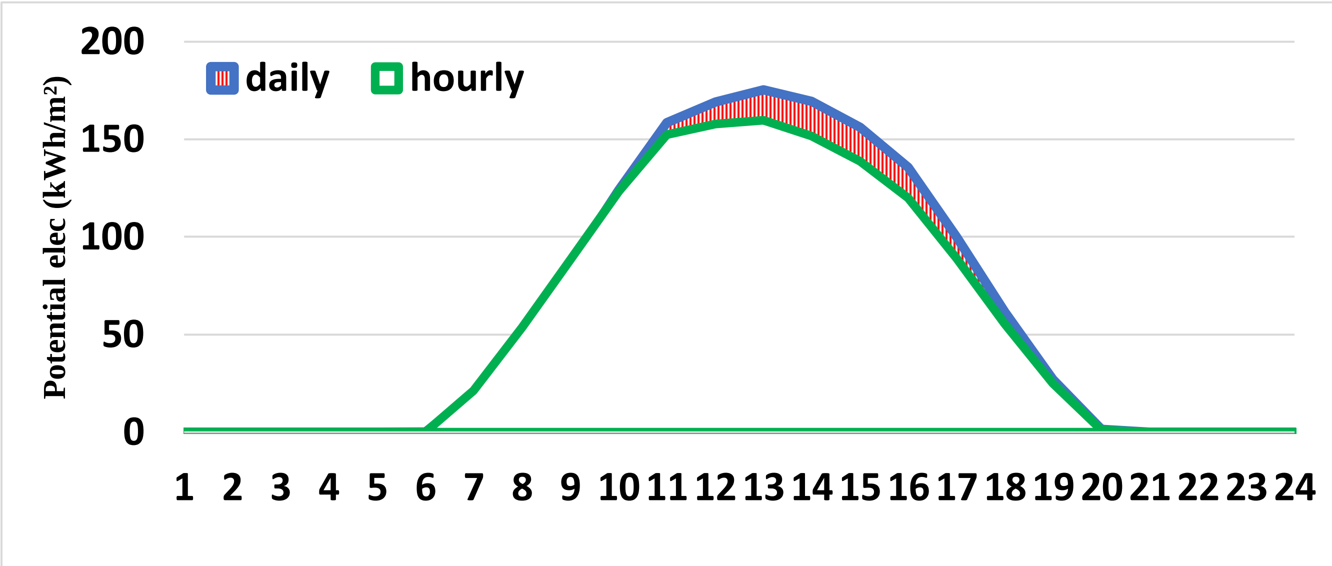

Figure 3.10:potential electricity (kwh/m²) daily and hourly of 2nd day of June.

In the figure displaying the potential electricity (kWh/m²) for both daily and hourly values on the second day of June, we can observe the comparison between the two in a single diagram. This representation allows us to easily understand the differences and relationships between the daily and hourly potential.

The graph will likely show two curves, one representing the daily potential and the other representing the hourly potential. The daily electrical potential is higher than the hourly values due to the characteristic of daily temperature measurement (mean values).

This is because the daily potential is calculated based on mean value (…..°C) for all the daily hours. On the other hand, the hourly potential is calculated based on a specified temperature measurement for each hour in the day. The hourly potential values are more accurate and provide a finer-grained understanding of the energy production patterns throughout the day.by presenting both the daily and hourly potentials in the same diagram, this helps us recognize the overall trend of higher daily potential compared to the hourly potential and appreciate the subtle variations that occur within the hourly measurements.

3.4 Hours of (T>25°):

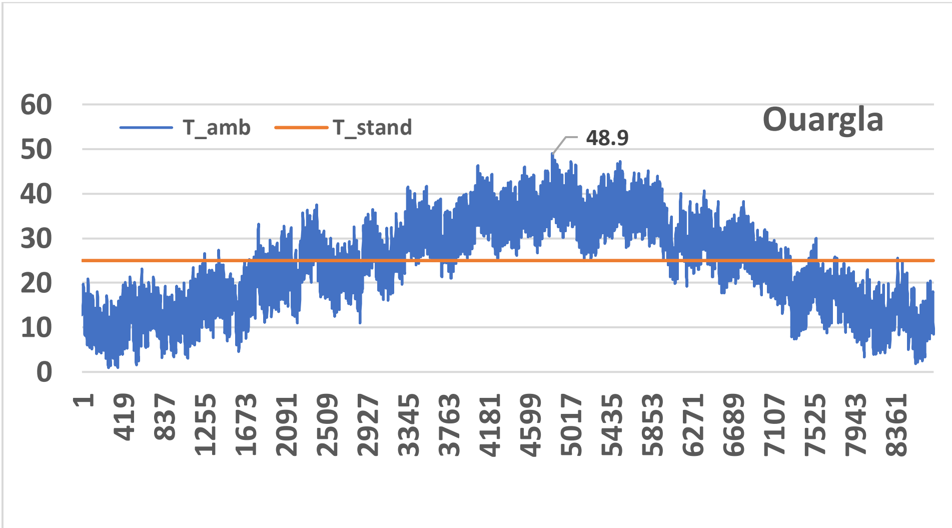

Figure 3.11: Hours of (T>25C°) on Ouargla

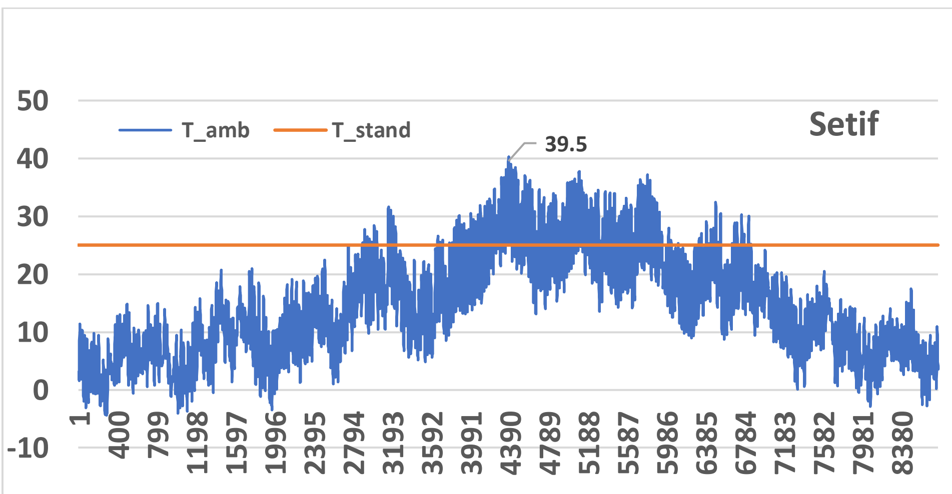

Figure 3.12: Hours of (T>25C°) on setif

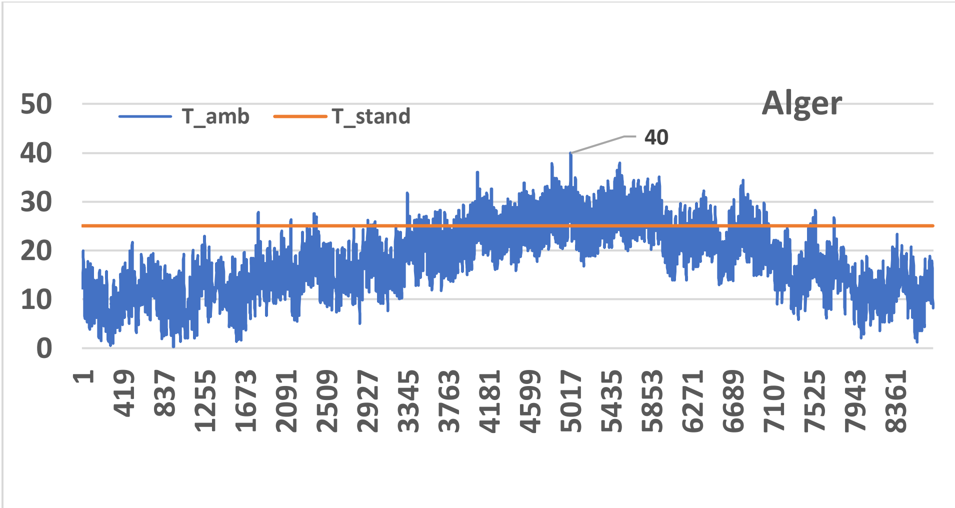

Figure 3.13: Hours of (T>25C°) on Alger

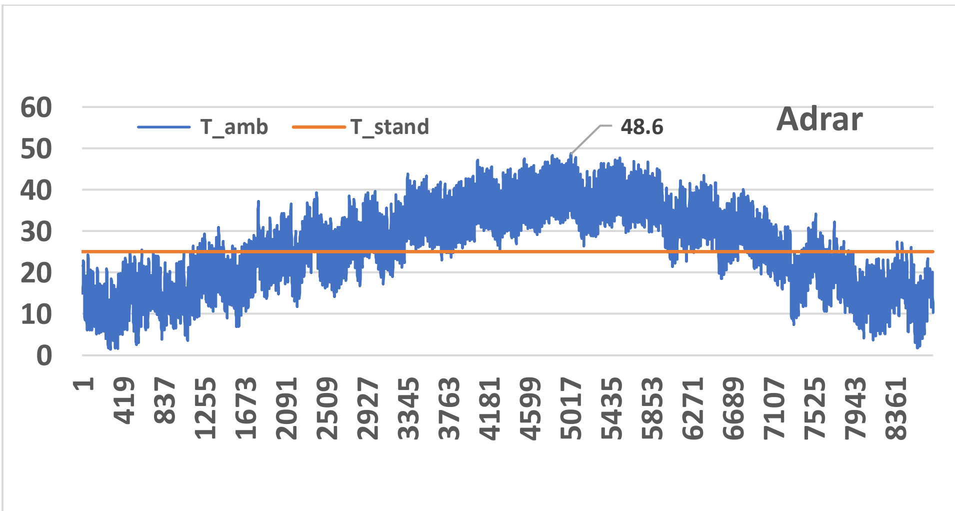

Figure 3.14: Hours of (T>25C°) on Adrar

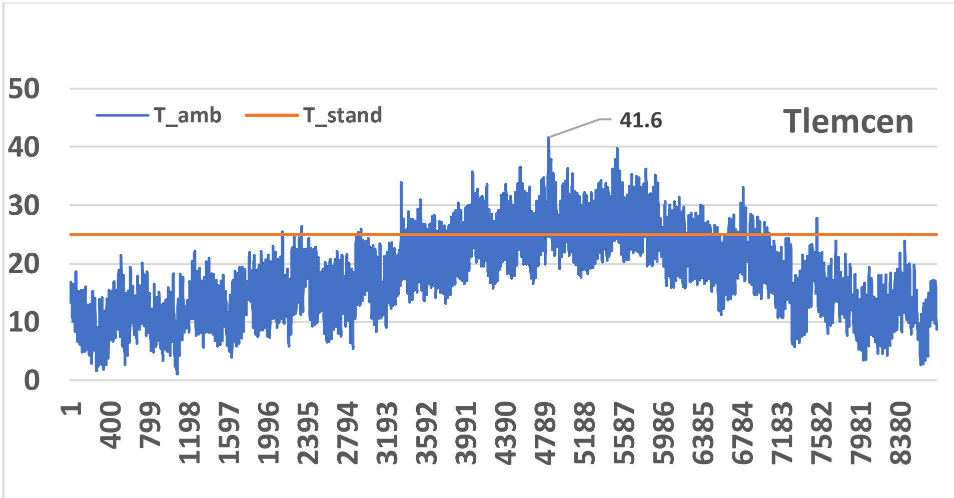

Figure 3.15: Hours of (T>25C°) on Tlemcen

The sensitivity analysis conducted on the temporal resolution and temperature effects on PV potential estimation reveals fascinating insights across various regions. Figures specifically showcasing Ouargla, Algiers, Setif, Adrar, and Tlemcen, demonstrate the collective goal of assessing the number of hours with a temperature exceeding 25°C (T>25°). These figures provide valuable information on the potential solar energy available in each state, considering the impact of temporal variations and temperature fluctuations. By examining the data, it becomes apparent that these regions share a common objective of understanding the extent and duration of favorable conditions for solar energy generation. Such comprehensive analysis aids in optimizing PV system planning and highlights the significance of temporal resolution and temperature factors in estimating PV potential accurately.

3.5 Temperature Analysis:

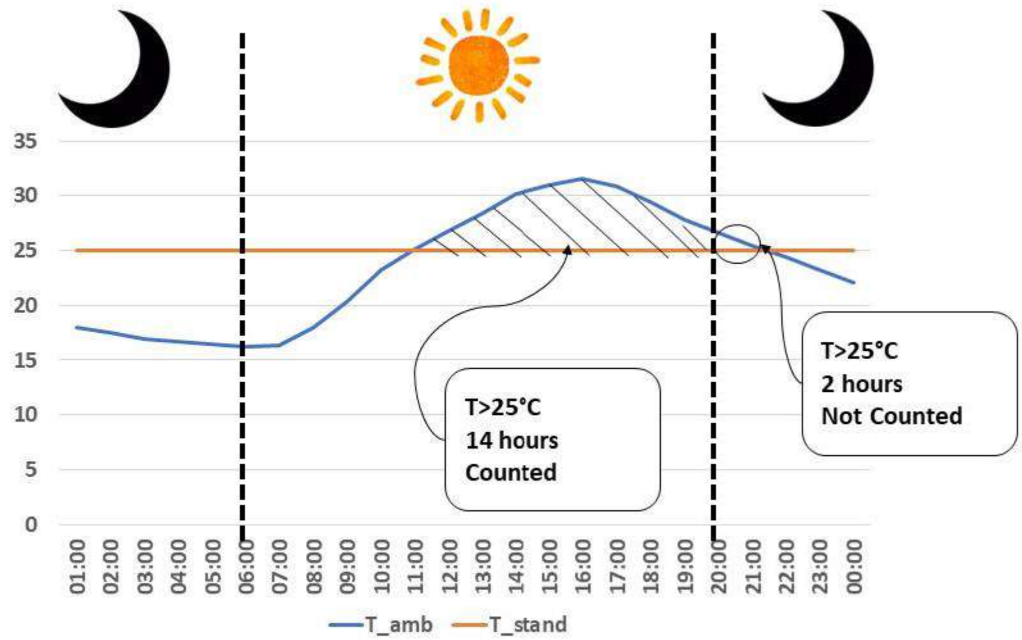

Figure 3.16 :Hourly Variation Above 25°C during Daytime.

The figure shows a 24-hour total curve, including day and night, on March 27 in Ouargla with emphasis on the temperature range above and below 25°C. Provides information on calculated and uncalculated hours. It is worth noting that the daytime period is from 6 am to 8 pm, with the period from 11 am to 8 pm. They are specifically evaluated as hours above the 25°C temperature threshold were counted. By examining the data, we can assess how much the temperature exceeded 25 degrees during this period, allowing for a more detailed understanding of temperature patterns and their effects. Figure results are shown in the table:

Tableau 3.3: Variation Above 25°C and counted one

Time	Temp > 25°C	Counted
00:00-05:00	Yes	No
06:00-10:00	No	No
11:00-20:00	Yes	Yes
20:00-00:00	No	No

3.6 Efficiency curves according to temperature:

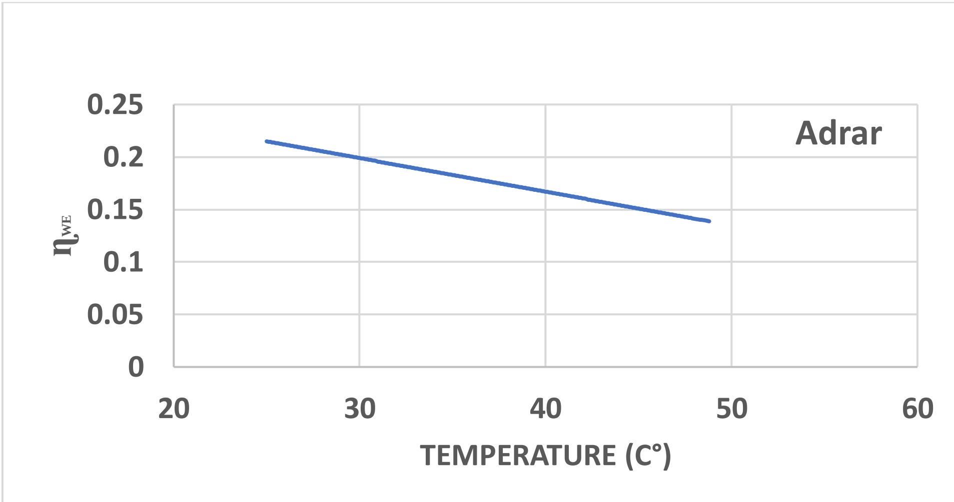

Figure 3.17: Efficiency curves according to temperature in Adrar

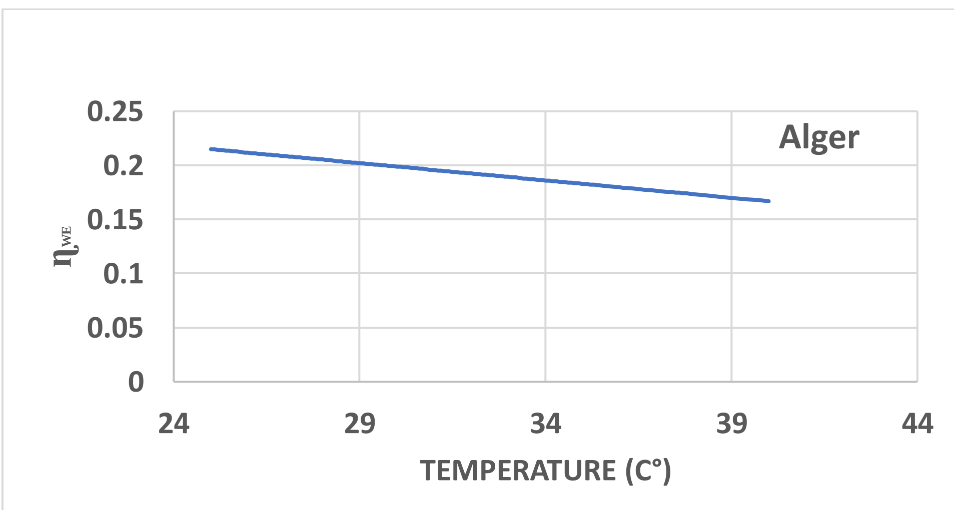

Figure 3.18: Efficiency curves according to temperature in Algiers

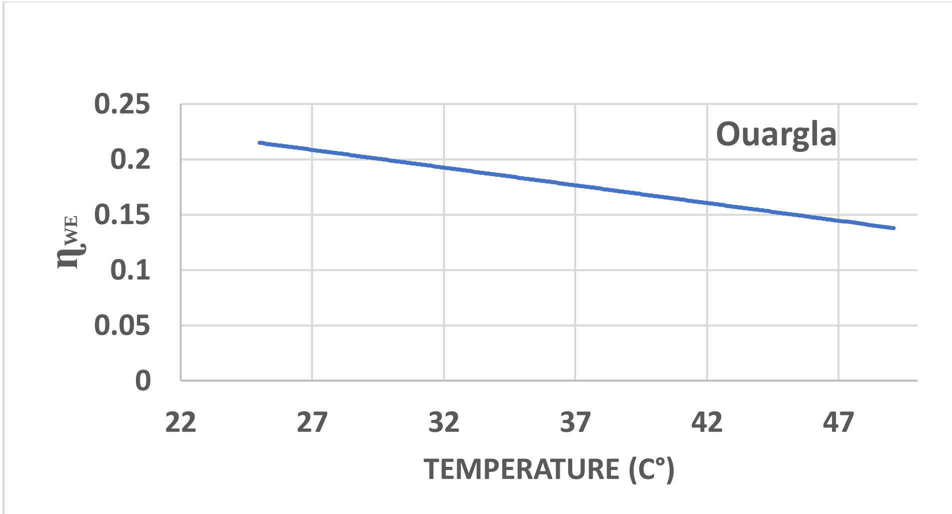

Figure 3.19: Efficiency curves according to temperature in Ouargla

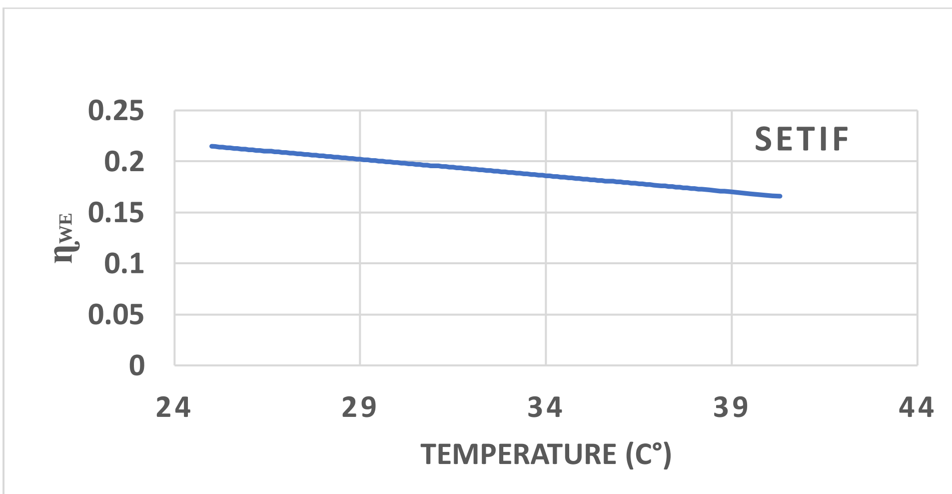

Figure 3.20: Efficiency curves according to temperature in Setif

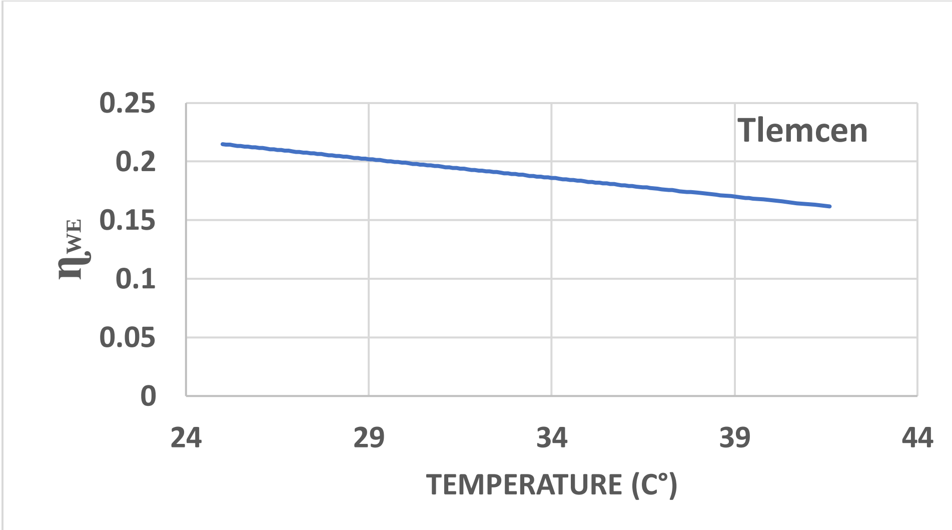

Figure 3.21: Efficiency curves according to temperature in Tlemcen

In the sensitivity analysis examining the effects of temporal resolution and temperature on photovoltaic (PV) potential estimation, it is evident from figures (3.17 to 3.21) that all the curves depicting the relationship between system efficiency and temperature exhibit a consistent trend of decreasing values. Regardless of variations in temporal resolution or additional factors considered, higher temperatures consistently lead to a decline in PV system efficiency. This finding underscores the detrimental impact of elevated temperatures on the overall performance and yield of PV systems, highlighting the importance of temperature management strategies in maximizing energy production.

3.7 Temperature degree and sunshine hours for T>25°C:

For PV systems operating at temperatures above 25°C, both temperature and sunshine hours play a significant role in performance. The figure shows the temperature degree of these data points, illustrating the impact on PV panel efficiency. As the temperature rises, the efficiency of PV panels gradually declines, affecting energy conversion. an increase in sunshine hours can offset the temperature effect, resulting in a higher overall energy output. By maximizing exposure to sunlight and considering temperature management techniques, PV systems can harness their full potential even in temperatures exceeding 25°C.

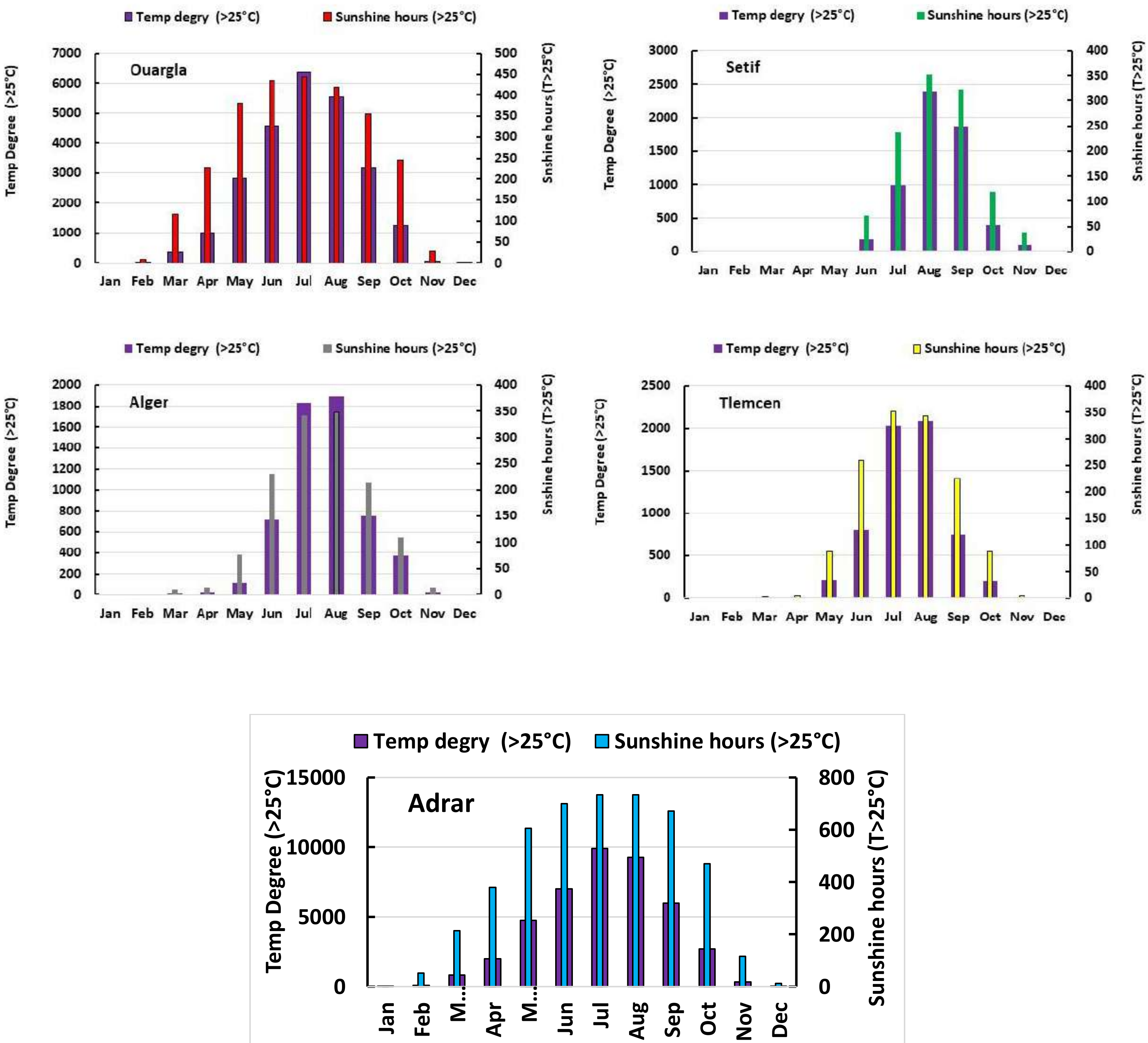

Figure 3.22:Temperature degree and sunshine Hours.

The figure 3.22 displays the temperature degrees (>25 °C) and sunshine hours corresponding to (T>25°C) for Ouargla, Adrar, Alger, Tlemcen, and Setif. providing valuable insights into the climatic conditions of these locations.

In terms of temperature, Ouargla exhibits the highest average degrees, maintaining its reputation as one of the hottest cities in Algeria. Adrar follows closely, showcasing a similar pattern of warm temperatures. Alger, the capital city, demonstrates moderate temperatures, while Tlemcen and Setif portray relatively cooler climates.

Regarding sunshine hours, Ouargla stands out as the location with the most abundant sunshine, reflecting its desert-like environment. Adrar experiences a comparable level of sunlight, contributing to its arid climate. Alger demonstrates a decent number of sunshine hours, indicating a balanced climate. Tlemcen and Setif, with fewer sunshine hours, experience a milder climate, often characterized by more cloud cover and cooler temperatures.

Overall, the graph illustrates the diverse climatic conditions across these five cities in Algeria. Ouargla and Adrar showcase hot and arid environments, Alger represents a moderate climate, while Tlemcen and Setif present cooler and slightly cloudier conditions. Understanding these temperature and sunshine patterns can aid in various sectors such as agriculture, tourism, and urban planning.

3.8 Comparing the state :

To compare the results of temperature degrees and sunshine hours, a scientific approach can be applied by using a coefficient (ɳ) to combine these two factors. Let's denote the temperature degree as T and the sunshine hours as S for a specific location. The combined measure can be obtained by calculating the coefficient multiplied by the ratio of temperature to sunshine hours, as shown in the equation:

$$Combined\ Measure = \eta * (T / S)$$

In this equation:

η : $coefficient.$

T : $temperature\ degree.$

S : $sunshine\ hours$.

By multiplying the coefficient with the ratio of temperature to sunshine hours, this equation creates a unified metric that takes into account both temperature and sunlight, providing a quantitative measure that combines these two variables. This approach enables a more comprehensive evaluation of the climatic conditions in a given area.

Using this scientific approach, you can conduct a more nuanced assessment of the relationship between temperature and sunshine hours, allowing for comparisons between different locations and obtaining a single value that reflects the combined influence of these two variables. The coefficient can be adjusted based on the specific significance or weight assigned to each factor in the evaluation.

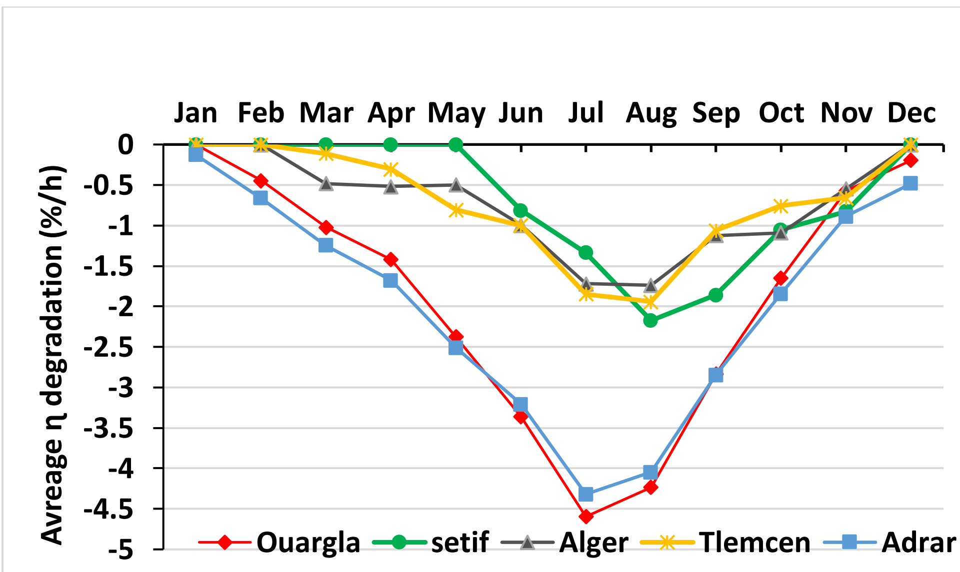

Figure 3.23:average η degradation (%/h) across five region (monthly)

The figures depicting the average η degradation (%/h) across five region - Ouargla, Adrar, Alger, Setif, and Tlemcen - provide valuable insights into the performance of these regions. Ouargla and Adrar stand out as the locations with the lowest minimum values of η degradation. These region experience significant efficiency loss, with Ouargla reaching a minimum value of -4.6% per hour and Adrar closely following with -4.3% per hour. These figures indicate a higher rate of degradation, potentially impacting the operational efficiency and reliability of systems or processes in these areas.

On the other hand, Alger, Setif, and Tlemcen exhibit comparatively higher minimum values of η degradation. Alger demonstrates a minimum value of -1.75% per hour, while Setif and Tlemcen display -2.2% and 1.95% per hour, respectively. Although these values are higher than the minimum values of Ouargla and Adrar, they still suggest a notable level of efficiency loss that should be taken into consideration.these figures emphasize the importance of monitoring and addressing η degradation to optimize performance and minimize efficiency loss. Industries, utilities, and other sectors in Ouargla, Adrar, Alger, Setif, and Tlemcen should pay attention to these metrics, implementing measures to mitigate degradation and ensure sustainable operations.

3) Conclusion :

The results of this study highlight the importance of considering the temporal resolution sensitivity analysis and the effects of temperature on the photovoltage estimation. Our analysis showed that the temporal resolution of weather and temperature data has a significant impact on the accuracy of PV potential estimation. We have found that using a higher temporal resolution and temperature calculation can lead to a more accurate estimation of the photoelectric potential.

Moreover, our study showed that different regions in Algeria have different PV potentials due to variation in weather conditions. The highest photovoltaic energy potential is observed in the southern regions of Adrar and Ouargla, which have higher health rates compared to other regions. However, it is important to note that even regions with low high-income health, such as Tlemcen, can still have significant PV potential given temperature and other weather variables are suitably considered.

Overall, the results of this study can be useful for policy makers and energy planners to make informed decisions regarding the deployment of PV systems in Algeria. Using high temporal resolution weather data and temperature calculation, an accurate estimation of the PV potential can be achieved, leading to more efficient and reliable PV system design and operation.

Conclusion General

Conclusion General

Based on the available research and literature, it can be concluded that sensitivity analysis of temporal resolution and temperature effects on PV potential estimation is crucial for accurate and reliable estimation of PV potential.

Temporal resolution refers to the time interval at which the solar radiation data is collected and analyzed. A higher temporal resolution provides more detailed and accurate information about the solar radiation patterns, which in turn affects the accuracy of the PV potential estimation. It is important to consider the appropriate temporal resolution based on the specific application and location.

Temperature is another important factor that affects the performance of PV systems. High temperatures can lead to decreased efficiency and output of PV modules. Therefore, accurate estimation of the temperature effects is necessary to optimize the performance of PV systems.

Sensitivity analysis is a valuable tool for identifying the effects of changes in these variables on the PV potential estimation. By conducting sensitivity analysis, it is possible to determine the optimal temporal resolution and temperature ranges for accurate and reliable estimation of PV potential.

Overall, sensitivity analysis of temporal resolution and temperature effects on PV potential estimation is essential for effective planning and deployment of PV systems .

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Annexes

Annexes

Tableau:Ouargla hourly

	Year	Month	Day	Hour	GHI (W/m^2)	T(°C)	ΔT (T_{ambi} -25)	Positif ΔT	η_{w_e} (with_ effect)	Electrical output η_{w_e} (Wh/m^2)	Standred Electrical output (Wh/m^2)
1	2005	1	1	1	0	12,8	-12,2	0	0,2149	0	0
2	2005	1	1	2	0	13,5	-11,5	0	0,2149	0	0
3	2005	1	1	3	0	13,2	-11,8	0	0,2149	0	0
4	2005	1	1	4	0	13,2	-11,8	0	0,2149	0	0
5	2005	1	1	5	0	13,2	-11,8	0	0,2149	0	0
6	2005	1	1	6	0	13,2	-11,8	0	0,2149	0	0
7	2005	1	1	7	0	13,1	-11,9	0	0,2149	0	0
8	2005	1	1	8	0	13,2	-11,8	0	0,2149	0	0
9	2005	1	1	9	49	14,1	-10,9	0	0,2149	10,5301	10,5301
10	2005	1	1	10	139	15,6	-9,4	0	0,2149	29,8711	29,8711
11	2005	1	1	11	218	17,1	-7,9	0	0,2149	46,8482	46,8482
12	2005	1	1	12	194	17,9	-7,1	0	0,2149	41,6906	41,6906
13	2005	1	1	13	246	18,7	-6,3	0	0,2149	52,8654	52,8654
14	2005	1	1	14	219	19,2	-5,8	0	0,2149	47,0631	47,0631
15	2005	1	1	15	251	19,7	-5,3	0	0,2149	53,9399	53,9399
16	2005	1	1	16	157	19,6	-5,4	0	0,2149	33,7393	33,7393
17	2005	1	1	17	68	18,9	-6,1	0	0,2149	14,6132	14,6132
18	2005	1	1	18	2	17,8	-7,2	0	0,2149	0,4298	0,4298
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8757	2005	12	31	21	0	12,4	-12,6	0	0,2149	0	0
8758	2005	12	31	22	0	11,1	-13,9	0	0,2149	0	0
8759	2005	12	31	23	0	9,8	-15,2	0	0,2149	0	0
8760	2005	12	31	24	0	8,5	-16,5	0	0,2149	0	0
	somme									362388,5	405273,5