https://ajeat.org/ ISSN: XXXX - XXXX

Academic Journal of Engineering Applications (AJEA)
Volume: 1 Issue: 1, July 2026, pp. 11 – 17

Analysis and Efficiency Evaluation of Renewable Energy Projects Using RETScreen: Application to Photovoltaic and Wind Energy

Abdelkader Harrouz [1], Hadj Fateh Ahmed[2], Abdelghani Bahakkou[3], Fatima Zohra Demraoui[2], Latifa Amhamdi[2], Hayat Bensoudan[1], Virgil Dumbrava[4]

[1] Department of Hydrocarbon and Renewable Energy, Laboratory LDDI, Adrar, Algeria.

[2] Department of Physics, Faculty of Science and Technology, University Ahmed Draïa of Adrar, Algeria.

[3] Department of Science and Technology, Laboratory LDDI, University Ahmed Draïa of Adrar, Algeria.

[4] Department of Electric Power Systems, Polytechnic University of Bucharest, Buchrest, Roumanie.

Abstract- This study assesses the potential and performance of renewable energy projects—particularly solar and wind using RET-Screen software. Focusing on installations located in the Adrar region of Algeria, this work examines the environmental, technical, and economic feasibility of photovoltaic and wind systems. Simulations performed with RETScreen integrate regional climate data, system technical specifications, and financial parameters to estimate energy production, profitability, and emission reductions. The results highlight the usefulness of RETScreen in renewable energy project planning and demonstrate that both systems can offer favorable payback periods while significantly reducing greenhouse gas emissions in southern Algeria.

Keywords - Adrar Region, Photovoltaic Systems, Renewable Energy, RETScreen, Wind Energy.

I. INTRODUCTION

Renewable energy plays a central role in the global transition to cleaner and more sustainable energy sources. Among these sources, photovoltaic and wind power stand out as the most promising, both in terms of technological maturity and development potential. This work aims to analyze the effectiveness of these two technologies in the Adrar region (Kabartene) using RETScreen software, a recognized tool for the technical and economic evaluation of renewable energy projects [1].

The manuscript is structured in three chapters. The first presents the fundamental principles of photovoltaic and wind systems. The second is devoted to modeling the systems under consideration, while the third presents the results of simulations performed with RETScreen software allows for a detailed assessment of the energy production, investment costs, savings, and environmental impacts of the projects studied. For solar photovoltaic, it takes into account parameters such as solar radiation, inclination, shading and heat loss.

For wind power, it relies on local wind data, mast height, turbine power and other site-specific factors. The simulation results show that both technologies have high profitability potential in the region studied. RETScreen also allows the identification of the best-performing scenarios thanks to its sensitivity analysis and return on investment calculation features. The analysis also confirms the significant reduction in greenhouse gas emissions, thus making an important contribution to the fight against climate change. In conclusion, RETScreen is a strategic tool for engineers, project developers and decision-makers, providing them with the necessary data to plan, optimize and validate the feasibility of renewable energy projects. The use of the results of this study highlights the value of investing in photovoltaic and wind systems for a cleaner, more economical and sustainable energy future.These major sections are: Abstract, Introduction, Research Methodology, Results or Finding and Conclusions.

II. RENEWABLE ENERGY (PHOTOVOLTAIC AND WIND) IN ALGERIA

Based on its geographical location, Algeria has one of the largest solar reserves in the world. Most of the country experiences sunshine hours exceeding 2,000 per year, reaching up to 3,900 hours in the highlands and the Sahara “Figure 1”, “Table I ” [2].

Submitted - April 2026; Final Version Received - June 2026; Accepted - June 2026; Published Online – July 2026

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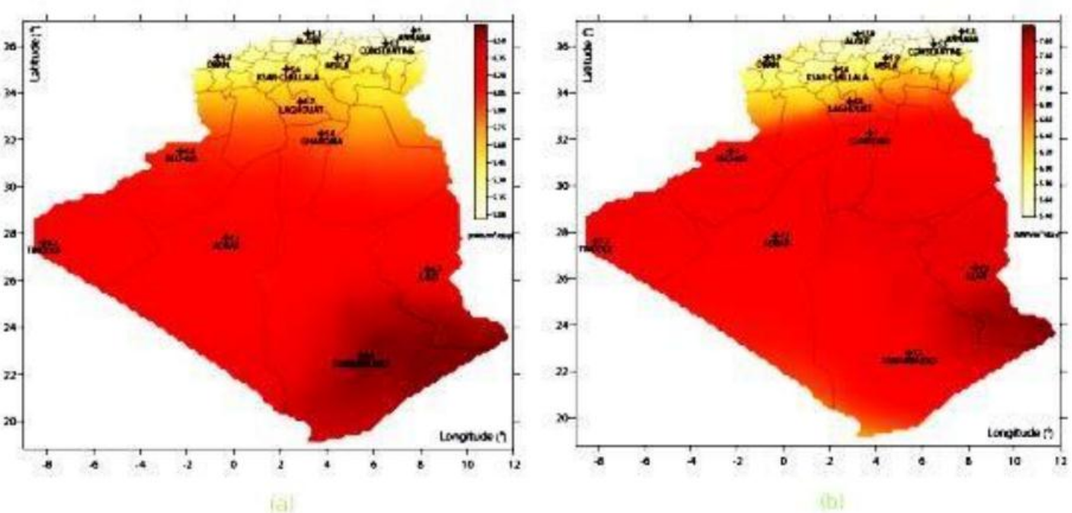

Figure 1 Solar deposits in Algeria

The goal of the National Renewable Energy Development Program, approved in 2011 and amended in 2015, is to achieve a total capacity of 22,000 megawatts (MW) dedicated exclusively to local consumption by 2030. For this reason, it plans to implement a wide range of technologies, with photovoltaic (PV) and wind power accounting for 13,575 MW and 5,010 MW, respectively, with the remainder being distributed among cogeneration, biomass, solar thermal (CSP), and geothermal energy "Table I ".

Table I: Capacity to be installed by sector for the period 2014/2030

Sector	Capacity to be installed
Photovoltaic	13,575
Wind	5,010
Solar thermal	2,000
Biomass	1,000
Cogeneration	400
Geothermal	15
Total	**22,000**

The province of Adrar, located in the far southwest of the country, is one of the regions in the world with a promising future for renewable energy due to its significant natural resources. In addition to fossil fuels, the province of Adrar boasts renewable resources, such as solar (Adrar, Kabetan, Zaouiet Kunata, Reggan, and Aoulef) and wind (Kabartene), making the region a global hub for renewable energy.

III. METHODOLOGY

RETscreen is a clean energy management software system designed for feasibility analysis of energy efficiency, renewable energy, and cogeneration projects, as well as for ongoing energy performance monitoring. RETscreen Expert, an advanced version of the software, is available free of charge in View Mode. RETscreen enables professionals, researchers, and decision-makers to rapidly identify, evaluate, and optimize the technical and economic viability of potential clean energy projects. This decision-intelligence software platform also allows facility managers to assess the actual energy performance of their installations and to identify additional opportunities for energy savings and production.

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In this work, our objective is to study, analyze, and evaluate a photovoltaic (PV) system project and a wind energy system at the Adrar site, through a series of simulation steps using RETscreen.

The next-generation power grid that integrates information, communication, and energy technologies from multiple sources to multiple destinations is known as a "smart grid" .

A smart grid is an electrical grid that can intelligently integrate the actions of all connected users to deliver energy efficiently. The primary objective of a smart grid is to improve the reliability of the power grid by providing alternative routes after a grid outage and the efficiency of power generation and energy management systems “Figure 2”.

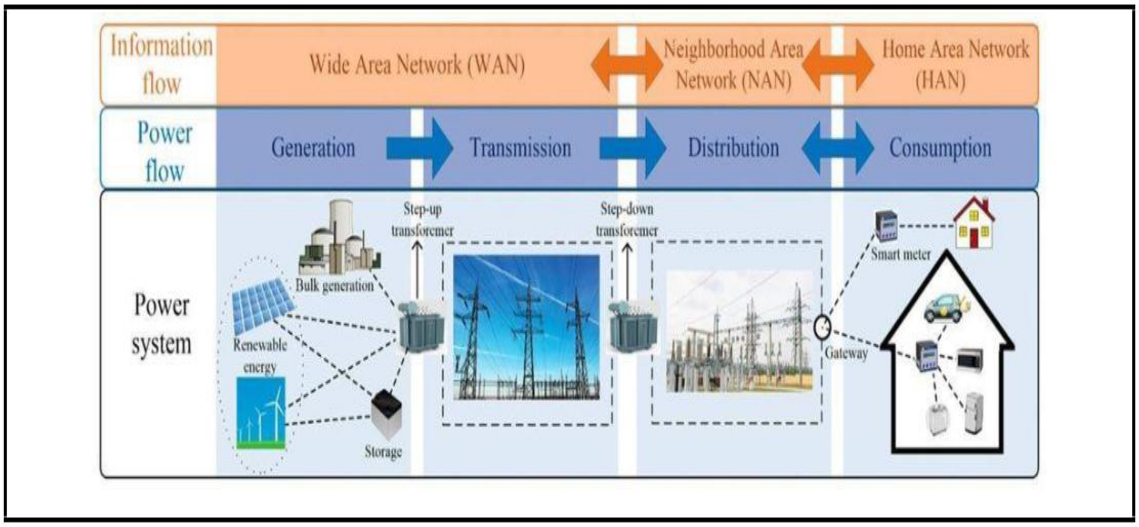

Figure 2 Types of Internet networks used for each smart grid segment.

AI makes decisions using sensors, smart meters, and other information-gathering devices and equipment. For example, AI can make load predictions to make the load quantity and energy output identical based on certain data, and algorithms predict load intensity with high accuracy. Grid artificial intelligence can predict the amount of renewable energy generated as it enters the grid based on data such as temperature, wind speed, and other data at different times. It can predict when renewable energy is generated and when an appropriate decision is made.

A. Hybrid Photovoltaic-Wind System

In our specific case, we focus on low-power systems that combine two components: wind energy and solar panels. Through electrochemical storage, these two energy sources produce direct current, which can be easily converted to alternating current by integrating a standalone inverter into the circuit “Figure 3” [15].

Connecting these systems to an energy storage device will provide the following benefits:

- Uninterrupted system operation.
- Ability to preserve the surplus energy produced by the system.
- Security of supply regardless of weather conditions [16].

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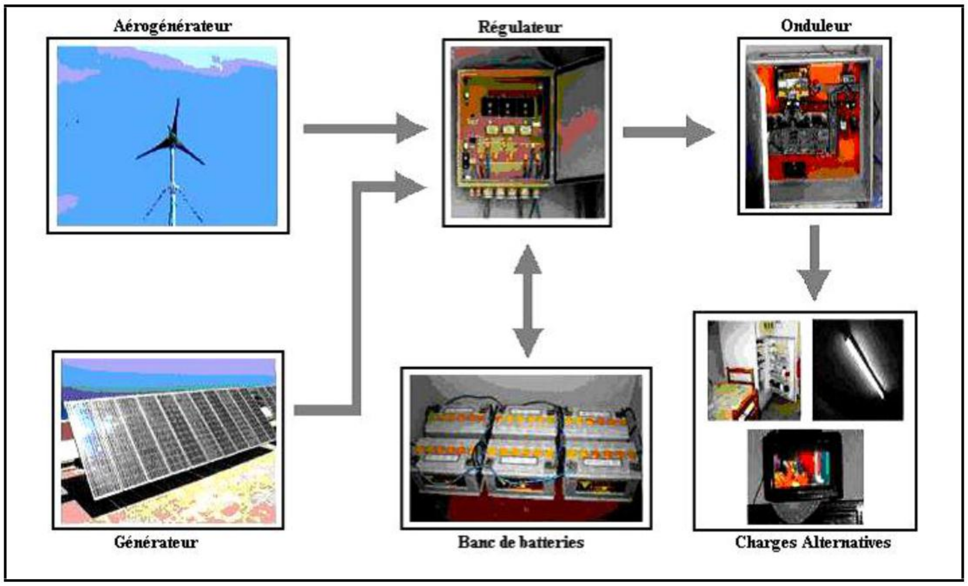

Figure 3 Block diagram of the hybrid system studied.

IV. RESULTS AND DISCUSSION

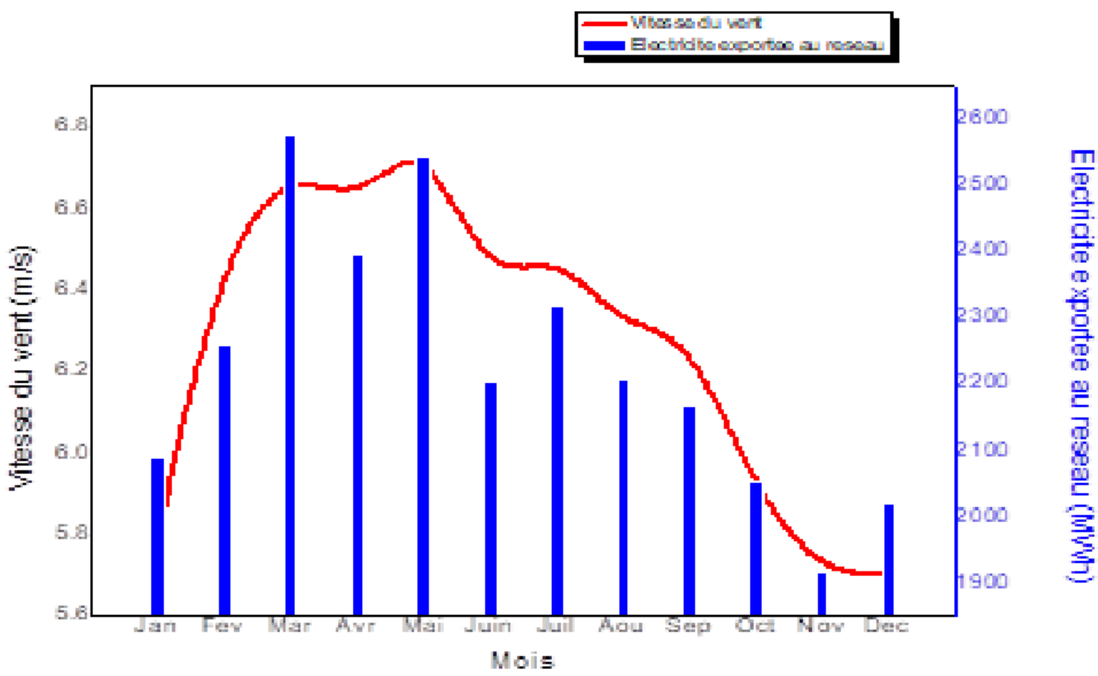

Figure 4 Monthly variation of average wind speed and electricity exported to the network in Adrar.

The graph in "Figure 4 " shows the monthly average wind speeds at a height of 10 meters in Adrar. In March, the maximum wind speed was 6.7 m/s, while in May it was 6.8 m/s. During these two months, electricity production reached its peak, with 2,578 MWh in March and 2,544 MWh in May. The months of November and December recorded the lowest wind speeds, reaching 5.7 m/s. Electricity production also reached its lowest values during these two months, with 1,916 MWh in November and 2,021 MWh in December.

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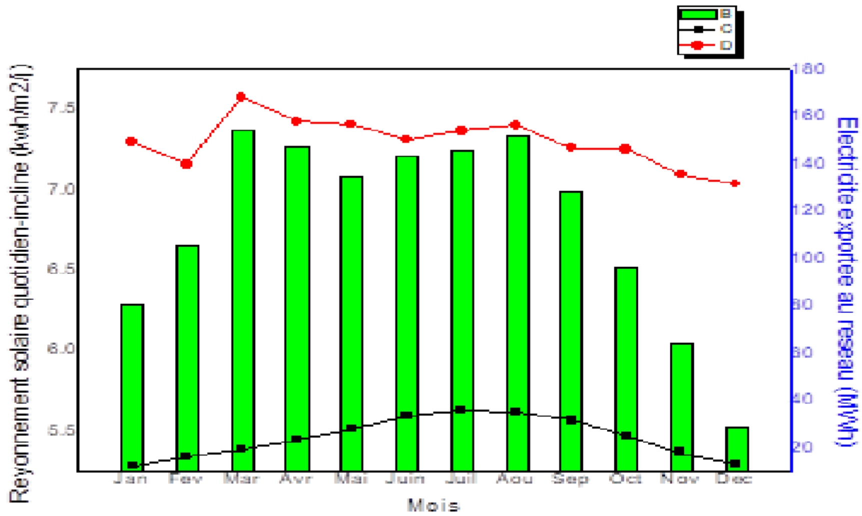

Figure 5 Monthly variation in air temperature and daily solar radiation - slope and electricity exported to the grid in Adrar.

The curve shown in "Figure 5" shows the monthly variation of air temperature and daily solar radiation-incline and electricity exported to the grid in Adrar. It is to our electricity production increases with radiation, from a peak in March (167.974 MWh) to a minimum in December (131.463 MWh). Despite the high radiation, electricity production was also reduced in May, June, and July due to the reduced voltage of the solar cells caused by high temperatures. The feasibility study plays an important role in the scoping phase of a project, and several factors must be addressed in this study:

- The availability of the energy resource (in our case, radiation).
- The choice of equipment.
- The parameters characterizing the available financing will influence the project's profitability, including the debt ratio, the term over which the loan can be repaid, and the interest rate.
- The initial cost of the project is crucial, as are any credits that can contribute to reducing the initial cost of the project compared to the costs of the chosen reference project.
- The level of risk.
- The avoided environmental impact. All these considerations must be part of the analysis that will determine whether a clean energy project is viable or not. We see that assessing a project's profitability depends on many other parameters presented in the study conducted above.

This study consists of exploring all the project's concepts while meeting a need expressed in terms of the objective to be achieved and better targeting development and evaluation efforts, as well as taking into account the plant's revenue while keeping the project's development costs as low as possible. Once our study is completed and validated, and once it shows that the project is viable, we can then begin the implementation phase.

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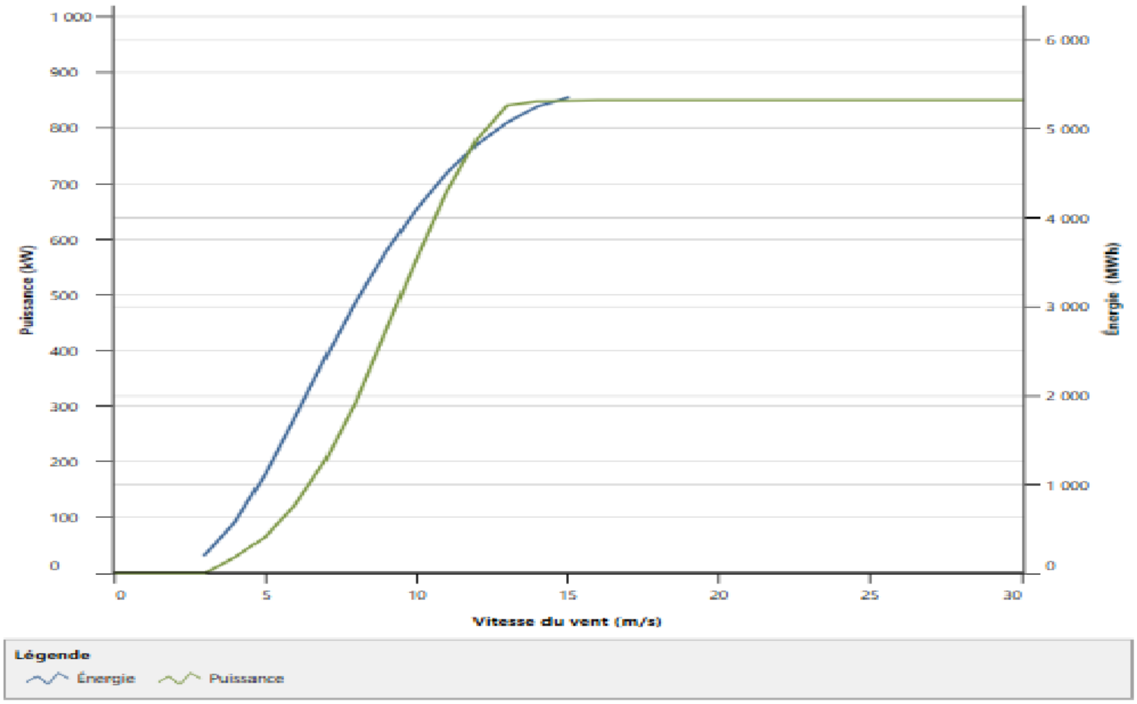

Figure 6 The screenshot represents the power and wind speed power curve.

Analysis of the results the installed power in the framework of this project is approximately 13208 KW for an electrical energy produced of 35537 MWh per year in a way exported to the RIS of 30KV "Figure 6". The investment cost is approximately 7578137783 DZD, the cost of the KWh produced is 23.26 DZD/KWh. Therefore, the cost of income is 314705468 DZD per year. According to the results on the cost of investment with a debt ratio of 70% and a return on investment achieved after 6 years at an interest rate on the debt equal to 7%, a priori, we will say that the project is very profitable.

When we take into account the advantages of installing this plant, starting from the free source (solar radiation and wind speed) and passing through the environmental contribution (31611 tCO_2 are avoided annually with an estimated reduction rate of 93%), On the other hand, the cost of implementation will be reduced if this type of installation becomes an energy reality in our country, and it will also be a good project to improve the National Renewable Energy Program, contributing to favorable energy development in Algeria.

V. Conclusion

This work focuses on analyzing and evaluating the efficiency of photovoltaic and wind energy systems in the Gérer region using RETScreen software. The first part presents a presentation of the basic principles of solar and wind power generation systems. The following sections evaluate the energy and economic performance of these systems, based on simulations performed using the RETScreen software analysis module.The objective is to examine the technical and economic viability of renewable energy projects through detailed analyses of potential energy production, cost savings, and greenhouse gas emission reductions. The study also takes into account specific parameters such as the orientation and tilt of solar panels, wind speed, and local climatic conditions. The results show that photovoltaic and wind energy represent a sustainable solution for electricity generation, with high potential for profitability and positive environmental impact. RETScreen is proving to be a valuable tool for modeling, simulating, and optimizing these projects, facilitating decision-making for developers and investors. In conclusion, the effective integration of these technologies helps accelerate the energy transition to a cleaner and more resilient model. It is essential to continue investing in research, improving existing technologies, and promoting the widespread adoption of these renewable solutions to address the challenges of climate change and ensure a sustainable energy future.

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ACKNOWLEDGMENT

This work was supported by a grant of the Ministry of Research, Innovation and Digitalization, project number PNRR-C9-I8-760090/23.05.2023, code CF 30/14.11.2022"

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Submitted - April 2026; Final Version Received - June 2026; Accepted - June 2026; Published Online – July 2026