Palestine Polytechnic University

Deanship of Graduate Studies and Scientific Research

Master Program of Renewable Energy and Sustainability

Techno – Economic Assessment of PV Power Plants utilizing artificial intelligence – Case Study of Wahaj Al Ghuzlan Power Plant at Al Dhahriya

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By

Iyad Abdul Jawwad Isaila

Supervisor

Dr. Fouad Zaro

Thesis submitted in partial fulfillment of requirements of the degree

Master of Science in Renewable Energy & Sustainability

January, 2024

The undersigned hereby certify that they have read, examined and recommended to the Deanship of Graduate Studies and Scientific Research at Palestine Polytechnic University and the Faculty of Science at Al-Qdus University the approval of a thesis entitled:

Techno – Economic Assessment of Photovoltaic Power Plant utilizing artificial intelligence – Case Study of Wahaj Al Ghuzlan Power Plant at Al Dhahriya

Submitted by

Iyad Abdul Jawwad Isaila

in partial fulfillment of the requirements for the degree of Master in Renewable Energy & Sustainability.

Graduate Advisory Committee:

Dr. Fouad Zaro
(Supervisor), Palestine Polytechnic University,

Signature:———————————— Date:————————————

Prof. Abdelkarim Daud
(Internal committee member), Palestine Polytechnic University,

Signature:———————————— Date:————————————

Dr. Hakam Shehadeh
(External committee member), Birzeit University,

Signature:———————————— Date:————————————

Thesis Approved by:

Name: Dr. Nafeth Nasereddin

Dean of Graduate Studies & Scientific Research

Palestine Polytechnic University

Signature:……

Date:……

ABSTRACT

The energy demand has been increased as the population increased all over the world, due to this increment and the harmful effect of conventional energy sources, renewable sources have become a preferable solution. A lot of tools and parameters have been used for evaluating renewable energy projects, the current study aims to techno-economic assessment of a 1.5 MW photovoltaic (PV) power plant located in Al Dhahriya south of Hebron district. The weather, climate, and energy parameters data of two years of continuous monitoring have been achieved from the PV power plant. The techno-economic performance parameters: final yield, reference yield, capacity utilization factor, net present value, simple payback period, and the annual average monthly Performance Ratio have been calculated through related mathematical expressions, the values of final energy yields for the years 2021 and 2022, are 1902 kWh/kW_p and 1867 kWh/kW_p, respectively, this result can be deemed as reasonable and acceptable values. The value of simple payback period on average is 4.82 years, this indicates that the project is feasible because all project costs will be reimbursed over the first five years of its lifetime. The optimal PV power plant location has also been studied utilizing Particle Swarm Optimization (PSO) method, the required inputs for this analysis have been obtained and entered to MATLAB software, The analysis process indicates that the optimal locations for all the proposed Distribution Generation (DG) plants for all scenarios are located in the furthest points from the main electricity feeding point in the grid, Those locations are associated with minimum real power losses in the grid as well as the most improved voltage profile. It concluded that the PSO method is an effective principle for the assessment of the studied aspects, it indicates the optimal location of the studied PV power plant within a few iterations, which makes PSO a very effective developed procedure in power system applications.

الملخص

التقييم التقني و الاقتصادي لمحطة طاقة كهروضوئية باستخدام تقنيات الذكاء الاصطناعي – دراسة حالة محطة كهرباء وهج الغزلان في الظاهرية

لقد تزايد الطلب على الطاقة مع زيادة عدد السكان في جميع أنحاء العالم، وبسبب هذه الزيادة والتأثير الضار لمصادر الطاقة التقليدية أصبحت المصادر المتجددة هي الحل المفضل، وقد تم استخدام الكثير من الأدوات والمعايير لتقييم مشاريع الطاقة المتجددة ، تهدف الدراسة الحالية إلى التقييم الفني والاقتصادي لمحطة توليد طاقة كهروضوئية بقدرة ١,٥ ميجاواط ، وتقع المحطة في الظاهرية جنوب محافظة الخليل. تم الحصول على بيانات الطقس والمناخ والطاقة لمدة عامين من المراقبة المستمرة من محطة الطاقة الكهروضوئية. تم حساب معايير الأداء الفني والاقتصادي: العائد النهائي، العائد المرجعي، عامل استغلال القدرة، صافي القيمة الحالية، فترة الاسترداد البسيطة، ومتوسط نسبة الأداء الشهري السنوي من خلال معادلات رياضية محددة، كانت قيم إنتاج الطاقة النهائية للأعوام ٢٠٢١ و٢٠٢٢ هي ١٩٠٢ كيلو وات ساعة/كيلو وات و١٨٦٧ كيلو وات ساعة/كيلو وات على التوالي، ويمكن اعتبار هذه النتيجة قيمة معقولة ومقبولة. بلغت قيمة فترة الاسترداد البسيطة في المتوسط ٤,٨٢ سنة، وهذا يدل على أن المشروع مجدي لأنه سيتم سداد جميع تكاليف المشروع على مدى السنوات الخمس الأولى من عمره. تمت دراسة الموقع الأمثل لمحطة الطاقة الكهروضوئية باستخدام طريقة Particle Swarm Optimization (PSO) ، وتم الحصول على المدخلات المطلوبة لهذا التحليل وإدخالها في برنامجMATLAB ، وتشير عملية التحليل إلى أن المواقع الأمثل لجميع محطات الطاقة الشمسية المقترحة تقع في أبعد النقاط عن نقطة التغذية الرئيسية بالكهرباء في الشبكة، وترتبط هذه المواقع بالحد الأدنى من فقدان الطاقة الحقيقي في الشبكة بالإضافة إلى تحسين جهد الشبكة. وخلصت الدراسة إلى أن طريقة PSO هي مبدأ فعال لتقييم هذه الجوانب المدروسة، فهي تشير إلى الموقع الأمثل لمحطة الطاقة الكهروضوئية ضمن تكرارات ومحاولات قليلة ، مما يجعل PSO إجراء متطور وفعال للغاية في تطبيقات أنظمة الطاقة.

DECLARATION

I declare that the Master Thesis entitled **" Techno – Economic Assessment of Photovoltaic Power Plant utilizing artificial intelligence – Case Study of Wahaj Al Ghuzlan Power Plant at Al Dhahriya "** is my own original work, and herby certify that unless stated, all work contained within this thesis is my own independent research and has not been submitted for the award of any other degree at any institution, except where due acknowledgement is made in the text.

Iyad Abdul Jawwad Isaila

Signature:———————————— Date:————————————

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DEDICATION

This thesis is dedicated to:

The sake of Allah, my Creator and my Master,

My great teacher and messenger, Mohammed (May Allah bless and grant him), who taught us the purpose of life,

My homeland Palestine, the warmest womb;

The great martyrs and prisoners, the symbol of sacrifice;

The Polytechnic University, my second magnificent home;

My great parents, who never stop giving of themselves in countless ways,

My beloved wife, daughter, and sons; leads me through the valley of darkness with light of hope and support

My supervisor Dr. Fouad Zaro

My friends who encourage and support

All the people in my life who touch my heart,

I dedicate this research.

ACKNOWLEDGEMENT

I would like to express my gratitude towards all the people who have contributed their precious time and efforts to help me in completing this thesis, without whom it would not have been possible for me to understand and analyze the thesis.

I would like to thank my thesis Supervisor Dr. Fouad Zaro for his guidance, support, motivation and encouragement throughout the period this work was carried out. His readiness for consultation at all times, his educative comments, his concern, and assistance have been invaluable.

I am also grateful to Prof. Sameer Khader Head of Department of JAMILA project, for providing the necessary facilities in the department. The co-operation showed by Eng. Mustafa Suwayti of PV Power plant supervisor.

Finally, I render my respect to my parents for giving me mental support and inspiration for carrying out my research work

List of Abbreviations

AC	Alternative Current
AI	Artificial Intelligence
ALOA	Ant-Lion Optimization Algorithms
BBO	Biogeography-Based Optimization
CO_2	Carbon dioxide
CUF	Capacity Utilization Factor
DC	Direct Current
DCF	Discounted Cash Flow
DE	Differential Evolution
DG	Distributed Generation
DHI	Diffuse Horizontal Irradiance
DNI	Direct Normal Irradiance
DPBP	Disconnected Payback Period
FC	Fuel Cells
FiT	Feed in Tariff
FLC	Fuzzy Logic Controller
F_V	Future Value
GA	Genetic Algorithm
GHG	Green House Gases
IRR	Internal Rate of Return
LCOE	Levelised Cost of Electricity
MENA	Middle East and North Africa
MPPT	Maximum Power Point Tracking
NOCT	Nominal Operating Cell Temperature
NPV	Net Present Value
PI	Profitability Index
POA	Plane of Array
PR	Performance Ratio
PR	Performance Ratio
PSO	Particle Swarm Optimization
PV	Photovoltaic
P_V	Present Value
SLD	Single Line Diagram
SPBP	Simple Payback Period
SSA	Salp Swarm Algorithm
TAPL	Total Active Power Losses

List of Nomenclature

Y_A	Array Yield
E_{DC}	DC energy output
Y_F	Final yield
E_{AC}	AC energy output
H_T	Solar Insolation
H_R	Reference Irradiance
Y_R	Reference yield
L_C	Array Capture Losses
L_S	System Loss
A_M	PV Module total Area
η_{pv}	Array Efficiency
η_{sys}	System Efficiency
η_{Inv}	Inverter Efficiency
T_{cell}	Cell Temperature
T_{amb}	Ambient Temperature
r	Interest Rate
n	Number of years
$\mathcal{S}_{Loss}$	Power Losses
P_{Loss}	Active Power Losses
Q_{Loss}	Reactive Power Losses
V	Voltage
I	Current
I_{DC}	DC Input Current
I_{AC}	AC Output Current
P_{DCr}	Rated DC Input Power
R	Resistance
X	Reactance
Z	Impedance

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