ANALYSIS ON GRID CONNECTED PHOTOVOLTAIC RETROFIT ON EXISTING SEWAGE INDUSTRY

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MASTER OF MECHANICAL ENGINEERING (ENERGY ENGINEERING)

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DECLARATION

I declare that this thesis entitled "Analysis On Grid Connected Photovoltaic Retrofit On Existing Sewage Industry" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :...

Name :..Yuhanis Iskandar bin Mansor.......................

Date :..08.03.2024...

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Mechanical Engineering (Energy Engineering)

Signature	:..
Supervisor Name	:..MOHD AFZANIZAM MOHD ROSLI........
Date	:..12 March 2024...

DEDICATION

To my beloved mother, father and my wife for always by my side during this journey who have supported me throughout my academic journey with their unconditional love and encouragement. They have taught me the value of hard work, perseverance, and curiosity. My project supervisor on his wise advising during this research project. I am forever grateful for their guidance and inspiration. May this work serve as a tribute to the countless hours of dedication, resilience, and passion invested in the pursuit of understanding, and may it inspire future generations to embrace the transformative power of lifelong learning

ABSTRACT

The adoption of renewable clean energy has been a long-standing practice, but it has recently acquired momentum as a commercial strategy to fulfil the commitment of governments and the world to utilise environmentally friendly power sources. This research involves analysing the retrofitting of a solar photovoltaic installation and its integration with the Tenaga Nasional Berhad (TNB) grid. The goal is to evaluate the accuracy of the system's energy cost efficiency calculations and identify any possible enhancements that could be beneficial for current and future research. The Indah Water sewerage treatment plant in Taman Meru Perdana, Ipoh was selected for research due to its strict compliance with the consultant's installation instructions, which ensured precise specification selection. Acquired information to compare it with theoretical calculations with the purpose of confirming their consistency with site study data. Following the installation of the site, a study of solar energy data undertaken for a duration of 60 days to assess the efficiency of solar photovoltaic in comparison to the cost of the conventional TNB grid. Subsequently, a typical computational software was constructed utilising Microsoft Excel to generate a dependable consultant programme calculation. Additionally, it can serve as a standardised instrument to validate and cross-check future project planning. The data obtained during the initial building and computation programme closely aligns with permissible deviations of within 0.5%. The solar energy data obtained over a period of 3 months was compared to the energy usage of both the complete sewage treatment plant and the TNB grid. Data was collected to authenticate the tangible cost savings and efficiency gains derived from solar photovoltaic systems. An integration of the electrical grid with solar energy results in a 37% reduction in energy use. A comparison was made within several types of solar panels available in the market as part of the program's calculations. After comparing the five popular types of solar panels available in the market, it has been determined that the thin layer type exhibits higher efficiency. Nevertheless, the installation of monocrystalline solar panels remains the superior choice when considering all factors. The purpose of this analysis is to compare several aspects, including efficiency and cost, in order to determine the most optimal solar power system.

ANALISIS PENGUBAHSUAIAN SURIA FOTOVOLTAN DENGAN SAMBUNGAN GRID DI LOJI RAWATAN KUMBAHAN INDUSTRI SEDIA ADA

ABSTRAK

Tenaga yang boleh di perbaharui tidak asing lagi di sejak sekian lama melalui tenaga hidro dan sebagainya. Walau bagaimanapun dengan kesedaran yang semakin tinggi penggunaan komersial telah mula di perluaskan. Ini adalah sejajar dengan komitmen negara dan negara-negara lain di dunia untuk lebih meluaskan penggunaan tenaga hijau yang lebih mampan. Projek ini memfokuskan pemasangan dan pengubahsuaian set panel tenaga suria di salah satu loji rawatan kumbahan di bawah seliaan Indah Water Konsortium (IWK) yang di sambung bersama grid Tenaga Nasional Berhad (TNB). Loji rawatan kumbahan yag terpilih terletak di Taman Meru Perdana, Ipoh yang telah menjalankan pengubahsuaian mengikut spesifikasi yang di sarankan oleh perunding untuk di kaji ketepatan maklumat yang di beri. Data sepanjang 60 hari setelah penjanaan tenaga suria pertama juga di ambil untuk kajian keberkesanan tenaga suria dari segi kos untuk dibandingkan dengan TNB. Akhir sekali menilai kelebihan dan kekurangan mengikut jenis kepingan suria di pasaran untuk perbandingan dan analisa di bandingkan dengan yang sedia ada di tapak.. Program pengiraan di lakar menerusi Microsoft Excel untuk membuktikan ketepatan perbandingan dengan program pengiraan matriks dari perunding membawa kepada keputusan yang boleh di terima dengan perbezaan pada 0.5%. Pengiraan program ini boleh di jadikan batu ukur untuk pemasangan solar akan datang untuk perbandingan pengiraan konsultan. Dengan 3 bulan data tenaga suria yang di jana, boleh di bandingkan dengan keseluruhan tenaga yang di jana bersama grid TNB. Data tersebut di analisis lalu menentukan kecekapan tenaga dan penjimatan sebenar di hasilkan

menunjukkan penjimatan 6% pada musim yang sama dan 18% untuk perbandingan penggunaan tenaga yang hampir sama. Ini menunjukkan tenaga lestari terbukti memberi penjimatan walaupun dengan kekangan persekitaran yang masih memerlukan tenaga grid sambungan. Satu perbandingan antara jenis kepingan suria di pasaran telah di uji menggunakan program pengiraan Microsoft Excel tersebut. 5 kepingan suria yang utama di pasaran telah uji menggunakan rangka pengiraan memberi keputusan jenis filem nipis moden menunjukkan keberkesanan yang terbaik. Walau bagaimanapun dari segi keseluruhan termasuk kos menunjukkan monokristalin masih berkelebihan ketika ini. Keputusan yang terhasil menunjukkan perbezaan dari segi kecekapan alir tenaga antara sel di samping faktor-faktor lain seperti kos panel untuk perbandingan pilihan.

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In conclusion, this work stands as a collective effort, and I am sincerely grateful to all who have played a role, big or small, in shaping this thesis. Your contributions have left an indelible mark on this academic endeavour, and I am truly thankful for the shared journey of intellectual exploration.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AC	-	Alternating current
ASEAN	-	Association of Southeast Asian Nations
IWK	-	Indah Water Konsortium
AWG	-	American wire gauge
BC	-	Before century
D-ETOU	-	Domestic-Enhanced Time of Use
DC	-	Direct current
TNB	-	Tenaga Nasional Berhad
GT	-	Gigaton
J	-	Joule
kA	-	Kilo ampere
kWh	-	Kilowatts hour
kWh/m^2	-	Kilowatts hour per meter square
MCB	-	Miniature circuit breaker
MCCB	-	Moulded case circuit brake
MSB	-	Main switcboard
PPA	-	Power purchased aggreement
PR	-	Performance ratio
PV	-	Photovoltaic
ROI	-	Return of investment
SELCO	-	Solar PV Self Consumption
STP	-	Sewerage Treatment Plant

$UTeM$	-	Universiti Teknikal Malaysia Melaka
W/m^2	-	Watt per meter square

LIST OF SYMBOLS

&	-	And
I_{mp}	-	Maximum power current
ρ	-	Resistivity
P_{max}	-	Rated maximum power
V_{mp}	-	Maximum power voltage
V_{oc}	-	Open circuit voltage
γ_{pmp}	-	Temperature coefficient of P_{max}
γ_{Vmp}	-	Temperature coefficient of Voc

LIST OF APPENDICES

INTRODUCTION

1.1 Background

With the exponential rise in the global population, energy generation is seen as a critical obstacle in industrial evolution. Communities are growing and moving into formerly deserted areas, and new technologies are emerging, which increases the energy demand generally and the electrical energy load in particular (de Amorim et al., 2018). Therefore, a reliable, sustainable, and efficient energy source is more important than ever for a vibrant, healthy society (Elsaid et al., 2020; Furlan & Mortarino, 2018). Coal, crude oil, and natural gas made up more than 80% of the primary energy supply in 2018, demonstrating the dominance of fossil fuels and traditional energy production methods (Rabaia et al., 2021).

In 2021, emissions increased by a record 1.9 GT to reach 36.6 GT, driven by a performance post-pandemic economic expansion, modest progress in reducing energy intensity, and a jump in coal consumption even as renewables capacity additions reached new heights on environmental hazardous level (Agency, 2022). Numerous hazardous environmental issues, such as land drought, heatwaves, wildfires, a rise in sea level, floods, and other extreme climatic phenomena have arisen as a result of the vast misuse of fossil fuels nearly everywhere (Bukhary et al., 2018; MacDougall & Friedlingstein, 2015; Rabaia et al., 2021; Von Schuckmann et al., 2016). To slow down the environmental impact, various technologies have been developed to replace the usage of natural gases. One of the solutions is the development of solar technology.

Solar technology is the technology that consumes the radiation of the sun and converts it to electrical energy. In just 1.5 days, the sun can produce 1.7 x 1022 J energy, equivalent to the 3 trillion barrels of oil from the world's reserves. On average, the total energy people use in a year is 4.6 x 1020 J, and the sun provides the same amount of energy in one hour (Crabtree & Lewis, 2007; Hayat et al., 2019). The main types of solar energy technologies are photovoltaic and concentrating solar-thermal power. Photovoltaics (PV) use sunlight to be converted into electrical energy using PV materials and equipment. A cell, a single PV device, produces an average power output of 1 to 2 watts, chained together to create bigger units known as panels to increase production. These cells are constructed of various semiconductor materials, combined between protective layers in a mix of glass and/or plastics to endure the outdoors for a long time (Solar Energy Technologies Office, 2022). Many countries benefited from this technology, and one of them is Malaysia.

Due to its tropical position, which receives tremendous average daily solar radiation (4500 kWh/m2) and ample sunlight for roughly 10 hours each day (Mekhilef et al., 2012), Malaysia has a strong potential to develop solar power plants (Soonmin et al., 2019). However, due to the high installation cost and solar power tariff rate, solar energy appears unpopular. To promote the expansion of solar energy, the government has implemented several incentives (Kardooni et al., 2018), funding (Soumia et al., 2018), laws (Halabi et al., 2018), investments (Al-Waeli et al., 2018), and strategies (as emphasised under the 9th and 10th Malaysia Plan). Despite limitations, renewable energy capacity is seen to increase yearly, from 32 MW in 2012 to 1787 MW in 2021 (Statista, 2022). One of the sectors that actively use renewable energy, apart from the residential and industrial, is the sewage treatment plants from the utility sector.

Sewage treatment plants (STP) in Malaysia were handled by Indah Water Konsortium (IWK). Up to these days, there were 7302 STPs operated by the company

(Malaysia Inks Upsized Solar STP Agreement, 2021). By installing solar PV technology, each site can lower its electricity bill by up to 10% monthly. For starters, only 1177 STPs were included in the project to ensure the capabilities to sustain and maintain the systems. In the future, lower carbon footprints should be expected from the application of this solar technology. This study had conducted to analyse solar PV installation accuracy, cost efficiency and performance expected from this project. Analysis on performance lead to possibility to determined same setup on different solar panel for comparison on future project criteria selection.

1.2 Problem Statement

Solar photovoltaic (PV) systems are essential in the shift towards sustainable and renewable energy sources. Nevertheless, despite technological breakthroughs and growing acceptance, solar photovoltaic (PV) systems have complex obstacles that impede their broad implementation and ideal efficiency. To tackle these problems, a thorough examination of multiple elements that impact the effectiveness, dependability, and financial feasibility of solar PV installations is necessary.

The issue at hand pertains to the necessity of improving the efficiency and financial feasibility of solar PV systems through the use of analysis and optimisation techniques. One of the main difficulties is performance variability. Solar PV systems might experience changes in energy production due to various factors, including weather conditions, shading, soiling, and system degradation. It is crucial to comprehend the influence of these variables on system performance in order to optimise energy output and dependability by selecting the appropriate components.

The techno-economic issues pose challenges in determining the economic viability of solar PV on this project. This viability depends on elements such as the energy cost post-implementation, which needs to be compared with the cost of traditional grid electricity to assess feasibility. Analysing energy consumption in relation to cost provides significant insights into cost-saving measures and contributes to lowering carbon footprint.

Implementing optimisation techniques can greatly enhance the efficiency and performance of solar PV systems during the early design stage, but it also presents critical problems. However, in order to identify and execute the most appropriate optimisation strategies, it is necessary to conduct a comprehensive study and assessment of system design, component selection, operation, and control. This can be effectively achieved through the use of a designed calculation programme, as proposed in this project.

Integrating solar PV systems into existing energy infrastructure presents technical, regulatory, and logistical obstacles, as indicated by the data provided by the consultant. It is crucial to have a comprehensive understanding of grid integration, energy storage solutions, and demand-side management in order to fully optimise the advantages of solar PV deployment and guarantee the stability and dependability of the power system.

In order to tackle these difficulties, the objective of this thesis is to carry out a thorough examination of solar PV systems, which includes evaluating their performance, assessing their economic viability, employing optimisation methods, and devising strategies for integration. The initial stage in this research is to utilise Microsoft Excel as a simulation tool to address issues. Additionally, developed calculation can serve as a guiding tool for future projects. This will provide a chance for further investigation in the selection of solar panels for variable implementation. An analysis of the energy consumption associated with cost following the generation of solar PV energy will also yield insights into cost savings and future implementation.

The primary objective of this research is to offer practical insights, recommendations, and optimal methods for the organisation, structure, implementation, and management of solar PV systems. This thesis contributes to enhancing the efficiency, reliability, and economic competitiveness of solar PV technology by addressing the identified challenges and taking advantage of opportunities for optimisation and integration. As a result, it accelerates the transition towards a sustainable and low-carbon energy future.