

OPTIMIZATION OF HYBRID SOLAR-WIND ENERGY SYSTEMS FOR RURAL ELECTRIFICATION

By

Cliff Jason Tristan Nugraha
11818001

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SUSTAINABLE ENERGY AND ENVIRONMENT
LIFE SCIENCE AND TECHNOLOGY



SWISS GERMAN UNIVERSITY
The Prominence Tower
Jalan Jalur Sutera Barat No. 15, Alam Sutera
Tangerang, Banten 15143 - Indonesia

Revision after the Thesis Defense on 7 July 2025

STATEMENT BY THE AUTHOR

I hereby declare that this submission is my own work and to the best of my knowledge, it contains no material previously published or written by another person, nor material which to a substantial extent has been accepted for the award of any other degree or diploma at any educational institution, except where due acknowledgement is made in the thesis.



Cliff Jason Tristan Nugraha

Student

14 July 2025

Date

Approved by:

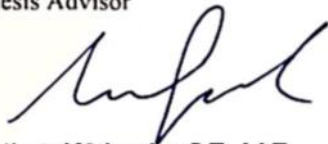


Dr.-Ing. Evita H. Legowo

Thesis Advisor

14 July 2025

Date



Aulia Arif Iskandar, S.T., M.T

Thesis Co-Advisor

14 . 07 . 25

Date



Dr. Hery Sutanto, S.Si., M.Si

Dean

14 July 2025

Date

ABSTRACT

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By

Cliff Jason Tristan Nugraha
Dr.-Ing. Evita H. Legowo, Advisor
Aulia Arif Iskandar, S.T., M.T, Co-Advisor

SWISS GERMAN UNIVERSITY

Access to electricity remains a major barrier to development in Papua, where many rural communities lack reliable power infrastructure. This study aims to design and evaluate a hybrid solar-wind renewable energy system tailored for off-grid electrification in Keerom Regency, serving as a replicable model for similar contexts. The primary objective is to ensure energy access for 72 households while balancing technical feasibility and economic viability. Methodologically, the study uses sequential load estimation, solar and wind potential analysis, component sizing, techno-economic modeling, and an optimization of the solar-to-wind ratio (ranging from 100:0 to 60:40) to identify the most cost-effective and reliable configuration. Results show that a 90:10 solar-to-wind ratio—with 29 PV panels, 11 wind turbines, 19 LiFePO₄ batteries, and one 30 kW inverter—provides optimal performance at a total CAPEX of Rp 1.37 billion. A detailed OPEX and revenue analysis using both subsidized (Rp 605/kWh) and unsubsidized (Rp 1,352/kWh) tariffs demonstrates financial feasibility. The study concludes that decentralized hybrid systems—when optimized for local conditions—offer a scalable, sustainable solution to rural energy poverty. The findings support broader energy equity goals and recommend future consideration of other renewables such as micro-hydro and biomass for regional integration.

Keywords: rural electrification, hybrid system, solar-wind optimization, Keerom, techno-economic analysis



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DEDICATION

This thesis is dedicated to the memory of my beloved father, whose unwavering belief in my potential continues to guide me even in his absence. Fulfilling his last wish for me to complete this degree has been my only motivation throughout the most difficult and uncertain stages of this journey. Your unwavering faith in me remains my guiding light, even after you left this world in April 2023. Every step I took to complete this thesis was driven by the promise I made to you. I hope I have made you proud.



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This thesis represents not only the completion of a degree, but also the fulfillment of a deeply personal promise. I carry forward the lessons learned here with humility and gratitude.



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