



FACULTY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL ENGINEERING

FINAL YEAR PROJECT REPORT

**RESEARCH TITLE: ANALYSIS OF GRID RELIABILITY IMPACT ON THE ENERGY
PRODUCTION AND ECONOMIC PERFORMANCE OF THE BUSITEMA SOLAR PV PLANT;
CASE STUDY 4 MW BUSITEMA SOLAR PV PLANT.**

BY

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DECLARATION

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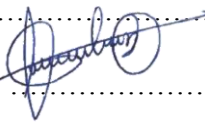
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DEDICATION

I would like to dedicate this report to my family members, friends and relatives.

ACKNOWLEDGMENT

I would like to express our sincere gratitude to our supervisors Eng. Eric Butime and Mr. George Kilama whose guidance has been of the utmost importance.

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ACRONYMS

AC- Alternating current

BESS-Battery Energy Storage System

BMS-Battery Management System

DERs-Distributed energy Systems

DC-Direct current

ERA -Electricity Regulatory System

IEEE- Institute of Electrical and Electronics Engineers

kVA- Kilo volt ampere. **kVAR**- Kilo Volt Ampere

Reactive **kWh**- **kilowatt** hour **kWP**- **kilowatt** power

MPPT-Maximum Power Point Tracker

MW-Megawatts

NPV-Net Present Value **PCS**- power conditioning systems

PHS-Pumped Hydro System

PV-Photovoltaic

SoC-state of charge

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ABSTRACT

This study investigates the effects of grid reliability on the energy production and economic performance of the 4 MW Busitema Solar Photovoltaic (PV) Plant in Uganda.

Despite the increasing deployment of grid-tied solar PV systems, frequent grid outages and voltage fluctuations in Uganda's power infrastructure pose significant challenges to their performance.

The research was conducted over a four-month period from November 2024 to March 2025, during which half-hourly solar generation data and grid conditions were analyzed. Results revealed a total of 360,556 kWh of unutilized solar energy due to 2,520 minutes (42 hours) of grid outages, translating into financial losses of approximately UGX 14.6 million (USD 3,980.49).

To mitigate these losses, three technical solutions were evaluated: Battery Energy Storage Systems (BESS), Pumped Hydro Storage (PHS), and hybrid inverter systems capable of islanding mode operation.

Technical simulations using MATLAB and cost-benefit analyses showed that while PHS had a negative Net Present Value due to high capital investment, both BESS and hybrid inverter systems presented financially viable options, with the hybrid inverter achieving the shortest payback period.

The study concludes that addressing grid reliability through smart storage and control technologies is essential for maximizing the potential of solar PV plants and achieving energy sustainability goals in Uganda. Recommendations include adopting BESS as the primary mitigation strategy and developing predictive outage management tools to enhance system resilience.

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