VOLTAGE PROFILE AND POWER LOSSES ANALYSIS ON COVENANT UNIVERSITY MICROGRID WITH PHOTOVOLTAIC PENETRATION

BY

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A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE MASTER OF ENGINEERING (M.Eng.) DEGREE IN ELECTRICAL AND ELECTRONICS ENGINEERING IN THE DEPARTMENT OF ELECTRICAL AND INFORMATION ENGINEERING, COLLEGE OF ENGINEERING, COVENANT UNIVERSITY.

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ACCEPTANCE

This is to attest that this dissertation has been accepted in partial fulfilment of the requirements for the award of the degree of Master of Engineering in Electrical and Electronics Engineering in the Department of Electrical and Information Engineering, College of Engineering, Covenant University, Ota, Nigeria.

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DECLARATION

I, ATTAH, AMARACHI RITA (18PCK02052) declares that this research was carried out by me under the supervision of Dr. Ayoade F. Agbetuyi of the Department of Electrical and Information Engineering, College of Engineering, Covenant University, Ota, Nigeria. I attest that the dissertation has not been presented either wholly or partially for the award of any degree elsewhere. All sources of data and scholarly information used in this dissertation are duly acknowledged.

ATTAH, AMARACHI RITA Signature and Date

CERTIFICATION

We certify that this dissertation titled "**VOLTAGE PROFILE AND POWER LOSSES ANALYSIS ON COVENANT UNIVERSITY MICROGRID WITH PV PENETRATION** is an original research work carried out by **ATTAH, AMARACHI RITA (18PCK02052)** in the Department of Electrical and Information Engineering, College of Engineering, Covenant University, Ota, Ogun State, Nigeria under the supervision of Dr. Ayoade F. Agbetuyi. We have examined and found this work acceptable as part of the requirements for the award of Master of Engineering.

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DEDICATION

This dissertation is dedicated, first of all, to the Almighty God for His mercies, grace, wisdom and favour throughout the Masters' programme. It is also dedicated to my dear parents Engr and Mrs D. O. Attah, siblings Kelechi Attah and Cheluchi Attah and friends for all their love, guidance, support, and prayers. This research work is also dedicated to Africa my continent, Nigeria my country and to Covenant University.

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LIST OF ABBREVIATIONS AND SYMBOLS

DISCO	Distribution Companies
FACTS	Flexible AC Transmission System.
GENCO	Generation Companies
HOMER	Hybrid Optimization Model for Electrical Renewables
IEA	International Energy Agency
IEEE	Institute of Electrical and Electronics Engineers
IRENA	International Renewable Energy Agency
KV	KiloVolts
MVA	MegaVolts-ampere
MVAr	MegaVolts-ampere of reactive power
MW	MegaWatts
NASA	National Aeronautics and Space Administration
NASENI	National Agency for Science and Engineering Infrastructure
NEPA	National Electrical Power Authority
NESI	Nigerian Electricity Supply Industry
NNG	Nigerian National Grid
PCC	Point of Common Coupling
PHCN	Power Holding Company of Nigeria
P_S, Pr	Real power at sending bus s and receiving bus r
Pu	Per unit
P	Active Power
Q_S, Qr	Reactive power at sending bus s and receiving bus r
Q	Reactive power
R	Line resistance
SERC	Sokoto Energy Research Centre
STATCOM	Static Synchronous Compensators
S_S, Sr	Apparent power at sending bus s and receiving bus r
TCN	Transmission Company of Nigeria
Tmax	Highest ambient temperature for the installation site
$\|V\|$	Voltage magnitude
Vmp_{min}	Minimum module voltage expected at site high temperature
V_S, V_r	Voltage at sending bus s and receiving bus r

VSI	Voltage Stability Index
X	Line reactance
Z	Line impedance
δ	Angle difference between sending and receiving end voltages

ABSTRACT

The impact of integrating distributed generation (DG) into a microgrid network in terms of voltage profile and reactive power losses can be assessed by two methods; dynamic and steady states through a power flow studies of the network busses. The impact has some positive aspects such as improved voltage profile and reactive power supply and control but can also lead to severe low or over voltages at different busses in the network and reverse power flows depending on the size, number, type and placement of the DG. This research investigated voltage profiles and reactive power losses on the Covenant University microgrid with and without hybrid energy sources to ascertain the impact of the hybrid energy sources on the voltage profile and reactive losses in the network. It looks into the supply of a portion of the daytime peak load using solar energy and energy storage and the impact of this on the existing network in terms of voltage profile and losses. In achieving this first, measurements of the existing network parameters using a Fluke 1730 Power Analyzer and an energy demand analysis from existing records of the campus was carried out. Secondly, the design of the microgrid was done using mathematical calculations and HOMER software which was used to optimize the microgrid design. Thirdly, a single line diagram of the existing network with and without DG was developed and steady analysis was carried out on the existing network with and without the DG using NEPLAN Software. A single line diagram of the campus disconnected from Canaanland supply was also developed with only DG supply and steady state analysis (load flow studies) was carried out using NEPLAN Software. The Load flow studies reveal that the integration of the DG and STATCOM used in the microgrid improve the voltage profile from 0.841, 0.8859 and 0.8895 to 0.9063, 0.8894 and 0.9444 with the inclusion of the diesel generators available on campus and solar and energy storage as obtained in calculations with further increase to 0.9065, 0.9414 and 0.9446 for undergraduate, post graduate and new estate LV BUSES respectively with STATCOM included in the grid connected analysis. Similar system behaviour was obtained for the islanded but overall profile performance was best in the grid connected. To achieve reactive power losses reduction STATCOM was required for the reactive power losses reduction by 47.64% for the grid connected and 52.36% for the islanded network.

Keywords: Campus Microgrids, Fluke 1730 Power Analyzer, HOMER, NEPLAN, Photovoltaic Penetration levels, Reactive Power Losses, Renewable Energy, Voltage.