The Optimization of Generating Plants in a Microgrid: The Covenant University Electric Power Network Experience

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CERTIFICATION

This is to certify that the Thesis titled "The Optimization of Generating Plants in a Microgrid: The Covenant University Electric Power Network Experience" by OROVWODE Hope Evwieroghene (Matric. Number CUGP060191), is an original research work and meets the requirements and regulations governing the award of Doctor of Philosophy (Ph.D) in Electrical Engineering and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This thesis is dedicated to the Almighty God – the Secret and Root of wisdom, understanding and knowledge. Also, I dedicate this thesis to the memories of my late beloved mother, Mrs. Janet Palmer Orovwode, who saw the beginning of this work but did not live to see the end. May her gentle soul rest in perfect peace, Amen.

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The Power Network Requirements, Development and Modeling

ABBREVIATIONS

AC	Alternating Current
ACS	Alternating Current Synchronization
CC	Common Coupling
CDS	College of Developmental Studies
CERTS	Consortium for Electric Reliability Technology Solution
CETC	CANMET Energy Technology Center
CLR	Centre for Learning Resources
CO_2	Carbon Dioxide
CP	Constant Power
CSIS	Center for Systems and Information Services
CST	College of Science and Technology
CU	Covenant University
CUEPN	Covenant University Electric Power Network
DC	Direct Current
DCS	Direct Current Synchronization
DCμG	Direct Current Microgrid
DER	Distributed Energy Resource
DG	Distributed Generation
EDT	Economic Dispatch problem
ENG BLK	Engineering Block
EU	European Union
GHG	Green House Gases
HOMER®	Hybrid system optimization for Electric renewables
IEA	International Energy Agency

KCL	Kirchoff's Current law
kW	kilo-Watt
LC	Local Controller
LR	Langrangian Relaxation
LV	Low Voltage
M	Modulating Index
NEDO	Energy and Industrial Technology Development Organization
NTUA	National Technical University of Athens
PCC	Point of Common Coupling
PG	Postgraduate School
PHCN	Power Holding Company of Nigeria
PI	Point of Interconnection
PSERC	Power Systems Engineering Research Center
PWM	Pulse Width Modulation
SCR	Silicon-Controlled Rectifier
SWPWM	Sine Wave Pulse Width Modulation
THD	Total Harmonic Distortion
UPS	Uninterrupted Power Supply
VSI	Voltage Source Inverter

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ABSTRACT

The use of fossil fuel in electricity generation has created three significant issues for the world to deal with. The issues are security (availability and reliability) of supply, climate change and the cost of fuel required for electricity generation. Covenant University, currently running a cluster of stand-alone diesel powered generating plants situated at different locations within the campus has a lot of unused available capacity within the system which invariably increases the operating (fuel) cost of power generation and also contributes to the environmental pollution through the emission of greenhouse gases within the campus. This research work, using a bottom- up approach, developed a new Electric Power network arrangement by integrating the power generators into a microgrid where there would be a common pool of energy sources for all the loads attached to the power network. The network operational functionality and a developed optimized dispatch algorithm were simulated in Matlab to select generators based on their operating parameters to serve the required loads. Hybrid System Optimization Model for Electric Renewables (HOMER 2.81) software was used as the simulation, sizing and optimization tool to evaluate the performance of the developed network. This method minimized the unused capacity being wasted by reducing power plant engagement and consequently reducing the cost of fuel and carbon-based environmental pollution from the power generators that are operated in the campus. This, in turn, should encourage greenness, curbed pollution, and enhances system security and reliability. The fuel cost and emission were reduced by as much as 44.3% and 51.8% respectively. Consequently, for the specific problem identified in the operation of the Covenant University Electric Power Network, a model was developed to solve it. The developed model, in all its intent and purposes, can be generalized; that is, it can be applied to any cluster of independent dissimilar power generating plants.