DEVELOPMENT OF A SOLAR CHARGING STATION FOR OFF-GRID APPLICATION

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A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES OF COVENANT UNIVERSITY, OTA, OGUN STATE, NIGERIA IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF ENGINEERING (M.Eng.) DEGREE IN MECHANICAL ENGINEERING, IN THE DEPARTMENT OF MECHANICAL ENGINEERING, COLLEGE OF ENGINEERING, COVENANT UNIVERSITY, OTA.

JULY, 2022

ACCEPTANCE

This is to attest that this dissertation is accepted in partial fulfillment of the requirements for the award of Master of Engineering (M.Eng.) degree in Mechanical Engineering, Department of Mechanical Engineering, College of Engineering, Covenant University, Ota, Ogun State, Nigeria.

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(Dean, School of Postgraduate Studies) **Signature and Date**

DECLARATION

I, AYOOLA, AANUOLUWA DANIEL (20PCM02101) declare that this research work titled "**DEVELOPMENT OF A SOLAR CHARGING STATION FOR OFF-GRID APPLICATION"** was carried out by me under the supervision of Dr. P.O Babalola of the Department of Mechanical Engineering, College of Engineering, Covenant University, Ota, Nigeria. I attest that this dissertation has not been presented either wholly or partially for the award of any degree elsewhere, and the results of this research were originally obtained. All information cited from published and unpublished literature has been duly referenced.

AYOOLA, AANUOLUWA DANIEL

Signature and Date

CERTIFICATION

This is to certify that the research work titled **"DEVELOPMENT OF A SOLAR CHARGING STATION FOR OFF-GRID APPLICATION"** is an original research work carried out by **AYOOLA, AANUOLUWA DANIEL** meets the requirements and regulations governing the award of Master of Engineering (M.Eng.) degree in Mechanical Engineering, from the Department of Mechanical Engineering, College of Engineering, Covenant University, Ota, and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

I dedicate this work first to the almighty God for His guidance and strength in carrying out this work. My Parents, Engr. Dr. Stephen Ayoola and Mrs. Titilola Ayoola for their support in different ways throughout the course of this work. Also, to my friends and every other person that made this work a success, I say thank you, and God bless you all abundantly.

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ABBRIEVATIONS, SYMBOLS AND NOMENCLATURE

AC	Alternating Current
BC-BJ	Back Contact Back Junction
BHJ	Bulk Heterojunction
CB	Conduction Band
CNT	Carbon nanotube
CVD	Chemical Vapour Deposition
D-A	Donor Acceptor
DC	Direct Current
D-D	Drift Diffusion
DISCOs	Distribution Companies
DSSCs	Dye Sensitized Solar Cells
EA	Electron Affinity
ESMAP	Energy Sector Management Assistance Program
ESPRA	Electric Power Sector Reform Act
ETL	Electron Transport Layer
FMP	Federal Ministry of Power
FMPS	Federal Ministry of Power and Steel
GaAs	Gallium Arsenide
GDP	Gross Domestic Product
GQDs	Graphene Quantum Dots
GW	Gigawatt
HOMER	Hybrid Optimization of Multiple Energy Resources
HTL	Hole Transport Layer
HQs	Headquarters
IBC	Integrated Back Contact
IP	Ionization Potential
KW	Kilowatt(s)
LGA	Local Government Area
LPE	Liquid Phase Epitaxy
MEG	Multiple Exciton Generation
MJ	Multijunction
MOCVD	Metal Organic Chemical Vapour Deposition
MW	Megawatt(s)

MWh	Megawatt-Hour
MWNCTs	Multi-walled Carbon Nanotubes
NEPP	National Electric Power Policy
NERC	National Electricity Regulatory Commission
NNPC	Nigeria National Petroleum Corporation
NREL	National Renewable Energy Laboratory
OMVPE	Organometallic Vapour Phase Epitaxy
OPVCs	Organic Photovoltaic Cells
PSCs	Polymer Solar Cells
PV	Photovoltaic
PVC	Photovoltaic Cells
QDs	Quantum Dots
QDSSCs	Quantum Dot-Sensitized Solar Cells
QE	Quantum Efficiency
REA	Rural Electrification Agency
REF	Rural Electrification Fund
REP	Rural Electrification Policy
RESIP	Rural Electrification Strategy and Implementation Plan
SDG	Sustainable Development Goal
SQ	Shockley Queisser
SWCNTs	Single-walled Carbon Nanotubes
TCEs	Transparent Conductive Electrodes
TCO	Transparent Conductive Oxides
UC	Up Conversion
UN	United Nations
UV	Ultraviolet
VB	Valence Band
VPE	Vapour Phase Epitaxy
W	Watt(s)
Ah	Ampere hour
a-Si	Aluminium Silicon
CdS	Cadmium Sulfide
CdTe	Cadmium Telluride
CdSe	Cadmium Selenide

CIGS	Copper Indium Gallium Selenide
c-Si	Crystalline Silicon
eV	Electron Voltage
FTO	Fluorine Doped Tin Oxide
G	Graphene
GO	Graphene Oxide
GPa	Gigapascal
Hz	Hertz
ITO	Indium Doped Tin Oxide
m	metre
m-Si	Monocrystalline Silicon
nm	Nanometre
P3HT	Poly(3-hexylthiophene)
PANI	Polyaniline
PEDOT: PSS	Poly(3,4-ethylenedioxythiophene)-Poly (styrene sulfonate)
PEN	Polyethylene Naphthalate
PET	Polyethylene Terephthalate
PPP	Poly(p-phenylene)
PPV	Poly (phenylene vinylene)
PPy	Polypyrrole
p-Si	Polycrystalline Silicon
PTFE	Polytetrafluoroethylene
scf	Standard Cubic Feet
TiO	Titanium dioxide
ZnO	Zinc Oxide
η	Efficiency
2D	2-Dimensional

ABSTRACT

At the core of the growth and development of any Nation is the availability of energy for driving the other spheres of the economy. Unfortunately, while the world is moving towards new trends in providing clean and affordable energy, many underdeveloped, and developing countries are still stuck with the challenge of inadequate exploration, and utilization of conventional energy sources, and this has kept these nations backwards as compared to the developed world. This study addresses a sustainable solution, which can serve as a framework for addressing the challenge of clean and affordable energy availability for meeting basic needs in Nigeria. Of particular interest among the various renewable energy sources is solar energy which is an abundant renewable energy source in Nigeria. This study discusses the current state of energy generation, transmission, and distribution in Nigeria, and also provides an insight into Nigeria's renewable energy potential with a focus on solar energy. The various photovoltaic technologies were also discussed, and the future of solar energy exploration too. A detailed design of solar energy charging station geared at meeting basic electricity need of people living in rural areas was presented, and the performance of this system was evaluated using the European Commission PV-GIS simulation software, and data obtained from NASA's database. The results showed that the system is a viable one both technically, and economically to meeting the basic electrical demand of rural dwellers and can be adopted on a larger scale by the Government. Recommendations were also made on how this work can be further advanced.

Keywords: Solar Energy, Energy, Solar Cells, Rural, Photovoltaics, Conventional.