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FEDERAL GOVERNMENT OF NIGERIA

NATIONAL BOARD FOR TECHNICAL EDUCATION

HIGHER NATIONAL DIPLOMA (HND)

SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY

CURRICULUM AND COURSE SPECIFICATIONS

PLOT B, BIDA ROAD, P.M.B. 2239, KADUNA –NIGERIA

APRIL, 2025

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FOREWARD

The need for a sustainable energy future has positioned solar photovoltaic (PV) technology as a cornerstone of global energy transition. This Higher National Diploma in Solar Photovoltaic Engineering Technology curriculum has been meticulously developed to produce highly skilled Solar PV engineers capable of significantly contributing to Nigeria's Renewable Energy sector.

This curriculum is designed to meet the demands of the growing Solar PV industry and adhere to international best practices. It is structured to equip students with the skills required to deliver high-quality and efficient Solar PV energy solutions.

I would like to express my sincere gratitude to the African Studies Center, Leiden (ASCL), Netherlands, under their INCLUDE Knowledge Platform, for the sponsorship and invaluable contribution to the development of this crucial curriculum. Their commitment to fostering expertise in renewable energy technologies has been instrumental in shaping this programme.

I am confident that effective implementation of this curriculum will produce competent Solar Photovoltaic professionals who will be at the forefront of deploying and managing Solar PV systems across Nigeria, thereby playing a vital role in achieving energy independence, environmental sustainability, and economic development.

Prof. Idris M. Bugaje
EXECUTIVE SECRETARY
NBTE, KADUNA

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GENERAL INFORMATION:

1.0 TITLE OF THE PROGRAMME: Higher National Diploma (HND) Solar Photovoltaic (PV) Engineering

2.0 GOAL AND OBJECTIVES:

2.1 GOAL: The Programme is designed to equip students with the knowledge and skills required in Solar Photovoltaic (PV) Engineering

2.2 OBJECTIVES OF THE PROGRAMME: A Diplomate of HND Solar PV Engineering should be able to:

1. Use and operate electronic devices
2. Classify and analyse renewable energy sources
3. Support in the design of solar PV systems
4. Carryout selection of Solar PV components appropriately
5. Install, test, commission, Operate and Maintain Solar PV System
6. Manage Solar PV system life cycle
7. Evaluate Economic values of Solar PV system
8. Support in the design and management of Grid and Hybrid Solar PV system
9. Operate and maintain high-voltage solar PV in an industry
10. Carryout mini project on solar PV system
11. Install, Operate and Maintain Smart Grids PV system
12. Carryout advanced PV system troubleshooting and maintenance
13. Install, Operate and Maintain solar PV Mini-Grid Power
14. Comply with Solar PV, climate adaptation and transition policies for sustainable energy
15. Write technical reports
16. Apply AI to achieve energy security and trading
17. Manage projects in Solar PV systems
18. Comply with engineering ethics and professional practices
19. Apply solar PV policies, regulations, and standards.
20. Model and simulate Solar PV System
21. Register, own, and manage Solar PV business
22. Comply with engineering ethics and professional practices

3.0 ENTRY REQUIREMENTS*:* The general entry requirements for the HND Solar PV Engineering Programme are:

i. In addition to the basic entry requirements for National Diploma in Renewable Energy Engineering, Chemical Engineering, Mechanical Engineering, Electrical/ Electronic Engineering, Computer Engineering, and Mechatronics Engineering.
ii. 1-year compulsory Industrial Training.

Diplomate with a Lower Credit pass in the ND examination with one or more years of cognate experience in the specific field as listed in (i).

4.0 CURRICULLUM

4.1 The curriculum of the HND programme consists of three main components. These are:
General studies/education
Foundation courses
Professional courses

4.2 The General Education component shall include courses in:

i. English Language
ii. Communication
iii. Mathematics
iv. Citizenship (the Nigerian Constitution)
v. Entrepreneurship

4.3 The General Education component shall account for no more than 15% of the programme's total contact hours

4.4 Foundation Courses include courses in Mathematics, Engineering, etc. The number of hours will vary with the programmes and may account for about 10 –15% of the total contact hours.
4.5 Professional Courses are courses that give the student the theory and practical skills he/she need to practice his/her field of calling at the technical/technologists level.

5.0 STRUCTURE OF PROGRAMME
This is a two-year program, consisting of four semesters of classroom, laboratory, field, and workshop activities at the institution. Each semester lasts 17 weeks, structured as follows: 15 weeks of instructional contact (including recitation, practical exercises, quizzes, and tests) and 2 weeks

for examinations and registration.

6.0 EVALUATION SCHEME

The HND Solar PV examination must undergo external moderation. For grading, theory accounts for 40%, while practical and project work constitute 60% (totaling 100%).

7.0 ACCREDITATION

Each Programme offered at the HND level shall be accredited by the NBTE before the Diplomates can be awarded the Higher National Diploma Certificates. Details about the process of accrediting a Programme for the award of the HND are available from the office of the Executive Secretary, National Board for Technical Education, Plot B, Bida Road, P.M.B. 2239, Kaduna, Nigeria.

8.0 CONDITIONS FOR THE AWARD OF HND SOLAR PV ENGINEERING:

Institutions offering this program will award the HND certificate to candidates who complete all prescribed coursework, examinations, and the final project; obtain certification from an NBTE-approved Solar PV industry organization; and fulfill a minimum requirement of 97 to 120 semester credit units

8.1 GRADING OF COURSES: Courses shall be graded as follows:

MARKED RANGE	LETTER GRADE	WEIGHTING
75% and above	A	4.00
70% – 74%	AB	3.50
65% – 69%	B	3.25
60% – 64%	BC	3.00
55% – 59%	C	2.75
50% – 54%	CD	2.50
45% – 49%	D	2.25
40% – 44%	E	2.00

8.2 CLASSIFICATION OF DIPLOMAS: Higher National Diploma Certificates shall be awarded based on the following classifications:

Distinction	-	CGPA 3.50-4.00
Upper Credit	-	CGPA 3.00-3.49
Lower Credit	-	CGPA 2.50-2.99
Pass	-	CGPA 2.00-2.49

9.0 QUALIFICATION OF THE TEACHERS

9.1 Holders of BSc / HND and Higher Degrees in:

i. Renewable Energy Engineering,
ii. Chemical Engineering,
iii. Mechanical Engineering,
iv. Electrical/ Electronic Engineering,
v. Computer Engineering,
vi. Mechatronics Engineering

9.2 In addition, teachers of this programme should have been trained and certified by:
(a) Council for the Regulation of Engineering in Nigeria (COREN)
(b) Industrial certifications in Engineering

9.3 Headship of the Department:
Holders of HND or Bachelor's degree in any of the Engineering fields listed in 9.1
Higher Degree: Renewable Energy Engineering and Energy Engineering, who must not be below the rank of a Senior Lecturer

10.0 GUIDANCE NOTES FOR TEACHERS OF THE PROGRAMME

10.1 The new curriculum is structured in unit courses, keeping with the provisions of the National Policy on Education. This policy emphasizes the introduction of semester credit units, which enable students to transfer completed units from institutions of similar standing, should they wish to transfer.

10.2 The curriculum design adopts a product-based modular system, ensuring each completed professional module provides students with practical technician skills for employment. Since the credit unit system's success relies on alignment between institutions and industry, the curriculum uses behavioral objectives to clearly define expected competencies for both students who complete courses and graduates of the program.
This performance-based curriculum uniquely specifies: (1) the required performance conditions and (2) acceptable performance criteria. This approach intentionally involves departmental faculty in developing institution-specific curricula that outline both the implementation conditions and performance standards. The institution's Academic Board may review final departmental curriculum submissions.

10.3 We remain committed to maintaining a robust internal evaluation system in every institution to ensure minimum standards and quality of education across all programs in the Technical and Vocational Education (TVE) system.

10.4 The teaching of theory and practical work should be integrated as much as possible. Practical exercises - particularly in professional courses and laboratory work - should not be taught in isolation from theory. For most courses, there should be a theory-to-practice ratio of either 40:60 or 60:40.

10.5 Internship: Internship should be carried out in Year One (I) Semester Two (II) at a relevant Industry for the period of 6- 8 weeks. Students' placement should be done by the Department with assigned Log books whose grade score of 3CU has been provided in the curriculum table.

Note that this Internship is not funded by ITF because only ND are to take part in the SIWES.

11.0 **Mandatory Skills Qualification (MSQ) for Higher National Diploma (HND) Programmes.**
See Guidelines for the Implementation of MSQ in Polytechnics in Nigeria

CURRICULUM TABLE

YEAR I SEMESTER I

S/N	COURSE CODE	COURSE TITLE	L	P	CU	CH
1	GNS 301	Use of English III	2	-	2	2
2	MEC 311	Engineer and Society	2	0	2	2
3	MSQ 311	Quality Assurance Assessor (QAA)	0	o	0	2
4	MTH 311	Advanced Algebra	1	1	2	2
5	STE 311	Fundamentals of Electrical Power System and Machines	2	1	3	3
6	SPE 311	Principles of Electronics	2	1	3	3
7	SPE 312	Principles of Renewable Energy	1	1	2	2
8	SPE 313	Fundamentals for Solar PV Systems	1	2	3	3
9	SPE 314	Solar Resource Assessment	1	2	3	3
10	SPE 315	Workshop Practice and Safety Procedures	1	1	2	2
11	SPE 316	Smart Grids & IoT in Solar PV System I	1	1	2	2
12	SPE 317	Energy Storage Technologies in Solar PV	1	2	3	3
13	SPE 318	Modelling and Simulation of Solar PV Systems	1	1	2	2
TOTAL			**16**	**13**	**29**	**31**

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YEAR I SEMESTER II

S/N	COURSE CODE	COURSE TITLE	L	P	CU	CH
1	GNS 302	Communication in English III	2	-	2	2
2	MTH 312	Advanced Calculus	2	0	2	2
3	ENT 326	Practice of Entrepreneurship I	2	2	2	4
4	MSQ 321	Quality Assurance Assessor (QAA)	0	0	0	2
5	CTE 323	Python Programming	1	2	3	3
6	SPE 321	Power Electronics	1	2	3	3
7	SPE 322	Techno-Economic analysis for Solar PV System	1	1	2	2
8	SPE 323	Solar PV System Configuration	1	2	3	3
9	SPE 324	Research Methodology in Solar PV	1	1	2	2
10	SPE 325	Solar Project Management & Tendering Process	1	1	2	2
11	SPE 326	Smart Grids & IoT in Solar PV System II	1	2	3	3
12	SPE 327	Internship (6-8 Weeks)	0	0	3	3
		TOTAL	**13**	**13**	**27**	**31**

YEAR II SEMESTER I

S/N	COURSE CODE	COURSE TITLE	L	P	CU	CH
1	GNS 401	Communication in English IV	2	-	2	2
2	MTH 412	Numerical Methods	2	0	2	2
3	ENT 416	Practice of Entrepreneurship II	2	2	4	4
4	EEC 324	Control Engineering	1	2	3	3
5	STE 414	Retrofitting & Energy Efficiency Techniques	1	2	3	3
6	SPE 411	Advanced Solar PV Technologies	1	1	2	2
7	SPE 412	Installation and Commissioning of Solar PV System	1	2	3	3
8	SPE 413	Advanced PV System Performance and Troubleshooting	1	1	2	2
9	SPE 414	Solar Mini-Grid and Rural Electrification (Field Trip)	1	2	2	3
10	SPE 415	Mini-Project on Solar PV System Installation	0	0	3	3
11	SPE 416	Solar PV Policy, Climate Adaptation & Energy Transition	2	0	2	2
12	SPE 417	Seminar	0	0	2	2
		TOTAL	**11**	**12**	**30**	**31**

YEAR II SEMESTER II

S/N	COURSE CODE	COURSE TITLE	L	P	CU	CH
1	MTH 422	Statistical Methods in Engineering	1	1	2	2
2	STE 423	Energy Efficiency and Demand-Side Management	2	0	2	2
3	STE 424	Engineering Ethics and Professional Practice	2	0	2	2
4	SPE 421	Solar PV Policy, Regulation, and Standards	1	1	2	2
5	SPE 422	Maintenance of Solar PV System	1	2	3	3
6	SPE 423	High-Voltage Solar PV & Industrial Applications	1	2	3	3
7	SPE 424	Application of AI for Energy Trading	1	2	3	3
8	SPE 425	Project	0	0	6	6
		TOTAL	**10**	**7**	**23**	**23**

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YEAR ONE SEMESTER ONE

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PRINCIPLES OF ELECTRONICS

PROGRAMME: HIGHER NATIONAL DIPLOMA (HND) SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY		
Course: **PRINCIPLES OF ELECTRONICS**	**Course Code:** SPE 311	**Contact Hours:** 3
	Credit Unit: 3	**Theoretical:** 1
Year: I **Semester:** I	**Pre-requisite:** NIL	**Practical:** 2
Goal: The Course is designed to acquaint students with the Knowledge and skills in usage of Electronic devices		
General Objective: On completion of this course, the student should be able to: 1.0 Know the concept and applications of PN Junction Diode 2.0 Know the operational principles of Bipolar Junction Transistor (BJT) and Field Effect Transistor (FET) and their applications 3.0 Know the basic principles of operation and applications of operational amplifiers 4.0 Know the general principles of Oscillators and Multivibrators 5.0 Know the general principles of electronic logic gates 6.0 Know the basic circuits used in power supplies		

PROGRAMME: HIGHER NATIONAL DIPLOMA (HND) SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY						
Course: PRINCIPLES OF ELECTRONICS		**Course Code:** SPE 311		**Contact Hours: 3**		
		Credit Unit: 3		**Theoretical:** 1		
Year: I **Semester:** I		**Pre-requisite:** NIL		**Practical:** 2		
Goal: The course is designed to acquaint students with the Knowledge and skills in usage of Electronic devices						
Course Specification: Theoretical Content				Practical Content		
General Objective 1.0: Know the concept and applications of PN Junction Diode						
Week	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's Activities**	**Resources**
1-3	Define Semiconductor Diode List type of diodes Describe PN Junctions in forward and reverse bias operations Describe the following applications of Semiconductor diodes; Voltage Stabilisation and Reference. Voltage Shifting. 1.5 Describe testing of diodes using multimeter	Explain the concept of Semiconductor diode Explain the types of diodes Explain PN Junctions in forward and reverse bias operations Explain the following applications of Semiconductor diodes: Voltage Stabilisation and Reference. Voltage Shifting. Explain testing of diodes using multimeter	Whiteboard Marker Textbooks Internet Computer Projector	Identify different types of diodes Demonstrate forward and reverse bias characteristics of PN Junction diodes. Carryout testing of diodes using multimeter	Guide students to: Identify different types of diodes Demonstrate forward reverse bias characteristics of PN Junction diodes. Demonstrate how to test diodes using multimeter	1. Practical manual 2. Breadboard Diodes Multi-meters Power supply Semiconductor Trainer/ module Resistors Capacitors
General Objective 2.0 : Know the operational principles of Bipolar Junction Transistor (BJT), Field Effect Transistors and their applications						
	2.1 Define the transistor	Explain the concept of	Whiteboard		Guide students to:	1. Practical

4-6	2.2 Explain the following; Collector Characteristic Curves, Cut Off Saturation DC Load line. 2.3 Explain the basic operation of Bipolar Junction Transistor as; Amplifier Switch 2.4 Describe testing of the following Bipolar Junction Transistor using multimeter. NPN PNP 2.5 Describe the basic operation of Field Effect Transistor. 2.6 Describe testing of the following Field Effect Transistor using multimeter. N-channel type P-channel type 2.7 Explain the principle of operation and design of the	transistors. Explain the following; Collector Characteristic Curves, Cut Off Saturation DC Load line. Explain the basic operation of Bipolar Junction Transistor as; Amplifier Switch Explain testing of the following Bipolar Junction Transistor using multimeter. NPN PNP Explain the basic operation of Field Effect Transistor. Explain how to test for the following Field Effect Transistor using multimeter. N-channel type P-channel type	Marker Textbooks Internet Computer Projector	Test the following Bipolar Junction Transistors. NPN PNP Test the following Field Effect Transistors using multi-meter. N-channel type P-channel type Design and Construct Transistor Amplifier and switching circuits Measure the voltage and power gains of the following; Fixed bias. Collector-base bias without and with a decoupling capacitor. Potential divider bias. Junction FET simple bias	1. Test the following Bipolar Junction Transistors. NPN PNP 2. Test the following Field Effect Transistors using multi-meter. N-channel type P-channel type Design and Construct Transistor Amplifier and switching circuits Measure the voltage and power gains of the following; Fixed bias. Collector-base bias without and with a decoupling capacitor. Potential divider bias. Junction FET simple bias Illustrate activities 2.2 to 2.8 using diagrams	manual Breadboards 2. BJT Transistors 3. FET Transistors 4. Resistors 5. Capacitors 6. Multi-meters 7. Variable power supply, 8.Semiconductor Trainer/ module 9. Oscilloscope 10. Signal generator

	following types of biasing arrangement of transistor amplifier: Fixed bias. Collector-base bias without and with a decoupling capacitor. Potential divider bias. Junction FET simple bias. 2.8 Explain the principles and coupling methods of common emitter and common source transistor amplifiers having; Resistive load, Transformer and Tuned circuit loads. 2.9 Explain how to calculate the voltage and power gains of the amplifiers in 2.8 2.10 List the application of the different coupling methods in 2.8.	Explain the principle of operation and design of the following types of biasing arrangement of transistor amplifier: Fixed bias. Collector-base bias without and with a decoupling capacitor. Potential divider bias. Junction FET simple bias. Explain the principles and coupling methods of common emitter and common source transistor amplifiers having; Resistive load, Transformer and Tuned circuit loads. Explain how to calculate the voltage and power gains of the amplifiers in 2.8 Explain the application of the different coupling methods in 2.8.		Illustrate activities 2.2 to 2.8 using diagrams Calculate the voltage and power gains of the amplifiers in 2.8. Draw the circuit diagram of a single stage common emitter and common source transistor amplifiers having; Resistive load, Transformer Tuned circuit loads.	Calculate the voltage and power gains of the amplifiers in 2.8 above Draw the circuit diagram of a single stage common emitter and common source transistor amplifiers having; Resistive load, Transformer Tuned circuit loads.	
General Objective 3.0: Know the basic principles of operation and applications of operational amplifiers.						

7-8	3.1 Explain the principles of operation of operational amplifiers (OP-AMP). 3.2 State the following characteristics of an ideal operational amplifier: • Infinite input resistance; • Zero output resistance; • Infinite voltage gain; • Infinite bandwidth; • No output when input voltages are equal • Characteristic, stable with temperature • No input current • Virtual earth at input; inverting and non-inverting input terminals. 3.3 Explain virtual earth in operational amplifier. 3.4 Distinguish between the operation of an OP/AMP with inverting and non-inverting inputs.	Explain the principles of operation of operational amplifiers (OP-AMP). Explain the following characteristics of an ideal operational amplifier: • Infinite input resistance; • Zero output resistance; • Infinite voltage gain; • Infinite bandwidth; • No output when input voltages are equal • Characteristic, stable with temperature • No input current • Virtual earth at input; inverting and non-inverting input terminals. Explain virtual earth in operational amplifier.	Whiteboard Marker Textbooks Internet Computer Projector	Design and Construct various Operational Amplifier circuits Demonstrate the effect of feedback in operational amplifier. Measure the amplitude and frequency of known operational amplifier-based oscillators. Solve problems involving OP-AMP, using circuits in 3.5.	Guide students to: Design and construct Operational Amplifier circuits Demonstrate the effect of feedback in operational amplifier Measure the amplitude and frequency of known oscillators. Solve problems involving OP-AMP, using circuits in 3.5.	1. Practical manual 2. Breadboard 3. Operational amplifiers 4. Resistors 5. Multi-meters 6. Variable Power supply 7. Operational Amp Trainer/ module 8.Oscilloscope 9. Signal generator

	3.5 Explain the applications of an operational amplifier as used in the following circuits: • Schmitt trigger circuit; • Constant current generator; • Voltage level indicator; • Peak voltage follower • Constant voltage source; • Voltage comparison • Voltage rectifier circuit; • Integrator; • Differentiator; • Log and Antilog circuit; • Equalizer circuit; • Voltage amplifier circuit; • Oscillators. 3.6 State the practical applications of operational amplifiers	Distinguish between the operation of an OP/AMP with inverting and non-inverting inputs. Explain the applications of an operational amplifier as used in the following circuits: • Schmitt trigger circuit; • Constant current generator; • Voltage level indicator; • Peak voltage follower • Constant voltage source; • Voltage comparison • Voltage rectifier circuit; • Integrator; • Differentiator; • Log and Antilog circuit; • Equalizer circuit; • Voltage amplifier circuit; • Oscillators.				

		State the practical applications of operational amplifiers				
General Objective 4.0: Know the general principles of Oscillators and Multivibrators						
9-11	4.1 Define positive and negative feedback in amplifiers. 4.2 Explain the general expression for stage gain of a basic feedback amplifier. 4.3 State the effect of applying negative feedback to an amplifier in relation to: • Gain. • Gain stability. • Bandwidth. • Distortion. • Noise. • Input and output resistance. 4.4 Explain how oscillations can be produced by an amplifier with positive feedback.	Explain positive and negative feedback in amplifiers. Explain the general expression for stage gain of a basic feedback amplifier. Explain the effect of applying negative feedback to an amplifier in relation to: • Gain. • Gain stability. • Bandwidth. • Distortion. • Noise. • Input and output resistance. Explain how oscillations can be produced by an amplifier with positive feedback.	Whiteboard Marker Textbooks Internet Computer Projector	Design and construct multivibrators using Switches Transistors and monolithic integrated circuit (ICs) Draw the block diagram of a basic feedback amplifier. Draw a simple electronic switch Draw multivibrator circuits.	Guide students to Design and construct multivibrators using Switches Transistors and monolithic integrated circuit (ICs) Draw the block diagram of a basic feedback amplifier. Draw a simple electronic switch Draw multivibrator circuits.	1. Practical manual 2. Breadboard 3. Transistors 4. Resistors 5. Capacitors 6. Multi-meter, 7. Variable power supply Monolithic integrated circuit (ICs) 9. Trainer/ module 10.Oscilloscope 11. Signal generator 12. Switches

	4.5 Explain the operation of: R-C Oscillator. L-C oscillator (Hartley & colpitts) Describe methods of employing frequency stability of oscillators using Piezo-electric crystal control. 4.7 Explain the principle of operation of the following multivibrators using switches: • Bistable. • Monostable • Astable. 4.8 Explain the operation of multi-vibrators in 4.8 using the following: • Transistors and • Monolithic integrated circuit (ICs) 4.9 State the expression for determining the frequencies and timing of multivibrators	Explain the operation of: R-C Oscillator. L-C oscillator (Hartley & colpitts) Explain methods of employing frequency stability of oscillators using Piezo-electric crystal control. Explain the principle of operation of the following multivibrators using switches, such as: • Bistable. • Monostable • Astable. Explain the operation of multi-vibrators in 4.8 using, such as: • Transistors and • Monolithic integrated circuit (ICs) Explain how to determine the frequencies and timing of multivibrators				

	4.10 Explain new trends in the switching circuits, oscillators and multivibrators	Explain new trends in the switching circuits, oscillators and multivibrators				
General Objective 5.0: Know the general principles of electronic logic gates						
12-13	5.1 Explain the basic Boolean functions 5.2 Explain the basic operation of the following electronic logic gates using appropriate symbols and truth tables: • The 'NOT' gate or inventers; • The 'AND' gate; • The 'OR' gate; • The 'NAND' gate • The 'NOR' gate 5.3 Describe classifications of logic gates as families. 5.4 Describe the following logics; • RTL(resistor transistor logic) • DCTL(direct coupled transistor	Explain the basic Boolean functions Explain the basic operation of the following electronic logic gates using appropriate symbols and truth tables: • The 'NOT' gate or inventers; • The 'AND' gate; • The 'OR' gate; • The 'NAND' gate • The 'NOR' gate Explain classifications of logic gates as families. Describe the following logics; • RTL(resistor transistor logic) • DCTL(direct	Whiteboard Marker Textbooks Internet Computer Projector	Perform logic gate operations using the following types of gates: The 'NOT' gate or inventers; • The 'AND' gate; • The 'OR' gate; • The 'NAND' gate • The 'NOR' gate Use software packages to show the logic gates functions and different ways they can be configured	Guide students to: Perform logic gate operations of the following using the following types of gates: • The 'NOT' gate or inventers; • The 'AND' gate; • The 'OR' gate; • The 'NAND' gate • The 'NOR' gate Use software packages to show the logic gates functions and different ways they can be configured	1. Practical manual 2. Breadboard 3. Power supplies, 4. Multimeters, 5. Connecting cables. Logic tutor, 6. Digital system trainer, 7. Logic pulser, 8. Logic probe. 9. Simulation Software

	logic) • IIL(integrated injection logic) • DTL(diode transistor logic) • HTL(high threshold logic) • TTL(transistor transistor logic) 5.5 Explain how they can be configured to form other logic gates. 5.6 State the characteristics and applications of logic gates	coupled transistor logic) • IIL(integrated injection logic) • DTL(diode transistor logic) • HTL(high threshold logic) • TTL(transistor transistor logic) Explain how they can be configured to form other logic gates. Explain the characteristics and applications of logic gates				
General Objective 6.0: Know the basic circuits used in power supplies						
14-15	6.1 Explain half-wave and full-wave rectification 6.2 Explain how to calculate ripple factors for half-wave and full-wave rectification 6.3 Explain the operation of a bridge rectifier.	Explain half-wave and full-wave rectification Explain how to calculate ripple factors for half-wave and full-wave rectification	Whiteboard Marker Textbooks Internet Computer Projector	Verify the output waveforms of the rectifiers Verify the effect of filter capacitor on the output of the rectifier.	Guide students to: Verify the output waveforms of rectifiers Verify the effect of filter capacitor on the output of the rectifier. Draw a simple power supply circuit diagrams	1. Practical manual 2. Breadboard 3. Power supplies, 4. Oscilloscope,

	6.4 Explain the use of the following as smoothing circuits: • The capacitor input filter. • The inductance input filter. 6.5 Explain the need for power supply regulation. 6.6 Explain the action of a stabilized power supply using: • Zener diode. • Series regulator	Explain the operation of a bridge rectifier. Explain the use of the following as smoothing circuits: • The capacitor input filter. • The inductance input filter. Explain the need for power supply regulation. Explain the action of a stabilized power supply using: • Zener diode. • Series regulator.		Draw a simple power supply circuit diagrams Calculate ripple factors for half wave and full-wave rectification	Calculate ripple factors for half wave and full-wave rectification	5. Capacitors, 6. Diodes, 7. Voltmeter, Ammeter, Connecting cables.
ASSESSMENT: Continuous Assessment: 60% Examination: 40%						

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PRINCIPLES OF RENEWABLE ENERGY

PROGRAMME: HIGHER NATIONAL DIPLOMA (HND) SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY		
COURSE TITLE: PRINCIPLES OF RENEWABLE ENERGY	**COURSE CODE**: SPE 312	**CONTACT HOURS:** 2
	CREDIT UNIT: 2	**THEORETICAL**: 1
YEAR: I **SEMESTER:** I	**PRE-REQUISITE:** NIL	**PRACTICAL:** 1
GOAL: This course is designed to enable the students to acquire knowledge and skills on the principles of Renewable Energy		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Know the concept of renewable energy 2.0 Understand the components of renewable energy 3.0 Understand the climatic indicators of renewable energy 4.0 Understand the Renewable Energy sustainability 5.0 Understand the mitigation of climate change		

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PROGRAMME: HIGHER NATIONAL DIPLOMA (HND) SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY		
COURSE TITLE: PRINCIPLES OF RENEWABLE ENERGY	**COURSE CODE**: 312	**CONTACT HOURS:** 2
	CREDIT UNIT: 3	**THEORETICAL**: 1
YEAR: 1 **SEMESTER:** 1	**PRE-REQUISITE:** NIL	**PRACTICAL:** 1
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL		
GOAL: This course is designed to enable the students to acquire knowledge and skills on the principles of Renewable Energy		
GENERAL OBJECTIVE 1.0: Know the concept of renewable energy		

THEORETICAL CONTENT				**PRACTICAL CONTENT**		
WEEK	**SPECIFIC LEARNING OUTCOME**	**TEACHER'S ACTIVITIES**	**RESOURCES**	**SPECIFIC LEARNING OUTCOME**	**TEACHER'S ACTIVITIES**	**RESOURCES**
1 - 9	1.1 Define Energy 1.2 Explain the forms of Energy: • Solar • Electrical • Mechanical (Kinetic and Potential) • Thermal (Heat) • Chemical, etc. 1.3 Explain the sources of Energy 1.4 List the consequences of using the following fossil fuels:	Explain the concept of Energy Explain the various forms of Energy: • Solar • Electrical • Mechanical (Kinetic and Potential) • Thermal (Heat) • Chemical, etc. Explain the sources of Energy Explain the consequences of using the following fossil fuels:	Textbooks, Journals, Publications, Whiteboard, Markers, Internet, Computer, Projector, Charts	Participate in group discussions and class presentations on different forms of energy transformation Using visual aids demonstrate how energy is been transformed	Guide the student on group discussions and class presentations on different forms of energy transformation Using visual aids demonstrate how energy is been transformed	Internet Computer, Projector, Concave mirror 5. Light source

	• Pollution • Global warming • Acid rain 1.5 Define Renewable Energy 1.6 Explain the benefits of the following Renewable Energy sources: • Solar • Wind • Hydro • Biomass • Geothermal • Tidal, etc. 1.7 Explain the benefits and opportunities of adopting renewable energy technologies: • Environmental Benefits • Social Benefits • Economic Benefits, etc.	• Pollution • Global warming • Acid rain Explain concept of Renewable Energy Explain the benefits of the following Renewable Energy sources: • Solar • Wind • Hydro • Biomass • Geothermal • Tidal, etc. Explain the benefits and opportunities of adopting renewable energy technologies: Environmental Benefits • Social Benefits • Economic Benefits, etc. Explain global shift away from fossil fuels to Renewable Energy				

	1.8 Explain global shift away from fossil fuels to Renewable Energy					
GENERAL OBJECTIVE 2.0: Understand the components of renewable energy systems						
	2.1 Explain the following components of Solar PV system: • PV Modules • Inverter • Charge Controller • Batteries • Balance of system, etc. 2.2 Explain the components of biomass 2.3 Explain the components of wind energy system 2.4 Explain the components of Solar thermal system 2.5 Explain the components of geothermal energy system 2.6 Explain by comparison the performance and	Explain the following components of Solar PV system: • PV Modules • Inverter • Charge Controller • Batteries • Balance of system, etc. Explain the components of biomass Explain the components of wind energy system Explain the components of Solar thermal system Explain the components of geothermal energy system Explain by comparison the performance and properties of solar PV	Textbooks, Journals, Publications, Whiteboard, Markers, Internet Computer, Projector, Charts			

	properties of solar PV and solar thermal systems	and solar thermal systems				
GENERAL OBJECTIVE 3.0: Understand the climatic indicators of renewable energy						
9 - 10	3.1. Explain the factors affecting renewable energy generation 3.2 Explain the use of renewable energy in the reduction of the following: • Greenhouse gas concentrations • Sea level rise • Ocean heat • Ocean acidification etc. 3.3 Explain the impacts of renewable energy on the environment 3.4 Explain the methods of mitigating the effect of the following climate change: • Regenerative Agricultural practices • Protecting and restoring forests and critical ecosystems	Explain the factors affecting renewable energy generation Explain the use of renewable energy in the reduction of the following: • Greenhouse gas concentrations • Sea level rise • Ocean heat • Ocean acidification etc. Explain the impacts of renewable energy on the environment Explain the Methods of mitigating the effect of the following climate change: • Regenerative Agricultural practices • Protecting and restoring forests	Textbooks, Journals, Publications, Whiteboard, Markers, Internet Computer, Projector, Animation, Charts			

	• Prevention of Greenhouse gas emissions, etc.	and critical ecosystems • Prevention of Greenhouse gas emissions, etc.				
GENERAL OBJECTIVE 4.0: Understand the Renewable Energy sustainability						
11 - 12	4.1 Explain Renewable Energy sustainability 4.2 Explain solar PV Energy sustainability 4.3 Explain solar thermal Energy sustainability 4.4 Explain wind Energy sustainability 4.5 Explain bio-mass Energy sustainability 4.6 Explain hydro Energy sustainability 4.7 Explain by comparison Energy sustainability of solar PV and solar thermal systems 4.8 Explain the impact of human activities on Energy sustainability of solar PV	Explain Renewable Energy sustainability Explain solar PV Energy sustainability Explain solar thermal Energy sustainability Explain wind Energy sustainability Explain bio-mass Energy sustainability Explain hydro Energy sustainability Explain by comparison Energy sustainability of solar PV and solar thermal systems	Textbooks, Journals, Publications, Whiteboard, Markers, Internet Computer, Projector			

	and solar thermal systems	Explain the impact of human activities on Energy sustainability of solar PV and solar thermal systems				
ASSESSMENT: Continuous Assessment (CA): 60% Examination: 40%						

Government of the Netherlands

FEDERAL GOVERNMENT OF NIGERIA

FUNDAMENTALS FOR SOLAR PHOTOVOLTAIC (PV) SYSTEM

PROGRAMME: HIGHER NATIONAL DIPLOMA (HND) SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY		
COURSE TITLE: FUNDAMENTALS FOR SOLAR PHOTOVOLTAIC (PV) SYSTEM	Course Code: SPE 313	Contact Hours: 3
	Credit Unit: 3	Theoretical: 1
Year: 1 Semester: 1	Pre-requisite: NIL	Practical: 2
GOAL: The course is designed to enable the students acquire knowledge and skills of Solar PV System		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Know the concept of Electromagnetic Waves in Solar PV System 2.0 Know the component of the Solar PV System 3.0 Know the application of Solar PV System		

PROGRAMME: HIGHER NATIONAL DIPLOMA (HND) SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY		
COURSE TITLE: FUNDAMENTALS FOR SOLAR PV SYSTEM	**COURSE CODE**: SPE 313	Contact Hours: 2 Hours
	Credit Unit: 3	Theoretical: 1
Year: 1 **Semester**: I	Pre-requisite: NIL	Practical: 2
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL		
GOAL: The course is designed to enable the students acquire knowledge and skills of Solar PV System		
GENERAL OBJECTIVE 1.0: Know the concept of Electromagnetic Waves in Solar PV System		

THEORETICAL CONTENT				**PRACTICAL CONTENT**		
Week	**Specific Learning Outcome**	**Teacher's Activities**	**Resources**	**Specific Learning Outcome**	**Teacher's Activities**	**Resources**
1- 4	1.1 Define Solar PV System 1.2 Explain the process of converting photons to Electrical Energy 1.3 Explain the effect of Photovoltaic (PV) on semiconductor materials 1.4 Explain the concept of the following Electromagnetic waves in Solar PV System • Electric Current	Explain the concept of Solar PV System Explain the process of converting photons to Electrical Energy Explain the effect of Photovoltaic (PV) on semiconductor materials Explain the concept of the following Electromagnetic	Textbooks, Publications Journals, Whiteboard Marker, Internet Computer, Projector	Illustrate the Electromagnetic spectrum, waves, fields on various semi – conductors Sketch the in – built electric field created by the positively and negatively charged junctions on semi conductor layers	Guide students to: Illustrate the Electromagnetic spectrum, waves fields on various semi – conductors Sketch the in – built electric field created by the positively and negatively charged junctions on semi conductor layers	1. Diagrams 2. Charts 3. Videos

	• Electric Charge • Electric Field etc. 1.5 Explain the effects of electric field on positively and negatively charged junctions on semiconductor layers	waves in Solar PV System • Electric Current • Electric Charge • Electric Field etc. Explain the effects of electric field on positively and negatively charged junctions on semi conductor layers				
General Objective 2.0: Know the component of the Solar PV System						
5 - 8	2.1 Explain the following components of Solar PV Systems: • Solar Panels • Solar Charge Controllers • Batteries • Protective Devices • Batteries Equalizers, etc.	Explain the following components of Solar PV Systems: • Solar Panels • Solar Charge Controllers • Batteries • Protective Devices • Batteries Equalizers, etc.	Textbooks, Journals, Whiteboard Marker, Internet, Computer, Projector	Identify the different types of Solar PV System	Guide students to identify the components of Solar PV System	1. Solar Panels 2. Solar Charge 3. Controllers Batteries Batteries Equalizers (BMS) DC/AC Bulbs

	2.2 Explain the different types of components in Solar PV System • Solar Panels (Mono - crystalline, Polycrystalline and thin – film) • Batteries (Lead – acid, Lithium ion, Tubular batteries etc.) • Solar charge controllers: Maximum Power Point Tracking (MPPT), Pulse width Modulation (PWM) 2.3 Explain the differences between the different types of components in 2.2	Explain the different types of components in Solar PV Systems: • Solar Panels (Mono - crystalline, Polycrystalline and thin – film) • Batteries (Lead – acid, Lithium ion, Tubular batteries etc.) • Solar charge controllers: Maximum Power Point Tracking (MPPT), Pulse width Modulation (PWM) Explain the differences between the different types of components in 2.2				Mounting structures Inverters Cable/ Connectors SPDs

General Objective 3.0: Know the application of Solar PV System						
9 - 14	3.1 Explain the importance of Solar PV Systems in various areas of application 3.2 Explain the following types of Solar PV installation Systems: • Off grid • Grid tied • Hybrid 3.3 List the following areas of Solar PV System applications: • Residential • Industrial • Enterprise • Agriculture etc. 3.4 Explain the limitations of Solar PV application Systems mentioned in 3.3	Explain the importance of Solar PV Systems in various areas of application Explain the following types of Solar PV installation Systems: • Off grid • Grid tied • Hybrid Explain the following areas of Solar PV System applications: • Residential • Industrial • Enterprise • Agriculture etc. Explain the limitations of Solar PV application Systems mention in 3.3	Textbooks, Journals, Whiteboard Marker, Internet Computer, Projector	Identify types of Solar PV installation Systems	Guide students to identify types of Solar PV installation Systems	Pictorials Videos

ASSESSMENT:
Continuous Assessment (CA): 60%
Examination: 40%

Solar Resource Assessment

PROGRAMME: HIGHER NATIONAL DIPLOMA (HND) SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY		
COURSE TITLE: Solar Resource Assessment	Course Code: SPE 314	Contact Hours: 3
	Credit Unit: 3	Theoretical: 1
Year: 1 Semester:1	Pre-requisite: NIL	Practical: 2
GOAL: This course is designed to equip students with knowledge and skills in solar resource assessment		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Know the basics of solar irradiance as solar energy resources 2.0 Know how to interpret and analyze solar energy data 3.0 Conduct site evaluation using appropriate tools and software 4.0 Evaluate feasibility of solar energy projects 5.0 Understand industrial standards in solar energy resource assessment 6.0 Know the application of solar energy resources for effective system design		

PROGRAMME: HIGHER NATIONAL DIPLOMA (HND) SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY		
COURSE TITLE: Solar Resource Assessment	**COURSE CODE**: 314	**CONTACT HOURS:** 3
	CREDIT UNIT: 3	**THEORETICAL**: 1
YEAR: I **SEMESTER:** I	**PRE-REQUISITE:** NIL	**PRACTICAL:** 2
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL		
GOAL: This course is designed to equip students with knowledge and skills in solar resource assessment		
GENERAL OBJECTIVE 1.0: Know the basics of solar irradiance as solar energy resources		

THEORETICAL CONTENT				**PRACTICAL CONTENT**		
WEEK	**SPECIFIC LEARNING OUTCOME**	**TEACHER'S ACTIVITIES**	**RESOURCES**	**SPECIFIC LEARNING OUTCOME**	**TEACHER'S ACTIVITIES**	**RESOURCES**
1-3	1.1 Define solar irradiance 1.2 Explain the following types of solar irradiance • Direct Normal Irradiance(DNI) • Global Horizontal Irradiance(GHI) • Diffuse Horizontal Irradiance(DHI) 1.3 Explain the relevance of each type of solar irradiant in 1.2 to energy systems.	Explain the concept of solar irradiance Explain the following types of solar irradiance • Direct Normal Irradiance(DNI) • Global Horizontal Irradiance(GHI) • Diffuse Horizontal Irradiance(DHI) Explain the relevance of each type of solar	Journals Text books Whiteboard Marker Internet Computer Projector	Identify the types of solar irradiance (DNI, GHI, DHI). Demonstrate how sunlight is converted into electricity and heat Demonstrate how solar energy is measured with simple tools Measure temperature, tilt angle and irradiance as factors affecting solar energy availability.	Guide students to: Identify the types of solar irradiance (DNI, GHI, DHI). Demonstrate how sunlight is converted into electricity and heat Demonstrate how solar energy is measured with simple tools Measure temperature, tilt angle and irradiance as	1. Sample Case studies 2. Charts 3. Diagrams 4. Pyranometer 5. Pyrheliometer 6. Videos 7. GPS 8. Magnetic Compass 9. PV trainer

	1.4 Describe the solar spectrum and its role in Solar Energy conversion 1.5 Explain the factors affecting solar irradiance, such as: • Atmospheric conditions, • Geographical location, and • Seasonal variations. 1.6 Explain solar resource availability across different geographical locations	irradiance in 1.2 to energy systems. Explain the solar spectrum and its role in Solar Energy conversion Explain the factors affecting solar irradiance, such as: • Atmospheric conditions, • Geographical location, and • Seasonal variations. Explain solar resource availability across different geographical locations		Compare solar radiation levels in different directions Compare solar resource availability across different directions	factors affecting solar energy availability. Compare solar radiation levels in different directions Compare solar resource availability across different directions	10. PV modules
GENERAL OBJECTIVE 2.0: Know how to interpret and analyze solar energy data						
4	2.1 Explain the sources of solar energy irradiance data in relation to:	Explain the sources of solar energy irradiance	Journals Textbooks Whiteboard	Select relevant solar energy datasets	Guide to students to: 1. Select relevant	1. Solar radiation datasets.

	• Satellite, • Meteorological station 2.2 Explain the selection process of extracting solar energy datasets 2.3 Explain solar radiation trends for prediction of solar energy output 2.4 Explain the application of statistical and computational tools to analyze solar energy patterns.	data in relation to: • Satellite, • Meteorological station Explain the selection process of extracting solar energy datasets Explain solar radiation trends for prediction of solar energy output Explain the application of statistical and computational tools to analyze solar energy patterns.	Marker Internet Computer Projector	Use computational tools to analyze solar energy patterns. Interpret solar radiation trends to predict energy output for solar energy systems. Demonstrate basic data processing using spreadsheets.	solar energy datasets 2. Use computational tools to analyze solar energy patterns. Interpret solar radiation trends to predict energy output for solar energy systems. 3. Demonstrate basic data processing using spreadsheets.	2. Computer Software 3. RETScreen 4. Sample solar data sources (NiMET, NASA PVGIS). 5. Graphs 6. Charts
GENERAL OBJECTIVE 3.0: Conduct Site Evaluation Using Appropriate Tools and Software						
5-7	3.1 Explain key factors in site selection of the following: • Shading • Terrain • Climate, etc.	Explain key factors in site selection of the following: • Shading • Terrain • Climate,	Journals Textbooks Whiteboard Marker Internet Computer Projector	Demonstrate the use of solar energy resource measurement tools and software for Solar energy resources assessment	Guide students to: 1. Demonstrate the use of solar energy resource measurement tools and software for	7. Pyranometers 8. Pyrheliometers 9. Maps 10. RETScreen

	3.2 Explain solar energy resource measurement tools such as: • Pyranometers • Pyrheliometers. • Magnetic Compass • Inclinometer • Measuring Tapes • GPS, etc. 3.3 Explain solar energy resource measurement software 3.4 Explain the generation of site assessment reports for solar energy resources using: • Tools • Software	etc. Explain solar energy resource measurement tools such as: • Pyranometers • Pyrheliometers • Magnetic Compass • Inclinometer • Measuring Tapes • GPS, etc. Explain solar energy resource measurement software Explain the generation of site assessment reports for solar energy resources using: • Tools • Software		Generate site assessment reports for solar energy resources	Solar energy resources assessment 2. Generate site assessment reports for solar energy resources	PVsyst Anemometer Magnetic Compass Inclinometer Measuring Tapes GPS 17. Sample feasibility reports.
GENERAL OBJECTIVE 4.0: Evaluate the Feasibility of Solar Energy Projects						
8-11	4.1 Explain the following economic factors affecting solar energy projects implementation:	Explain the following economic factors affecting solar	Journals Textbooks Whiteboard Marker	Conduct economic analysis on solar energy projects such as:	Guide to student to: Conduct economic analysis on solar	1. Sample of solar project data. 2. Calculators

	• Initial capital • Maintenance Cost • Payback period, • Return on investment (ROI), and • Cost-benefit analysis, etc 4.2 Explain the following environmental factors affecting solar Energy projects implementation: • Carbon footprint reduction and • Land use 4.3 Explain the following social factors affecting solar energy projects implementation: • Security • Civilization • Infrastructure	energy projects implementation: • Initial capital • Maintenance Cost • Payback period, • Return on investment (ROI), and • Cost-benefit analysis, etc Explain the following environmental factors affecting solar energy projects implementation: • Carbon footprint reduction and • Land use Explain the following social factors affecting solar energy projects system implementation: • Security	Internet Computer Projector	• Initial capital • Maintenance • Payback period, • Return on investment (ROI), • Cost-benefit analysis, etc. Evaluate environmental factors affecting solar energy projects, such as • Carbon footprint reduction and • Land use Compare the feasibility of solar energy systems with alternative energy sources	energy projects such as: • Initial capital • Maintenance • Payback period, • Return on investment (ROI), and • Cost-benefit analysis, etc. Evaluate environmental factors affecting solar energy projects, such as • Carbon footprint reduction and • Land use reclamation Compare the feasibility of solar	3. Sample of Environmental Impact Assessment (EIA)reports. 4. Sample of Social impact reports. 5. Charts 6. Map 7. RETScreen HOMER System Advisor Model(SAM)

		• Civilization • Infrastructure			energy systems with alternative energy sources	
GENERAL OBJECTIVE 5.0: Understand industrial standards in solar energy resource assessment						
12	5.1 Explain industrial standards in solar energy resource assessment 5.2 Explain the types of industrial standards in solar energy resource assessment in relation to: • Technical • Environment • Social, etc. 5.3 Explain international standards for solar energy resource assessment 5.4 Explain practices in system monitoring and reporting.	Explain industrial standards in solar energy resource assessment Explain the types of industrial standards in solar energy resource assessment in relation to: • Technical • Environment • Social, etc. Explain international standards for solar energy resource assessment Explain practices in system monitoring and reporting.	Journals Textbooks Whiteboard Marker Internet Computer Projector			

GENERAL OBJECTIVE 6.0: Know the Application of Solar Energy Resources for Effective Design						
13-15	6.1 Explain factors to consider in sizing solar energy system for effective design 6.2 Explain optimal panel/collector positioning for maximum energy for effective design 6.3 Explain optimal conditions for effective design in storage device installations 6.4 Explain conditions for installation of other devices for effective design such as: • Inverters/heat exchangers • Cables/Pipes • Controllers, etc.	Explain factors to consider in sizing solar energy system for effective design Explain optimal panel/collector positioning for maximum energy for effective design Explain optimal conditions for effective design in storage device installations Explain conditions for installation of other devices for effective design such as: • Inverters/heat exchangers • Cables/Pipes • Controllers, etc.	Journals Textbooks Whiteboard Marker Internet Computer Projector	Design solar energy systems based on: Performance efficiency Sizing Climatic condition, etc. Demonstrate the effect of solar PV orientation and tilt angle Demonstrate the effect of solar collector orientation and tilt angle	Guide the students to: 1. Design solar energy systems based on: Performance efficiency Sizing Climatic condition, etc. 2. Demonstrate the effect of solar PV orientation and tilt angle 3. Demonstrate the effect of solar collector orientation and tilt angle	1. Solar PV panel 2. Solar Thermal Collector 3. RETScreen HOMER SAM 4. Multimeter 5. Clamp meter Inclinometer 6. Spirit level 7. Pyranometer 8. pyrheliometer 9. Power analyzer 10. Thermometer 10. Sample solar energy system designs.

ASSESSMENT: Continuous Assessment (CA): 60% Examination: 40%

Workshop Practice and Safety Procedure

PROGRAMME: HIGHER NATIONAL DIPLOMA (HND) SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY		
COURSE TITLE: Workshop Practice and Safety Procedure	Course Code: SPE 315	Contact Hours: 2
	Credit Unit: 2	Theoretical: 1
Year: I Semester: I	Pre-requisite:	Practical: 1
GOAL: This course is designed to equip students with the knowledge, skills of workshop operations and safety procedures in Solar Energy System		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Know Workshop Safety and Protocols 2.0 Know Risk Assessment and Accident Prevention 3.0 Know Workshop Tools and Equipment 4.0 Know Fabrication and Assembly Techniques		

PROGRAMME: HIGHER NATIONAL DIPLOMA (HND) SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY		
COURSE TITLE: Workshop Practice and Safety Procedure	**COURSE CODE**: SPE 315	Contact Hours: 2
	Credit Unit: 2	Theoretical: 1
Year: I Semester: I	Pre-requisite:	Practical: 1
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL		
GOAL: This course is designed to equip students with the knowledge, skills of workshop operations and safety procedures in Solar Energy System		
GENERAL OBJECTIVE 1.0: Know Workshop Safety and Protocols		

THEORETICAL CONTENT				PRACTICAL CONTENT		
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
1-3	1.1 Define Hazards 1.2 Explain the common causes of hazards 1.3 Explain common workshop hazards 1.4 Explain the methods of preventing workshop hazard 1.5 Explain the importance of emergency response procedures 1.6 Explain occupational health and safety (OHS)	Explain the concept of Hazards Explain the common causes of hazards Explain common workshop hazards Explain the methods of preventing workshop hazard Explain the importance of emergency response procedures	Textbook Projector Journal Computer Marker Marker Board Safety Regulations	Demonstrate the use of PPE Demonstrate first aid procedures Demonstrate emergency response procedures Demonstrate the use of fire extinguisher	Guide Students to: 1. Demonstrate the use of PPE 2. Demonstrate first aid procedures. 3. Demonstrate emergency response procedures. 4. Demonstrate the use of fire extinguisher.	1. PPE Kits 2. First Aid Kit 3. Fire extinguishers 4. Safety signs 5. Fire Alarm 6. Sand bucket 7. Fire

	regulations 1.7 Explain Health safety, environment rules and regulations (HSE) 1.8 Explain the following uses of protective and safety equipment: • PPE • Fire Extinguisher 1.9 Explain first aid in relation to: • Types of first aid • Uses of first aid box/kit • Contents of the first aid box/kit 1.10 Explain the importance of first aid 1.11 Explain proper material storage and waste disposal methods.	Explain occupational health and safety (OHS) regulations Explain Health safety, environment rules and regulations (HSE) Explain the uses of following protective and safety equipment: • PPE • Fire Extinguisher Explain first aid in relation to: • Types of first aid • Uses of first aid box/kit • Contents of the first aid box/kit Explain the importance of first aid Explain proper material storage and waste disposal methods.				Blanket 8. Smoke Detectors 9. Gas Detectors
General Objective 4.0: Know Risk Assessment and Accident Prevention						
4-6	4.1 Define risk assessment 4.2 Explain the importance of	Explain the concept of risk assessment	Textbook Projector Journal	Carryout A Risk Assessment	Guide students to:	1. Risk Assessment checklist and

	risk assessment in workshop safety. 4.3 Explain risk assessment for the following tasks: • Fabrication of parts • Installation of solar PV system • Solar Thermal system installation • Other RE systems installations 4.4 Define accident 4.5 Explain the following types of accidents: • Active • Passive 4.6 Explain the procedures for accident preventions 4.7 Explain strategies for fostering safety culture.	Explain the importance of risk assessment in workshop safety. Explain risk assessment for the following tasks: • Fabrication of parts • Installation of solar PV system • Solar Thermal system installation • Other RE systems installations Explain accident Explain the following types of accidents: • Active • Passive Explain the procedures for accident preventions Explain strategies for fostering safety culture.	Computer Marker Marker Board Safety Regulations	Develop A Safety Checklist For Solar PV, Solar Thermal, And Other renewable energy System Installations. Identify Types Of Accidents Identify The Procedures For Accident Preventions Use Case Study Involving Risk of installation of RE systems	1. Carryout a risk assessment 2. Develop a safety checklist for Solar PV, Solar Thermal, and other renewable energy system installations. 3. Identify types of accidents 4. Identify the procedures for accident preventions 5. Show Case Study Involving Risk installation of RE systems	tools 2. PPE 3. Pictorials 4. Videos clips
General Objective 3.0: Know Fabrication and Assembly Techniques						
7-10	3.1 Explain fabrication and the following fabrication techniques:	Explain fabrication and the following fabrication techniques: • Cutting	Textbook Projector Journal Computer	Perform material cutting, welding, soldering and	Guide students to: 1. Perform material cutting, welding and	4.Fabrication Materials 5. Pipes

	• Cutting • Welding • Soldering • Bending, etc. 3.2 Explain the properties of materials used in Solar PV and Solar thermal fabrication • Copper • Aluminum • Insulation, etc. 3.3 Explain quality control in fabrication. 3.4 Explain assembling and disassembling techniques for the following: • Connections (wiring and piping) • Mounting structures • Civil structure casting	• Welding • Soldering Bending, etc Explain the properties of materials used in Solar PV and Solar thermal fabrication • Copper • Aluminum • Insulation, etc. Explain quality control in fabrication. Explain assembling and disassembling techniques for the following: • Connections (wiring and piping) • Mounting structures • Civil structure casting	Marker Marker Board Safety Regulations	drilling, etc, for solar energy system Assemble and disassemble solar PV: Connections (wiring and piping) Mounting structures Pre-cast solar mounting base Inspect fabricated components for defects and compliance with specifications	drilling, etc, for solar energy system 2. Assemble and disassemble: Connections (wiring and piping) Mounting structures Pre-cast solar mounting base 3. Inspect fabricated components for defects and compliance with specifications	6. Clamping Tools 7. Measuring instruments 8. Cutting Tools 9. Drilling Tools 10. Bending Tools 11. Pictorials 12. Videos Clips Charts
General Objective 2.0: Know Workshop Tools and Equipment						
11-15	2.1 Define tools 2.2 Define equipment 2.3 Explain the differences between tools and equipment	Explain the concept of of tools and equipment Explain the differences between tools and equipment	Textbook Projector Journal Computer Marker Marker Board	Identify the following hand-held tools: • Screwdrivers, • Hacksaws	Guide students to: 1. Identify the following hand-held tools: • Screwdrivers, • Hacksaws	1. hand held tools 2.Equipment 3. Maintenance

	2.4 Explain the classification of tools in renewable energy workshop 2.5 Explain the classification of equipment in renewable energy workshop 2.6 Explain the uses of tools and equipment in renewable energy workshop 2.7 Describe handling and maintenance of tools and equipment.	Explain the classification of tools in renewable energy workshop Explain the classification of equipment in renewable energy workshop Explain the uses of tools and equipment in renewable energy workshop Explain handling and maintenance of tools and equipment.	Safety Regulations	• Spanners , • Drills, etc. Draw and label the following tools: • Screwdrivers, • Hacksaws • Spanners, • Drills, etc. Handle tools and equipment appropriately Maintain tools and equipment appropriately	• Spanner • Drills, etc. Draw and label the following: • Screwdrivers, • Hacksaws • Spanners, • Drills, etc. Handle tools and equipment appropriately Maintain tools and equipment appropriately	Kits 4. Pictorials 5. Videos clips 6. Charts 7. Manuals
EVALUATION: CA 60% EXAMINATION: 40%						

Government of the Netherlands

FEDERAL GOVERNMENT OF NIGERIA

Smart Grids & IoT in PV System I

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY		
COURSE TITLE: Smart Grids & IoT in PV System I	Course Code: SPE 316	Contact Hours: 2
	Credit Unit: 2	Theoretical: 1
Year: I Semester: I	Pre-requisite: NIL	Practical: 1
GOAL: The course is designed to enable students acquire knowledge and skills of Smart Grids and IoT in Solar PV System		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Know the concept of Smart Grids 2.0 Know how to monitor, control, and automate Smart Grids 3.0 Understand the fundamentals of IoT 4.0 Know the fundamentals of Sensors and Actuators in IoT 5.0 Know how to integrate IoT in PV Systems		

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY		
COURSE TITLE: Smart Grids & IoT in PV System I	**COURSE CODE**: SPE 316	Contact Hours: 2
	Credit Unit: 1	Theoretical: 1
Year: 1 **Semester**: 1	Pre-requisite: NIL	Practical: 1
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL		
GOAL: The course is designed to enable students acquire knowledge and skills of Smart Grids and IoT in Solar PV System		
GENERAL OBJECTIVE 1.0: Know the concept of Smart Grid		

THEORETICAL CONTENT				**PRACTICAL CONTENT**		
Week	**Specific Learning Outcome**	**Teacher's Activities**	**Resources**	**Specific Learning Outcome**	**Teacher's Activities**	**Resources**
1- 2	1.1 Define Smart Grid and Traditional Grid 1.2 Explain the evolution of Smart Grids 1.3 Explain how smart grid differs from traditional grid 1.4 Explain smart grid classifications based on the following: • Functional Components • Application Areas • Technological Integration	Explain Smart Grid and Traditional Grid Explain the evolution of Smart Grids Explain how smart grid differs from traditional grid Explain smart grid classifications based on the following: • Functional Components • Application Areas • Technologica	Textbooks, Publications Journals, Whiteboard, Marker, Internet Computer, Projector	Identify small traditional grid and small smart grid	Guide students to identify small traditional grid and small smart grid	1. Practical Manual 2.Traditional Grid Models or Trainers 3. Smart Grid Models or Trainers 4. Videos Pictorials

	• Operational Levels • Grid Architecture, etc. 1.5 Explain major areas of Smart Grid system applications such as; • Energy Generation • Energy Storage Systems • Distribution Network • Smart Meters & End-User Devices • Communication Infrastructure • Demand Response Systems, etc. 1.6 Explain the importance of Smart Grids for modern energy distribution	l Integration • Operational Levels • Operational Levels • Grid Architecture etc. Explain major areas of Smart Grid system applications such as; • Energy Generation • Energy Storage Systems • Distribution Network • Smart Meters & End-User Devices • Communication Infrastructure • Demand Response Systems, etc. Explain the importance of Smart Grids for modern energy distribution				

General Objective 2.0: Know how to monitor, control, and automate Smart Grids						
3-6	2.1 Explain Smart Grid Communication 2.2 Explain the following smart grid communication protocols; • Zigbee, • MQTT, • Modbus 2.3 Explain following smart grid systems: • Monitoring, • Control, and • Automation systems. 2.4 Explain the application of Smart Grid technologies for the following : • Demand response management • Fault detection and self-healing in grids • Energy storage integration • Smart Meters & End-User Devices	Explain Smart Grid Communication Explain the following smart grid communication protocols; • Zigbee, • MQTT, • Modbus Explain following smart grid systems: Monitoring, Control, and Automation systems Explain the application of Smart Grid technologies for the following : • Demand response management • Fault detection and self-healing in grids • Energy	Textbooks, Journals, Publications, Whiteboard, Marker, Internet, Computer, Projector	Monitor power consumption by AC loads using smart meter Control AC loads using smart circuit breaker Automate the operation of AC loads using smart circuit breaker	Guide the students to: 1. Monitor power consumption by AC loads using smart meter 2. Control AC loads using smart circuit breaker 3. Automate the operation of AC loads using smart circuit breaker	1. Practical Manual 3. Smart Meters 3. Bulbs 4. Tool box 5. Cables 6. Smart Beakers 7. Routers 8. Internet 9. Android phone

		storage integration • Smart Meters & End-User Devices				
General Objective 3.0: Understand the fundamentals of IoT						
7-9	3.1 Define internet of things (IoT) 3.2 Explain the role of the following components in IoT • Sensors/Devices • Connectivity/Communication Network • Edge Devices/Gateways • Data Processing/Analytics • Cloud Computing/Storage • User Interface (UI) / Applications • Actuators • Security • Protocols • Power Supply	Explain internet of things (IoT) Explain the role of the following components in IoT • Sensors/Devices • Connectivity/Communication Network • Edge Devices/Gateways • Data Processing/Analytics • Cloud Computing/Storage • User Interface (UI) / Applications • Actuators • Security	Textbooks, Journals, Publications, Whiteboard, Marker, Internet Computer, Projector			

	3.3 Explain the IoT architecture based on the following layers: • Sensing Layer • Network Layer • Middleware • Application Layer • Business Layer. 3.4 Explain each of the following IoT communication models: • Device-to-Device Communication (D2D) • Device-to-Cloud Communication (D2C) • Device-to-Gateway Communication (D2G) • Cloud-to-Cloud Communication (C2C) • Machine-to-Machine (M2M) Communication • Hybrid Communication Model.	• Protocols • Power Supply Explain the IoT architecture based on the following layers: • Sensing Layer • Network Layer • Middleware • Application Layer • Business Layer. Explain each of the following IoT communication models: • Device-to-Device Communication (D2D) • Device-to-Cloud Communication (D2C) • Device-to-Gateway Communication (D2G) • Cloud-to-Cloud				

	3.5 Explain the use of IoT in the context of the following: • Smart Grid Management • Smart Metering and Energy Consumption Monitoring • Predictive Maintenance and Asset Management • Renewable Energy Integration and Optimization • Energy Efficiency and Demand Side Management (DSM)	Communication (C2C) • Machine-to-Machine (M2M) Communication • Hybrid Communication Model. Explain the use of IoT in the context of: the following: • Smart Grid Management • Smart Metering and Energy Consumption Monitoring • Predictive Maintenance and Asset Management • Renewable Energy Integration and Optimization • Energy Efficiency and Demand Side Management (DSM)]				

General Objective 4.0: Know the Fundamentals of Sensors and Actuators in IoT						
10-12	4.1 Explain the principle of each of these sensors used in IoT for smart grids: • Temperature sensor, • Irradiance sensor, • Voltage sensor, • Current monitoring sensor 3.2 Explain the principle of each of the following types of actuators used in IoT for smart grids: • Electromechanical Devices • Hydraulic/Pneumatic Devices • Solid-state devices • Smart Relays 3.3 Explain the roles of IoT actuators in smart grid. • Control Power Flow • Optimize Energy Distribution • Enhance Grid Stability • Automate Fault Management • Renewable Integration	Explain the principle of each of these sensors used in IoT for smart grids: • Temperature sensor, • Irradiance sensor, • Voltage sensor, • Current monitoring sensor Explain the principle of each of the following types of actuators used in IoT for smart grids: • Electromechanical Devices • Hydraulic/Pneumatic Devices • Solid-state devices • Smart Relays Explain the roles of IoT actuators in smart grid. • Control Power Flow	Textbooks, Journals, Publications, Whiteboard, Marker, Internet Computer, Projector	Identify each of these sensors used in IoT for smart grids: • Temperature sensor, • Irradiance sensor, • Voltage sensor, • Current monitoring sensor Identify each of these types of actuators used in IoT for smart grids: • Electromechanical Devices • Hydraulic/Pneumatic Devices • Solid-state devices • Smart Relays	Guide the students to: Identify each of the following sensors used in IoT for smart grids: • Temperature sensor, • Irradiance sensor, • Voltage sensor, • Current monitoring sensor Identify each of these types of actuators used in IoT for smart grids: • Electromechanical Devices • Hydraulic/Pneumatic Devices • Solid-state devices • Smart Relays	1. Practical Manual 2. Smart Meters 3. Bulbs 4. Tool box 5. Cables 6. Smart Beakers 7. Routers 8. Internet 9. Android phone 10.Temperature sensor, 11.Irradiance sensor, 12. Voltage sensor, and 13. Current monitoring

	3.4 Explain Wireless sensor networks for smart grids	• Optimize Energy Distribution • Enhance Grid Stability • Automate Fault Management • Renewable Integration Explain Wireless sensor networks for smart grids				sensor. 14. Electromechanical Devices 15.Hydraulic /Pneumatic Devices 16. Solid-state devices 17. Smart Relays
General Objective 5.0: Know how to integrate IoT in PV Systems						
13-15	5.1 Explain the following in relation to PV Systems: • IoT-based Monitoring and Control of PV Systems • Real-time monitoring of energy generation and consumption • Remote control and fault detection using IoT • Data logging and analysis using IoT devices 3.2 Explain the operation of IoT-enabled Smart Inverters	Explain the following in relation to PV Systems: • I IoT-based Monitoring and Control of PV Systems • Real-time monitoring of energy generation and consumption • Remote control and fault detection using IoT • Data logging and analysis using IoT devices	Textbooks, Journals, Publications, Whiteboard, Marker, Internet Computer, Projector	Carryout experiment using IoT to Carryout monitoring and control of inverters Carryout real-time monitoring of energy generation and consumption in PV system Demonstrate remote short circuit and open circuit fault detection using IoT Demonstrate data logging and analysis using IoT devices	Guide students to Carryout experiment using IoT to Carryout monitoring and control of inverters Carryout real-time monitoring of energy generation and consumption in PV system Demonstrate remote short circuit and open circuit fault detection using IoT Demonstrate data logging and analysis using IoT devices	1. Practical Manual 2. Smart Meters 3. Bulbs Tool box 4. Cables 5. Smart Beakers 6. Routers 7. Internet

	3.3 Explain the role of IoT in the following inverter controlled grid support functions: • Frequency regulation, • Voltage control. 3.4 Explain inverter communication with grid operators using IoT devices.	Explain the operation of IoT-enabled Smart Inverters Explain the role of IoT in the following inverter controlled grid support functions: • Frequency regulation, • Voltage control. Explain inverter communication with grid operators using IoT devices.				8. Data logger 9. Android phone 10. Software and PC
ASSESSMENT: Continuous Assessment (CA): 60% Examination: 40%						

Government of the Netherlands

FEDERAL GOVERNMENT OF NIGERIA

Energy Storage Technologies in Solar PV systems

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY		
COURSE TITLE: Energy Storage Technologies in Solar PV systems	Course Code: SPE 317	Contact Hours: 3
	Credit Unit: 3	Theoretical: 1
Year: 1 Semester:1	Pre-requisite: NIL	Practical: 2
GOAL: This course is designed to enable the students acquire basic knowledge and skills in Energy Storage Technologies in Solar PV systems		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Know Energy Storage fundamentals in Solar PV system 2.0 Know design and maintenance of Storage Solutions for PV system 3.0 Know sustainable strategies for extending battery life span. 4.0 Understand recycling methods, policies, and environmental impact of PV storage systems		

INCLUDE
KNOWLEDGE PLATFORM ON INCLUSIVE DEVELOPMENT POLICIES

NBTE

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY		
COURSE TITLE: ENERGY STORAGE TECHNOLOGIES IN SOLAR PV	**COURSE CODE**: 317	**CONTACT HOURS:** 3
	CREDIT UNIT: 3	**THEORETICAL**: 1
YEAR: I **SEMESTER:** I	**PRE-REQUISITE:** NIL	**PRACTICAL:** 2
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL		
GOAL: This course is designed to enable the students acquire basic knowledge and skills in Energy Storage Technologies in Solar PV systems		
GENERAL OBJECTIVE 1.0: Know Energy Storage fundamentals in Solar PV system		

THEORETICAL CONTENT				**PRACTICAL CONTENT**		
WEEK	**SPECIFIC LEARNING OUTCOME**	**TEACHER'S ACTIVITIES**	**RESOURCES**	**SPECIFIC LEARNING OUTCOME**	**TEACHER'S ACTIVITIES**	**RESOURCES**
1-3	1.1 Explain Energy storage 1.2 Explain the following different forms of storage technologies • Battery Storage • Thermal Storage • Mechanical Storage 1.3 Explain the form of Solar storage listed in 1.2	Explain the concept of Energy storage Explain the following different forms of storage technologies • Battery Storage • Thermal Storage • Mechanical Storage Explain the form of Solar storage listed in 1.2	Journals Textbooks Whiteboard Marker Internet Computer Projector	Identify types of energy storage (batteries, thermal, mechanical).	Guide students to identify types of energy storage (batteries, thermal, mechanical).	1. Charts 2. Batteries 3. Videos

	1.4 Explain the technologies of the various storage systems in 1.3 1.5 Explain the application of the various storage systems in 1.4 for solar PV systems. 1.6 Explain the types of battery technologies in solar PV. 1.7 State the various applications of the batteries listed in 1.4 in relation to: • Electric vehicle • Phones • Laptops etc.	Explain the technologies of the various storage systems in 1.3 Explain the application of the various storage systems in 1.4 for solar PV systems. Explain the types of battery technologies in solar PV. Explain the various applications of batteries listed in relation to 1.4: • Electric vehicle • Phones Laptops etc				
GENERAL OBJECTIVE 2.0: Know design and maintenance of Storage Solutions for PV system						
4-7	2.1 Explain the types of batteries base on technology 2.2 Explain the operation of the following types of	Explain the types of batteries base on technology Explain the operation of the following types of batteries:	Journals Textbooks Whiteboard Marker Internet Computer Projector			

	batteries: • Lead acid batteries • Lithium ion batteries • Nickel based batteries • Flooded batteries etc. 2.3 Explain the performance of each of listed in 2.2 2.4 Explain the techno-economic of each mentioned in 2.2 2.5 Explain new trend in solar PV battery storage system	• Lead acid batteries • Lithium ion batteries • Nickel based batteries • Flooded batteries etc. Explain the performance of each of the listed in 2.2 Explain the techno-economic of each 2.2 Explain new trend in solar PV battery storage system				
GENERAL OBJECTIVE 3.0: Know sustainable strategies for extending battery life span.						
8-11	3.1 Explain the following factors affecting battery life span: • Temperature • Rate of charge and discharge, • Climatic conditions, • Materials, etc.	Explain the following factors affecting battery life span: • Temperature • Rate of charge and discharge, • Climatic conditions, • Materials, etc.	Journals Textbooks Whiteboard Marker Internet Computer Projector	Implement sustainable practices to minimize solar PV waste and extend battery life.	Guide student to iimplement sustainable practices to minimize solar PV waste and extend battery life.	1. Sustainability reports on battery life cycle 2. Government policies on solar waste

	3.2 Explain sustainable practice to reduce battery waste 3.3 Explain circular economy concept in battery 3.4 Explain how 3.3 can improve solar PV installation efficiency in: • Residential • Industrial • Hospitals, etc. 3.5 Explain the importance of circular economy over the traditional methods of battery management 3.6 Explain battery management system 3.7 Explain the use of battery management system to enhance battery performance	Explain sustainable practice to reduce battery waste Explain circular economy concept in battery Explain how 3.3 can improve solar PV installation efficiency in: • Residential • Industrial • Hospitals, etc. Explain the importance of circular economy over the traditional methods of battery management Explain battery management system Explain the use of battery management system to enhance battery performance				3. Case studies on battery

GENERAL OBJECTIVE 4.0: Understand recycling methods, policies, and environmental impact of PV storage systems.						
12-15	4.1 Explain battery recycling 4.2 Explain the methods of recycling battery in solar PV system 4.3 Explain the recycling policies for Solar PV battery system 4.4 Explain environmental, social, and economic impacts of battery storage system	Explain the concept of battery recycling Explain the methods of recycling battery in solar PV system Explain the recycling policies for Solar PV battery system Explain environmental, social, and economic impacts of battery storage	Journals Textbooks Whiteboard Marker Internet Computer Projector			
ASSESSMENT: Continuous Assessment (CA): 60% Examination: 40%						

Modelling and Simulation of Solar PV Systems

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY		
COURSE TITLE: Modelling and Simulation of Solar PV Systems	**COURSE CODE**: SPE 318	**CONTACT HOURS:** 2
	CREDIT UNIT: 2	**THEORETICAL**: 1
YEAR: I **SEMESTER:** I	**PRE-REQUISITE:**	**PRACTICAL:** 1
GOAL: To enable students acquire basic knowledge and skills in Modelling and Simulation of Solar PV Systems		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Know the design principles and components of solar PV systems 2.0 Know the application of mathematical models to simulate solar PV systems 3.0 Know the software tools and techniques used for simulation of solar PV systems		

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY		
COURSE TITLE: Modelling and Simulation of Solar PV Systems	**COURSE CODE**: SPE 318	**CONTACT HOURS:** 2
	CREDIT UNIT: 2	**THEORETICAL**: 1
YEAR: I **SEMESTER:** I	**PRE-REQUISITE:**	**PRACTICAL:** 1
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL		
GOAL: This course is designed to enable students acquire basic knowledge and skills in Modelling and Simulation of Solar PV Systems		
GENERAL OBJECTIVE 1.0: Know the principles of designing Solar PV System		

THEORETICAL CONTENT				**PRACTICAL CONTENT**		
WEEK	**SPECIFIC LEARNING OUTCOME**	**TEACHER'S ACTIVITIES**	**RESOURCES**	**SPECIFIC LEARNING OUTCOME**	**TEACHER'S ACTIVITIES**	**RESOURCES**
1-3	1.1 Explain the principles of solar PV system design in relation to: • Sizing • Placement • Integration of components for better efficiency 1.2 Explain the following factors influencing PV system design : • Geographical location, • Climate, • Load requirements • System orientation 1.3 Describe sizing requirements	Explain the principles of solar PV system design in relation to: • Sizing • Placement • Integration of components for better efficiency Explain factors the following influencing PV system design such as: • Geographical location, • Climate, • Load requirements • System orientation	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts	Design the layout of a basic solar PV system Assess the factors influencing solar PV system design Calculate to determine the appropriate sizing of components like collectors, storage tanks, and heat exchangers based on system demands and design parameters.	Guide students to; 1. Design the layout of a basic solar PV system. 2. Assess the factors influencing solar PV system design. 3. Calculate and determine the appropriate sizing of components like collectors, storage tanks, and heat exchangers based on system demands and design parameters.	1. Computer 2. Calculator 3. Sample layout design 4. Design software (AutoCAD)

		Explain sizing requirements				
GENERAL OBJECTIVE 2.0: Know the application of mathematical models to simulate solar PV systems						
5-9	2.1 Explain the basic mathematical models used in solar PV system simulation 2.2 Explain solar PV performance equations used to model solar collectors 2.3 Explain the process of validating simulated data using real-world data	Explain the basic mathematical models used in solar PV system simulation Explain solar PV performance equations used to model solar collectors Explain the process of validating simulated data using real-world data	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts	Apply thermal performance equations to model solar collectors in relation to: Heat transfer Energy equations Use mathematical models to calculate the behavior of heat storage systems such as: Heat losses Charging/ discharging cycle	Guide students to: Apply thermal performance equations to model solar collectors in relation to: Heat transfer Energy equations Use mathematical models to calculate the behavior of heat storage systems such as: Heat losses Charging/discharging cycle	1. Computer 2. Calculator 3. Thermometer
GENERAL OBJECTIVE 3.0: Know the software tools and techniques used for simulating solar PV systems						
10-15	3.1 Explain commonly used software for solar PV system simulation 3.2 Describe the functionalities and capabilities of simulation software.	Explain commonly used software for solar PV system simulation Explain the functionalities and	Textbooks Journals Internet Computer Projector White Board Marker Animations	Identify commonly used software for solar PV system simulation Navigate user interface and set up basic simulation	Guide students to: 1. Identify commonly used software for solar PV system simulation 2. Navigate user	1. Computer 2. Calculator 3. Simulation Software

	3.3 Explain input system parameters and environmental data into simulation software 3.4 Explain the simulation and generation of output from the software	capabilities of simulation software. Explain input system parameters and environmental data into simulation software Explain the simulation and generation of output from the software	Charts	models in any available software Input system parameters and environmental data into simulation software Interpret software-generated outputs and simulation graphs	interface and set up basic simulation models in any available software 3. Input system parameters and environmental data into simulation software 4. Interpret software-generated outputs and simulation graphs	
ASSESSMENT: Continuous Assessment (CA): 60% Examination: 40%						

YEAR ONE SEMESTER TWO

Power Electronics

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY		
Course Title: Power Electronics	**Course Code:** SPE 321	**Contact Hours:** 3
	Contact Unit: 3	**Theoretical:** 1
Year: 1 Semester: II	Pre-requisite: SPE 311	Practical: 2
Goal: The Course is designed to acquaint the students with Knowledge and Skills of Power electronics		
General Objective: On completion of this module, the student should be able to: 1.0 Understand the concept of power electronics and it applications 2.0 Know the concept of power diodes and switched RLC Circuits 3.0 Know diode rectifier and its applications 4.0 Know the basic concept of Power Transistor and its applications 5.0 Know the concept of DC-DC converters 6.0 Know the concept of DC-AC converters		

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY						
Course Title: Power Electronics		**Course Code: SPE 321**			**Contact Hours:** 3	
		Contact Unit: 3			**Theoretical: 1 hour/week**	
Year: 1 Semester: II		Pre-requisite: SPE 311			Practical: 2 hours /week	
Goal: The Course is designed to acquaint the students with Knowledge and Skills of Power electronics						
Course Specification: Theoretical Content				Practical Content		
General Objective 1.0: Understand the concept of power electronics and it applications						
Week	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**	**Specific Learning Outcomes**	**Teacher's activities**	**Resources**
1-2	1.1 Describe power Electronics. 1.2 List applications of power electronics 1.3 List major types of power electronics Equipment 1.4 List the major parts of power electronics Equipment. 1.5 List the characteristics of power electronic switching devices 1.6 List the characteristics and specifications of practical power	Explain the concept power Electronics. Explain the applications of power electronics Explain major types of power electronics Equipment Explain the major parts of power electronics Equipment. Explain the characteristics of power electronics switching devices Explain the characteristics and specifications of practical power	Whiteboard Textbooks Internet Computer Projector Marker			

	switching devices 1.7 Explain power electronic semiconductor devices 1.8 Explain concept of the following power electronics modules: • Power modules • Intelligent modules	switching devices Explain power electronics semiconductor devices Explain the concept of the following power electronics modules: • Power modules • Intelligent modules				
General Objective 2: Know the concept of power diodes and switched RLC Circuits						
3-4	2.1 Describe Power diode 2.2 Explain the operational principles and characteristics of power diodes. 2.3 List the types of power diodes. 2.4 Explain the series and parallel operations of power diodes 2.5 Explain and calculation of the following in relation to ; • Reverse recovery	Explain the concept of Power diode Explain the operational principles and characteristics of power diodes. Explain the types of power diodes. Explain the series and parallel operations of power diodes Explain and the following in relation to power diodes;	Whiteboard Textbooks Internet Computer Projector Marker	Calculate the following in relation to power diodes; Reverse recovery current of diodes Steady state capacitor voltage of an RC circuit and amount of stored energy. Steady state capacitor voltage of an RL circuit and amount of stored energy. Steady state capacitor voltage of an LC circuit and amount of stored energy. Steady state capacitor voltage of an RLC circuit and amount of stored energy. The initial di/dt and dv/dt	Guide students to: 1. Calculate the following in relation to power diodes; Reverse recovery current of diodes Steady state capacitor voltage of an RC circuit and amount of stored energy. Steady state capacitor voltage of an RL circuit and amount of stored energy. Steady state capacitor voltage of an LC circuit and amount of stored energy.	Calculator

	current of diodes • Steady state capacitor voltage of an RC circuit and amount of stored energy. • Steady state capacitor voltage of an RL circuit and amount of stored energy. • Steady state capacitor voltage of an LC circuit and amount of stored energy. • Steady state capacitor voltage of an RLC circuit and amount of stored energy. • The initial di/dt and dv/dt of RLC circuits	• Reverse recovery current of diodes • Steady state capacitor voltage of an RC circuit and amount of stored energy. • Steady state capacitor voltage of an RL circuit and amount of stored energy. • Steady state capacitor voltage of an LC circuit and amount of stored energy. • Steady state capacitor voltage of an RLC circuit and amount of stored energy. • The initial di/dt and dv/dt of RLC circuits		of RLC circuits	Steady state capacitor voltage of an RLC circuit and amount of stored energy. The initial di/dt and dv/dt of RLC circuits	
	General Objective 3: Know Power Diode Rectifier and its application					
5-7	3.1 List the types of diode rectifiers, their advantages and disadvantages	Explain the types of diode rectifier, their advantages and disadvantages Explain the operation	Whiteboard Textbooks Internet Computer Projector Marker	Simulate the performance of diode rectifiers Evaluate the performance of diode rectifiers	Guide students to: Simulate the performance of diode rectifier Evaluate the	1. Practical manual 2. Computers, 3. simulation

	3.2. Explain the operation and characteristics of diode rectifiers. 3.3 Explain how to calculate the performance parameters of diode rectifiers 3.4 Explain the design of diode rectifier circuits. 3.5. Explain the design output side filter for diode rectifiers. 3.6 Explain the effects of load inductance on load current. 3.7. Explain the effects of source inductance on the rectifier output voltage.	and characteristics of diode rectifiers. Explain how to calculate the performance parameters of diode rectifiers Explain the design of diode rectifier circuits. Explain the design output side filter for diode rectifiers. Explain the effects of load inductance on load current Explain the effects of source inductance on the rectifier output voltage.		Determine the Fourier components of rectifiers outputs. Calculate the performance parameters of diode rectifiers Design diode rectifier circuits. Determine the effects of load inductance on load current. Design output side filter for diode rectifiers. Determine the effects of source inductance on the rectifier output voltage.	performance of diode rectifier Determine the Fourier components of rectifier outputs. Calculate the performance 1. 1. 1. parameters of diode rectifiers 2. Design diode rectifier circuits. 3. Determine the effects of load inductance on load current. 4. Design output side filter for diode rectifiers. 5. Determine the effects of source inductance on the rectifier output voltage.	software

General Objective 4: Know the basic concept of Power Transistor and application						
8-10	4.1. List the characteristics of an ideal transistor switch 4.2 Describe the switching characteristics the following power transistors: • BJT • MOSFETs • COOLMOS • IGBTs • SITs 4.3 Describe the limitation of each of the transistor in 4.2 above as a switch 4.4 Describe the gate control requirement and models of power transistors 4.5 Explain the design of di/dt protection circuits for transistors. 4.6 Describe the arrangements for operating transistors in	Explain the characteristics of an ideal transistor switch Explain the switching characteristics of the following types of power transistors: • BJT • MOSFETs • COOLMOS • IGBTs • SITs Explain the limitation of each of the transistor in 4.2 above as a switch Explain the gate control requirement and models of power transistors Explain the design of di/dt protection circuits for transistors.	Whiteboard Textbooks Internet Computer Projector Marker	Measure the gate drive characteristics for the following types of transistors: • BJT • MOSFETs • IGBTs Calculate the gate drive characteristics and requirements of the following types of transistor: • BJT • MOSFETs • IGBTs Design di/dt protection circuits for transistors.	Guide students to: 1. Measure the gate drive characteristics for the following types of transistors: • BJT • MOSFETs • IGBTs Calculate the gate drive characteristics and requirements of the following types of transistor:: • BJT • MOSFETs • IGBTs Design di/dt protection circuits for transistors.	1. Practical manual 2. Power ele1. ctronics trainer, 3. Oscilloscope, 4. Multi-meter, 5. Clamp meter, 6. Signal generator, 7. Power supply BJT 8. MOSFETs 9. IGBTs 10. Breadboard

	series and parallel 4.7 Explain the calculation of the gate drive characteristics and requirements of • BJT • MOSFETs • IGBTs 4.8 Describe the isolation techniques between the high-level power circuit and the low-level gate drive circuit.	Explain the arrangements for operating transistors in series and parallel Explain the calculation of the gate drive characteristics and requirements of • BJT • MOSFETs • IGBTs Explain the isolation techniques between the high-level power circuit and the low-level gate drive circuit.				
General Objective 5: Know the concept of DC-DC converters						
11-13	5.1. Describe the DC-DC conversion 5.2 Describe the switching technique for DC-DC conversion: 5.3 List the types of DC-DC converters	Explain the concept of DC-DC conversion Explain the switching technique for DC-DC conversion: Explain types of DC-DC converters	Whiteboard Textbooks Internet Computer Projector Marker	Simulate the performance parameters of DC-DC Converters Measure the performance parameters of DC-DC Converters	Guide students to: 1. Simulate the performance parameters of DC-DC Converters 2. Measure the performance parameters of DC-DC Converters	1. Practical manual 2. Computers, 3. Simulation software 4. Power electronics trainer,

	5.4 Describe the principles of operation of DC-DC converters listed in 5.3 5.5 List the performance parameters of DC-DC converters listed in 5.3. 5.6 Explain the design of DC-DC converter systems	Explain the principles of operation of DC-DC converters listed in 5.3 Explain the performance parameters of DC-DC converters listed in 5.3. Explain the design of DC-DC converter systems		Design DC-DC converter systems	3. Design DC-DC converter systems	5. Oscilloscope, 6. Multi-meter, 7. Clamp meter, 8. Signal generator, 9. Power supply
General Objective 6: Know the concept of DC-AC converters						
14-15	6.1. Describe DC-AC conversion 6.2 Describe the switching technique for DC-AC conversion(Inverter) 6.3 Describe the types of inverters in the following categories based on: • Output waveform (square, modified or pure sine wave) • Operation method	Explain DC-AC conversion Explain the switching technique for DC-AC conversion (Inverter) Explain the types of inverters in the following categories based on: • Output waveform (square, modified or pure sine wave) • Operation method	Whiteboard Textbooks Internet Computer Projector Marker	Simulate the performance parameters of inverters. Measure the performance parameters of inverters	Guide students to: 1. Simulate the performance parameters of inverters 2. Measure the performance parameters of inverters	1. Practical manual 2. Computers, 3. Spices simulation software 4. Power electronics trainer, 5. Oscilloscope, 6. Multi-

	(Voltage or current) • Phase type (Single or three phase) • Switching technology (PWM or Resonant) • Special types (multi-level, grid-tie and standalone) 6.4. Explain the operating principle of each of the inverters listed in 6.3 6. 5 Explain the performance parameters of inverters listed in 6.3. 6.6 List the different types of modulation techniques used to produce near sinusoidal wave forms 6.7 List the different types of techniques used for elimination of harmonies	(Voltage or current) • Phase type (Single or three phase) • Switching technology (PWM or Resonant) • Special types (multi-level, grid-tie and standalone) Explain the operating principle of each of the inverters listed in 6.3 Explain the performance parameters of inverters listed in 6.3. Explain the different types of modulation techniques used to produce near sinusoidal wave forms				meter, 7. Clamp meter, 8. Signal generator, 9. Power supply

		Explain the different types of techniques used for elimination of harmonies				
ASSESSMENT: Continuous Assessment: 60% Examination: 40%						

Government of the Netherlands

FEDERAL GOVERNMENT OF NIGERIA

Techno-Economic analysis for Solar PV System

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY		
COURSE TITLE: Techno-Economic analysis for Solar PV System	Course Code: SPE 322	Contact Hours: 2
	Credit Unit: 2	Theoretical: 1
Year: 1 Semester: II	Pre-requisite:	Practical: Hour/week: 1
GOAL: This course is design to provide students with knowledge and skills of techno-economic analyses for solar PV systems		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Know the technical and economic aspects of solar PV system deployment. 2.0 Know presentation of financial modeling 3.0 Know the evaluation of different business models for solar PV projects 4.0 Know business plan development for a solar PV project. 5.0 Know risks assessment, incentives, and policy impacts on solar PV investments.		

INCLUDE
KNOWLEDGE PLATFORM ON INCLUSIVE DEVELOPMENT POLICIES

NBTE

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY					
COURSE TITLE: Techno-Economic analysis for Solar PV System		**COURSE CODE**: 322		Contact Hours: 2	
		Credit Unit: 2		Theoretical: 1	
Year: I Semester: I		Pre-requisite:		Practical: 1	
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL					
GOAL: This course is design to provide students with knowledge and skills of techno-economic analyses for solar PV systems					
GENERAL OBJECTIVE 1.0: Know the technical and economic aspects of solar PV system deployment.					
THEORETICAL CONTENT				PRACTICAL CONTENT	
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
1-3	1.1 Explain solar PV technology and market trends. 1.2 Describe Capital Expenditure (CAPEX) / Operational Expenditure (OPEX) for PV systems 1.3 Explain the following key stakeholders in Solar PV Market: • Utilities, • Developers	Explain solar PV technology and market trends. Explain Describe Capital Expenditure (CAPEX) / Operational Expenditure (OPEX) for PV systems Explain the following key stakeholders in Solar PV Market: • Utilities, • Developers • Regulators	Whiteboard Lecture notes Computer Marker Projector Journals Internet Textbooks Software: HOMER, ODYSIS etc.	Perform CAPEX/OPEX spreadsheet modelling for 10 kW system Map stakeholder's roles in a sample project	Guide the students to: 1. Carryout CAPEX/OPEX spreadsheet modelling for 10 kW system 2. Map stakeholder's roles in a sample project	Software: HOMER, ODYSIS

	• Regulators • Communities • Financial institutions etc.	• Communities Financial institutions				
General Objective 2.0: Know presentation of financial modeling						
4-7	2.1 Define Levelized cost of energy (LCOE) and its calculation. 2.2 Explain the NPV/IRR for feasibility. 2.3 Describe the following Assess risk factors: Policy Technical 2.4 Explain financing options in financing Solar Projects 2.5 Explain the use of financial models in evaluating business decisions 2.6 Explain financial statement analysis	Explain the concept of Levelized cost of energy (LCOE) and its calculation. Explain the NPV/IRR for feasibility. Explain the following Assess risk factors: Policy, Technical Explain financing options in financing Solar data Projects Explain the use of financial models in evaluating business decisions Explain financial statement analysis	Whiteboard Lecture notes Computer Marker Projector Journals Internet Textbooks	Perform LCOE calculations Perform NPV/IRR calculation Build financial models with appropriate software tools	Guide students to: 1. Perform LCOE calculations 2. Perform NPV/IRR calculation 3. Build financial models with appropriate software tools	1. Spreadsheets 2. Software 3. Calculators

General Objective 3.0: Know the evaluation of different business models for solar PV projects						
8-10	3.1 Explain Power Purchase Agreement (PPAs) model for Solar PV projects 3.2 Explain Leasing model for Solar PV projects 3.3 Explain net metering/feed-in tariffs. 3.4 Explain the design procedure for a community PV solar model.	Explain Power Purchase Agreement (PPAs) model for Solar PV projects Explain Leasing model for Solar PV projects Explain net metering/feed-in tariffs. Explain the design procedure for a community PV solar model.	Whiteboard Lecture notes Computer Marker Projector Journals Internet Textbooks	Contrast PPAs vs. leasing models. Develop power purchase agreement (PPAs) model for Solar PV projects Design procedure for community Solar PV Model	Guide students to: 1. Contrast PPAs vs. leasing models. 2. Develop power purchase agreement (PPAs) model for Solar PV projects 3. Design procedure for community Solar PV Model	1. Sample project 2. Models
General Objective 4.0: Know business plan development for a solar PV project.						
11-13	4.1 Explain the structure of Solar PV business plan. 4.2 Explain the computation of financial projections for a Solar PV project. 4.3 Explain pitching of a solar PV project.	Explain the structure of Solar PV business plan. Explain the computation of financial projections for a Solar PV project. Explain pitching of a solar PV project.	Whiteboard Lecture notes Computer Marker Projector Journals Internet Textbooks	Prepare a grand application for solar mini grid Prepare a 5kw solar system proposal which include: Technical specifications Financial model Risk mitigation plan Policies compliance checklist	Guide students to: 1. Prepare a grand application for solar mini grid 2. Prepare a 5kw solar system proposal which include: Technical specifications Financial model Risk mitigation plan	3. Computer 4. Microsoft tools

				Load profile etc.	Policies compliance checklist Load profile etc.	
General Objective 5.0: Know risks assessment, incentives, and policy impacts on solar PV investments						
14-15	5.1 Explain the key risk assessments associated with Solar investments. • Operational risk • Technical risk • Financial risk, etc. 5.2 Explain the effectiveness of financial and regulatory incentives for Solar projects 5.3 Explain the impact of Government policies on Solar energy adoption	Explain the key risk assessments associated with Solar investments. • Operational risk • Technical risk • Financial risk, etc. Explain the effectiveness of financial and regulatory incentives for Solar projects Explain the impact of Government policies on Solar energy adoption		Perform the SWOT analysis on an existing Nigeria solar project Analyse a failed solar projects and present key lessons	Guide the student to: 1. Perform the SWOT analysis on an existing Nigeria solar project Analyse a failed solar projects and present key lessons	5. Computer 6. Marker 7. Projector 8. Journals 9. Internet 10. Textbooks
ASSESSMENT: Continuous Assessment: 60% Examination: 40%						

Government of the Netherlands

FEDERAL GOVERNMENT OF NIGERIA

Solar PV System Configuration

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY		
COURSE TITLE: Solar PV System Configuration	Course Code: SPE 323	Contact Hours: 3
	Credit Unit: 3	Theoretical: 1
Year: 1 Semester: II	Pre-requisite: NIL	Practical: 2
GOAL: This course is designed to enable the students develop knowledge and skills in Solar PV System Configuration		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Know various grid system configurations 2.0 Know Mini-grid system configurations 3.0 Know Off-grid system configurations 4.0 Know Hybrid system configurations 5.0 Know Grid tied system configurations		

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PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY		
COURSE TITLE: Solar PV System Configuration	**COURSE CODE**: 323	**CONTACT HOURS:** 3
	CREDIT UNIT: 3	**THEORETICAL**: 1
YEAR: I **SEMESTER:** II	**PRE-REQUISITE:** NIL	**PRACTICAL:** 2
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL		
GOAL: This course is designed to enable the students develop knowledge and skills in Solar PV System Configuration		
GENERAL OBJECTIVE 1.0: Know various solar PV grid system configurations		

THEORETICAL CONTENT				**PRACTICAL CONTENT**		
WEEK	**SPECIFIC LEARNING OUTCOME**	**TEACHER'S ACTIVITIES**	**RESOURCES**	**SPECIFIC LEARNING OUTCOME**	**TEACHER'S ACTIVITIES**	**RESOURCES**
1-3	1.1 Define: • Mini-Grid, • hybrid and off-grid systems 1.2 State the features of 1.1 systems 1.3 Explain the differences between PV configuration listed in 1.1 1.4 Explain standard and safe practices for each of the configuration in 1.1	Explain: • Mini-Grid, • hybrid and off-grid systems Explain the features of 1.1 systems Explain the differences between PV configuration listed in 1.1 Explain standard and safe practices for each of the configuration in 1.1	Journals Textbooks Whiteboard Marker Internet Computer Projector	Identify • Mini-Grid, • Off-Grid, and • Hybrid systems	Guide students to : Identify • Mini-Grid, • Off-Grid, and • Hybrid systems	Charts

GENERAL OBJECTIVE 2.0: Know Solar PV Mini-grid system configurations						
4-6	2.1 Explain Solar PV Mini-grid system 2.2 Explain the component of Solar PV mini-grid system 2.3 Explain the effective steps in Solar PV mini-grid design project 2.4 List maintenance operations in Solar PV mini-grid operations 2.5 Explain the various types of Solar PV mini-grid system: • Interconnected mini-grid • Community mini-grid etc.	Explain Solar PV Mini-grid system Explain the component of Solar PV of Solar PV mini-grid system Explain the effective steps in Solar PV mini-grid design project Explain maintenance operations in Solar PV mini-grid operations Explain the various types of Solar PV mini-grid system: • Interconnected mini-grid • Community mini-grid etc.	Journals Textbooks Whiteboard Marker Internet Computer Projector	Identify the components of Solar PV Mini-Grid Identify the various types of Solar PV mini-grid system	Guide students to: Identify the components of Solar PV Mini-Grid Identify the various types of Solar PV mini-grid system	Charts
GENERAL OBJECTIVE 3.0: Know Solar PV Off-grid system configurations						
7-10	3.1 Explain the component of Solar PV Off-grid system 3.2 Explain the effective steps in Solar PV Off-grid design project	Explain the component of Solar PV Off-grid system Explain the effective steps in Solar PV Off-grid design project	Journals Textbooks Whiteboard Marker Internet Computer Projector	Identify the components of Solar PV Off-grid system	Guide students to: Identify the components of Solar PV Off-grid system	Charts

	3.3 List maintenance operations in Solar PV Off-grid operations 3.4 Explain the various types of Solar PV Off-grid system	Explain maintenance operations in Solar PV Off-grid operations Explain the various types of Solar PV Off-grid system		Identify the various types of Solar PV Off-grid system	Identify the various types of Solar PV Off-grid system	
GENERAL OBJECTIVE 4.0: Know Hybrid system configurations						
11-13	4.1 Explain the component of Solar PV • Hybrid system • PV/Wind • PV/Biomass • PV/Hydro power etc. 4.2 Explain the various types of Hybrid system • PV/Wind • PV/Biomass • PV/Hydro power etc. 4.3 Explain the effective steps of Hybrid system design project 4.4 List maintenance operations in Hybrid system operations	Explain the component of Solar PV • Hybrid system • PV/Wind • PV/Biomass PV/Hydro power etc Explain the various types of Hybrid system • PV/Wind • PV/Biomass • PV/Hydro power etc. Explain the effective steps of Hybrid system design project Explain maintenance operations in Hybrid system operations	Journals Textbooks Whiteboard Marker Internet Computer Projector	Identify the components of Solar PV Hybrid system Identify the various types of Solar PV Hybrid system	Guide students to: Identify the components of Solar PV Hybrid system Identify the various types of Solar PV Hybrid system	Charts

GENERAL OBJECTIVE 5.0: Know Grid tied system configurations						
14-15	5.1 Explain the component of Solar PV Grid tied system 5.2 Explain the various types of Grid tied system 5.3 Explain the effective steps of Grid tied system design project 5.4 List maintenance operations in Grid tied system operations	Explain the component of Solar PV Grid tied system Explain the various types of Grid tied system Explain the effective steps of Grid tied system design project Explain maintenance operations in Grid tied system operations	Journals Textbooks Whiteboard Marker Internet Computer Projector	Identify the components of Grid tied system Identify the various types of Grid tied system	Guide students to: Identify the components of Grid tied system Identify the various types of Grid tied system	Charts
ASSESSMENT: Continuous Assessment (CA): 60% Examination: 40%						

Research Methodology in Solar PV

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY		
COURSE TITLE: Research Methodology in Solar PV	**COURSE CODE**: SPE 324	**CONTACT HOURS:** 2
	CREDIT UNIT: 2	**THEORETICAL**: 1
YEAR: I **SEMESTER:** II	**PRE-REQUISITE:**	**PRACTICAL:** 1
GOAL: To enable students acquire basic knowledge and skills in Research methodology in relation to Solar PV Systems		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Understand the fundamental concepts of research in solar PV energy. 2.0 Know the process of formulating research problems, hypotheses, and objectives specific to solar PV applications. 3.0 Know the design and conduct of experiments/field studies in solar PV systems using appropriate methodologies. 4.0 Know data collection techniques and analysis tools relevant to solar PV research. 5.0 Know the compilation, presentation, and interpretation of research findings in a standard technical report format. 6.0 Understand technical reporting in RE and engineering fields 7.0 Understand Supplementary elements, reviewing, editing, and presenting technical reports		

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PV ENGINEERING TECHNOLOGY		
COURSE TITLE: Research Methodology in Solar PV	**COURSE CODE**: SPE 324	**CONTACT HOURS:** 2
	CREDIT UNIT: 2	**THEORETICAL**: 1
YEAR: I **SEMESTER:** II	**PRE-REQUISITE:**	**PRACTICAL:** 1
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL		
GOAL: To enable students acquire basic knowledge and skills in Research methodology in relation to Solar PV Systems		
GENERAL OBJECTIVE 1.0: Understand the fundamental concepts of research in solar PV energy		

THEORETICAL CONTENT				**PRACTICAL CONTENT**		
WEEK	**SPECIFIC LEARNING OUTCOME**	**TEACHER'S ACTIVITIES**	**RESOURCES**	**SPECIFIC LEARNING OUTCOME**	**TEACHER'S ACTIVITIES**	**RESOURCES**
1-2	1.1 Define Research 1.2 Explain the importance of Research 1.3 Describe types of Research, such as: • Experimental, • Descriptive, and • Applied research etc. 1.4 Explore existing research and analyze prior findings on solar PV technologies 1.5 Explain ethical issues such as plagiarism, data falsification, and consent	Explain Research Explain the importance of Research Explain types of Research, such as: • Experimental, • Descriptive, and • Applied research etc. Explore existing research and analyze prior findings on solar PV technologies Discuss ethical issues such as plagiarism, data	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts			

	1.6 Explain the properties of a good research	Explain the properties of a good research				
GENERAL OBJECTIVE 2.0: Know the process of formulating research problems, hypotheses, and objectives specific to solar PV applications.						
3-4	2.1 Explain the essential parts of a research such as title, background study, problem statement, objectives, etc. 2.2 Explain problem statement, objectives and Research questions 2.3 Explain Literature Review and citation Explain the methodology of the research State Data interpretation, conclusion and recommendation of the research work Explain the properties of a good abstract	Explain the essential parts of a research such as title, background study, problem statement, objectives, etc. Explain problem statement, objectives and Research questions Discuss Literature Review citation Explain the methodology of the research Explain Data interpretation, conclusion and recommendation of the research work	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts	Write a concise and clear title along with background information relevant to solar PV energy Formulate a research problem relating to solar PV and derive appropriate objectives for it Create precise and researchable problem statements and research questions Draft a literature review section of a Research proposal Write an abstract Summarize relevant studies	Guide students to: Write a concise and clear title along with background information relevant to solar PV energy Formulate a research problem relating to solar PV and derive appropriate objectives for it Create precise and researchable problem statements and research questions Draft a literature review section of a Research proposal Write an abstract Summarize relevant	Journals Internet Research papers on solar PV

		Explain the properties of a good abstract		and highlight research gaps in solar PV energy	studies and highlight research gaps in solar PV energy	
GENERAL OBJECTIVE 3.0: Know the design and conduct of experiments/field studies in solar PV systems using appropriate methodologies						
5-6	3.1 Define research objectives for experimental or field study 3.2 Explain appropriate research design and methodology selection 3.3 Outline the steps and instruments needed to carry out the study on Solar PV	Explain research objectives for experimental or field study Explain appropriate research design and methodology selection Explain the steps and instruments needed to carry out the study on Solar PV	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts	Select appropriate research design and methodology Develop experimental or field procedure for the research on any area of your choice on Solar PV Conduct the study using tools and techniques in real or simulated environments	Guide students to: Select appropriate research design and methodology. Develop experimental or field procedure Conduct the study using tools and techniques in real or simulated environments	Journals Internet Research papers on solar PV Thermal plant Software for simulation if applicable
GENERAL OBJECTIVE 4.0: Know data collection techniques and analysis tools relevant to solar PV research.						
7-8	4.1 Explain different data collection methods e.g.: Surveys, Experiments, Sensor data collection 4.2 Explain data analysis methods	Explain different data collection methods (e.g.: Surveys, Experiments, Sensor data collection Explain data analysis methods	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts	Analyse data sets using appropriate software tools	Guide students to: Analyse data sets using appropriate software tools	Data sets collected Analysis software tool (Excel, MATLAB, Python)

	4.3 Describe data analysis software tools e.g.: • Excel, • MATLAB, • Python • SAS etc. 4.4 Explain the Interpretation of results from data analysis in the context of solar PV energy systems	Explain data analysis software tools e.g.: • Excel, • MATLAB, • Python • SAS etc. Explain the Interpretation of results from data analysis in the context of solar PV energy systems				
GENERAL OBJECTIVE 5.0: Know the compilation, presentation, and interpretation of research findings in a standard technical report format.						
10-11	5.1 Explain the structure of a technical report 5.2 Explain the compilation and analysis of research data into coherent sections 5.3 Explain the implications of Research results/findings 5.4 Explain referencing and citation in Research report 5.5 Explain power point preparation and presentation	Explain the structure of a technical report Discuss how to Compile research data and analysis into coherent sections Discuss the implications of Research results Explain referencing and citation in Research report Discuss power point preparation and presentation	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts	Compile research data and analysis into coherent sections Interpret the implications of research results Apply correct citation and referencing styles in a technical report	Guide students to; Compile research data and analysis into coherent sections Interpret the implications of research results Apply correct citation and referencing styles in a technical report	Computer Printer

GENERAL OBJECTIVE 6.0: Understand technical reporting in RE and engineering fields						
12-13	6.1 Explain the importance of technical reporting in engineering and RE projects 6.2 Explain the role of communication, documentation and decision making derived from technical reports in RE/engineering reports Feasibility reports Progress/Interim reports Research/project reports Incident or troubleshooting reports Close-out reports 6.3 Explain the parts of technical report writing in engineering and RE project • Title page • Abstract/Executive summary • Introduction • Methodology • Results/Findings/Budg	Explain the importance of technical reporting in engineering and RE projects Explain the role of communication, documentation and decision making derived from technical reports in RE /engineering reports Feasibility reports Progress/Interim reports Research/project reports Incident or troubleshooting reports Close-out reports Explain the parts of technical report writing in engineering and thermal project • Title page • Abstract/Executive summary • Introduction • Methodology • Results/Findings/Budget	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts			

	et • Discussions and conclusions • References • Appendices 6.4 Explain the structure and components of a standard report 6.5 Explain the difference between technical and non-technical readers 6.6 Explain ethical and professional practice in technical reporting. 6.7 Describe the steps involved in planning and writing a technical report 6.8 Describe how report structure supports clarity and readability 6.9 Explain content tailoring to suit different report types and purposes	• Discussions and conclusions • References • Appendices Explain the structure and components of a standard report Explain the difference between technical and non-technical readers Explain ethical and professional practice in technical reporting. Explain the steps involved in planning and writing a technical report Discuss how report structure supports clarity and readability Explain content tailoring to suit different report types and purposes Explain the importance of coherence, flow, and technical language in report writing				

	6.10 Explain the importance of coherence, flow, and technical language in report writing 6.11 Explain the common errors in report writing and how to avoid them	Explain the common errors in report writing and how to avoid them				
GENERAL OBJECTIVE 7.0: Understand Supplementary elements, reviewing, editing, and presenting technical reports						
14-15	7.1 Explain the types of supplementary elements commonly used in technical reports 7.2 Explain when and how to use visuals charts, tables, diagram 7.3 Explain the importance of source citation and referencing 7.4 Explain the different referencing styles • APA • Chicago • IEEE, etc.	Explain the types of supplementary elements commonly used in technical reports Explain when and how to use visuals charts, tables, diagram Explain the importance of source citation and referencing Explain the different referencing styles • APA • Chicago • IEEE, etc.	Textbooks Journals Internet Computer Projector White Board Marker Animations Charts	Write a/an: • Progress/Interim report • Feasibility report • Incident or troubleshooting report Demonstrate the use of citation and referencing tools • Zotero • Mendeley	Guide students to write a/an: • Progress/Interim report • Feasibility report • Incident or troubleshooting report Demonstrate the use of citation and referencing tools • Zotero • Mendeley	Sample reports Zotero Mendeley

	7.5 Explain the different tools used for citation and referencing • Zotero • Mendeley • MS Word Reference manager • EndNote 7.6 Explain the importance of integrating supplementary elements. 7.7 Explain the importance of maintaining a consistent and professional layout throughout the report 7.8 Explain the importance of reviewing and editing in producing high-quality reports 7.9 Explain common errors in technical report writing and how to correct them 7.10 List the key elements of a professional presentation of reports	Explain the different tools used for citation and referencing • Zotero • Mendeley • MS Word Reference manager • EndNote Discuss the importance of integrating supplementary elements Explain the importance of maintaining a consistent and professional layout throughout the report Explain the importance of reviewing and editing in producing high-quality reports Explain common errors in technical report writing and how to correct them				

	7.11 Explain best practices for submitting or delivering technical reports in academic or workplace settings	Explain key elements of a professional presentation of reports Explain best practices for submitting or delivering technical reports in academic or workplace settings				
ASSESSMENT: Continuous Assessment (CA): 60% Examination: 40%						

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY		
COURSE TITLE: SOLAR PV PROJECT MANAGEMENT AND TENDERING PROCESS	**COURSE CODE**: SPE 325	**CONTACT HOURS:** 2
	CREDIT UNIT: 2	**THEORETICAL**: 1
YEAR: 1 **SEMESTER:** II	**PRE-REQUISITE:** NIL	**PRACTICAL:** 1
GOAL: This course is designed to provide students with knowledge and skills of Project Management and Tendering Process		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Know the basic concepts of Solar PV Project Management and Tendering Process 2.0 Understand the Solar PV Project Lifecycle 3.0 Know Solar PV Project Requirements, Designing and Documentation 4.0 Understand Work Breakdown Structure and Project Estimation of Solar PV System 5.0 Understand Project Quality Management of Solar PV System 6.0 Understand Project Risk Management of a given Solar PV System		

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY		
COURSE TITLE: SOLAR PV PROJECT MANAGEMENT AND TENDERING PROCESS	**COURSE CODE**: SPE 325	**CONTACT HOURS:** 2 Hours
	CREDIT UNIT: 2	**THEORETICAL**: 1
YEAR: 1 **SEMESTER:** 2	**PRE-REQUISITE:** NIL	**PRACTICAL:** 1
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL		
GOAL: This course is designed to provide students with knowledge and skills of Project Management and Tendering Process		
GENERAL OBJECTIVE 1.0: Know the basic concepts of Solar PV Project Management		

THEORETICAL CONTENT				**PRACTICAL CONTENT**		
WEEK	**SPECIFIC LEARNING OUTCOME**	**TEACHER'S ACTIVITIES**	**RESOURCES**	**SPECIFIC LEARNING OUTCOME**	**TEACHER'S ACTIVITIES**	**RESOURCES**
`1 - 4	1.1 Define Tendering process 1.2 Explain the various types of Tendering process 1.3 Define Solar PV Project Management and its importance 1.4 Explain the various types of projects and its characteristics 1.5 Distinguish between Solar PV project, Solar PV seminar and Solar PV technical team work	Explain Tendering process Explain the various types of Tendering process Explain Project management and its importance in relation to Solar PV Explain the various types of projects and its characteristics Explain the differences between Solar PV project, Solar PV seminar and Solar PV technical team work	Textbooks, Journals, Publications, Whiteboard, Markers, Internet Computer, Projector	Create New Solar PV Project using project management software Generate Solar PV project scope and milestones	Guide students to: Create a New Solar PV Project using project management software Generate project scope and milestones	Application packages

	1.6 List Solar PV Project scope and limitation 1.7 Explain Solar PV Project Management Application software package, examples and their uses e.g. MS word, Excel, spreadsheet etc.	Explain Solar PV Project scope and limitation Explain Solar PV Project Management Application software package, examples and their uses e.g. MS word, Excel, spreadsheet etc.				
GENERAL OBJECTIVE 2.0: Understand the Solar PV Project Lifecycle						
5 - 8	2.1 Define Solar PV Project Lifecycle 2.2 Explain the stages of Solar PV Project 2.3 Explain Solar PV Project Lifecycle: • Initiation, • Planning, • Execution, • Monitoring/control • Closure 2.4 Explain project proposal 2.5 Explain Solar PV project checklist 2.6 Explain Solar PV project teamwork and role of	Explain Solar PV Project Lifecycle Explain the stages of Solar PV Project Explain Solar PV Project Lifecycle: • Initiation, • Planning, • Execution, • Monitoring/control • Closure Explain Project Proposal Explain Solar PV Project Proposal checklist Explain Solar PV project teamwork and	Textbooks, Journals, Publications, Whiteboard, Markers, Internet Computer, Projector			

	each members in project cycle	role of each members in project cycle				
GENERAL OBJECTIVE 3.0: Know Solar PV Project Requirements, Designing and Documentation						
9 - 10	3.1 Explain Solar PV project requirements 3.2 Explain projects requirements gathering techniques 3.3 Explain Solar PV Project Requirement Analytical tools 3.4 Explain the components requirements of solar PV system project document: • Technical • Planning • Testing • Evaluation etc. 3.5 Explain each of the following terms, used in designing Solar PV system: • Stakeholder - Information • Interpretation • Report • Procedures • Timing • Format	Explain Solar PV project requirements Explain project requirements gathering techniques Explain Solar PV Project Requirement Analytical tools Outline the components of a requirements solar PV system document: • Technical • Planning • Testing • Evaluation etc Describes each of the following terms, used in Solar PV system: • Stakeholder - Information • Interpretation • Report • Procedures • Timing	Textbooks, Journals, Publications, Whiteboard, Markers, Internet Computer, Projector	Use a Computer Application packages to design and document a project	Guide students to: Use a Computer Application packages to design and document a project	Computers, Software

	3.6 Explain computer application packages relevant to solar PV project management. 3.7 Explain procedures of documenting findings in solar PV projects	• Format Explain computer application packages relevant to solar PV project management. Explain procedures of documenting findings in solar PV projects				
GENERAL OBJECTIVE 4.0: Understand Work Breakdown Structure and Project Estimation of Solar PV System						
11	4.1 Define work breakdown structure 4.2 Explain the importance of work breakdown in Solar PV system project management 4.3 Explain the conventional and non-conventional designs of solar PV System Management. 4.4 Explain the steps involved in designing Solar PV System e.g.:	Explain work breakdown structure Explain the importance of work breakdown in Solar PV system project management Explain the conventional and non-conventional designs of solar PV System Management. Explain the steps involved in designing Solar PV System e.g.:	Textbooks, Journals, Publications, Whiteboard, Markers, Internet Computer, Projector			

	• Pre installation, • Installation • Post – installation 4.5 Explain software usage in Solar PV System	• Pre installation, • Installation • Post – installation Explain software usage in Solar PV System				
GENERAL OBJECTIVE 5.0: Understand Project Quality Management of Solar PV System						
12	5.1 Explain project quality management of Solar PV System 5.2 Explain Quality Assurance and Quality Control in Solar PV System Management 5.3 Explain project progress report in Solar PV system management.	Explain project quality management of Solar PV System Explain Quality Assurance and Quality Control in Solar PV System Management Explain project progress report in Solar PV system management.	Textbooks, Journals, Publications, Whiteboard, Markers, Internet Computer, Projector			
GENERAL OBJECTIVE 6.0: Understand Project Risk Management of a given Solar PV System						
13 - 14	6.1 Explain Project Risk and Risk Management in a given Solar PV System project 6.2 List the various categories of Solar PV project risks: • Business Solar PV System risks,	Explain Project Risk and Risk Management in a given Solar PV System project Explain the various categories of Solar PV project risks: • Business Solar PV System risks,	Textbooks, Journals, Publications, Whiteboard, Markers, Internet Computer, Projector			

	• Technical Solar PV System risk; • Generic and product Solar PV System risks etc. 6.3 List the stages in Risk management process: Identification, Financial analysis, Ranking etc. 6.4 Explain Risk mitigation in a given Solar PV System	• Technical Solar PV System risk; • Generic and product Solar PV System risks etc. Explain the stages in Risk management process: Identification, Financial analysis, Ranking etc. Explain Risk mitigation in a given Solar PV System				
ASSESSMENT: Continuous Assessment (CA): 60% Examination: 40%						

Smart Grids & IoT in PV System II

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY		
COURSE TITLE: Smart Grids & IoT in PV System II	Course Code: SPE 326	Contact Hours: 3
	Credit Unit: 3	Theoretical: 1
Year: 1 Semester: II	Pre-requisite: SPE 316	Practical: 2
GOAL: The course is designed to enable students to acquire knowledge and skills of Smart Grids and IoT in PV System		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Know advances in Smart Grids & IoT for PV systems 2.0 Know Smart Grid Communication and Cybersecurity 3.0 Understand the Data Analytic in Smart Grids 4.0 Understand Machine Learning in Smart Grids and PV systems 5.0 Know practical applications of IoT in PV systems and Smart Grids 6.0 Know how to **e**nhance Solar PV Systems with Smart Devices		

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY						
COURSE TITLE: Smart Grids & IoT in PV System II			COURSE CODE: SPE 326		Contact Hours: 3	
			Credit Unit: 3		Theoretical: 1	
Year: 1 Semester: II			Pre-requisite: SPE 316		Practical: 2	
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL						
GOAL: The course is designed to enable students to acquire knowledge and skills of Smart Grids and IoT in PV System						
GENERAL OBJECTIVE 1.0: Know advances in Smart Grids & IoT for PV systems						
THEORETICAL CONTENT				PRACTICAL CONTENT		
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
1- 3	1.1 Explain the following key Components of a Smart Grid PV System: • Energy Storage Systems • Energy Management Systems (EMS) • Communication Networks • Demand Response and Control Systems • Grid Control Systems • Cybersecurity and Protection • Power Quality Monitoring	Explain the following key Components of a Smart Grid PV System: • Energy Storage Systems • Energy Management Systems (EMS) • Communication Networks • Demand Response and Control Systems • Grid Control	Textbooks Publications Journals, Whiteboard, Marker, Internet Computer, Projector	Identify Smart grid devices such as Smart Meters & End-User Devices and how use them	Guide students to identify Smart devices such as Smart Meters & End-User Devices	1. Practical Manual 2. Smart Meters Smart Breakers Routers Android phone

	1.2 Explain Demand Response and Distributed Energy Resources (DER) 1.3 Explain the Integration of PV systems, storage, and demand energy response programs 1.4 Explain advance control strategies for energy distribution 1.5 List components of a Microgrid 1.6 Explain the role of PV and IoT in microgrid management 1.7 Explain the importance of energy storage in Smart Grids 1.8 Explain Battery technologies and their management through IoT systems	Systems • Cybersecurity and Protection • Power Quality Monitoring Explain the Integration of PV systems, storage, and demand energy response programs Explain advance control strategies for energy distribution Explain components of a Microgrid Explain the role of PV and IoT in microgrid management Explain the importance of energy storage in Smart Grids				

	1.9 Explain Grid Decentralization and Smart Grid Evolution 1.10 Explain role of blockchain in decentralized energy transactions	Explain Battery technologies and their management through IoT systems Explain Grid Decentralization and Smart Grid Evolution Explain role of blockchain in decentralized energy transactions				
General Objective 2.0: Know Smart Grid Communication and Cybersecurity						
4 - 7	2.1 Explain the following Communication Networks for Smart Grids: • Wired • Wireless • Supervisory control and Data acquisitions (SCADA) systems 2.2 Explain the role of each of the communication Networks for Smart Grids in 2.1	Explain the following Communication Networks for Smart Grids: • Wired • Wireless • Supervisory control and Data acquisitions (SCADA) systems	Textbooks, Journals, Publications, Whiteboard, Marker, Internet, Computer, Projector	Monitor power consumption by AC loads using smart meter Control AC loads using smart circuit breaker Automate the operation of AC loads using smart circuit breaker	Guide students to: 1. Monitor power consumption by AC loads using smart meter 2. Control AC loads using smart circuit breaker 3. Automate the operation of AC loads using smart circuit breaker	1. Practical Manual 2. Smart Meters 3. Bulbs 4. Tool box 5. Cables Smart Beakers Routers

	2.3 Explain cybersecurity challenges in smart grids 2.4 Explain cybersecurity protocols and encryption of Smart Grids and IoT in PV systems 2.5 Explain data privacy and integrity in PV systems and smart grids	Explain the role of each of the communication Networks for Smart Grids in 2.1 Explain cybersecurity challenges in smart grids Explain cybersecurity protocols and encryption of Smart Grids and IoT in PV systems Explain data privacy and integrity in PV systems and smart grids				Internet Android phone
General Objective 3.0: Understand the Data Analytics in Smart Grids						
	3.1 Define Data Collection and Processing	Explain Data Collection and	Textbooks, Journals,			

8 - 9	3.2 Explain the following types of data collected from PV systems and smart grids; • Energy Generation Data. • Weather Data. • System Performance Data. • Operational Data. • Health and Diagnostics Data. • Energy Storage Data. • Power Quality Data. • Grid Health and Stability Data. • Metering and Billing Data. • Market and Trading Data. • Cybersecurity Data.	Processing Explain the following types of data collected from PV systems and smart grids; • Energy Generation Data. • Weather Data. • System Performance Data. • Operational Data. • Health and Diagnostics Data. • Energy Storage Data. • Power Quality Data. • Grid Health and Stability Data. • Metering and Billing Data. • Market and Trading Data. • Cybersecurity	Publications Whiteboard, Marker, Internet Computer, Projector			

	Explain the following in relation to PV systems and smart grids • Big Data management and storage solutions • Time-series analysis for energy forecasting	Data. Explain the following in relation to PV systems and smart grids • Big Data management and storage solutions • Time-series analysis for energy forecasting				
General Objective 4.0: Understand Machine Learning in Smart Grids and PV systems						
10-11	4.1 Explain Machine Learning (ML) in Energy Systems 4.2 Explain the use of Machine Learning for; • Predictive maintenance in PV systems • Energy demand forecasting 4.3 Explain Optimization algorithms for	Explain Machine Learning (ML) in Energy Systems Explain the use of Machine Learning for; • Predictive maintenance in PV systems • Energy demand forecasting	Textbooks, Journals, Publications Whiteboard, Marker, Internet Computer, Projector			

	• Smart grid • PV system • Hybrid PV Grid system Explain the use of Artificial Intelligence (AI) and machine learning (ML) to predict faults in PV systems and smart grids	Explain Optimization algorithms for • Smart grid • PV system • Hybrid PV Grid system Explain the use of Artificial Intelligence (AI) and machine learning (ML) to predict faults in PV systems and smart grids				
General Objective 5.0: Know practical applications of IoT in PV systems and Smart Grids						
12-13	5.1 Explain practical applications of IoT in PV systems and Smart Grids 5.2 Explain the implementation of IoT in existing PV systems	Explain practical applications of IoT in PV systems and Smart Grids Explain the implementation of IoT in existing PV systems	Textbooks, Journals, Publications Whiteboard, Marker, Internet Computer, Projector	Implement a small-scale Smart Grid using IoT-enabled PV systems Connect a smart energy meter to a PV inverter Use a smart plug	Guide students to: 1. Implement a small-scale Smart 2. Grid using IoT-enabled PV systems 3. Connect a smart energy meter to a PV inverter	1. Practical Manual 2. Software 3. Computer 4. Smart device 5. Domestic appliance 6. PV systems

	5.3 Explain how Smart Devices Interact with these Solar PV Systems • Grid-tied • Off-grid • Hybrid 5.4 Explain features of advanced Smart Grid and IoT PV systems 5.5 Explain how to monitor a small-scale Smart Grid using IoT-enabled PV systems 5.6 Explain how to control a small-scale Smart Grid using IoT-enabled PV systems 5.7 Explain the different types of optimization techniques of a small-scale IoT-enabled PV systems for improved performance.	Explain how Smart Devices Interact with these Solar PV Systems • Grid-tied • Off-grid • Hybrid Explain features of advanced Smart Grid and IoT PV systems Explain how to monitor a small-scale Smart Grid using IoT-enabled PV systems Explain how to control a small-scale Smart Grid using IoT-enabled PV systems Explain the different types of optimization techniques of a small-scale IoT-enabled PV		to automate a domestic appliance based on PV output Set up real-time monitoring dashboards Use simulation software for Smart Grid and PV system modeling Control a small-scale Smart Grid using IoT-enabled PV systems	4. Use a smart plug to automate a washing machine based on PV output 5. Set up real-time monitoring dashboards 6. Use of simulation software for Smart Grid and PV system modeling 7. Control a small-scale Smart Grid using IoT-enabled PV systems	

		systems for improved				
General Objective 6.0: Know how to enhance Solar PV Systems with Smart Devices						
14-15	6.1 Explain the following categories of smart devices: • Smart meters • Smart plugs/sockets • Smart thermostats • Energy management systems (EMS) • Smart inverters and batteries Explain the integration of smart devices for enhanced performances through; • Solar tracking • Load scheduling etc. 6.3 Explain the following integration planning procedures to enhance performance • Compatibility • Network setup • Safety and electrical	Explain the following categories of smart devices: • Smart meters • Smart plugs/sockets • Smart thermostats • Energy management systems (EMS) • Smart inverters and batteries Explain the integration of smart devices for enhanced performances through; • Solar tracking • Load scheduling etc. Explain the following	Textbooks, Journals, Publications Whiteboard, Marker, Internet Computer, Projector	Demonstrate how to control Smart plug scheduling for appliances Demonstrate Smart solar tracking for solar panels Demonstrate how to use of wire and wireless networking for enhance performance	Guide students to: 1. Demonstrate how to control Smart plug scheduling for appliances. 3. Demonstrate Smart solar tracking for solar panels 3. Demonstrate how to use of wire verse wireless networking for enhance performance	1. Practical Manual 2. Software 3. Computer 4. Smart device 5. Domestic appliance 6. PV systems 7. Smart thermostats 8. Smart plugs/sockets

	code compliance • Tools and apps required (e.g., Home Assistant, SmartThings, Sense)	integration planning procedures to enhance performance: • Compatibility • Network setup • Safety and electrical code compliance • Tools and apps required (e.g., Home Assistant, SmartThings, Sense)				
ASSESSMENT: Continuous Assessment (CA): 60% Examination: 40%						

YEAR TWO SEMESTER ONE

Advanced Solar PV Technologies

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY		
COURSE TITLE: Advanced Solar PV Technologies	Course Code: SPE 411	Contact Hours: 2
	Credit Unit: 2	Theoretical: 1
Year: II Semester: I	Pre-requisite:	Practical: 1
GOAL: This course is designed to equip students with knowledge and skills in advanced solar photovoltaic (PV) technologies.		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Know the working principles of an advanced solar PV system 2.0 Know the components of an advanced PV system. 3.0 Understand the functions of Smart inverter Systems 4.0 Know the working principles of High Voltage and High Current Charge Controllers 5.0 Understand the Working Principles of Battery Management Systems (BMS) 6.0 Understand current trends, innovations, and future prospects in solar PV technologies.		

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY		
COURSE TITLE: Advanced Solar PV Technologies	**COURSE CODE**: SPE 411	Contact Hours: 2
	Credit Unit: 2	Theoretical: 1
Year: II Semester: I	Pre-requisite:	Practical: 1
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL		
GOAL: This course is designed to equip students with knowledge and skills in advanced solar photovoltaic (PV) technologies		
GENERAL OBJECTIVE 1.0: Know the working principles of an advanced solar PV system		

THEORETICAL CONTENT				**PRACTICAL CONTENT**		
Week	**Specific Learning Outcome**	**Teacher's Activities**	**Resources**	**Specific Learning Outcome**	**Teacher's Activities**	**Resources**
1-2	1.1 Explain the concept advanced Solar PV System 1.2 Explain the differences between traditional and advanced Solar PV Modules. 1.3 Explain efficiency factors in advanced Solar PV systems. 1.4 Explain Building-Integrated Photovoltaics (BIPV) panels	Explain the concept of advanced Solar PV System Explain the differences between traditional and advanced Solar PV Modules. Explain efficiency factors in advanced Solar PV systems. Explain Building-Integrated Photovoltaics (BIPV) panels	Whiteboard Lecture notes Computer Marker Projector Journals Internet Textbooks	Demonstrate the working principles of a traditional and advanced Solar PV modules Measure I-V characteristics under the following conditions: Load Temperature Irradiance Measure the characteristics of Solar PV using	Guide Students to: 1. Demonstrate the working principles of a traditional and advanced Solar PV modules 2. Measure I-V characteristics under the following conditions: Load Temperature Irradiance 3. Measure the characteristics of Solar PV using	1. Solar simulator 2. I-V curve tracer 3. PV modules Multimeters 4. Data loggers 5. Irradiance Meter 6. Digital Thermometers 7.Resistive Load

	1.5 Explain Floating Solar (Photovoltaics) panels	Explain Floating Solar (Photovoltaics) panels		solar simulator	solar simulator	
General Objective 2.0: Know the components of an advanced PV system.						
3-4	2.1 List components in an advanced solar PV system. 2.2 Explain the functions of : • Advanced PV Modules • smart inverters, • MPPTs, • Modern batteries. 2.3 Explain the characteristics of 2.2 above 2.4 Explain the use of Datasheets and manufacturer's manual to identify components parameters in advanced Solar PV System 2.5 Explain advanced configuration (Series and Parallel) options in advanced Solar PV System	Explain components in advanced solar PV system. Explain the functions of : • Advanced PV Modules • smart inverters, • MPPTs, • Modern batteries. Explain the characteristics of 2.2 above Explain the use of Datasheets and manufacturer's manual to identify components parameters in advanced Solar PV System Explain advanced configuration (Series and Parallel) options in advanced Solar PV	Whiteboard Lecture notes Computer Marker Projector Journals Internet Textbooks	Use labeled diagrams and datasheets to identify components in advanced Solar PV System	Guide students to on how to use of datasheets to identify components parameters in advanced Solar PV System	1. PV module 2. Smart Inverter 3. Smart Batteries 4. Tool box 5. Component datasheets 6. Circuit diagrams 7. Manufacturer manuals 5. Controller MPPT

	2.6 Explain components matching in advanced Solar PV systems.	System Explain component matching in advanced Solar PV System.				
General Objective 3.0: Understand the functions of Smart inverter Systems						
5-7	3.1 Explain the basic operating principles of power inverters and their evolution to smart inverters 3.2 Describe the advanced functions of smart inverter systems 3.3 Explain the role of smart inverters in grid stability, reliability, and resilience 3.4 Describe smart inverter settings for specific grid support applications and battery types	Explain the basic operating principles of power inverters and their evolution to smart inverters Explain the advanced functions of smart inverter systems Explain the role of smart inverters in grid stability, reliability, and resilience Explain smart inverter settings for specific grid support applications and battery types	Whiteboard Lecture notes Computer Marker Projector Journals Internet Textbooks			
General Objective 4.0: Understand the working principles of High Voltage and High Current Charge Controllers						
8-9	4.1 Explain the evolution from simple to advanced charge controllers	Explain the evolution from simple to advanced charge controllers	Whiteboard Lecture notes Computer	Demonstrate the different between PWM and MPPT	Guide students and demonstrate the different between PWM and MPPT	1. MPPT Charge Controller 2. PWM

	4.2 Explain the concept of advanced PWM charge controllers 4.3 Explain Battery Charging Algorithms, control features, limitation and optimization in PWM Controllers 4.4 Explain advanced MPPT charge controllers	Explain the concept of advanced PWM charge controllers Explain Battery Charging Algorithms, control features, limitation and optimization in PWM Controllers Explain advanced MPPT charge controllers	Marker Projector Journals Internet Textbooks	charge controllers	charge controllers	Charge controller
General Objective 5.0: Understand the Working Principles of Battery Management Systems (BMS)						
10-13	5.1 Explain Battery Management systems operation based on: • State of charge (SoC) • State of health (SoH) monitoring techniques. • Depth of discharge • Number of cycles. 5.2 Explain battery Storage Systems Battery technologies and chemistries • Battery	Explain Battery Management systems operation based on: • State of charge (SoC) • State of health (SoH) monitoring techniques. • Depth of discharge • Number of cycles. Explain battery Storage Systems Battery technologies and chemistries • Battery	Whiteboard Lecture notes Computer Marker Projector Journals Internet Textbooks			

	characteristics and ratings • Battery charging cycles and states 5.3 Explain critical parameters affecting battery life and performance	characteristics and ratings • Battery charging cycles and states Explain critical parameters affecting battery life and performance				
General Objective 6.0: Understand current trends, innovations, and future prospects in solar PV technologies.						
13 - 15	6.1 Explain global trends in PV technologies. • Bifacial Solar Technology • Dye-Synthesize Solar cells DSSC etc. 6.2 Explain innovations like smart and IoT-based monitoring. 6.3 Explain future prospects in solar PV technologies	Explain global trends in PV technologies. • Bifacial Solar Technology • Dye-Synthesize Solar cells DSSC etc. Explain innovations like smart and IoT-based monitoring. Explain future prospects in solar PV technologies				
EVALUATION: CA 60% EXAMINATION: 40%						

Installation and Commissioning of Solar PV System

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY		
COURSE TITLE: Installation and Commissioning of Solar PV System	Course Code: SPE 412	Contact Hours: 3
	Credit Unit: 3	Theoretical: 1
Year: II Semester: I	Pre-requisite: NIL	Practical: 2
GOAL: This course is designed to enable the students develop knowledge and skills for installing and commissioning of Solar PV systems.		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Know Practical Installation and System Design 2.0 Know Testing of Solar PV Systems 3.0 Know Installation and Commissioning of Solar PV Systems 4.0 Maintain and Troubleshoot Solar PV Systems		

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY		
COURSE TITLE: Installation and Commissioning of Solar PV System	**COURSE CODE**: SPE 412	**CONTACT HOURS:** 3
	CREDIT UNIT: 3	**THEORETICAL**: 1
YEAR: II **SEMESTER:** I	**PRE-REQUISITE:** NIL	**PRACTICAL:** 2
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL		
GOAL: This course is designed to enable the students develop knowledge and skills for installing and commissioning of Solar PV systems.		
GENERAL OBJECTIVE 1.0: Know Practical Installation and System Design		

THEORATICAL				**PRACTICAL**		
Week	**Specific Learning Outcome**	**Teacher's Activities**	**Resources**	**Specific Learning Outcome**	**Teacher's Activities**	**Resources**
1-3	1.1 Explain the required steps in performing site load analysis 1.2 Explain site assessment and load analysis. 1.3 Explain calculations on system sizing for different applications 1.4 Explain component selection for optimized system performance 1.5 Explain system layouts and wiring diagrams.	Explain the required steps in performing site load analysis Explain site assessment and load analysis. Explain the calculations on system sizing for different applications Explain component selection for optimized system performance Explain system layouts and wiring diagrams.	Journals Textbooks Whiteboard Marker Internet Computer Projector	Performing load calculations. Provide hands-on training in system design software. Review case studies of existing solar PV installations.	Guide students to: 1. Performing load calculations. 2. Provide hands-on training in system design software. 3. Review case studies of existing solar PV installations.	1. Load 2. Calculators 3. Design 4. Software. 5. Wire 6. Diagrams 7. Technical datasheets.

GENERAL OBJECTIVE 2.0: Know major testing in Solar PV system						
4-6	2.1 Explain the importance of carrying out testing on solar PV system 2.2 Explain Electrical Performance Tests 2.3 Explain Safety and Protection Tests 2.4 Explain Mechanical and Structural Tests	Explain the importance of carrying out testing on solar PV system Explain Electrical Performance Tests Explain Safety and Protection Tests Explain Mechanical and Structural Tests	Journals Textbooks Whiteboard Marker Internet Computer Projector	Performing pre-commissioning tests. Troubleshoot common PV faults. Diagnose real or simulated system issues. Apply safety procedures for electrical testing. Demonstrate grounding and earthing tests. Show how to use imaging cameras.	Guide students to: 1. Performing pre-commissioning tests. 2. Troubleshoot common PV faults. 3. Diagnose real or simulated system issues. 4. Apply safety procedures for electrical testing. 5. Demonstrate grounding and earthing tests. 6. Show how to use imaging cameras.	1. Grounding rods, 2. Earth testers. 3. Surge protection devices. 4. Cameras, 5. Solar panels, 6. Multimeters, 7. I-V curve tracers. Wire 8. Diagrams 9. Testing manuals 10. PPE 11. Faulty PV panels and system Simulators. 12. Clamp

						meters, 13. Diode testers Checklist
GENERAL OBJECTIVE 3.0: Know Installation and Commissioning of Solar PV Systems.						
7-10	3.1 Explain how to assemble and mount solar panels securely. 3.2 Explain wiring and connections for AC/DC circuits in PV system for: • Charge controllers, • Inverters, • Battery storage systems etc. 3.3 Explain Grounding and protection in PV system.	Explain how to assemble and mount solar panels securely. Explain wiring and connections for AC/DC circuits in PV system for: • Charge controllers, • Inverters, • Battery storage systems etc. Explain Grounding and protection in PV system.	Journals Textbooks Whiteboard Marker Internet Computer Projector	Demonstrate Solar Panel installation procedures Verify system performance and troubleshooting common issues. Test system performance after installation	Guide students to: 1. Demonstrate Solar Panel installation procedures 2. Verify system performance and troubleshooting common issues. 3. Test system performance after installation	1. Solar PV installation kits. 2. PPE 3. Multimeters 4. Insulation testers
GENERAL OBJECTIVE 4.0: Maintain and Troubleshoot Solar PV Systems						
11-15	4.1 Explain common solar PV faults and preventive maintenance strategies. 4.2 Explain procedures for cleaning and monitoring solar panel for long-term efficiency.	Explain common solar PV faults and preventive maintenance strategies Explain procedures for cleaning and monitoring solar panel for long-	Journals Textbooks Whiteboard Marker Internet Computer Projector	Perform solar panel routine system maintenance. Identify and resolve common faults in solar PV setups.	Guide student to: 1. Perform solar panel routine system maintenance. 2. Identify and	1. Test board 2. Electrostatic discharge kits 3. Work bench 4. Trainer

	4.3 Explain how to adhere to local and international electrical and safety regulations. 4.4 Explain basic system operation and maintenance. 4.5 Describe installation procedures and standards. 4.6 Explain commissioning steps and quality checks. 4.7 Explain emerging trends and innovations in solar PV technology.	term efficiency. Explain how to adhere to local and international electrical and safety regulations. Explain basic system operation and maintenance. Describe installation procedures and standards. Explain commissioning steps and quality checks. Explain emerging trends and innovations in solar PV technology.	Installation guides Standards and codes Instructional videos	Identify and repair faults in solar PV setups. Mount modules and connect components. Perform commissioning checklist activities.	resolve common faults in solar PV setups. 3. Identify and repair faults in solar PV setups. 4. Mount modules and connect components. 5. Perform commissioning checklist activities.	5. Faulty system components 6. Maintenance checklists 7. Troubleshooting guides. 8. Simulation tools 9. Mounting structures 10. PPE
ASSESSMENT: Continuous Assessment (CA): 60% Examination: 40%						

ADVANCE PV SYSTEM PERFORMANCE AND TROUBLESHOOTING

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY		
COURSE TITLE: ADVANCE PV SYSTEM PERFORMANCE AND TROUBLESHOOTING	Course Code: SPE 413	Contact Hours: 2
	Credit Unit: 2	Theoretical: 1
Year: II Semester I	Pre-requisite: NIL	Practical: 1
GOAL: The course is designed to enable students acquire knowledge and skills in Advance PV System Performance Troubleshooting and Maintenance		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Know the troubleshooting techniques for PV system performance 2.0 Know the factors affecting the performance PV system components performance 3.0 Know the advance method for diagnosing and troubleshooting performance of PV systems 4.0 Know the advance method for monitoring and optimization of PV systems performance 5.0 Know the process of solving real-world problems in PV systems.		

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY		
COURSE TITLE: Advance PV System Performance and Troubleshooting	**COURSE CODE**: SPE 413	Contact Hours: 2 Hours
	Credit Unit: 2	Theoretical: 1
Year: II **Semester**: I	Pre-requisite: NIL	Practical: 1
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL		
GOAL: This course is designed to enable students acquire knowledge and skills in Advance PV System Performance Troubleshooting and Maintenance		
GENERAL OBJECTIVE 1.0: Know the troubleshooting techniques for PV system performance		

THEORETICAL CONTENT				**PRACTICAL CONTENT**		
Week	**Specific Learning Outcome**	**Teacher's Activities**	**Resources**	**Specific Learning Outcome**	**Teacher's Activities**	**Resources**
1- 4	1.1 Explain troubleshooting methodologies and safety protocols for PV systems 1.2 Explain structured troubleshooting approach in relation to PV systems 1.3 Explain traditional troubleshooting tools; • Multimeter, • Clamp meter, • Solar PV imaging, • Power analyzer.	Explain troubleshooting methodologies and safety protocols for PV systems Explain structured troubleshooting approach in relation to PV systems Explain traditional troubleshooting tools; • Multimeter, • Clamp meter, • Solar PV imaging, • Power analyzer.	Textbooks, Publications Journals, Whiteboard, Marker, Internet Computer, Projector	Identify common faults in PV systems and troubleshooting using tools: • Module-level, • Inverter-level, • Wiring Identify traditional troubleshooting tools; • Multimeter, • Clamp meter, • Solar PV imaging, • Power analyzer	Guide students to: Identify common faults in PV systems and troubleshooting using tools: • Module-level, • Inverter-level, • Wiring Identify traditional troubleshooting tools; • Multimeter, • Clamp meter, • Solar PV imaging, • Power analyzer	Practical Manual Multimeter Clamp meter, Solar PV imaging, Data loggers, Cloud-based monitoring platforms Computer Software

General Objective 2.0: Know the factors affecting the performance PV system components performance						
5 - 8	2.1 Explain the following advance factors affecting Solar PV component performances; • Degradation of Solar PV Modules, • Faults in inverters (e.g., overvoltage, under voltage), • Faults in MPPT controllers. • Environmental Factors (e.g., dust, shading, temperature) Explain the use of the following advance PV system performance monitoring tools; • Data loggers, • Battery management system • Cloud-based monitoring platforms, • IoT. etc.	Explain the following advance factors affecting Solar PV component performances; • Degradation of Solar PV Modules, • Faults in inverters (e.g., overvoltage, under voltage), • Faults in MPPT controllers. • Environmental Factors (e.g., dust, shading, temperature) Explain the use of the following advance PV system performance monitoring tools; • Data loggers, • Battery management system • Cloud-based monitoring platforms, • IoT. etc.	Textbooks, Journals, Publications, Whiteboard, Marker, Internet, Computer, Projector	Identify the following advance performance monitoring tools; • Data loggers, • Battery management system • Cloud-based monitoring platforms, Measure the performance of the Solar PV component affected by; • Degradation of Solar PV Modules, • Faults in inverters (e.g., overvoltage, under voltage), • Faults in MPPT controllers. • Environmental Factors (e.g., dust, shading, temperature)	Guide students to Identify the following performance monitoring tools; • Data loggers, • Battery management system • Cloud-based monitoring platforms, Measure the performance of the Solar PV component affected by; • Degradation of Solar PV Modules, • Faults in inverters (e.g., overvoltage, under voltage), • Faults in MPPT controllers. • Environmental Factors (e.g., dust, shading, temperature)	Practical Manual Battery management system

	2.3 Explain diagnosing and troubleshooting of the following electrical faults; • Module Faults • Inverter Faults • Cabling and Connections • Grounding	Explain diagnosing and troubleshooting of the following electrical faults; • Module Faults • Inverter Faults • Cabling and Connections • Grounding				
General Objective 3.0: Know the advance method for diagnosing and troubleshooting performance of PV systems						
9 - 14	3.1 Explain the role of Manufacturer Manuals in fault diagnosing and troubleshooting component performance 3.2 Explain advanced inverter diagnostics using; • Inverter Fault Codes • Inverter Parameters: • Voltage, • Current, • Frequency, and power checks. 3.4 Explain advanced charge controller diagnostics using: • Fault Codes • Parameters	Explain the role of Manufacturer Manuals in fault diagnosing and troubleshooting component performance Explain advanced inverter diagnostics using; • Inverter Fault Codes • Inverter Parameters: • Voltage, • Current, • Frequency, and power checks. Explain advanced charge controller diagnostics using: • Fault Codes • Parameters	Textbooks, Journals, Publications, Whiteboard, Marker, Internet, Computer, Projector	Diagnose the following component faults based on codes; Inverter .controller and battery	Guide students to Diagnose the following component faults based on codes; Inverter .controller and battery	Inverter Controller Battery Manufacturer Manuals

	3.5 Explain solar module diagnostics using: • Performance Testing: • Thermal Imaging • Electroluminescence (EL) Testing: 3.6 Explain energy storage systems diagnostics using: • Battery Faults codes, • Battery Management Systems (BMS). • Optimizing Battery Performance	Explain solar module diagnostics using: • Performance Testing: • Thermal Imaging • Electroluminescence (EL) Testing: Explain energy storage systems diagnostics using: • Battery Faults codes, • Battery Management Systems (BMS). • Optimizing Battery Performance				
General Objective 4.0: Know the advance method for monitoring and optimization of PV systems performance						
	4.1 Explain monitoring tools used to analyzed PV system 4.2 Explain PV system performance monitoring 4.3 Explain solar PV system optimization process using software 4.4 Explain data collection and analysis for PV system performance improvement	Explain monitoring tools used to analyzed PV system Explain PV system performance monitoring Explain solar PV system optimization process using software Explain data collection and analysis for PV system performance improvement	Textbooks, Journals, Publications, Whiteboard, Marker, Internet, Computer, Projector	Calculate the Performance Ratio (PR) in PV system Compare PV system performance by replacing underperforming components.	Guide students to: Calculate the Performance Ratio (PR) in PV system Compare PV system performance by replacing underperforming components.	PV system

	4.5 Explain the calculation of performance Ratio (PR) in PV system 4.6 Explain how to improve PV system performance by replacing underperforming components.	Explain the calculation of performance Ratio (PR) in PV system Explain how to improve PV system performance by replacing underperforming components.				
General Objective 5.0: Know the process of solving real-world problems in PV systems.						
	5.1 Explain the process required to solve low energy yield due to module degradation 5.2 Explain the process required to solve inverter malfunction leading to system downtime. 5.3 Explain the process required to solve environmental issues affecting system performance. 5.4 Explain the process required to solve Battery failures in hybrid systems.	Explain the process required to solve low energy yield due to module degradation Explain the process required to solve inverter malfunction leading to system downtime. Explain the process required to solve environmental issues affecting system performance. Explain the process required to solve Battery failures in hybrid systems.	Textbooks, Journals, Publications, Whiteboard, Marker, Internet, Computer, Projector	Measure solar power generated due to panels dust and solve the problem Repair a faulty inverter with error code 4, and solve the problem	Guide student to: Measure solar power generated due to panels dust and solve the problem Repair a faulty inverter with error code 4, and solve the problem	Inverter Tool box Solar power meter Solar panel

	5.5 Explain troubleshooting techniques to diagnose complex PV system problems.	Explain troubleshooting techniques to diagnose complex PV system problems.				
ASSESSMENT: Continuous Assessment (CA): 60% Examination: 40%						

Government of the Netherlands

FEDERAL GOVERNMENT OF NIGERIA

Solar Mini-Grid and Rural Electrification

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY		
COURSE TITLE: Solar Mini-Grid and Rural Electrification	Course Code: SPE 414	Contact Hours: 3
	Credit Unit: 2	Theoretical: 1
Year: II Semester 1	Pre-requisite: NIL	Practical: 2 Hour/week
GOAL: The course is designed to enable students acquire knowledge and skills in Solar PV Mini-Grid and Rural Electrification		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Know the basics of solar PV Mini grids for rural electrification. 2.0 Know factors to consider for Mini grid site selection and deployment in rural area 3.0 Know the system design and sizing of solar PV Mini grids for rural electrification 4.0 Know the implementation of solar PV Mini grids for rural electrification. 5.0 Know the Operational, Maintenance, and Monitoring of Solar PV Mini grids 6.0 Understand Scaling Up and Long-Term Sustainability in Mini grids for rural areas		

INCLUDE
KNOWLEDGE PLATFORM ON INCLUSIVE DEVELOPMENT POLICIES

NBTE

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY		
COURSE TITLE: Solar Mini-Grid and Rural Electrification	**COURSE CODE**: SPE 414	Contact Hours: 3 Hours
	Credit Unit: 2	Theoretical: 1
Year: II **Semester**: I	Pre-requisite: NIL	Practical: 2
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL		
GOAL: The course is designed to enable students acquire knowledge and skills in Solar Mini-Grid and Rural Electrification		
GENERAL OBJECTIVE 1.0: Know the basics of solar PV mini grids for rural electrification.		

THEORETICAL CONTENT				PRACTICAL CONTENT		
Week	**Specific Learning Outcome**	**Teacher's Activities**	**Resources**	**Specific Learning Outcome**	**Teacher's Activities**	**Resources**
1- 4	1.1 Define Mini grid 1.2 Explain the benefits of solar mini grids 1.3 Explain the two types of Mini Grids: • Isolated (off-grid) • Hybrid systems. 1.4 Explain the applications of solar Mini grids in: • Rural electrification, • Small industries, • Schools, • Healthcare, • Households	Explain Mini grid Explain the benefits of solar mini grids Explain the two types of Mini Grids: • Isolated (off-grid) • Hybrid systems. Explain the applications of solar Mini grids in: • Rural electrification, • Small industries, • Schools, • Healthcare, and • Households	Textbooks, Publications Journals, Whiteboard, Marker, Internet Computer, Projector	Identify types of mini grids in your community;	Guide students to: Identify types of mini grids in your community;	Charts

	1.5 Explain the composition of Solar PV Mini grid system 1.6 Explain challenges associated with Mini-grid implementation in rural areas.	Explain the composition of Solar PV Mini grid system Explain challenges associated with Mini-grid implementation in rural areas.				
General Objective 2.0: Know factors to consider for mini grid site selection and deployment in rural area						
5 - 8	2.1 Explain consumer's load assessment and energy demand assessment 2.2 Explain the importance of solar resource availability in relation to: • Solar Radiation Data, • Shading Analysis, And • Geographical Factors • Space 2.3 Explain the importance of daily/seasonal energy profile. 2.4 Explain socio-economic impacts of electricity supply.	Explain consumer's load assessment and energy demand assessment Explain the importance of solar resource availability in relation to: • Solar Radiation Data, • Shading Analysis, And • Geographical Factors • Space Explain the importance of daily/seasonal energy profile.	Textbooks, Journals, Publications, Whiteboard, Marker, Internet, Computer, Projector	Carryout solar resource assessment of a rural community Develop daily/seasonal energy profile of a community	Guide students to: Carryout solar resource assessment of a rural community Develop daily/seasonal energy profile of a community	Practical Manual Dataset Irradiance meter Clamp meters

	2.5 Explain economic benefits of mini grid to rural communities 2.6 Explain the social impacts of mini grids in rural areas. 2.7 Explain the importance of community engagement.	Explain socio-economic impacts of electricity supply. Explain economic benefits of mini grid to rural communities Explain the social impacts of mini grids in rural areas. Explain the importance of community engagement.				
General Objective 3.0: Know the system design and sizing of solar PV mini grids for rural electrification						
9 - 10	3.1 Explain Mini grid design process. 3.2 Explain the use of simulation software for solar mini-grid design 3.3 Explain solar PV system design 3.4 Explain solar PV system sizing • Solar Arrays, • Battery Storage, • Inverters,	Explain Mini grid design process. Explain the use of simulation software for solar mini-grid design Explain solar PV system design Explain solar PV system sizing • Solar Arrays, • Battery Storage, • Inverters, • Balance of System	Textbooks, Journals, Publications, Whiteboard, Marker, Internet, Computer, Projector	Design a small solar PV Mini grid	Guide students to; Design a small solar PV Mini grid	Software tools Simulation tools

	• Balance of System (BoS). 3.5 Explain the importance of power and energy calculations based on: • Peak Demand, • Energy Yield, • Battery Sizing for the Desired Autonomy. 3.6 Explain technical standards and guidelines for mini grid systems. • Nesis Code	(BoS). Explain the importance of power and energy calculations based on: • Peak Demand, • Energy Yield, • Battery Sizing for the Desired Autonomy. Explain technical standards and guidelines for mini grid systems. • Nesis Code				
General Objective 4.0: Know the implementation of solar PV mini grids for rural electrification.						
11-13	4.1 Explain installation planning and site assessment 4.2 Explain site selection and surveying 4.3 Explain civil works and infrastructure setup e.g. • Mounting Systems • Battery Storage Area, • Inverter Placement.	Explain installation planning and site assessment Explain site selection and surveying Explain civil works and infrastructure setup e.g. • Mounting Systems • Battery Storage Area, • Inverter Placement.	Textbooks, Journals, Publications, Whiteboard, Marker, Internet, Computer, Projector	Carryout installation setting of a small-scale solar PV mini grid .	Guide students to: Carryout installation setting of a small-scale solar PV mini grid .	PV module Cables Inverter Battery Tools Box

	4.4 Explain the importance of permits and regulations. • Council For The Regulation of Engineering in Nigeria(COREN) • Nigeria Electricity Management Agency Service (NEMSA) • Nigeria Energy Regulation Commission (NERC) 4.5 Explain installation of solar modules and balance of system • Panel Installation • Wiring and Electrical Connections 4.6 Explain inverter setup, installation, programming, and testing processes. 4.7 Explain battery installation: sizing and integration into the grid.	Explain the importance of permits and regulations. • Council For The Regulation of Engineering in Nigeria(COREN) • Nigeria Electricity Management Agency Service (NEMSA) • Nigeria Energy Regulation Commission (NERC) Explain installation of solar modules and balance of system • Panel Installation • Wiring and Electrical Connections Explain inverter setup, installation, programming, and testing processes. Explain battery installation: sizing and integration into the grid.				

	4.8 Explain troubleshooting and commissioning of the mini grid	Explain troubleshooting and commissioning of the mini grid				
General Objective 5.0: Know the Operational, Maintenance and Monitoring of Solar PV Mini Grids						
14	5.1 Explain operations, maintenance, and monitoring of solar PV Mini grids 5.2 Explain some monitoring and control tools use for remote monitoring of mini grid system performance. 5.3 Explain Key Performance Indicators (KPIs) to consider while assessing the efficiency and health of the system e.g.: • Performance Ratio, • Battery Efficiency, • Power Output 5.4 Explain the use of advance monitoring devises such as Data Loggers and Sensors: 5.5 Explain the importance of preventative and corrective maintenance through; • Routine Maintenance	Explain operations, maintenance, and monitoring of solar PV Mini grids Explain some monitoring and control tools use for remote monitoring of mini grid system performance. Explain Key Performance Indicators (KPIs) to consider while assessing the efficiency and health of the system e.g.: • Performance Ratio, • Battery Efficiency, • Power Output Explain the use of advance monitoring devises such as Data Loggers and Sensors:	Textbooks, Journals, Publications, Whiteboard, Marker, Internet, Computer, Projector	Carryout Field Trip Carryout system maintenance and troubleshooting Simulation of common failures, troubleshooting and repairing the system.	Guide students to: Carryout Field Trip Carryout system maintenance and troubleshooting Simulation of common failures, troubleshooting and repairing the system	PV system

	• Repairing Faults	Explain the importance of preventative and corrective maintenance through; • Routine Maintenance • Repairing Faults				
General Objective 6.0: Understand Scaling Up and Long-Term Sustainability in Mini grids for rural areas						
15	6.1 Explain the importance of scaling up and long-term sustainability in solar PV systems. 6.2 Explain the challenges in scaling mini grids to larger rural areas 6.3 Explain the challenges of integrating mini grids with the national grid. 6.4 Explain Sustainability Challenges such as; • Financial Sustainability, • System Durability, • Community ownership.	Explain the importance of scaling up and long-term sustainability in solar PV systems. Explain the challenges in scaling mini grids to larger rural areas Explain the challenges of integrating mini grids with the national grid. Explain Sustainability Challenges such as; • Financial Sustainability, • System Durability, • Community Ownership.	Whiteboard, Marker, Internet, Computer, Projector			
ASSESSMENT: Continuous Assessment (CA): 60% Examination: 40%						

MINI – PROJECT ON SOLAR PV SYSTEM INSTALLATION

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY		
COURSE TITLE: MINI – PROJECT ON SOLAR PV SYSTEM INSTALLATION	**COURSE CODE**: SPE 415	**CONTACT HOURS:** 3
	CREDIT UNIT: 3	**THEORETICAL**: 0
YEAR: 2 **SEMESTER:** 1	**PRE-REQUISITE:** NIL	**PRACTICAL:** 0
GOAL: This course is aim to acquaint students with knowledge and skills of Mini – project on Solar PV System Installation		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Propose a mini project on solar PV System 2.0 Carryout literature survey on solar PV System 3.0 Design mini solar PV System 4.0 Construct the design 5.0 Test the design 6.0 Present a report		

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Solar PV Policy, Climate Adaptation & Energy Transition

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY		
COURSE TITLE: Solar PV Policy, Climate Adaptation & Energy Transition	Course Code: SPE 416	Contact Hours: 2
	Credit Unit: 2	Theoretical: 2
Year: II Semester:1	Pre-requisite: NIL	Practical: 0
GOAL: This course is designed to equip students with knowledge and skills of solar PV policies, climate adaptation, and energy transition		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Know Solar PV Policies and Regulations 2.0 Understand Climate Adaptation Strategies for solar PV systems 3.0 Understand Energy Transition in various Sectors using solar PV systems 4.0 Understand implement and promotion of solar PV systems		

INCLUDE
KNOWLEDGE PLATFORM ON INCLUSIVE DEVELOPMENT POLICIES

NBTE

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY		
COURSE TITLE: Solar PV Policy, Climate Adaptation & Energy Transition	**COURSE CODE**: SPE 416	**CONTACT HOURS:** 2
	CREDIT UNIT: 2	**THEORETICAL**: 2
YEAR: II **SEMESTER:** I	**PRE-REQUISITE:** NIL	**PRACTICAL:** 0
COURSE SPECIFICATION: THEORETICAL& PRACTICAL		
GOAL: This course is designed to equip students with knowledge and skills of solar PV policies, climate adaptation, and energy transition		
GENERAL OBJECTIVE 1.0: Know Solar PV Policies and Regulations		

THEORETICAL CONTENT				**PRACTICAL CONTENT**		
WEEK	**SPECIFIC LEARNING OUTCOME**	**TEACHER'S ACTIVITIES**	**RESOURCES**	**SPECIFIC LEARNING OUTCOME**	**TEACHER'S ACTIVITIES**	**RESOURCES**
1-4	1.1 Explain renewable energy policies and regulations 1.2 Explain policies governing solar PV at national and global levels. 1.3 Explain government incentives, subsidies, and tariff structures towards solar PV systems 1.4 Explain compliance requirements for solar PV projects.	Explain renewable energy policies and regulations Explain policies governing solar PV at national and global levels. Explain government incentives, subsidies, and tariff structures towards solar PV systems Explain compliance requirements for solar PV projects.	Journals Textbooks Whiteboard Marker Internet Computer Projector Policy documents	Participate in group discussions and class presentations Participate in Seminars	Guide students on how to: Organize group discussions and class presentations Organise Seminars	Journals Textbooks Whiteboard Marker Internet Computer Projector Policy documents

	1.5 Explain policy influence on investment and market growth in solar PV system 1.6 Explain the role of policy in achieving solar PV system targets.	Explain policy influence on investment and market growth in solar PV system Explain the role of policy in achieving solar PV system targets.				
GENERAL OBJECTIVE 2.0: Understand Climate Adaptation Strategies for solar PV systems						
5-7	2.1 Explain the impact of climate change on energy demand and supply. 2.2 Explain how solar PV can support climate adaptation and resilience. 2.3 Explain case studies of renewable energy integration in climate action plans. 2.4 Explain innovations in solar PV to address environmental challenges.	Explain the impact of climate change on energy demand and supply. Assess how solar PV can support climate adaptation and resilience. Explain case studies of renewable energy integration in climate action plans. Discuss innovations in solar PV to address environmental challenges	Journals Textbooks Whiteboard Marker Internet Computer Projector			

GENERAL OBJECTIVE 3.0: Understand Energy Transition in various Sectors using solar PV systems						
8-10	3,1 Explain energy transition 3.2 Explain the significance of energy transition and sustainability of solar PV systems 3.3 Explain the economic and social impacts of transitioning to solar PV. 3.4 Explain technological advancements driving energy transition. 3.5 Explain global trends and commitments to clean energy adoption.	Explain energy transition Explain the significance of energy transition and sustainability of solar PV systems Explain the economic and social impacts of transitioning to solar PV. Explain technological advancements driving energy transition. Explain global trends and commitments to clean energy adoption.	Journals Textbooks Whiteboard Marker Internet Computer Projector			
GENERAL OBJECTIVE 4.0: Understand the implementation and promotion of solar PV systems						
11-14	4.1 Explain challenges and opportunities in large-scale solar PV deployment. 4.2 Explain business models for solar PV financing and investment.	Explain challenges and opportunities in large-scale solar PV deployment. Explain business models for solar PV financing and	Journals Textbooks Whiteboard Marker Internet Computer Projector			

	4.3 Explain regulatory frameworks supporting solar energy growth. 4.4 Explain the impact of innovation on solar PV adoption. 4.5 Explain strategies for increasing solar PV accessibility and affordability.	investment. Explain regulatory frameworks supporting solar energy growth. Explain the impact of innovation on solar PV adoption. Explain strategies for increasing solar PV accessibility and affordability.				
ASSESSMENT: Continuous Assessment (CA): 40% Examination: 60%						

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YEAR TWO SEMESTER TWO

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KNOWLEDGE PLATFORM ON INCLUSIVE DEVELOPMENT POLICIES

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Solar PV Policy, Regulation, and Standards

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY		
COURSE TITLE: Solar PV Policy, Regulation, and Standards	Course Code: SPE 421	Contact Hours: 2
	Credit Unit: 2	Theoretical: 1
Year: II Semester: II	Pre-requisite: NIL	Practical: 1
GOAL: This course is designed to enable students acquire knowledge and skills of solar PV policies, regulations, and standards.		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Know Policy Frameworks for solar PV systems 2.0 Understand financial Mechanisms and Incentives for Solar PV Systems 3.0 Understand the Regulations Governing Solar PV Systems 4.0 Understand licencing and regulatory compliance for solar PV installation 5.0 Understand Technical Standards and Quality Assurance for solar PV systems		

INCLUDE
KNOWLEDGE PLATFORM ON INCLUSIVE DEVELOPMENT POLICIES

NBTE

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY		
COURSE TITLE: Solar PV Policy, Regulation, and Standards	**COURSE CODE**: 421	**CONTACT HOURS:** 2
	CREDIT UNIT: 2	**THEORETICAL**: 1
YEAR: II **SEMESTER:** II	**PRE-REQUISITE:** NIL	**PRACTICAL:** 1
COURSE SPECIFICATION: THEORETICAL & PRACTICAL		
GOAL: This course is designed to enable students acquire knowledge and Skills of solar PV policies, regulations, and standards.		
GENERAL OBJECTIVE 1.0: Know Policy Frameworks for solar PV systems		

THEORETICAL CONTENT				**PRACTICAL CONTENT**		
WEEK	**SPECIFIC LEARNING OUTCOME**	**TEACHER'S ACTIVITIES**	**RESOURCES**	**SPECIFIC LEARNING OUTCOME**	**TEACHER'S ACTIVITIES**	**RESOURCES**
1-3	1.1 Explain the need for solar PV energy policies 1.2 Explain the incentives, tariffs, and subsidy programs associated with PV energy policies 1.3 Explain national policies of government in solar PV energy promotion. • Renewable Energy Master Plan (REMP) • National Renewable Energy and Energy Efficiency Policy (NREEEP), • Electricity Act 2023, etc.	Explain the need for solar PV energy policies Explain the incentives, tariffs, and subsidy programs associated with PV energy policies Explain national policies of government in solar PV energy promotion. • Renewable Energy Master Plan (REMP) • National Renewable Energy and Energy Efficiency Policy (NREEEP),	Journals Textbooks Whiteboard Marker Internet Computer Projector	Participate in group discussion Evaluate the level of policies implementation Participate in Seminars	Guide the student to Organize in group discussion Evaluate the level of policies implementation Organise Seminars	Journals Textbooks Whiteboard Marker Internet Computer Projector Policy documents

	1.4 Explain the technical and safety standards applicable to solar PV installations in Nigeria. 1.5 Explain the roles of relevant standard regulatory bodies e.g.: • SON • IEC. Etc.	• Electricity Act 2023, etc. Explain the technical and safety standards applicable to solar PV installations in Nigeria. Explain the roles of relevant standard regulatory bodies e.g.: • SON, • IEC, etc.				
GENERAL OBJECTIVE 2.0: Understand financial Mechanisms and Incentives for Solar PV System						
4-6	2.1 Explain financial models and incentives 2.2 Explain financial models, incentives, and investment opportunities in Nigeria's solar energy sector 2.3 Explain the following financial model- Power Purchase Agreements (PPA) Leasing models	Explain financial models and incentives Explain financial models, incentives, and investment opportunities in Nigeria's solar energy sector Explain the following financial model- Power Purchase Agreements (PPA) Leasing models	Journals Textbooks Whiteboard Marker Internet Computer Projector			

	2.4 Explain the following financial incentives • Feed-in-tariff • Tax incentives 2.5 Explain the following financial investment opportunities: • Large scale solar project • Off-Grid and Mini-grid systems • Solar component Manufacturing 2.6 Explain the use of PPA and leasing for solar PV projects	Explain the following financial incentives • Feed-in-tariff • Tax incentives Explain the following financial investment opportunities: • Large scale solar project • Off-Grid and Mini-grid systems • Solar component Manufacturing Explain the use of PPA and leasing for solar PV projects				
GENERAL OBJECTIVE 3.0: Understand the Regulations Governing Solar PV Systems						
7-9	3.1-Define regulation 3.2 Explain legal and policy framework for solar PV sector in Nigeria 3.3 Explain Electricity act 2023 and its implications in Nigeria PV sector	Explain regulation Explain legal and policy frame work for solar PV sector in Nigeria Explain Electricity act 2023 and its implications in Nigeria PV sector	Journals Textbooks Whiteboard Marker Internet Computer Projector			

	3.4-Explain the levels of policies implementation and their roles in solar PV deployment. 3.5 Explain the roles and mandate of the following regulatory bodies in Nigeria: • NERC • COREN • REA • NEMSA • SON • ECN • Federal Ministry of Power • NESREA • SERCs	Explain the levels of policies implementation and their roles in solar PV deployment. Explain the roles and mandate of the following regulatory bodies in Nigeria: • NERC • COREN • REA • NEMSA • SON • ECN • Federal Ministry of Power • NESREA • SERCs				
GENERAL OBJECTIVE 4.0: Understand licencing and regulatory compliance for solar PV installation						
10-12	4.1 Explain licencing 4.2 Explain procedures and requirements for obtaining necessary licenses 4.3 Explain the types of licenses for : • Generation; • Distribution,	Explain licencing Explain procedures and requirements for obtaining necessary licenses Explain the types of licenses for : • Generation; • Distribution,	Journals Textbooks Whiteboard Marker Internet Computer Projector			

	• Embedded generation 4.4 Explain the procedure for compliance with regulation for mini-grid PV installations for: • NERC • NEMSA 4.5 Explain strategies for maintaining compliance throughout project lifecycles.	• Embedded generation Explain the procedure for compliance with regulation for mini-grid PV installations for: • NERC • NEMSA Explain strategies for maintaining compliance throughout project lifecycles.				
GENERAL OBJECTIVE 5.0: Understand Technical Standards and Quality Assurance for solar PV systems						
13-15	5.1 Explain Technical Standards 5.2 Explain Quality Assurance 5.3 Explain quality assurance measures essential for solar PV system integrity and performance 5.4 Explain technical standards essential for solar PV system integrity and performance	Explain Technical Standards Explain Quality Assurance Explain quality assurance measures essential for solar PV system integrity and performance Explain technical standards essential for solar PV system integrity and performance	Journals Textbooks Whiteboard Marker Internet Computer Projector			

	5.5 Explain the following technical standards: • Component standards • System Design and Installation Standards • Inspection and Compliance • Importation and Quality Control • International Standards Integration 5.6 Explain the following quality assurance measure: • Pre-Production Quality Assurance • Production and Manufacturing Oversight • Pre-Shipment and Post-Delivery Inspections • Installation Quality Assurance • Operational Monitoring and Maintenance • Documentation and Continuous Improvement	Explain the following technical standards: • Component standards • System Design and Installation Standards • Inspection and Compliance • Importation and Quality Control • International Standards Integration • Explain the following quality assurance measure: • Assurance • Production and Manufacturing Oversight • Pre-Shipment and Post-Delivery Inspections • Installation Quality Assurance • Operational Monitoring and Maintenance				

		Documentation and Continuous Improvements				
ASSESSMENT: Continuous Assessment (CA): 40% Examination: 60%						

Maintenance of Solar PV Systems

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY		
COURSE TITLE: Maintenance of Solar PV Systems	Course Code: SPE 422	Contact Hours: 3
	Credit Unit: 3	Theoretical: 1
Year: II Semester: II	Pre-requisite:	Practical: 2
GOAL: This course is designed to equip students with knowledge and skills of maintenance of solar PV systems		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Know Solar PV System Components and Configurations 2.0 Know maintenance techniques for optimized PV system 3.0 Know Routine Maintenance of Solar PV Systems 4.0: Know the Operational, Maintenance, and Monitoring of Solar PV Mini Grids		

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY						
COURSE TITLE: Maintenance of Solar PV Systems		**COURSE CODE**: SPE 422		Contact Hours: 3		
		Credit Unit: 3		Theoretical: 1		
Year: I Semester: I		Pre-requisite:		Practical: 2		
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL						
GOAL: This course is designed to equip students with knowledge and skills of maintenance of solar PV systems						
GENERAL OBJECTIVE 1.0: Know Solar PV System Components and Configurations						
THEORETICAL CONTENT				PRACTICAL CONTENT		
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
1-4	1.1 Explain Solar PV components: • Solar panels • Inverters • Charge controllers, • Batteries • Protection devices • Cables, etc. 1.2 Explain the types of each components in 1.1 1.3 Explain the function of each component in 1.1 1.4 Explain different charging algorithms:	Explain Solar PV components: • Solar panels • Inverters • Charge controllers, • Batteries • Protection devices • Cables, etc. Explain the types of each component in 1.1 Explain the function of each component in 1.1	Journals Textbooks Whiteboard Marker Internet Computer Projector	Identify Solar PV System Components: • Solar panels • Inverters • Charge controllers, • Batteries • Protection devices • Cables, etc. Trace the flow of energy in a physical PV system based on a provided schematic diagram	Guide students to: Identify Solar PV System Components: Solar panels Inverters Charge controllers, Batteries Protection devices Cables, etc. Trace the flow of energy in a physical PV system based on a provided schematic diagram Identify the flow of energy through	PPE Multimeter Wire strippers Crimping tool Sample system schematic diagrams. Solar panels Inverters Charge controllers

	• Pulse Width Modulation (PWM) • Maximum Power Point Tracking (MPPT). 1.5 Explain the principle of operation of each component in 1.1 1.6 Define Configuration 1.7 Explain types of Solar PV system configurations	Explain different charging algorithms: • Pulse Width Modulation (PWM) • Maximum Power Point Tracking (MPPT). Explain the principle of operation of each component in 1.1 Explain Configuration Explain types of Solar PV system configurations		Identify the flow of energy through different PV system configurations. Identify how to configure PV System	different PV system configurations. Demonstrate how to configure PV systems	(PWM) MPPT Batteries Cables Screwdrivers Pliers Insulation tapes MC4 connector Cable lug
General Objective 2.0: Know maintenance techniques for optimized PV system						
5-7	2.1 Define Maintenance 2.2 Explain types of Maintenance: • Preventive • Corrective	Define Maintenance Explain types of Maintenance • Preventive • Corrective	Journals Textbooks Whiteboard Marker Internet Computer	Carryout routine maintenance checks, including; • Cleaning, • Visual	Guide students to Carryout routine maintenance checks, including; Cleaning, • Visual	Cleaning materials Data logger Hydro phobic

	2.3 Explain different types of Maintenance actions • Perfect • Minimal repair • Imperfect 2.4 Explain preventative maintenance in PV system • Systematic • Conditional • Predictive 2.5 Explain corrective maintenance • Deferred • Emergency 2.6 Explain dust and debris management in PV system 2.6 Explain electrical and mechanical integrity checks in PV system	Explain different types of Maintenance actions • Perfect • Minimal repair • Imperfect Explain preventative maintenance in PV system • Systematic • Conditional • Predictive Explain corrective maintenance • Deferred • Emergency Explain dust and debris management in PV system Explain electrical and mechanical integrity checks in PV system	Projector	inspections, and System health assessments.	inspections, and • System health assessments.	solution Anti-soiling coating

General Objective 3.0: Know Routine Maintenance of Solar PV Systems						
8-10	3.1 Explain Faults in PV system 3.2 Explain Failure in PV System 3.3 Explain Failure and its characteristics • Human error • Natural event • Design flows • Failure related to component etc. 3.4 Explain failure causes Interconnector failure • Corrosion • Delamination • Hotspot • Potential Induced Degradation (PID) • Cables etc. 3.5 Explain the impact of shading on PV system performance	Explain Faults in PV system Explain Failure in PV System Explain Failure and its characteristics • Human error • Natural event • Design flows • Failure related to component etc. Explain failure causes Interconnector failure • Corrosion • Delamination • Hotspot • Potential Induced Degradation (PID) • Cables etc. Explain the impact of shading on PV system performance Describe environmental	Journals Textbooks Whiteboard Marker Internet Computer Projector	Identify faults in solar PV System components Simulate the effect of shading on a small PV array (using opaque materials), power curve Identify potential areas where environmental degradation might occur on a physical system. Carry Out Repairs/ Replacements on Solar PV system components Demonstrate record-keeping for maintenance activities	Guide students to: Identify faults in solar PV System components Simulate the effect of shading on a small PV array (using opaque materials), power curve Identify potential areas where environmental degradation might occur on a physical system. Carry Out Repairs/ Replacements on Solar PV system components Demonstrate record-keeping for maintenance activities	PPE Solar PV System components Multimeter, Ladder Imaging camera Inspection mirror Cleaning materials

	• 3.6 Describe environmental degradation factors affecting PV systems • UV radiation • Temperature cycling • Humidity • Dust accumulation 3.7 Explain the importance of record-keeping for maintenance activities	degradation factors affecting PV systems • UV radiation • Temperature cycling • Humidity • Dust accumulation Explain the importance of record-keeping for maintenance activities				
General Objective 4.0: Know the Operational, Maintenance, and Monitoring of Solar PV systems						
11-15	4.1 Explain operations of solar PV systems 4.2 Explain maintenance, and monitoring of solar PV systems 4.3 Explain monitoring and control tools use for solar PV systems 4.4 Explain Key Performance Indicators (KPIs) to consider while assessing the efficiency and health of the system: e.g.: Performance ratio, Battery efficiency,	Explain operations of solar PV systems Explain maintenance, and monitoring of solar PV systems Explain monitoring and control tools use for solar PV systems Explain Key Performance Indicators (KPIs) to consider while assessing the efficiency and health	Journals Textbooks Whiteboard Marker Internet Computer Projector	Carryout system maintenance and troubleshooting Simulation of common failures, troubleshooting and repairing the system.	Guide students to: Carryout system maintenance and troubleshooting Simulation of common failures, troubleshooting and repairing the system.	PV system PPE Solar PV System components Multimeter, Imaging camera Inspection mirror Cleaning

	Power output 4.5 Explain the use of advance monitoring devices such as Data Loggers Sensors etc,	of the system: e.g.: Performance ratio, Battery efficiency, Power output Explain the use of advance monitoring devices such as Data Loggers Sensors etc.				materials Demonstration board
EVALUATION: CA 70% EXAMINATION: 30%						

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HIGH – VOLTAGE SOLAR PV AND INDUSTRIAL APPLICATION

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY		
COURSE TITLE: HIGH – VOLTAGE SOLAR PV AND INDUSTRIAL APPLICATION	**COURSE CODE**: SPE 423	**CONTACT HOURS:** 3
	CREDIT UNIT: 3	**THEORETICAL**: 1
YEAR: II **SEMESTER:** II	**PRE-REQUISITE:**	**PRACTICAL:** 2
GOAL: This course is designed to enable students acquire knowledge and skills in high – voltage solar PV and industrial application		
GENERAL OBJECTIVE: On completion of this course, the students should be able to: 1.0 Know the principles of high voltage solar PV 2.0 Know working mechanism of high voltage solar PV 3.0 Know the Industrial Application of High Voltage Solar PV		

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY		
COURSE TITLE: HIGH – VOLTAGE SOLAR PV AND INDUSTRIAL APPLICATION	**COURSE CODE**: SPE 423	**CONTACT HOURS:** 3
	CREDIT UNIT: 3	**THEORETICAL**: 1
YEAR: II **SEMESTER:** II	**PRE-REQUISITE:**	**PRACTICAL:** 2
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL		
GOAL: This course is designed to enable students acquire knowledge and skills in high – voltage solar PV and industrial application		
GENERAL OBJECTIVE 1.0: Know the principles of high voltage solar PV		

THEORETICAL CONTENT				**PRACTICAL CONTENT**		
WEEK	**SPECIFIC LEARNING OUTCOME**	**TEACHER'S ACTIVITIES**	**RESOURCES**	**SPECIFIC LEARNING OUTCOME**	**TEACHER'S ACTIVITIES**	**RESOURCES**
1 - 4	1.1 Define high voltage PV 1.2 Explain the operational components of high voltage PV • High voltage energy storage devices • Higher voltage Inverter/ Charge controller • System balancing component • High voltage solar panel • Monitoring system • High voltage power system network	Explain high voltage PV Explain the operational components of high voltage PV in 1.2 High voltage energy storage devices: Battery bank System balancing component: Transformers, Blocking diodes High voltage solar panel: above 48 volts Monitoring system: Computers High voltage power system network:	Textbooks, Journals, Publications, Whiteboard, Markers, Internet Computer, Projector, Charts,	Demonstrate the use of the following devices: Transformers Blocking Diodes Transmission towers and lines Grid Battery bank Inverter/ Charge controller	Guide students to: Demonstrate the use of the following devices: Transformers Blocking Diodes Transmission towers and lines Grid Battery bank Inverter/ Charge controller	Charts Pictorials Videos

	1.3 List the Application of components in 1.2 1.4 List the main types of high voltage solar PV system • Standalone System • Grid – connected System	Transmission towers and lines Explain the Application of high voltage PV Explain the main types of high voltage solar PV system • Standalone System • Grid – connected System				
GENERAL OBJECTIVE 2.0: Know working mechanism of high voltage solar PV System						
5 - 9	2.1. Explain the working mechanism of high voltage Standalone PV Systems 2.2 List the categorization of high voltage Standalone PV System: • Direct coupled: • with battery storage • with batteries and Charge controller • with AC and DC Loads • Hybrid Standalone System 2.3 Explain each of the Standalone System categorization in 2.2	Explain the working mechanism of high voltage Standalone PV System Explain the categorization of high voltage Standalone System • Direct coupled: • with battery storage • with batteries and Charge controller • with AC and DC Loads • Hybrid Standalone System	Textbooks, Journals, Publications, Whiteboard, Markers, Internet Computer, Projector, Charts	Demonstrate on the categories of High Voltage standalone PV system	Guide students to: Demonstrate on the categories of High Voltage standalone PV system	Charts Pictorials Videos

	2.4 Explain the working mechanism of Grid connected high voltage PV System in 2.2 based on: • Dependency • Usage • Connection 2.5 Explain the merits and demerits of Standalone System categorization in 2.2	Explain each of the Standalone System categorization in 2.2 Explain the working mechanism of Grid connected high voltage PV System in 2.2 based on: • Dependency • Usage • Connection Explain the merits and demerits of Standalone System categorization in 2.2				
GENERAL OBJECTIVE 3.0: Know the Industrial Application of High Voltage Solar PV						
10 - 14	3.1 Explain the application of high voltage PV system in the following Industries: • Power • Transportation • Telecommunications • Agriculture etc. 3.2 List the economic feasibility of Industrial high voltage solar PV Application	Explain the application • of high voltage PV system in the following Industries: • Power • Transportation • Telecommunications • Agriculture etc. Explain the economic feasibility of Industrial high voltage solar PV Application	Textbooks, Journals, Publications, Whiteboard, Markers, Internet Computer, Projector	Visit an industrial high voltage PV plants	Guide students to: Visit an industrial high voltage PV plants	

	3.3 Explain the maintenance associated with Industrial high voltage solar PV	Explain the maintenance associated with Industrial high voltage solar PV				
ASSESSMENT: Continuous Assessment (CA): 60% Examination: 40%						

Application of AI for Energy Trading

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY		
COURSE TITLE: Application of AI for Energy Trading	Course Code: SPE 424	Contact Hours: 3
	Credit Unit: 3	Theoretical: 1
Year: II Semester: II	Pre-requisite: Python	Practical: 2Hour/week:
GOAL: This course is designed to provide students with knowledge and Application of AI for energy trading.		
GENERAL OBJECTIVES: On completion of this course, the students should be able to: 1.0 Know the fundamentals of blockchain technology, machine learning algorithms and their application in energy markets 2.0 Know models that can predict energy production, consumption, and pricing 3.0 Understand smart contracts for automated P2P energy transactions 4.0 Know Decentralized Applications (DApps) for Energy Trading Platforms 5.0 Know energy trading using reinforcement learning 6.0 Know security, privacy, and regulatory challenges in blockchain-based energy systems		

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY						
COURSE TITLE: Application of AI for Energy Trading		COURSE CODE: SPE424		Contact Hours: 3		
		Credit Unit: 3		Theoretical: 1		
Year: II Semester: II		Pre-requisite: Python		Practical: 2		
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL						
GOAL: This course is designed to provide students with knowledge and Application of AI for energy trading.						
GENERAL OBJECTIVE 1.0: Know the fundamentals of blockchain technology, machine learning algorithms and their application in energy markets						
THEORETICAL CONTENT				PRACTICAL CONTENT		
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
1-3	1.1 Explain blockchain technology and distributed ledgers for energy markets 1.2 Explain peer- to -peer (P2P) energy market fundamentals 1.3 Explain AI and its application in energy market. 1.4 Explain Machine learning (ML) basics with a focus on energy applications	Explain blockchain technology and distributed ledgers for energy markets Explain peer- to -peer (P2P) energy market fundamentals Explain AI and its application in energy market. Explain Machine learning (ML) basics with a focus on energy applications	Whiteboard Marker Internet Computer Projector Textbooks Videos USB drives	Use machine learning to forecast: Energy demand Energy Market Energy output etc. Write a simple machine learning language: Python	Guide student to: Use machine learning to forecast: Energy demand Energy Market Energy output etc. Write a simple machine learning language: Python	Computer system Software

	1.5 Explain Data structures and cryptography for blockchain systems	Explain Data structures and cryptography for blockchain systems				
General Objective 2.0: Know models that can predict energy production, consumption, and pricing						
4-6	2.1 Explain Time series forecasting for energy production and consumption using the following economic indicators: • GDP, • Unemployment, • Inflation 2.2 Explain Price forecasting models and market dynamics 2.3 Explain Anomaly detection in energy data streams	Explain Time series forecasting for energy production and consumption using the following economic indicators: • GDP, • Unemployment, • Inflation Explain Price forecasting models and market dynamics Explain Anomaly detection in energy data streams	Whiteboard Marker Internet Computer Projector Textbooks Videos USB drives	Demonstrate Time series forecasting for energy production and consumption using the following Software: MATLAB Python	Guide students to: Demonstrate Time series forecasting for energy production and consumption using the following Software: MATLAB Python	Software: MATLAB Python RETScreen SQL Pandas
General Objective 3.0: Understand smart contracts for automated P2P energy transactions						
6-9	3.1 Explain Smart contract development for automated energy transactions 3.2 Explain Token economics and incentive design for energy markets 3.3 Explain Interoperability between energy trading platforms	Explain Smart contract development for automated energy transactions Explain Token economics and incentive design for energy markets Explain Interoperability	Whiteboard Marker Internet Computer Projector Textbooks Videos USB drives			

	3.4 Explain the intersection of AI and energy systems 3.5 Explain different types of energy data: Production, Consumption, Pricing, etc. 3.6 Explain smart contract writing specifically for energy transactions	between energy trading platforms Explain the intersection of AI and energy systems Explain different types of energy data: Production, Consumption, Pricing. Etc. Explain smart contract writing specifically for energy transactions				
General Objective 4.0: Know Decentralized Applications (DApps) for Energy Trading Platforms						
10-11	4.1 Explain the concept of decentralized energy trading. 4.2 Explain how different decentralized energy trading platforms works Transparency Efficiency Security, etc. 4.3 Explain the benefits of decentralized energy trading	Explain the concept of decentralized energy trading. Explain how different decentralized energy trading platforms works Transparency Efficiency Security, etc. Explain the benefits of decentralized energy trading	Whiteboard Marker Internet Computer Projector Textbooks Videos USB drives	Simulate stability in decentralized grid control systems	Guide student to: Simulate grid stability in decentralized grid control systems	Software: Python Prophet Cloud base platform (AWS, google colab) Siemens spectrum power

	4.4 Explain the merits and demerits of different energy trading platforms. 4.5 Explain how to ensure solar grid stability with decentralized control systems	Explain the merits and demerits of different energy trading platforms. Explain how to ensure solar grid stability with decentralized control systems				
General Objective 5.0: Know energy trading using reinforcement learning						
12-13	5.1 Explain Reinforcement learning. 5.2 Explain multi-agent systems for decentralized energy coordination 5.4 Explain the impact of energy market volatility, and the need for automated strategies Explain the concept of Markov Decision Processes (MDPs) through a simplified game with states, actions, rewards, and transitions.	Explain Reinforcement learning. Explain multi-agent systems for decentralized energy coordination Explain the impact of energy market volatility, and the need for automated strategies Explain the concept of Markov Decision Processes (MDPs) through a simplified game with states, actions, rewards, and transitions.	Whiteboard Marker Internet Computer Projector Textbooks Videos USB drives	Simulate energy trading using MDPs software	Guide students to: Simulate energy trading using MDPs software	MATLAB Video clips
General Objective 6.0: Know security, privacy, and regulatory challenges in blockchain-based energy systems						

14-15	Explain Blockchain Energy security models 6.2 Explain: Decentralization, Immutability, Transparency Explain the application of blockchain technology to energy networks e.g. Peer-to-peer trading Smart grids Renewable energy credits 6.4 Explain the Threat modeling specific to energy infrastructure and grid systems 6.5 Explain the Energy Market Regulations and Trading Rules 6.6 Explain strategy for Blackout Prevention	Explain Blockchain Energy security models Explain: Decentralization, Immutability, Transparency Explain the application of blockchain technology to energy networks e.g. Peer-to-peer trading Smart grids Renewable energy credits Explain the Threat modeling specific to energy infrastructure and grid systems Explain the Energy Market Regulations and Trading Rules Explain strategy for Blackout Prevention	Whiteboard Marker Internet Computer Projector Textbooks Videos USB drives	Simulate: Blockchain energy security model Threat model Blockchain system optimization Blackout prevention	Guide students to simulate: Blockchain energy security model Threat model Blockchain system optimization Blackout prevention	MATLAB Video clips
EVALUATION: CA 60% EXAMINATION: 40%						

PRACTICAL MANUALS

SPE 311 PRINCIPLES OF ELECTRONICS	1. Identify different types of diodes 2. Demonstrate forward and reverse bias characteristics of PN Junction diodes. 3. Carryout testing of diodes using multimeter 4. Test the following Bipolar Junction Transistors. NPN PNP 5. Test the following Field Effect Transistors using multi-meter. N-channel type P-channel type 6. Design and Construct Transistor Amplifier and switching circuits 7. Measure the voltage and power gains of the following; Fixed bias. Collector-base bias without and with a decoupling capacitor. Potential divider bias. Junction FET simple bias 8. Illustrate using diagrams activities 2.2 to 2.8 9. Calculate the voltage and power gains of the amplifiers in 2.8.

	10. Draw the circuit diagram of a single stage common emitter and common source transistor amplifiers having; Resistive load, Transform Tuned circuit loads. 11. Design and Construct various Operational Amplifier circuits 12. Demonstrate the effect of feedback in operational amplifier. 13. Measure the amplitude and frequency of known operational amplifier-based oscillators. 14. Solve problems involving OP-AMP, using circuits in 3.5. 15. Design and construct multivibrators using Switches: Transistors monolithic integrated circuit (ICs) 16. Draw the block diagram of a basic feedback amplifier. 17. Draw a simple electronic switch 18. Draw multivibrator circuits. 19. Perform logic gate operations using: The 'NOT' gate or inventers; The 'AND' gate; The 'OR' gate; The 'NAND' gate The 'NOR' gate

	20. Use software packages to show the logic gates functions and different configuration methods. 21. Verify the output waveforms of rectifiers 22. Verify the effect of filter capacitor on the rectifiers output. 23. Draw a simple diagram of the power supply circuit 24. Calculate ripple factors for half wave and full-wave rectification
SPE 312 PRINCIPLES OF RENEWABLE ENERGY	Form and guide in group discussions, and class presentations on different types of energy transformation Demonstrate using visual aids on how energy been transform
SPE 313 FUNDAMENTALS FOR SOLAR PHOTOVOLTAIC (PV) SYSTEM	1. Illustrate the Electromagnetic spectrum, waves, fields on various semi – conductors 2. Sketch the in – built electric field created by the positively and negatively charged junctions on semi – conductor layers 3. Identify the different types of Solar PV System 4. Identify types of Solar PV installation Systems
SPE 314 SOLAR RESOURCE ASSESSMENT	1. Identify the types of solar radiation (DNI, GHI, DHI). 2. Demonstrate how sunlight is converted into electricity and heat 3. Demonstrate how solar energy is measured with simple tools 4. Measure temperature, tilt angle and irradiance as factors affecting solar energy availability. 5. Compare solar radiation levels in different directions

	6. Compare solar resource availability across different directions 7. Select relevant solar energy datasets 8. Use computational tools to analyze solar energy patterns. 9. Interpret solar radiation trends to predict energy output for solar energy systems 10. Demonstrate basic data processing using spreadsheets. 11. Demonstrate the use of solar energy resource measurement tools and software for Solar energy resources assessment 12. Generate site assessment reports for solar energy resources 13. Conduct economic analysis on solar energy projects such as: Initial capital Maintenance Payback period, Return on investment (ROI), Cost-benefit analysis, etc.. 14. Evaluate environmental factors affecting solar energy projects, such as Carbon footprint reduction and Land use reclamation. 15. Compare the feasibility of solar energy systems with alternative energy sources 16. Design solar energy systems based on: Performance ratio Sizing

	Climatic condition, etc. 17. Demonstrate the effect of solar collector orientation and tilt angle.
SPE 315 WORKSHOP PRACTICE AND SAFETY PROCEDURE	1.Demonstrate the use of PPE. 2. Demonstrate first aid procedures. 3. Demonstrate emergency response procedures 4. Demonstrate the use of fire extinguisher 5. Identify the following hand tools: Screwdrivers, Hacksaws Spanners , Drills, etc. 6. Draw and label the following hand tools: Screwdrivers, Hacksaws Spanners, Drills, etc. 7. Handle tools and equipment appropriately. 8. Maintain tools and equipment appropriately. 9. Perform material cutting, welding, soldering and drilling, etc, for solar energy system 10. Demonstrate how to Assemble and disassemble solar PVs through:

	Connections (wiring and piping) Mounting structures Pre-cast solar mounting base 11. Inspect fabricated components for defects and compliance with specifications 12. Carryout a risk assessment 13. Develop a safety checklist for Solar PV/Thermal system installation. 14. Identify Types of Accidents. 15. Identify The Procedures for Accident Preventions. 16. Use Case Study Involving Risk of installation of RE systems.
SPE 316 SMART GRIDS & IoT IN PV SYSTEM I	1. Identify a mini traditional grid and mini smart grid 2. Monitor power consumption by AC loads using smart meter 3. Control AC loads using smart circuit breaker 4. Automate the operation of AC loads using smart circuit breaker 5. Identify each of these sensors used in IoT for smart grids: Temperature sensor, Irradiance sensor, Voltage sensor, Current monitoring sensor. 6. Identify each of these types of actuators used in IoT for smart grids: Electromechanical Devices Hydraulic/Pneumatic Devices

	Solid-state devices Smart Relays 7. Carryout experiment using IoT based system 8. Carryout an assessment on how to monitor and control of inverters. 9. Carryout real-time monitoring of energy generation and consumption in PV system 10. Demonstrate remote short circuit and open circuit fault detection using IoT 11. Demonstrate data logging and analysis using IoT devices
SPE 317 ENERGY STORAGE TECHNOLOGIES IN SOLAR PV SYSTEMS	1. Identify types of energy storage (batteries, thermal, mechanical). 2. Implement sustainable practices to minimize solar PV waste and extend battery life.
SPE 318 MODELLING AND SIMULATION OF SOLAR PV SYSTEMS	1. Design the layout of a basic solar PV system 2. Assess the factors influencing solar PV system design 3. Calculate to determine the appropriate sizing of components like collectors, storage tanks, and heat exchangers based on system demands and design parameters. 4. Apply thermal performance equations to model solar collectors: Heat transfer Energy equations 5. Use mathematical models to calculate the behavior of heat storage systems Heat losses Charging/ discharging cycle

	6. Identify commonly used software for solar PV system simulation 7. Navigate user interface and set up basic simulation models in any available software 8. Input system parameters and environmental data into simulation software 9. Interpret software-generated outputs and simulation graphs
SPE 321 POWER ELECTRONICS	1. Calculate the following; Reverse recovery current of diodes Steady state capacitor voltage of an RC circuit and amount of stored energy. Steady state capacitor voltage of an RL circuit and amount of stored energy. Steady state capacitor voltage of an LC circuit and amount of stored energy. Steady state capacitor voltage of an RLC circuit and amount of stored energy. The initial di/dt and dv/dt of RLC circuits 2. Simulate the performance of diode rectifier. 3. Evaluate the performance of diode rectifier. 4. Determine the Fourier components of diode rectifier outputs. 5. Calculate the performance parameters of diode rectifiers. 6. Design a diode rectifier circuit.

	7. Determine the effects of load inductance on load current. 8. Design the output side filter for diode rectifiers. 9. Determine the effects of source inductance on the rectifier output voltage. 10. Measure the gate drive characteristics of the following transistors: BJT MOSFETs IGBTs 11. Calculate the gate drive characteristics and requirements of the following transistors: BJT MOSFETs IGBTs 12. Design di/dt protection circuits for transistors. 13. Simulate the performance parameters of DC-DC Converters. 14. Measure the performance parameters of DC-DC Converters. 15. Design DC-DC converter systems. 16. Simulate the performance parameters of inverters. 17. Measure the performance parameters of inverters.

SPE 322 TECHNO-ECONOMIC ANALYSIS FOR SOLAR PV SYSTEM	Carryout CAPEX/OPEX spreadsheet modelling for 10 kW system. Map stakeholder's roles in a sample project. Perform LCOE calculations. Perform NPV/IRR calculation. Build financial models with appropriate the software tools. 6. Contrast PPAs vs. leasing models. 7. Develop power purchase agreement (PPAs) model for Solar PV projects 8. Design procedure for community Solar PV Model 9. Prepare a grand application for solar mini grid 10. Prepare a 5kw solar system proposal which include: Technical specifications Financial model Risk mitigation plan Policies compliance checklist Load profile etc. 11. Perform the SWOT analysis on an existing Nigeria solar project 12. Analyse a failed solar projects and present key lessons
SPE 323 SOLAR PV SYSTEM CONFIGURATION	1. Identify the each of following grid systems: Mini-Grid systems. Off-Grid systems. Hybrid systems. 2. Identify the components of Solar PV Mini-Grid

	3. Identify the various types of Solar PV mini-grid systems. 4. Identify the components of Solar PV Off-grid systems. 5. Identify the various types of Solar PV Off-grid systems. 6. Identify the components of Solar PV Hybrid systems. 7. Identify the various types of Solar PV Hybrid systems. 8. Identify the components of Grid tied systems. 9. Identify the various types of Grid tied systems.
SPE 324 RESEARCH METHODOLOGY IN SOLAR PV	1. Write a concise and clear title along with background information relevant to solar PV energy. 2. Formulate a research problem relating to solar PV and derive appropriate objectives for it. 3. Create precise and researchable problem statements and research questions. 4. Draft a literature review section of a Research proposal. 5. Write a comprehensive abstract. 6. Summarize relevant studies and highlight research gaps in solar PV energy. 7. Select appropriate research design and methodology.

	8. Develop experimental or field procedure for the research on any area of your choice on Solar PV. 9. Conduct the study using tools and techniques in real or simulated environments. 10. Analyze data sets using appropriate software tools. 11. Compile research data and analysis into coherent sections. 12. Interpret the implications of research results. 13. Apply correct citation and referencing styles in a technical report.
SPE 325 SOLAR PV PROJECT MANAGEMENT AND TENDERING PROCESS	1. Create New Solar PV Project using project management software. 2. Generate Solar PV project scope and milestones. 3. Use a Computer Application packages to design and document a project.
SPE 326 SMART GRIDS & IoT IN PV SYSTEM II	1. Identify Smart grid devices such as Smart Meters and End-User Devices. 2. Monitor power consumption by AC loads using smart meter. 3. Control AC loads using smart circuit breaker. 4. Automate the operation of AC loads using smart circuit breaker. 5. Implement a small-scale Smart Grid using IoT-enabled PV systems. 6. Connect a smart energy meter to a PV inverter. 7. Use a smart plug to automate a domestic appliance based on PV output.

	8. Set up real-time monitoring dashboards. 9. Use simulation software for Smart Grid and PV system modeling. 10. Control a small-scale Smart Grid using IoT-enabled PV systems. 11. Demonstrate Smart plug scheduling for appliance control. 12. Demonstrate Smart solar tracking for solar panels. 13. Demonstrate the use of wire verse wireless networking for enhance performance.
SPE 411 ADVANCED SOLAR PV TECHNOLOGIES	1. Demonstrate the working principles of a traditional and advanced Solar PV modules. 2. Measure I-V characteristics under the following conditions: Load Temperature Irradiance 3. Measure the characteristics of Solar PV using solar simulator. 4. Use labeled diagrams and datasheets to identify components in advanced Solar PV System 5. Demonstrate the different between PWM and MPPT charge controllers
SPE 412 INSTALLATION AND COMMISSIONING OF SOLAR PV SYSTEM	1. Perform calculations related to load analysis. 2. Provide hands-on training in system design software. 3. Review case studies of existing solar PV installations. 4. Perform pre- commissioning tests.

	5. Troubleshoot common PV faults. 6. Diagnose real or simulated system issues. 7. Apply safety procedures for electrical testing. 8. Demonstrate grounding and earthing tests. 9. Show how to use imaging cameras. 10. Demonstrate Solar Panel installation procedures. 11. Verify system performance and troubleshooting common issues. 12. Test system performance after installation. 13. Perform solar panel routine system maintenance. 14. Identify and resolve common faults in solar PV setups. 15. Identify and repair faults in solar PV setups. 16. Mount modules and connect components. 17. formulate the commissioning checklist of activities
SPE 413 ADVANCE PV SYSTEM PERFORMANCE AND TROUBLESHOOTING	1. Identify the common faults in PV systems and troubleshoot using the following tools: Module-level, Inverter-level, Wiring

	2. Identify each of the following traditional troubleshooting tools; Multimeter, Clamp meter, Solar PV imaging, Power analyzer 3. Identify the following advance performance monitoring tools; Data loggers, Battery management system Cloud-based monitoring platforms, 4. Measure the performance of the Solar PV component affected by the following; Degradation of Solar PV Modules, Faults in inverters (e.g., overvoltage, under voltage), Faults in MPPT controllers. Environmental Factors (e.g., dust, shading, temperature) 5. Diagnose the following component faults based on codes; Inverter Controller and Battery 6. Calculate the Performance Ratio (PR) in PV system 7. Compare PV system performance by replacing it with underperforming components. 8. Measure solar power generated due to panels dust and provide solution. 9. Repair a faulty inverter with error code 4.
SPE 414 SOLAR MINI-GRID AND RURAL ELECTRIFICATION	1. Identify the types of mini grids in your community. 2. Carryout solar resource assessment of a rural community. 3. Develop daily/seasonal energy profile of a community.

	4. Design a small solar PV Mini grid. 5. Carryout installation setting of a small-scale solar PV mini grid. 6. Carryout Field Trips. 7. Carryout system maintenance and troubleshooting. 8. Simulation of common failures, troubleshooting and repairing the system.
SPE 416 Solar PV Policy, Climate Adaptation & Energy Transition	Organize in group discussions and class presentations Organise Seminars
SPE 421 Solar PV Policy, Regulation, and Standards	Organize class group discussion Evaluate the level of policies implementation Organise Seminars
SPE 422 MAINTENANCE AND REPAIRS OF SOLAR PV SYSTEMS	1. Identify the following Solar PV System Components: Solar panels Inverters Charge controllers, Batteries Protection devices Wiring, etc. 2. Trace the flow of energy in a physical PV system based on provided schematic diagram Identify the flow of energy through different PV system configurations Demonstrate how to configure PV systems

	4. Carryout routine maintenance checks, including; Cleaning, Visual inspections, and System health assessments. 5. Identify faults in solar PV System components 6. Simulate the effect of shading on a small PV array (using opaque materials). 7. Identify potential areas where environmental degradation might occur on a physical system. 8. Carry Out Repairs/ Replacements on Solar PV system components 9. Demonstrate record-keeping for maintenance activities 10. Carryout system maintenance and troubleshooting 11. Simulation common failures, troubleshoot and repair the system.
SPE 423 HIGH – VOLTAGE SOLAR PV AND INDUSTRIAL APPLICATION	Illustrate on: Transformers Blocking Diodes Transmission towers and lines Grid Battery bank Inverter/ Charge controller Demonstrate on the categories of High Voltage standalone PV system Visit an industrial high voltage PV plant
SPE 424 Application of AI for Energy Trading	1. Use machine learning technique to forecast the following: Energy demand

	Energy Market Energy output etc. 6. Write a simple machine learning language using Python programming language. 7. Demonstrate Time series forecasting for energy production and consumption using the following Software: MATLAB Python 8. Simulate stability in decentralized grid control systems 9. Simulate energy trading using MDPs software. 10. Simulate the following models: Blockchain energy security model. Threat model. Blockchain system optimization. Blackout prevention.

LIST OF SOLAR PV TOOLS AND EQUIPMENT

S/N	EQUIPMENT	QUANTITY	REMARKS
	WORKSHOP TOOLS//EQUIPMENT		
1	Ammeter	12	
3	AC Bulbs	Assorted	
4	Bolt and Nuts	Assorted	
5	Controller (PWM, MPPT)	5 each	
6	Nails	Assorted	
7	Screws	Assorted	
8	DC Bulbs	Assorted	

9	Diagrams	Assorted	
10	Digital Thermometers	10	
11	Faulty system components (Inverters, charge controllers, panels, batteries, breakers, diodes)	Assorted	
12	Fire extinguishers	5	
13	First Aid Kit	5	
14	Inverter	Assorted	
15	Irradiance meter	5	
16	Risk assessment templates	Assorted	
17	Load (Resistive capacitive and inductive)	Assorted	
18	Expansion bolts	Assorted	
19	Flash band	2 roles	
20	Maintenance Kits	5	
21	Manufacturer Manuals	Assorted	
22	Maps	Assorted	
23	Multi-meter	5	
24	Pictorials	Assorted	
25	PPE Set	15 sets	
27	Solar PV module	Assorted	
28	Solar PV module cables	Assorted	
29	Safety Charts	Assorted	
30	Smart Breakers	Assorted	
31	Smart DC Switches	Assorted	
32	Temperature sensor	Assorted	
33	Toolbox (complete)	15	
34	Batteries	Assorted	
35	Batteries Equalizers	5	
36	Batteries Analyzer	2	
37	Batteries Load tester	2	
38	Cables	Assorted	
39	Calculators	Assorted	

40	Checklist	Assorted	
41	Clamp meter	5	
42	Resistor	Assorted	
43	Magnetic compass	12	
44	Operational amplifiers	Assorted	
45	Connecting cables (Jumper)	Assorted	
46	Cutting & Drilling Tools	5 each	
47	Diodes	Assorted	
48	Domestic appliance	2	
49	Metal Sheets	10	
50	Mounting structures	Assorted	
51	Mounting Poles	5	
52	Solar PV system models (Mini-grid, Off-grid, Hybrid, Smart Grid)	1 each	
53	Solar PV installation kits.	5	
54	Test board (MBF)	Assorted	
55	Thermal cameras	5	
56	Distribution board	12	
57	MC4 connector	Assorted	
58	Cable lug	Assorted	
59	Insulation tapes(Different color)	Assorted	
60	Cable ties/clams	Assorted	
61	Insulation resistance tester(megger)	1	
62	Earth resistance tester	1	
63	Cleaning materials	Assorted	
64	Component datasheets	10	
65	Fire Alarm	Assorted	
66	Sand bucket	Assorted	
67	Fire Blanket	Assorted	
68	Smoke Detectors	Assorted	
69	Gas Detectors	Assorted	

70	Safety signs	Assorted	
71	Fabrication Materials	Assorted	

	LABORATORY TOOLS//EQUIPMENT		
S/N	**EQUIPMENT**	**QUANTITY**	**REMARKS**
1	BJT Transistors	Assorted	
2	Breadboard	Assorted	
3	Capacitors	Assorted	
4	Integrated Circuit (e.g. 555 timer, LM 74, 7805. 7812)	Assorted	
5	Cloud-based monitoring platforms	Assorted	
6	Electrostatic discharge kits	10	
7	FET Transistors	Assorted	
8	GPS	5	
9	IGBTs	Assorted	
10	I-V curve tracer	10 sets	
11	Monolithic integrated circuit (ICs)	5	
12	MOSFETs	5	
13	Operational Amp Trainer/ module	5	
14	Oscilloscope,(storage screen 4 channel)	5	
15	Power electronics trainer,	2	
16	Solar PV trainer	1	
17	Pyranometer	1	
18	Pyrheliometer	1	
19	Semiconductor Trainer/ module	3	
20	Router	1	
21	Smart Inverter (3kva – 5kva)	Assorted	

22	Smart plugs/sockets	Assorted	
23	Smart thermostats	Assorted	
24	Switches	Assorted	
25	System monitoring dashboard	1	
26	Audio visual	Assorted	
27	Ammeter	12	
28	Anemometers	5	
29	AC Bulbs	Assorted	
30	Charts	Assorted	
31	Controller (PWM, MPPT)	5 each	
32	Data logger	5	
33	Dataset	Assorted	
34	DC Bulbs	Assorted	
35	Diagrams	Assorted	
36	Digital Thermometers	10	
37	Faulty system components (Inverters, charge controllers, panels, batteries, breakers, diodes)	Assorted	
38	Fire extinguishers	5	
39	First Aid Kit	5	
40	Inverter	Assorted	
41	Irradiance meter	5	
42	Risk assessment templates	Assorted	
43	Load (Resistive capacitive and inductive)	Assorted	
44	Logic pulser,	10	
45	Logic probe.	10	
46	Solar Maintenance Kits	5	
47	Manufacturer Manuals	Assorted	
48	Maps	Assorted	
49	Multi-meter	5	
50	Pictorials	Assorted	
51	PPE set	15 sets	

52	Solar PV meter	10	
53	Solar PV module	Assorted	
54	Solar PV module cables	Assorted	
55	Safety Charts	Assorted	
56	Smart Batteries	Assorted	
57	Smart Beakers	Assorted	
58	Smart DC Switches	Assorted	
59	Temperature sensor,	Assorted	
60	Toolbox (complete)	5	
61	Batteries	Assorted	
62	Batteries Equalizers	5	
63	Cables	Assorted	
64	Calculators	Assorted	
65	Checklist	Assorted	
66	Clamp meter,	5	
67	Cleaning materials	Assorted	
68	Magnetic Compass	10	
69	Component datasheets	10	
70	Connecting cables (Jumper)	Assorted	
71	Cutting & Drilling Tools	5 each	
72	Resistors	Assorted	
73	Domestic appliance	2	
74	Metal Sheets	10	
75	Mounting structures	Assorted	
76	Mounting Poles	5	
77	Solar PV system (Mini-grid, Off-grid, Hybrid, Smart Grid)	1 each	
78	Solar PV installation kits.	5	
79	Test board (MBF)	Assorted	
80	Thermal cameras	1	
81	Concave mirror	5	

82	Light beam	5	
83	Diodes	Assorted	
84	Operational amplifiers	Assorted	
85	Signal generator	5	
86	Inclinometer	1	
87	Spirit level	1	
88	Fire Alarm	Assorted	
89	Sand bucket	Assorted	
90	Fire Blanket	Assorted	
91	Smoke Detectors	Assorted	
92	Gas Detectors	Assorted	
93	Safety signs	Assorted	

	STUDIO TOOLS//EQUIPMENT		
S/N	**EQUIPMENT**	**QUANTITY**	**REMARKS**
1	Computers	30	
2	Solar PV system design simulation software	Assorted	
3	Projectors	Assorted	
4	Energy Audit tools	Assorted	
5	Software: e.g (RETScreen, PVsyst, HOMER, System Advisor Model(SAM), Microsoft tools, Python MATLAB, SQL, Pandas, Prophet, Cloud base platform{AWS, google colab}, Siemens spectrum power)	Assorted	

	SOLAR FARM		
S/N	**EQUIPMENT**	**QUANTITY**	**REMARKS**
1	Demonstration Solar PV farm (5KW)	1	

Government of the Netherlands

FEDERAL GOVERNMENT OF NIGERIA

LIST OF PARTICIPANTS HND SOLAR PHOTOVOLTAIC (PV) PRE-CRITIQUE WORKSHOP

S/N	NAME	ADDRESS	E-MAIL
1.	Engr. Dr. Salihu Bala	Federal University of Technology, Minna	
2.	Engr. Dr. Batholomew Paul Naanman	Kaduna Polytechnic, Kaduna	
3.	Engr. Shobo Olufemi	Lagos Energy Academy	
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