



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



INCLUDE KNOWLEDGE PLATFORM ON INCLUSIVE DEVELOPMENT POLICIES



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 -CONAL-BOARL **EXECUTIVE SECRETARY NBTE, KADUNA**

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Solar Mini-Grid and Rural Electrification	
MINI – PROJECT ON SOLAR PV SYSTEM INSTALLATION	
Solar PV Policy, Climate Adaptation & Energy Transition	
Solar PV Policy, Regulation, and Standards	
Maintenance of Solar PV Systems	









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

ING OF COURSES: Courses	snall be graded as follows:	
MARKED RANGE	LETTER GRADE	WEIGHTING
75% and above	А	4.00
70%-74%	AB	3.50
65% - 69%	В	3.25
60% - 64%	BC	3.00
55% - 59%	С	2.75
50% - 54%	CD	2.50
45% - 49%	D	2.25
40% - 44%	E	2.00

8.1 GRADING OF COURSES: Courses shall be graded as follows







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
- CGPA 2.00-	2.49	

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QUALIFICATION OF THE TEACHERS 9.0

- Holders of BSc / HND and Higher Degrees in: 9.1
- i. Renewable Energy Engineering,
- ii. Chemical Engineering,
- iii. Mechanical Engineering,
- Electrical/ Electronic Engineering, iv.
- Computer Engineering, v.
- Mechatronics Engineering vi.

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

Headship of the Department: 9.3

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

GUIDANCE NOTES FOR TEACHERS OF THE PROGRAMME 10.0

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

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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 <u>not</u> 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

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CURRICULUM TABLE

YEAR	I SEMESTER I	CURRICULUM TABLE		200		
S/N	COURSE CODE	COURSE TITLE	L	Р	CU	СН
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	0	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
TOT	AL	· · · · · · · · · · · · · · · · · · ·	16	13	29	31







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YEAR I SEMESTER II

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S/N	COURSE CODE	COURSE TITLE	L	Р	CU	СН
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		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
		IONA-BOARD				
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YEAR II SEMESTER I

SN COURSE CODE COURSE TITLE L P CU CH 1 GNS 401 Communication in English IV 2 - 2 2 2 MITH 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 Retrofiting & Energy Efficiency Techniques 1 1 2 2 6 SPE 411 Advanced Solar PV Technologies 1 1 2 2 7 SPE 412 Installation and Commissioning of Solar PV System 1 2 2 3 9 SPE 414 Solar PV System Performance and Troubleoting 1 2 2 3 10 SPE 414 Solar PV Policy, Climate Adaptation & Energy Transition 0 0 2 2 12 SPE 417 Seminar 0 0 2	C/N						
2MTH 412Numerical Methods20223ENT 416Practice of Entrepreneurship II22444EEC 324Control Engineering12335STE 414Retrofitting & Energy Efficiency TechniquesV2336SPE 411Advanced Solar PV Technologies112227SPE 412Installation and Commissioning of Solar PV System12338SPE 413Advanced PV System Performance and Troubleshooting112239SPE 414Solar Mini-Grid and Rural Electrification (Field Trip)1223310SPE 415Mini-Project on Solar PV System Installation0033311SPE 416Solar PV Policy, Climate Adaptation & Energy Transition202212SPE 417Seminar00222TOTAL	3 /1 1	COURSE CODE	COURSE TITLE	L	P	CU	CH
3 ENT 416 Practice of Entrepreneurship II 2 2 4 4 4 EEC 324 Control Engineering 1 2 3 3 5 STE 414 Retrofiting & Energy Efficiency Techniques 1 2 3 3 6 SPE 411 Advanced Solar PV Technologies 1 1 2 2 3 3 7 SPE 412 Installation and Commissioning of Solar PV System 1 2 3 3 8 SPE 411 Advanced PV System Performance and Troubleshooting 1 1 2 2 3 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 3 TOTAL 11 12 30 31	1	GNS 401	Communication in English IV	2	(- X	2	2
4 EEC 324 Control Engineering 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 3 3 6 SPE 411 Advanced Solar PV Technologies 1 1 2 2 3 3 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 3 9 SPE 414 Solar Mini-Grid and Rural Electrification (Eield Trip) 1 2 2 3 10 SPE 416 Solar PV Policy, Climate Adaptation & Energy Transition 2 0 2 2 12 SPE 417 Seminar 0 0 2 2 2 12 SPE 417 Seminar 0 0 2 2 2 12 SPE 417 Seminar 0 0 2 2 3 <td>2</td> <td>MTH 412</td> <td>Numerical Methods</td> <td>2</td> <td>0</td> <td>2</td> <td>2</td>	2	MTH 412	Numerical Methods	2	0	2	2
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 3 10 SPE 415 Mini-Project on Solar PV System Installation 0 0 3 3 11 SPE 415 Solar PV Policy, Climate Adaptation & Energy Transition 2 0 2 2 12 SPE 417 Seminar 0 0 2 3 3	3	ENT 416	Practice of Entrepreneurship II	2	2	4	4
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 11 12 30 31	4	EEC 324	Control Engineering		2	3	3
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 12 SPE 417 Seminar 0 0 2 2 11 12 30 31	5	STE 414	Retrofitting & Energy Efficiency Techniques		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 12 SPE 417 Seminar 0 0 2 2 12 SPE 417 Seminar 0 0 2 2 TOTAL 11 12 30 31	6	SPE 411	Advanced Solar PV Technologies	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	7	SPE 412	Installation and Commissioning of Solar PV System	1	2	3	3
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	8	SPE 413		1	1	2	2
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	9	SPE 414		1	2	2	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	10	SPE 415	Mini-Project on Solar PV System Installation	0	0	3	3
12 SPE 417 Seminar 0 0 2 2 TOTAL 11 12 30 31	11	SPE 416		2	0	2	2
	12	SPE 417	Seminar	0	0	2	2
TOWALBOARDFOR			TOTAL	11	12	30	31
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YEAR II SEMESTER II

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S/N	COURSE CODE	COURSE TITLE	L	P	CU	СН
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
		FOR				
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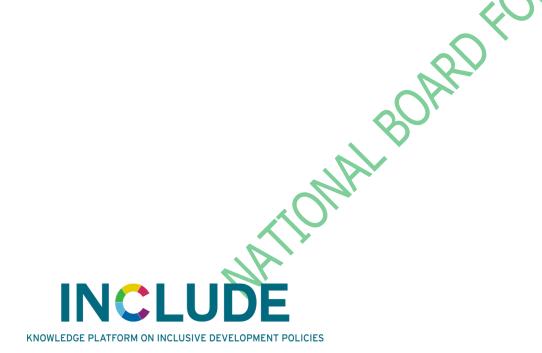
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YEAR ONE SEMESTER ONE







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

Year: I Semester: I **Pre-requisite:** NIL

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

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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

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PROG	RAMME: HIGHER NATION	AL DIPLOMA (HND) SC	DLAR PHOTO	VOLTAIC (PV) ENGINI	EERING TECHNOLOG	Y
Course	: PRINCIPLES OF ELECTRON	NICS Course Code:	SPE 311		Contact Hours: 3	
		Credit Unit:	3		Theoretical: 1	
Year: I	Semester: I	Pre-requisite:	NIL		Practical: 2	
Goal: 7	The course is designed to acquain	nt students with the Knowle	edge and skills	in usage of Electronic devic	es	
	Specification: Theoretical Con			Practical Content		
Genera	Objective 1.0: Know the conc		Junction Diode			-
Week	Specific Learning	Teacher's Activities	Resources	Specific Learning	Teacher's Activities	Resources
	Outcomes			Outcomes		
	Define Semiconductor Diode	Explain the concept of	Whiteboard		Guide students to:	1. Practical
1-3		Semiconductor diode	Marker			manual
	List type of diodes		TT (1 1			2. Breadboard
		Explain the types of	Textbooks	Identify different types	Identify different types	Diodes
	Describe PN Junctions in	diodes	Internet	of diodes	of diodes	Multi-meters Power supply
	forward and reverse bias		Internet	Demonstrate forward	Demonstrate forward	Semiconductor
	operations	Explain PN Junctions in	Computer	and reverse bias	reverse bias	Trainer/ module
	operations	forward and reverse bias	Computer	characteristics of PN	characteristics of PN	Resistors
	Describe the following	operations	Projector	Junction diodes.	Junction diodes.	Capacitors
	applications of					Cupuellois
	Semiconductor diodes;	Explain the following				
	Voltage Stabilisation and	applications of		Carryout testing of		
	Reference.	Semiconductor diodes:		diodes using multimeter		
	Voltage Shifting.	Voltage Stabilisation			Demonstrate how to	
		and Reference.			test diodes using	
	1.5 Describe testing of	Voltage Shifting.			multimeter	
	diodes using multimeter					
		Explain testing of				
<u> </u>		diodes using multimeter				
Genera	l Objective 2.0 : Know the open			nsistor (BJT), Field Effect T		
	2.1 Define the transistor	Explain the concept of	Whiteboard		Guide students to:	1. Practical





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





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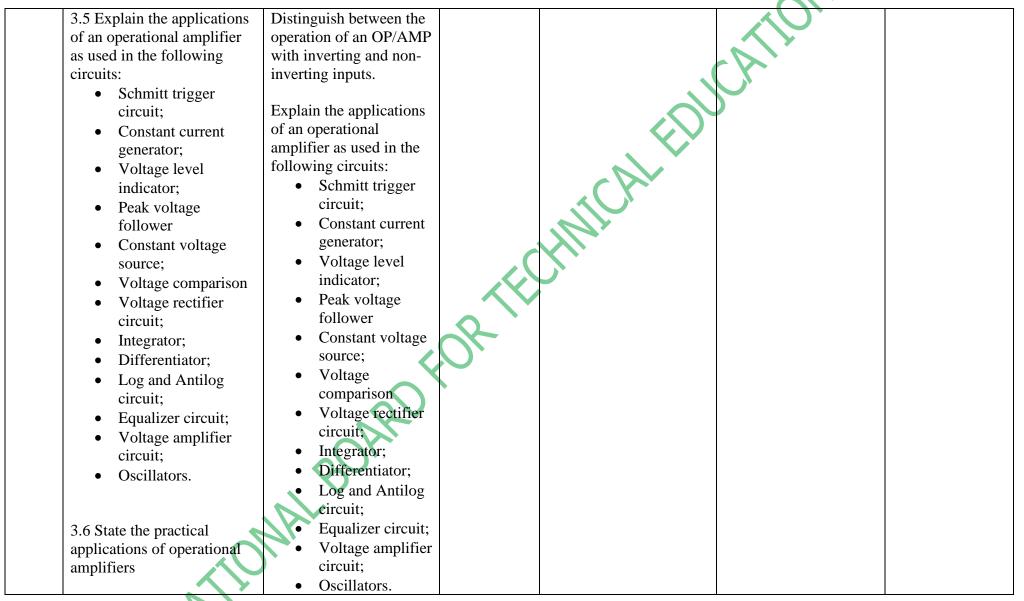


	3.1 Explain the principles of	Explain the principles of	Whiteboard		Guide students to:	
7-8	operation of operational	operation of operational	Marker	Design and Construct	Design and construct	1. Practical
	amplifiers (OP-AMP).	amplifiers (OP-AMP).	Textbooks	various Operational	Operational Amplifier	manual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



INVERTING INPUTS.











-			-			
		State the practical applications of operational amplifiers				
Genera	l Objective 4.0: Know the gene	eral principles of Oscillators	s and Multivibra	ators		
Genera 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. 	 eral principles of Oscillators 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. 	s and Multivibra 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.	 Practical manual Breadboard Transistors Resistors Capacitors Multi-meter, Variable power supply Monolithic integrated circuit (ICs) Trainer/ module Oscilloscope Signal generator Switches





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4.5 Explain the operation of:				NO.	
R-C Oscillator.	R-C Oscillator.				
L-C oscillator (Hartley &	L-C oscillator (Hartley				
colpitts)	& colpitts)				
Describe methods of employing frequency stability of oscillators using Piezo-electric crystal control.	Explain methods of employing frequency stability of oscillators using Piezo-electric crystal control.		TCALED		
 4.7 Explain the principle of operation of the following multivibrators using switches: Bistable. Monostable Astable. 	Explain the principle of operation of the following multivibrators using switches, such as: • Bistable. • Monostable • Astable.	OR-	YM.		
4.8 Explain the operation of multi-vibrators in 4.8 using the following:	Explain the operation of multi-vibrators in 4.8 using, such as:				
Transistors and	 Transistors and 				
Monolithic	Monolithic				
integrated circuit	integrated circuit				
(ICs)	(ICs)				
4.9 State the expression for	Explain how to				
determining the frequencies	determine the				
and timing of multivibrators	frequencies and timing				
	of multivibrators				





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







	 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 	OR-FE			
	al Objective 6.0: Know the basi		-		Cuido atradonte to:	1 Dreatical
14-15	6.1 Explain half-wave and full-wave rectification	Explain half-wave and full-wave rectification	Whiteboard Marker Textbooks	Verify the output waveforms of the	Guide students to: Verify the output waveforms of rectifiers	1. Practical manual
	6.2 Explain how to calculate ripple factors for half-wave	Explain how to calculate ripple factors for half-	Internet Computer	rectifiers	Verify the effect of	2. Breadboard
	and full-wave rectification	wave and full-wave	Projector		filter capacitor on the	3. Power
	6.3 Explain the operation of	rectification		Verify the effect of filter capacitor on the output	output of the rectifier.	supplies,
	a bridge rectifier.			of the rectifier.	Draw a simple power supply circuit diagrams	4. Oscilloscope,

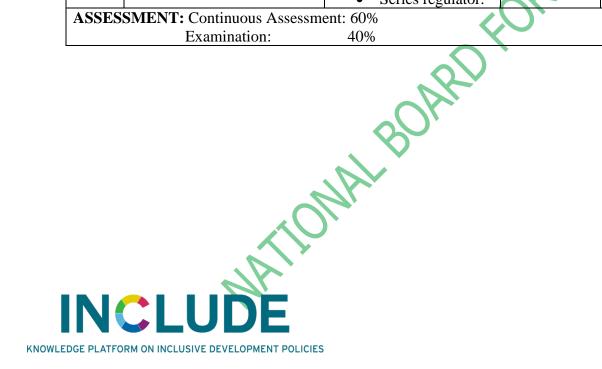




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6.4 Explain the use of the	Explain the operation of		Draw a simple power	×U'	5. Capacitors,
following as smoothing	a bridge rectifier.		supply circuit diagrams		
circuits:	Explain the use of the			Calculate ripple factors	6. Diodes,
• The capacitor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





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PRINCIPLES OF RENEWABLE ENERGY

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PRINCIPLES OF	RENEWABLE ENERGY	
PROGRAMME: HIGHER NATIONAL DIPLOMA (HND) SO	DLAR PHOTOVOLTAIC (PV) EN	GINEERING TECHNOLOG
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 kn	nowledge and skills on the principles	of Renewable Energy
GENERAL OBJECTIVES: On completion of this course, the stud	dents should be able to:	
1.0 Know the concept of renewable energy2.0 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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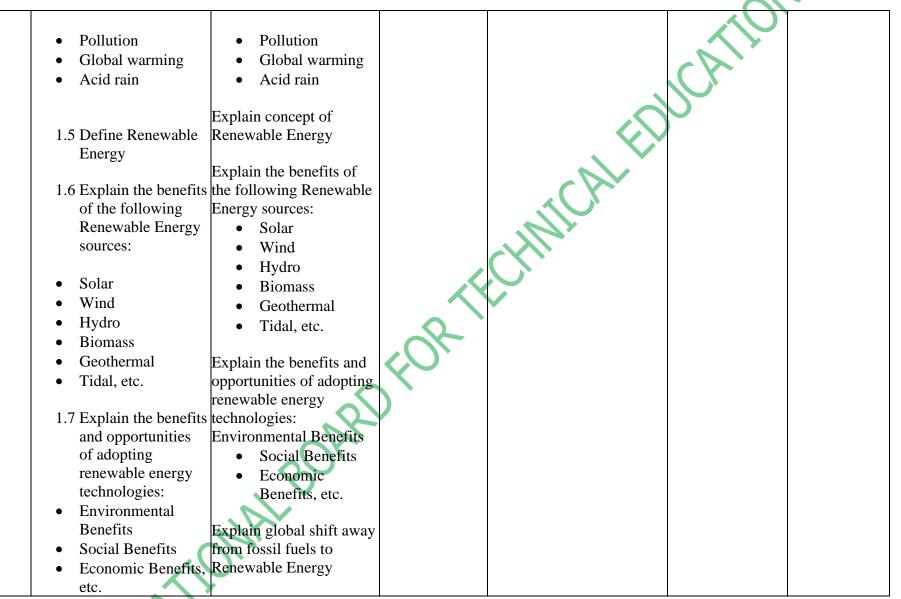
	AMME: HIGHER NATIO						
COURSE TITLE: PRINCIPLES OF RENEWABLE ENERGY				JRSE CODE: 312		ONTACT HOURS: 2	
			CRE	CDIT UNIT: 3	THEORETICAL	<i>.</i> : 1	
YEAR:	1 SEMESTER: 1		PRE	-REQUISITE: NIL	PRACTICAL:	1	
COURSE	E SPECIFICATION: THE	ORETICAL AND PRACT	ΓICAL				
GOAL: T	This course is designed to en	able the students to acquir	e knowledge and	skills on the principles of R	enewable Energy		
GENERA	AL OBJECTIVE 1.0: Know	w the concept of renewable	e energy				
THEORE	ETICAL CONTENT			PRACTICAL CONTENT			
WEEK	SPECIFIC LEARNING	TEACHER'S	RESOURCES	SPECIFIC LEARNING	TEACHER'S	RESOURCES	
	OUTCOME	ACTIVITIES		OUTCOME	ACTIVITIES		
	1.1 Define Energy	Explain the concept of	Textbooks,	<i>.0×</i>	Guide the student	Internet	
		Energy	Journals,	Participate in group	on group		
	1.2 Explain the forms		Publications,	discussions and class	discussions and	Computer,	
	of Energy:	Explain the various	Whiteboard,	presentations on different	class		
	• Solar	forms of Energy:	Markers,	forms of energy	presentations on	Projector,	
1 - 9	Electrical	• Solar	Internet	transformation	different forms of		
	Mechanical	Electrical	Computer,		energy	Concave	
	(Kinetic and	Mechanical	Projector,		transformation	mirror	
	Potential)	(Kinetic and	Charts		** • • • • •		
	• Thermal (Heat)	Potential)		Using visual aids	Using visual aids	5. Light source	
	• Chemical, etc.	• Thermal (Heat)		demonstrate how energy is been transformed			
		• Chemical, etc.		been transformed	energy is been transformed		
					transformed		
	1.3 Explain the sources	-					
	of Energy	Energy					
	1.4 List the						
		Eveloin the					
		Explain the					
	fossil fuels:	consequences of using the following fossil fuels:					
		the following lossif fuels:					





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



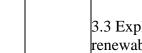


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	properties of solar PV and solar thermal systems	and solar thermal systems				
NFR	AL OBJECTIVE 3.0: Unde	5	ors of renewable	energy		
	3.1. Explain the factors	Explain the factors	Textbooks,			
	affecting renewable energy	-	Journals,		V.	
	generation	energy generation	Publications,			
	generation	energy generation	Whiteboard,			
	3.2 Explain the use of	Explain the use of	Markers,			
- 10	renewable energy in the	renewable energy in the	Internet			
10	reduction of the following:	reduction of the	Computer,			
	Greenhouse gas	following:	Projector,			
	concentrations	Greenhouse gas	Animation,			
	 Sea level rise 	concentrations	Charts			
	Ocean heat	 Sea level rise 		CXV.		
	 Ocean acidification 	Ocean heat				
	• Ocean actumcation etc.	Ocean Ocean				
	etc.	acidification etc.		·		
		aciumcation etc.				
	3.3 Explain the impacts of					
	renewable energy on the	Explain the impacts of				
	environment	renewable energy on the				
	environment	environment				
	3.4 Explain the methods of					
		Explain the Methods of				
	following climate change:	mitigating the effect of				
	Regenerative	the following climate				
	• Regenerative Agricultural	change:				
	practices	Regenerative				
	-	Agricultural				
	Protecting and restoring forests	practices				
	and critical	 Protecting and 				
		restoring forests				
	ecosystems	restoring tofests				





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	• Prevention of Greenhouse gas	and critical ecosystems			
	emissions, etc.	• Prevention of			
		Greenhouse gas			
		emissions, etc.			
GENERA					
GENERA	L OBJECTIVE 4.0: Under	rstand the Renewable Ener	gy sustainability		
11 - 12	4.1 Explain Renewable	Explain Renewable	Textbooks,		
	Energy sustainability	Energy sustainability	Journals,		
			Publications,		
	4.2 Explain solar PV		Whiteboard,		
		1 65	Markers,		
	1	sustainability	Internet		
	Energy sustainability		Computer,		
		Explain solar thermal	Projector		
	1 00	Energy sustainability			
	sustainability				
		Explain wind Energy			
	1	sustainability	\sim		
	Energy sustainability				
	1 2 65	Explain bio-mass Energy			
	sustainability	sustainability			
	4.7 Explain by comparison				
		Explain hydro Energy			
	solar PV and solar thermal	sustainability			
	systems	Evelow by companies			
		Explain by comparison Energy sustainability of			
	human activities on Energy				
	sustainability of solar PV	thermal systems		l	







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	Explain the impact of human activities on Energy sustainability of		Ŷ
	solar PV and solar thermal systems		
ASSESSMENT: Continuous Assessm Examination: 40%			I
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FUNDAMENTALS FOR SOLAR PHOTOVOLTAIC (PV) SYSTEM PROGRAMME: HIGHER NATIONAL DIPLOMA (HND) SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY . (X

a Cada, SDE 212	
e Code: SPE 313	Contact Hours: 3
t Unit: 3	Theoretical: 1
quisite: NIL	Practical: 2
of Solar PV System	·
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overnment of the Netherlands											
							FEI				
							J				
PROG	RAMME: HIGHER NATIO	NAL DIPLON	1A (HN	D) SOLAR P	HOTOVOLTAIC (PV) ENGINEERING TH	CHNOLOGY				
PROGRAMME: HIGHER NATIONAL DIPLOMA (HND) SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLCOURSE TITLE: FUNDAMENTALS FORCOURSE CODE: SPE 313Contact Hours: 2 Hours											
SOLAR PV SYSTEM											
			Credit Unit: 3			Theoretical: 1					
Year: 1 Semester: I			Pre-requisite: NIL			Practical: 2					
	SE SPECIFICATION: THE										
	: The course is designed to ena			<u> </u>							
GENE	RAL OBJECTIVE 1.0: Kno	w the concept o	f Electr	omagnetic Wa	ives in Solar PV Syste	em					
THEORETICAL CONTENT					PRACTICAL CONTENT						
Week	Specific Learning	Teacher's Act	ivities	Resources	Specific Learning	Teacher's Activities	Resources				
	Outcome				Outcome						
1-4	1.1 Define Solar PV System	Explain the con	ncept	Textbooks,		Guide students to:	1. Diagrams				
		of Solar PV Sy	vstem		Illustrate the	Illustrate the					
				Journals,	Electromagnetic	Electromagnetic	2. Charts				
	1.2 Explain the process of	Explain the process		Whiteboard	spectrum, waves,	spectrum, waves fields					
	converting photons to	of converting		Marker,	fields on various	on various semi –	3. Videos				
	Electrical Energy	photons to Elec	ctrical		semi – conductors	conductors					
		Energy		Computer,		Sketch the in – built					
	1.3 Explain the effect of	Explain the eff	act of	Projector	Sketch the in –	electric field created by					
	Photovoltaic (PV) on	Photovoltaic (I			built electric field	the positively and					
	semiconductor materials	semiconductor			created by the	negatively charged					
		materials			positively and	junctions on semi					
	1.4 Explain the concept of				negatively charged	conductor layers					
	the following				junctions on semi						
	Electromagnetic waves in	Explain the con	ncept		conductor layers						
	Solar PV System	of the followin			-						
	Electric Current	Electromagnet	ic								





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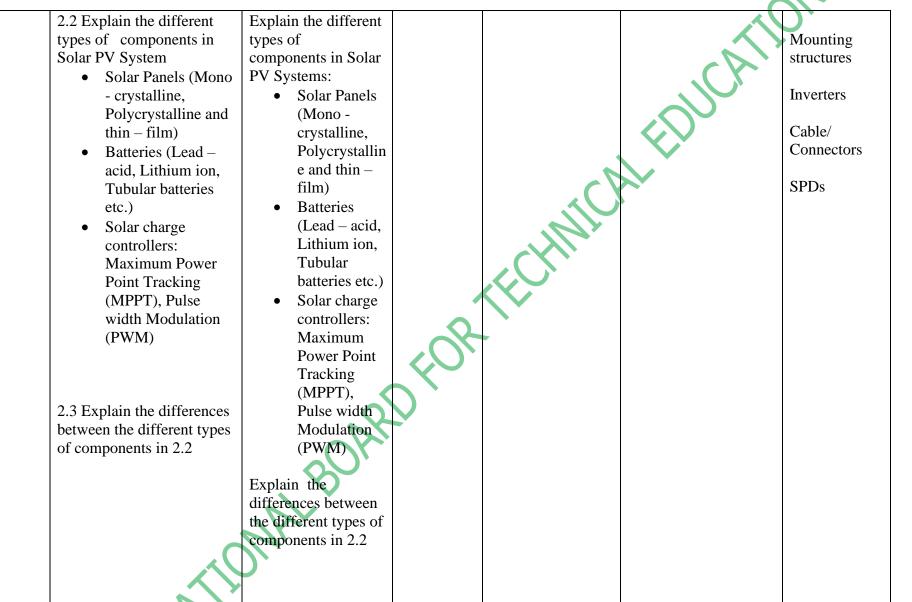
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	 Electric Charge Electric Field etc. 1.5 Explain the effects of electric field on positively and negatively charged junctions on semiconductor layers	 waves in Solar PV System Electric Current Electric Charge Electric Field etc. Explain the effects of electric field on positively and negatively charged junctions on semi conductor layers 		CHN		
Gener 5 - 8	 al Objective 2.0: Know the constraints of Solar PV Systems: Solar Panels Solar Charge Controllers Batteries Protective Devices Batteries Equalizers, etc. 	 mponent of the Solar P Explain the following components of Solar PV Systems: Solar Panels Solar Charge Controllers Batteries Protective Devices Batteries Equalizers, etc. 	V System 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	 Solar Panels Solar Charge Controllers Batteries Batteries Equalizers (BMS) DC/AC Bulbs





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Jenera	l Objective 3.0: Know the app	-		1		<u> </u>
	3.1 Explain the importance	Explain the	Textbooks,		Guide students to	Pictorials
	of Solar PV Systems in	importance of Solar	Journals,	Identify types of	identify types of Solar	
	various areas of application	PV Systems in	Whiteboard	Solar PV	PV installation	Videos
) - 14		various areas of	Marker,	installation	Systems	
		application	Internet	Systems		
	3.2 Explain the following		Computer,			
	types of Solar PV	Explain the	Projector			
	installation Systems:	following types of		1		
	• Off grid	Solar PV installation				
	Grid tied	Systems:			r	
	Hybrid	 Off grid 				
		• Grid tied				
		 Hybrid 				
	3.3 List the following areas					
	of Solar PV System	Explain the				
	applications:	following areas of	0			
	Residential	Solar PV System				
	Industrial	applications:				
	• Enterprise	Residential				
	• Agriculture etc.	Industrial				
		• Enterprise				
		• Agriculture				
		etc.				
	3.4 Explain the limitations					
	of Solar PV application	Explain the				
	Systems mentioned in 3.3	limitations of Solar				
		PV application				
		Systems mention in				
		3.3				



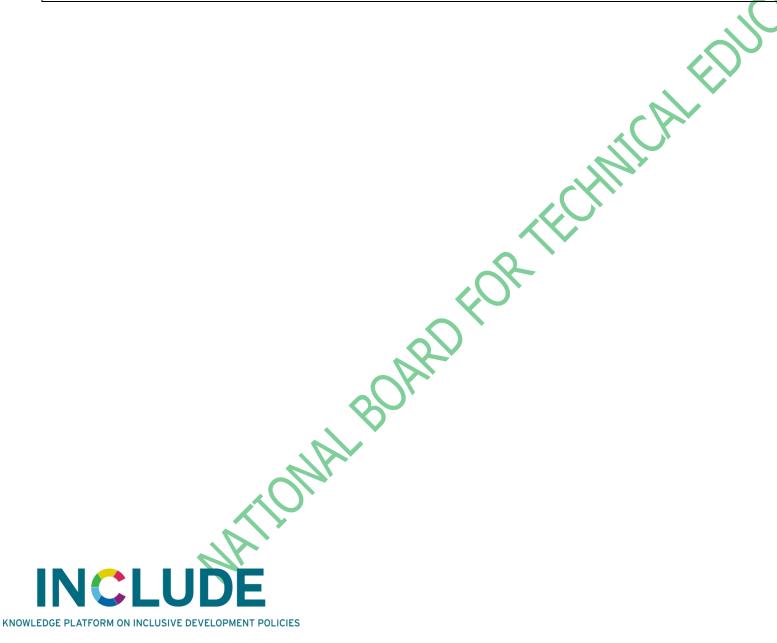


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FEDERAL GOVERNMENT OF NIGERIA

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 Practical: 2 Pre-requisite: NIL 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





-	AMME: HIGHER NATIO									
COURS	E TITLE : Solar Resource A	ssessment	COURSE CO		CONTACT HOURS:	: 3				
			CREDIT UN	IT: 3	THEORETICAL:	1				
YEAR:	I SEMESTER: I		PRE-REQU	ISITE: NIL	PRACTICAL:	2				
COURSE SPECIFICATION: THEORETICAL AND PRACTICAL										
GOAL:	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										
THEOR	ETICAL CONTENT			PRACTICAL CONTEN	Г					
WEEK	SPECIFIC LEARNING	TEACHER'S	RESOURCES	SPECIFIC LEARNING	TEACHER'S	RESOURCES				
	OUTCOME	ACTIVITIES		OUTCOME	ACTIVITIES					
1-3	1.1 Define solar	Explain the	Journals		Guide students to:	1. Sample Case				
	irradiance	concept of solar	Text books 🧳	Identify the types of solar	Identify the types	studies				
		irradiance	Whiteboard 🔨	irradiance (DNI, GHI,	of solar irradiance					
	1.2 Explain the following		Marker	DHI).	(DNI, GHI, DHI).	2. Charts				
	types of solar irradiance	Explain the	Internet							
	Direct Normal	following types of	Computer	Demonstrate how sunlight		3. Diagrams				
	Irradiance(DNI)	solar irradiance	Projector	is converted into	sunlight is					
	Global Horizontal			electricity and heat	converted into	4. Pyranometer				
	Irradiance(GHI)	Irradiance(DNI)			electricity and heat					
	• Diffuse Horizontal					5. Pyrheliometer				
	Irradiance(DHI)	Horizontal		Demonstrate how solar	Demonstrate how					
		Irradiance(GHI)		energy is measured with	solar energy is	6. Videos				
		• Diffuse		simple tools	measured with					
	1.3 Explain the relevance	Horizontal			simple tools	7. GPS				
	of each type of solar	Irradiance(DHI)		Maggura tomporatura 4:14	Measure	8 Magnetia				
	irradiant in 1.2 to energy			Measure temperature, tilt angle and irradiance as	temperature, tilt	8. Magnetic				
	systems.	Explain the		factors affecting solar	angle and	Compass				
		relevance of each		energy availability.	irradiance as	9. PV trainer				
	· / /	type of solar		energy availability.	maulance as	9. r v uaillei				



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	 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 	D F OR	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
		Explain solar				
GENER	AL OBJECTIVE 2.0: Knc	w how to interpret a	nd analyze solar e	nergy data		
4	2.1 Explain the sources of		Journals	inity and	Guide to students	1. Solar radiation
	solar energy irradiance	sources of solar	Textbooks	Select relevant solar	to:	datasets.
	data in relation to:	energy irradiance	Whiteboard	energy datasets	1. Select relevant	
J			1			L]





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





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<u> </u>						<u> </u>
		etc.			Solar energy	PVsyst
	3.2 Explain solar energy	F 1 ' 1			resources	•
	resource measurement	Explain solar		Generate site assessment	assessment	Anemometer
	tools such as:	energy resource		reports for solar energy		Manualia
	• Pyranometers	measurement tools		resources	2. Generate site	Magnetic
	• Pyrheliometers.	such as:			assessment reports	Compass
	• Magnetic	• Pyranometers			for solar energy resources	Inclinometer
	Compass	• Pyrheliometers			resources	mennometer
	• Inclinometer	• Magnetic				Measuring Tapes
	 Measuring Tapes 	Compass				wiedsuring Tapes
	• GPS, etc.	• Inclinometer				GPS
		• Measuring				015
		Tapes				17. Sample
		• GPS, etc.				feasibility
	3.3 Explain solar energy	F 1-1	X			reports.
	resource measurement	Explain solar				- I
	software	energy resource measurement				
		software				
	3.4 Explain the generation	sonware				
	of site assessment reports	Explain the	\sim			
	for solar energy resources	generation of site	N			
	using:	assessment reports				
	Tools	for solar energy				
	 Software 	resources using:				
	boltware	• Tools				
		Software				
GENER	AL OBJECTIVE 4.0: Eval		f Solar Energy Pro	ojects	1	
8-11	4.1 Explain the following		Journals		Guide to student to:	1. Sample of
	economic factors	following	Textbooks	Conduct economic		solar project data.
	affecting solar energy	economic factors	Whiteboard	analysis on solar energy	Conduct economic	1 5
	projects implementation:	affecting solar	Marker	projects such as:	analysis on solar	2. Calculators





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





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		•	•			
		Civilization			energy systems	
		• Infrastructure			with alternative	
					energy sources	
GENER	RAL OBJECTIVE 5.0: Und	erstand industrial stat	ndards in solar er	nergy resource assessment		
12	5.1 Explain industrial	Explain industrial	Journals			
	standards in solar energy	standards in solar	Textbooks		\sim	
	resource assessment	energy resource	Whiteboard			
		assessment	Marker			
			Internet			
	5.2 Explain the types of	Explain the types	Computer			
	industrial standards in	of industrial	Projector			
	solar energy resource	standards in solar		.07		
	assessment in relation to:	energy resource				
	Technical	assessment in				
	 Environment 	relation to:				
	• Social, etc.	Technical	^			
		Environme	0			
		nt				
	5.3 Explain international	• Social, etc.				
	standards for solar					
	energy resource	Explain	\mathbf{O}			
	assessment	international				
		standards for solar				
		energy resource				
	5.4 Explain practices in	assessment				
	system monitoring and					
	reporting.	Explain practices				
		in system				
		monitoring and				
		reporting.				





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





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ASSESSMENT: Continuous Assessment (CA): 60% Examination: 40% CHMICAI RECH -Contraction INCLU KNOWLEDGE PLATFORM ON INCLUSIVE DEVELOPMENT POLICIES



NBTE

402

Workshop Practice and Safety Procedure

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 kno Solar Energy System	wledge, skills of workshop of	perations and safety procedures
GENERAL OBJECTIVES: On completion of this course, the s	students should be able to:	
1.0 Know Workshop Safety and Protocols2.0 Know Risk Assessment and Accident Prevention		
3.0 Know Workshop Tools and Equipment		
4.0 Know Fabrication and Assembly Techniques		
5 1		
X		
MAL BOARD		



PROC	GRAMME: HIGHER NATIO	NAL DIPLOMA (HND)				OLOGY
COUI	RSE TITLE : Workshop Practice	e and Safety Procedure	COURSE COD	E: SPE 315	Contact Hours: 2	
			Credit Unit: 2		Theoretical: 1	
Year:	I Semester: I		Pre-requisite:		Practical: 1	
COUI	RSE SPECIFICATION: THEC	DRETICAL AND PRAC	1			
GOA	L: This course is designed to equ	up students with the kno	wledge, skills of v	vorkshop operations and	l safety procedures in S	olar Energy
System	• •	1		1 1		
GENI	ERAL OBJECTIVE 1.0: Know	w Workshop Safety and F	Protocols			
THEC	RETICAL CONTENT			PRACTICAL CONTI	ENT	
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
1-3	1.1 Define Hazards	Explain the concept of	Textbook		Guide Students to:	1. PPE Kits
		Hazards	Projector	Demonstrate the use		
	1.2 Explain the common		Journal	of PPE	1. Demonstrate the	2. First Aid
	causes of hazards	Explain the common	Computer		use of PPE	Kit
		causes of hazards	Marker	Demonstrate first aid		
	1.3 Explain common		Marker	procedures	2. Demonstrate first	3. Fire
	workshop hazards	Explain common	Board		aid procedures.	extinguishers
		workshop hazards	Safety	Demonstrate		
	1.4 Explain the methods of		Regulations	emergency response	3. Demonstrate	4. Safety
	preventing workshop	Explain the methods of		procedures	emergency response	signs
	hazard	preventing workshop			procedures.	
		hazard		Demonstrate the use		5. Fire
	1.5 Explain the importance of		c	of fire extinguisher	4. Demonstrate the	Alarm
	emergency response	Explain the importance	IO		use of fire	C Can 1
	procedures	emergency response			extinguisher.	6. Sand
	1 C Evaluia accumational	procedures				bucket
	1.6 Explain occupational					7 Eine
	health and safety (OHS)					7. Fire





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





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





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3.2 Exp material and Sola 3.3 Exp fabricati 3.4 Exp disasser the follo	lain assembling and nbling techniques for	 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 	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 	 Clamping Tools Measuring instruments Cutting Tools Drilling Tools Drilling Tools Hending Tools Pictorials Videos Clips
	Mounting structures Civil structure casting	 Mounting structures Civil structure casting 				Charts
General Object	ive 2.0: Know Worksh	op Tools and Equipment	1	1	1	<u> </u>
11-15 2.1 Defi	ine tools	Explain the concept of of tools and equipment	Textbook Projector	Identify the	Guide students to: 1. Identify the	1. hand held tools
	ine equipment lain the differences	Explain the differences	Journal Computer Marker	following hand-held tools: • Screwdrivers,	following hand-held tools: • Screwdrivers,	2.Equipment
	a tools and equipment	between tools and equipment	Marker Board	Screwdrivers,Hacksaws	Screwdrivers,Hacksaws	3. Maintenance





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	2.4 Explain the classification		Safety	• Spanners,	• Spanner	Kits
	of tools in renewable energy	Explain the classification	Regulations	• Drills, etc.	• Drills, etc.	
	workshop	of tools in renewable				4. Pictorials
		energy workshop		Draw and label the	Draw and label the	
	2.5 Explain the classification			following tools:	following:	5. Videos
	of equipment in renewable	Explain the classification		• Screwdrivers,	• Screwdrivers,	clips
	energy workshop	of equipment in renewable		Hacksaws	Hacksaws	
		energy workshop		• Spanners,	• Spanners,	6. Charts
	2.6 Explain the uses of tools			• Drills, etc.	• Drills, etc.	
	and equipment in renewable					7. Manuals
	energy workshop	Explain the uses of tools		Handle tools and	Handle tools and	
		and equipment in		equipment	equipment	
	2.7 Describe handling and	renewable energy		appropriately	appropriately	
	maintenance of tools and	workshop				
	equipment.	Evalsia headline and		Maintain tools and	Maintain tools and	
		Explain handling and maintenance of tools and		equipment	equipment	
			\circ	appropriately	appropriately	
		equipment.				
EVAL	UATION: CA 60%		J ·			
	INATION: 40%					
LAAN	1110A11010.40%					



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Smart Grids & IoT in PV System I

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 knowl	edge and skills of Smart Grids	and IoT in Solar PV System
GENERAL OBJECTIVES: On completion of this course, the s	tudents 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	CX V	
4.0 Know the fundamentals of Sensors and Actuators in IoT		
5.0 Know how to integrate IoT in PV Systems		
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al BON		
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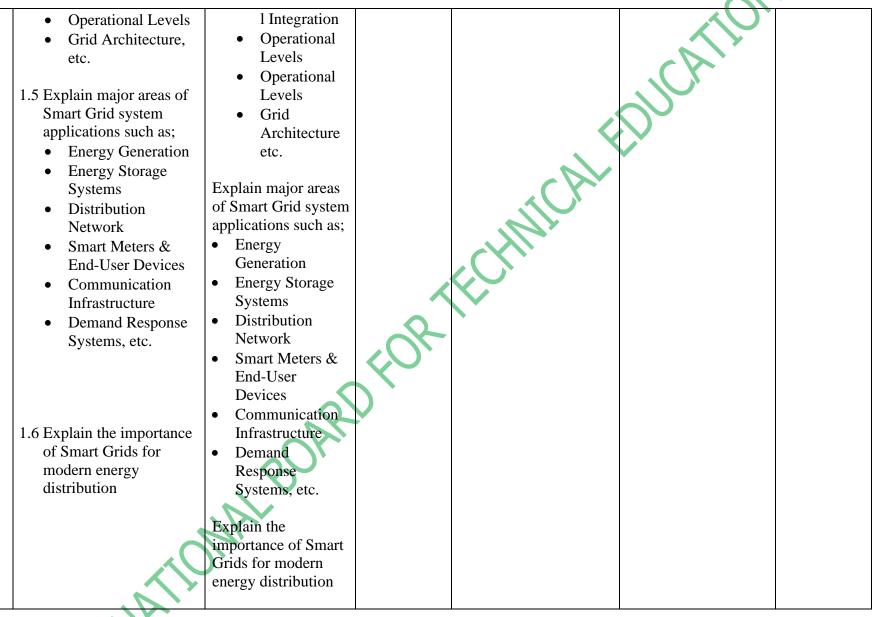


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	RAMME: HIGHER NATIO			OLTAIC (PV) ENG		GY
	SE TITLE: Smart Grids &	COURSE CODE: SP	E 316		Contact Hours: 2	
loT in	PV System I	Credit Unit: 1			Theoretical: 1	
Year:	1 Semester : 1	Pre-requisite: NIL			Practical: 1	
COUR	SE SPECIFICATION: THE	ORETICAL AND PRA	CTICAL			
GOAL	: The course is designed to en	able students acquire kr	owledge and s	kills of Smart Grids ar	nd IoT in Solar PV System	
GENE	RAL OBJECTIVE 1.0: Kno	w the concept of Smart	Grid			
THEO	RETICAL CONTENT			PRACTICAL CON	TENT	
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 	 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 	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	 Practical Manual Traditional Grid Models or Trainers Smart Grid Models or Trainers Videos Pictorials















						-
Genera	l Objective 2.0: Know how to	monitor, control, and a	utomate Smart	Grids		
3-6	2.1 Explain Smart Grid	Explain Smart Grid	Textbooks,		Guide the students to:	1. Practical
	Communication	Communication	Journals,	Monitor power	1. Monitor power	Manual
			Publications,	consumption by AC	consumption by AC	
	2.2 Explain the following	Explain the	Whiteboard,	loads using smart meter	loads using smart	
	smart grid	following smart grid	Marker,		meter	3. Smart
	communication	communication	Internet,			Meters
	protocols;	protocols;	Computer,	Control AC loads using	2. Control AC loads	
	• Zigbee,	• Zigbee,	Projector	smart circuit breaker	using smart circuit	3. Bulbs
	• MQTT,	• MQTT,			breaker	
	Modbus	Modbus				4. Tool box
				Automate the operation	3. Automate the	
	2.3 Explain following smart			of AC loads using smart	-	5. Cables
	grid systems:	Explain following		circuit breaker	using smart circuit	
	• Monitoring,	smart grid systems:			breaker	6. Smart
	• Control, and	Monitoring,				Beakers
	Automation	Control, and				7.0.
	systems.	Automation systems				7. Routers
						Q. Internet
	2.4 Explain the application	Explain the				8. Internet
	of Smart Grid	application of Smart				9. Android
	technologies for the	Grid technologies for				phone
	following :	the following :				phone
	 Demand response 	• Demand				
	management	response				
	• Fault detection and	management				
	self-healing in grids	• Fault				
	 Energy storage 	detection and				
	integration	self-healing				
	• Smart Meters &	in grids				
	End-User Devices	• Energy				





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





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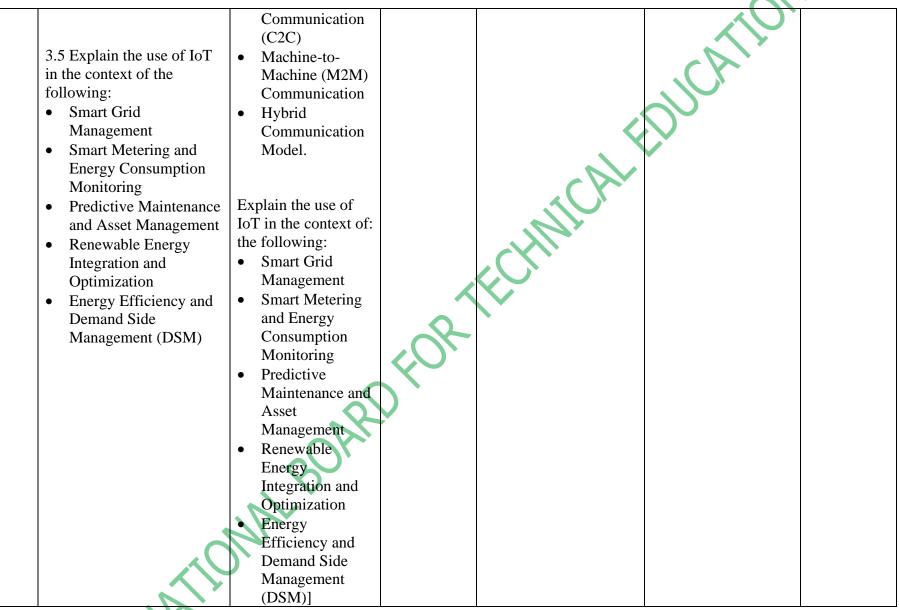
	Protocols		XU.	
	• Power Supply			
3.3 Explain the IoT				
architecture based on	Explain the IoT			
the following layers:	architecture based on			
	the following layers:			
Sensing Layer	• Sensing Layer			
• Network Layer	• Network Layer			
Middleware	• Middleware			
Application Layer	 Application 	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





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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 			DUCATIO	sensor. 14. Electromech anical Devices 15.Hydraulic /Pneumatic Devices 16. Solid- state devices 17. Smart Relays
General Objective 5.0: Know how to		ystems			
 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	 Practical Manual Smart Meters Bulbs Tool box Cables Smart Beakers Routers Internet







			FEDERAL GOVE
 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 InvertersExplain 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.	DUCATION	8. Data logger 9. Android phone 10. Software and PC
ASSESSMENT: Continuous Assessment (CA): 60% Examination: 40%	NAL-BOARD		
INCLUDE			



KNOWLEDGE PLATFORM ON INCLUSIVE DEVELOPMENT POLICIES



Energy Storage Technologies in Solar PV systems

COURSE TITLE: Energy Storage Technologies in	Course Code: SPE 317	Contact Hours: 3
Solar PV systems	Credit Unit: 3	Theoretical: 1
Year: 1 Semester:1	Pre-requisite: NIL	Practical: 2
GOAL: This course is designed to enable the students a	acquire basic knowledge and skill	ls in Energy Storage Technologies in Solar PV
systems		
GENERAL OBJECTIVES: On completion of this cou		
GENERAL OBJECTIVES : On completion of this could be a set of the	stem	
GENERAL OBJECTIVES: On completion of this cou	stem for PV system	



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Government of th	ne Netherlands					
					ATIO	
PROGR	AMME: HIGHER NAT	IONAL DIPLOMA SC	DLAR PHOTOV	OLTAIC (PV) ENGINEE	RING TECHNOLO	GY
COURS	E TITLE: ENERGY STO	RAGE TECHNOLOGI	ES COURSE C	ODE : 317	CONTACT HOUR	S: 3
IN SOLA	AR PV		CREDIT U	NIT: 3	THEORETICAL:	1
YEAR:	I SEMESTER: I		PRE-REQU	VISITE: NIL	PRACTICAL:	2
COURS	E SPECIFICATION: TH	HEORETICAL AND PH	RACTICAL			
systems	This course is designed to AL OBJECTIVE 1.0: Ki			dge and skills in Energy Stor	rage Technologies in	Solar PV
	ETICAL CONTENT			PRACTICAL CONTENT	Г	
WEEK	SPECIFIC LEARNING OUTCOME	TEACHER'S ACTIVITIES	RESOURCES	SPECIFIC LEARNING OUTCOME	TEACHER'S ACTIVITIES	RESOURCES
1-3	1.1 Explain Energy storage	Explain the concept of Energy storage	Journals Textbooks Whiteboard	Identify types of energy storage (batteries,	Guide students to identify types of energy storage	 Charts Batteries
	1.2 Explain the	Explain the	Marker	thermal, mechanical).	(batteries, thermal,	2. Datteries
	following different	following different	Internet	thormal, moonanicar).	mechanical).	3. Videos
	forms of storage	forms of storage	Computer		,	
	technologies	technologies	Projector			
	Battery Storage	Battery Storage				
	Thermal Storage	• Thermal Storage				
	Mechanical Storage	 Mechanical Storage 				
	1.3 Explain the form of	Explain the form of				
	Solar storage listed in	Solar storage listed in				
	1.2	1.2				







tech	Explain the nologies of the ous storage systems .3	Explain the technologies of the various storage systems in 1.3			WATE	
	Explain the	Explain the				
	ication of the	application of the				
	ous storage systems	various storage				
	4 for solar PV	systems in 1.4 for				
syste	ems.	solar PV systems.				
batte	Explain the types of ery technologies in r PV.	Explain the types of battery technologies		CCHM1		
		in solar PV.				
	State the various					
	ications of the	Explain the various		r		
	eries listed in 1.4 in	applications of				
	tion to:	batteries listed in				
• H	Electric vehicle	relation to 1.4:	\mathbf{O}			
• F	Phones	Electric vehicle				
• I	Laptops etc.	Phones	C			
		Laptops etc				
GENERAL O	BJECTIVE 2.0: Kn	ow design and mainten	ance of Storage So	olutions for PV system		
	Explain the types of	Explain the types of	Journals			
batte	eries base on	batteries base on	Textbooks			
tech	nology	technology	Whiteboard			
			Marker			
	Explain the	Explain the operation	Internet			
-	ation of the	of the following	Computer			
follo	owing types of	types of batteries:	Projector			





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						NIGER
	 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 	 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 	R		JUATO	
	storage system	storage system				
GENER	AL OBJECTIVE 3.0: Kn	now sustainable strategie	es for extending b	attery 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.	 Sustainability reports on battery life cycle Government policies on solar waste







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3.2 Explain sustainable	Explain sustainable			3. Case studies
practice to reduce	practice to reduce			on battery
battery waste	battery waste			
3.3 Explain circular	Explain circular			
economy concept in	economy concept in		\sim	
battery	battery			
3.4 Explain how 3.3 can	Explain how 3.3 can			
improve solar PV	improve solar PV			
installation efficiency	installation efficiency			
in:	in:			
Residential	• Residential			
Industrial	Industrial			
• Hospitals, etc.	• Hospitals, etc.			
3.5 Explain the	Explain the	0		
importance of circular	importance of			
economy over the	circular economy			
traditional methods of	over the traditional			
battery management	methods of battery	\mathbf{O}		
	management			
3.6 Explain battery				
management system	Explain battery	•		
	management system			
3.7 Explain the use of				
battery management	Explain the use of			
system to enhance	battery management			
battery performance	system to enhance			
×	battery performance			

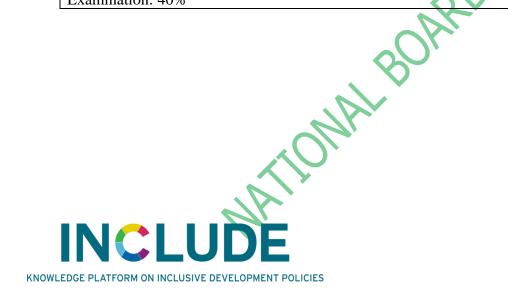




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GENER	AL OBJECTIVE 4.0: U	nderstand recycling met	hods, policies, and	l environmental impact of P	V storage systems.	
12-15	4.1 Explain battery	Explain the concept	Journals			
	recycling	of battery recycling	Textbooks			
			Whiteboard			
	4.2 Explain the methods	Explain the methods	Marker			
	of recycling battery in	of recycling battery	Internet		\sim	
	solar PV system	in solar PV system	Computer		$\mathbf{\vee}$	
			Projector			
	4.3 Explain the	Explain the recycling				
	recycling policies for	policies for Solar PV				
	Solar PV battery system	battery system				
	4.4 Explain	Explain		CX V		
	environmental, social,	environmental,				
	and economic impacts	social, and economic				
	of battery storage	impacts of battery				
	system	storage				
		C				
ASSESS	MENT:			······································		•
	ous Assessment (CA): 60%		\sim			
	tion: 40%		\mathbf{v}			
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PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY

COURSE TITLE: Modelling and Simulation of Solar	COURSE CODE: SPE 318	CONTACT HOURS: 2	
PV Systems	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			COURSE CODE: SPE 318		ONTACT HOURS: 2			
Systems		CREDIT UNIT: 2 T		THEORETICAL: 1				
YEAR:	I SEMESTER: I		PRE-REQUISIT	E: PRA	CTICAL: 1			
COURSI	E SPECIFICATION: THE	ORETICAL AND PRACT	TICAL		J			
GOAL:	This course is designed to en	able students acquire basic	knowledge and s	kills in Modelling and Sim	lation of Solar PV Syst	ems		
GENER	AL OBJECTIVE 1.0: Knov	w the principles of designing	ng Solar PV Syst	em				
THEOR	ETICAL CONTENT			PRACTICAL CONTEN	Г			
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 	 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 	Journals Internet Computer Projector White Board Marker Animations Charts	Design the layout of a basis solar PV system Assess the factors influencing solar PV syste design Calculate to determine the appropriate sizing of components like collectors storage tanks, and heat exchangers based on syste demands and design parameters.	 Guide students to; C 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 	 Computer Calculator Sample layout design Design software (AutoCAD) 		





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





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dovernment of the rectlemands				4	FEDERAL GOVERNMENT OF
 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	3. Input system parameters and environmental data into simulation	
ASSESSMENT: Continuous Assessment (CA): 60% Examination: 40%		FOR		generated outputs and simulation graphs	
	ONAL BOAR				
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YEAR ONE SEMESTER TWO

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Power Electronics

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY

Course Title: I	Power Electronics	Contact Hours: 3							
		Contact Unit: 3	Theoretical: 1						
Year: 1	Semester: II	Pre-requisite: SPE 311	Practical: 2						
Goal: The Cour	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	1.0 Understand the concept of power electronics and it applications								
2.0 Know the c	2.0 Know the concept of power diodes and switched RLC Circuits								
3.0 Know diode	3.0 Know diode rectifier and its applications								
4.0 Know the b	4.0 Know the basic concept of Power Transistor and its applications								
5.0 Know the c	5.0 Know the concept of DC-DC converters								
6.0 Know the c	6.0 Know the concept of DC-AC converters								



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PROGR	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: Th	ne Course is designed to acc	quaint the students with Kno	owledge and Sk	tills of Power electronics			
	Specification: Theoretical (Practical Content			
		the concept of power electronic e	ronics and it ap			-	
Week	Specific Learning	Teacher's activities	Resources	Specific Learning	Teacher's activities	Resources	
	Outcomes			Outcomes			
	1.1 Describe power	Explain the concept	Whiteboard				
1-2	Electronics.	power Electronics.	Textbooks				
			Internet				
	1.2 List applications of	Explain the applications	Computer				
	power electronics	of power electronics	Projector				
	1.2 List major types of	Evaluin major types of	Marker				
	1.3 List major types of power electronics	Explain major types of power electronics					
	Equipment	Equipment					
	Equipment	Equipment					
	1.4 List the major parts	Explain the major parts	K V				
	of power electronics	of power electronics					
	Equipment.	Equipment.					
	1.5 List the	Explain the					
	characteristics of	characteristics of power					
	power electronic	electronics switching					
	switching devices	devices					
	1.6 List the	Explain the					
	characteristics and	characteristics and					
	specifications of	specifications of					
	practical power	practical power					





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





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 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 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. Steady state capacitor voltage of an RLC circuit and amount of stored energy. The initial di/dt and dv/dt of RLC circuits	08-14	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		nd its application	on		
	xplain the types of	Whiteboard	Simulate the performance	Guide students to:	1. Practical
5-7 diode rectifiers, their die	ode rectifier, their	Textbooks	of diode rectifiers	Simulate the	manual
advantages and ad	vantages and	Internet		performance of	
, j	sadvantages	Computer	Evaluate the performance	diode rectifier	2. Computers,
	-	Projector	of diode rectifiers		-
Ex	xplain the operation	Marker		Evaluate the	3. simulation



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3.2. Explain the	and characteristics of		Determine the Fourier	performance of	software
operation and	diode rectifiers.		components of rectifiers	diode rectifier	
characteristics of diode			outputs.		
rectifiers.				Determine the	
	Explain how to calculate		Calculate the performance	Fourier	
3.3 Explain how to	the performance		parameters of diode	components of	
calculate the	parameters of diode		rectifiers	rectifier outputs.	
performance parameters	rectifiers				
of diode rectifiers			Design diode rectifier	Calculate the	
			circuits.	performance 1.1.	
	Explain the design of		Determine the effects of	1. parameters of	
3.4 Explain the design	diode rectifier circuits.		load inductance on load	diode rectifiers	
of diode rectifier			current.		
circuits.			CX V	2. Design diode	
	Explain the design		Design output side filter for	rectifier circuits.	
3.5. Explain the design	output side filter for		diode rectifiers.		
output side filter for	diode rectifiers.			3. Determine the	
diode rectifiers.			Determine the effects of	effects of load	
	Explain the effects of		source inductance on the	inductance on load	
3.6 Explain the effects	load inductance on load		rectifier output voltage.	current.	
of load inductance on	current				
load current.					
	Explain the effects of			4. Design output	
3.7. Explain the effects	source inductance on the			side filter for diode	
of source inductance on	rectifier output voltage.			rectifiers.	
the rectifier output					
voltage.				5. Determine the	
				effects of source	
	\sim			inductance on the	
∠ (rectifier output	
				voltage.	
		1			1







	al Objective 4: Know the bas 4.1. List the	Explain the	Whiteboard	Measure the gate drive	Guide students to:	1. Practical
10	characteristics of an	characteristics of an	Textbooks	characteristics for the	1. Measure the gate	manual
	ideal transistor switch	ideal transistor switch	Internet	following types of	drive	
			Computer	transistors:	characteristics for	2. Power ele1
	4.2 Describe the	Explain the switching	Projector	• BJT	the following types	ctronics
	switching characteristics	characteristics of the	Marker	MOSFETs	of transistors:	trainer,
	the following power	following types of		• IGBTs	• BJT	
	transistors:	power transistors:			 MOSFETs 	3.
	• BJT	• BJT		C V	• IGBTs	Oscilloscope
	MOSFETs	 MOSFETs 		Calculate the gate drive		
	COOLMOS	COOLMOS		characteristics and	Calculate the gate	4. Multi-
	• IGBTs	• IGBTs		requirements of the	drive	meter,
	• SITs	• SITs		following types of	characteristics and	
				transistor:	requirements of the	5. Clamp
	4.3 Describe the			✓ BJT	following types of	meter,
	limitation of each of the		\circ	MOSFETs	transistor::	
	transistor in 4.2 above as	Explain the limitation of		• IGBTs	• BJT	6. Signal
	a switch	each of the transistor in			 MOSFETs 	generator,
		4.2 above as a switch			• IGBTs	7 0
	4.4 Describe the gate		•			7. Power
	control requirement and				Design di/dt	supply BJT
	models of power	Explain the gate control		Design di/dt protection	protection circuits	DII
	transistors	requirement and models		circuits for transistors.	for transistors.	8. MOSFET
		of power transistors				$0.\mathbf{WOSPET}$
	4.5 Explain the design					9. IGBTs
	of di/dt protection					<i>9</i> . IOD15
	circuits for transistors.	Explain the design of				10.
		di/dt protection circuits				Breadboard
	4.6 Describe the	for transistors.				Dicadoodiu
	arrangements for					
	operating transistors in					





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	series and parallel	Explain the				
		arrangements for				
	4.7 Explain the	operating transistors in				
	calculation of the gate	series and parallel				
	drive characteristics and	-				
	requirements of	Explain the calculation				
	• BJT	of the gate drive				
	MOSFETs	characteristics and				
	IGBTs	requirements of				
	• 10013	• BJT				
	4.8 Describe the	MOSFETs		MCALED		
	isolation techniques	 IGBTs 				
	between the high-level	• 10013				
	power circuit and the					
	low-level gate drive	Explain the isolation				
	circuit.	techniques between the				
	cheun.	high-level power circuit				
		and the low-level gate				
		drive circuit.				
Conoral	Objective 5. Know the co	ncept of DC-DC converters				
General	5.1. Describe the DC-	Explain the concept of	Whiteboard	Simulate the performance	Guide students to:	1. Practical
11-13	DC conversion	DC-DC conversion	Textbooks	parameters of DC-DC	Oulde students to.	nanual
11-15	DC conversion	DC-DC conversion		Converters	1. Simulate the	manual
	5.2 Describe the	Evaluin the switching	Internet	Conventers		2 Computors
		Explain the switching	Computer		performance	2. Computers,
	switching technique for DC-DC conversion:	technique for DC-DC conversion:	Projector Marker	Measure the performance	parameters of DC- DC Converters	3. Simulation
	DC-DC conversion:	conversion.	IVIAIKEI	parameters of DC-DC	De Converters	software
				Converters	2. Measure the	sonware
	5.2 List the types of DC			Converters		4. Power
	5.3 List the types of DC- DC converters	Evaluin types of DC			performance	4. Power electronics
	DC converters	Explain types of DC- DC converters			parameters of DC- DC Converters	
		-DC converters			DC Converters	trainer,





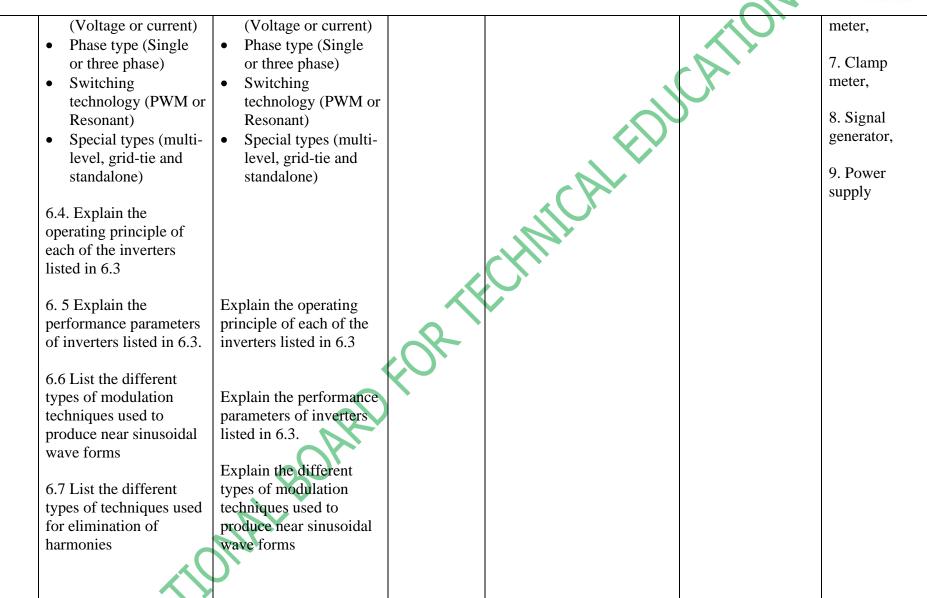


of DC-DC converters listed in 5.3converters listed in 5.3converters listed in 5.35.5 List the performance parameters of DC-DC converters listed in 5.3.Explain the performance parameters of DC-DC converters listed in 5.3.Explain the performance parameters of DC-DC converters listed in 5.3.6. Mu meter.5.6 Explain the design of DC-DC converter systemsExplain the design of DC-DC converter systems8. Sig general6.4 Mu meter.14-156.1. Describe DC-AC conversionExplain DC-AC conversionWhiteboard Textbooks InternetSimulate the performance parameters of inverters.14-156.1. Describe DC-AC conversionExplain DC-AC conversionWhiteboard Textbooks InternetSimulate the performance parameters of inverters.Guide students to: 1. Simulate the performance	
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Isted in 5.3Explain the performance parameters of DC-DC converters listed in 5.3.Explain the performance parameters of DC-DC converters listed in 5.3.Explain the performance parameters of DC-DC converters listed in 5.3.6. Mu meter.5.6 Explain the design of DC-DC converter systemsExplain the design of DC-DC converter systems8. Sig general6. Mu meter.Explain the design of DC-DC converter systems9. Pov supply6. Au meter.8. Sig general14-156.1. Describe DC-AC conversionExplain DC-AC conversion6. 2. Describe the switching technique for DC-AC conversion (Inverter)Explain the switching technique for DC-AC conversion (Inverter)6. 2. Describe the switching technique for DC-AC conversion (Inverter)Explain the switching technique for DC-AC conversion (Inverter)6. 2. Describe the switching technique for DC-AC conversion (Inverter)Explain the switching technique for DC-AC conversion (Inverter)6. 2. Describe the switching technique for DC-AC conversion (Inverter)Explain the switching technique for DC-AC conversion (Inverter)6. 2. Describe the switching technique for DC-AC conversion (Inverter)Explain the switching technique for DC-AC conversion (Inverter)7. Cla MarkerMarker7. Cla Simulate the performance parameters of inverters8. Sig DC-AC conversion (Inverter)9. Develop DC-AC conversion (Inverter)9. Develop DC-AC conversion (Inverter)9. Develop DC-AC conversion (Inverter) </td <td>oscope,</td>	oscope,
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5.5 List the performance parameters of DC-DC converters listed in 5.3.Explain the performance parameters of DC-DC converters listed in 5.3.Explain the performance parameters of DC-DC converters listed in 5.3.7. Cla meter5.6 Explain the design of DC-DC converter systemsExplain the design of DC-DC converter systemsExplain the design of DC-DC converter systems8. Sig general14-156.1. Describe DC-AC conversionExplain DC-AC converters conversionWhiteboard Textbooks InternetSimulate the performance parameters of inverters.Guide students to: 1. Simulate the performance parameters of 1. Simulate the performance parameters of inverters1. Pra a manual performance parameters of inverters2. Conversion	ti-
parameters of DC-DC converters listed in 5.3.parameters of DC-DC converters listed in 5.3.parameters of DC-DC converters listed in 5.3.7. Cla meter.5.6 Explain the design of DC-DC converter systemsExplain the design of DC-DC converter systemsExplain the design of DC-DC converter systems8. Sig general6.1. Describe DC-AC conversionExplain DC-AC convertersSimulate the performance parameters of inverters.Guide students to: 1. Simulate the performance parameters of inverters1. Pra manuary14-156.1. Describe DC-AC conversionExplain the switching technique for DC-AC conversion (Inverter)Whiteboard Textbooks Internet ProjectorSimulate the performance parameters of invertersGuide students to: 1. Simulate the performance parameters of inverters1. Pra manuary6.2 Describe the switching technique for DC-AC conversion (Inverter)Explain the switching technique for DC-AC conversion (Inverter)MarkerMeasure the performance parameters of invertersSimulate the performance parameters of inverters2. Con simulate	
General Objective 6: Know the concept of DC-AC converters14-156.1. Describe DC-AC conversionExplain DC-AC conversionWhiteboard Textbooks InternetSimulate the performance parameters of inverters.Guide students to: 1. Simulate the performance parameters of inverters6.2 Describe the switching technique for DC-AC conversion(Inverter)Explain the switching technique for DC-AC conversion (Inverter)Computer Projector MarkerMeasure the performance parameters of invertersGuide students to: 1. Simulate the parameters of inverters2. Measure the simulate	
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DC-AC conversion (Inverter) Marker parameters of inverters 2. Measure the simula	nputers,
DC-AC conversion(Inverter)conversion (Inverter)Markerparameters of inverters3. Spi simula2. Measure the	•
	ces
norformanaa aaftuu	tion
performance softwa	ire
parameters of	
6.3 Describe the types of Explain the types of 4. Pow	/er
inverters in the inverters in the electro	onics
following categories following categories trained	•
based on: based on:	
Output waveform Output waveform 5.	
	oscope,
pure sine wave) pure sine wave)	± ·
• Operation method • Operation method 6. Mu	ti-



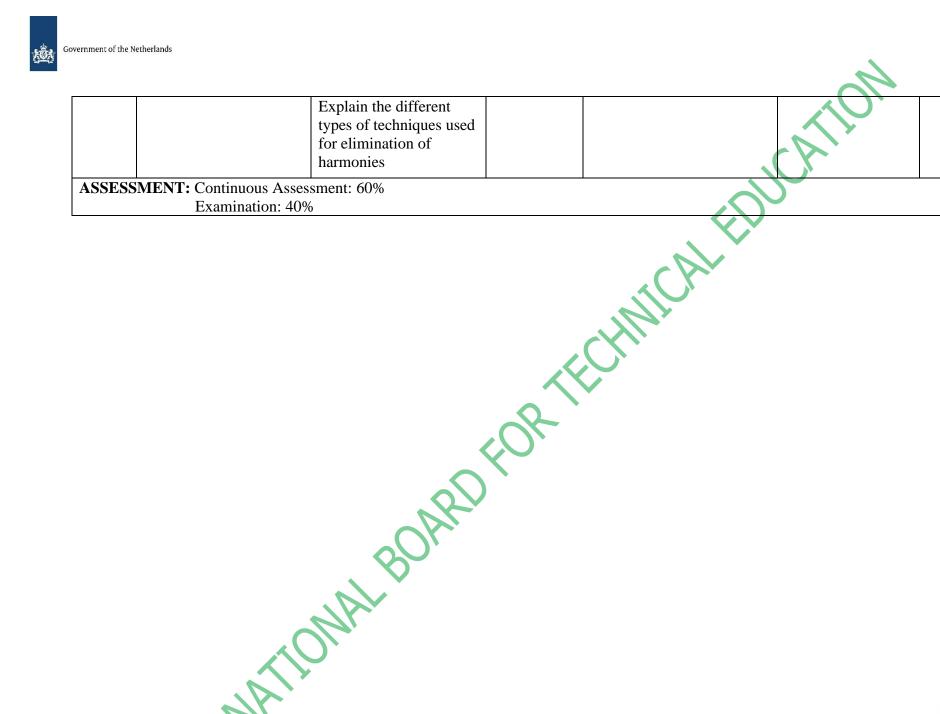














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KNOWLEDGE PLATFORM ON INCLUSIVE DEVELOPMENT POLICIES

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Techno-Economi	c analysi	s tor	Solar	\mathbf{PV}	System
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PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY

COURSE TITLE: Techno-Economic analysis for	Course Code: SPE 322	Contact Hours: 2
Solar PV System	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.





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RAMME: HIGHER NATIO	NAL DIPLOMA SOLA	R PHOTOVO	LTAIC (PV) ENGINI	CERING TECHNOI	LOGY
		Credit Unit:	2	Theoretical: 1	
I Semester: I		Pre-requisite	:	Practical: 1	
E SPECIFICATION : THEO	ORETICAL AND PRACT	ΓICAL			
This course is design to provi	de students with knowled	ge and skills of	techno-economic analy	yses for solar PV syst	ems
ETICAL CONTENT			PRACTICAL CONTR	ENT	
Specific Learning	Teacher's Activities	Resources	Specific Learning	Teacher's	Resources
Outcome			Outcome	Activities	
1.1 Explain solar PV	Explain solar PV	Whiteboard	Perform	Guide the student	Software:
	0.			s to:	HOMER,
trends.	trends.		1	•	ODYSIS
	X	1	e		
1			system	1	
		5		-	
				kW system	
1			1	2.14	
for PV systems	for PV systems		1	1	
	Explain the following		project		
1.3 Explain the following				in a sample project	
	,				
 Developers 	 Regulators 				
	 AMME: HIGHER NATIO E TITLE: Techno-Economic Semester: I E SPECIFICATION: THEO This course is design to provi AL OBJECTIVE 1.0: Know ETICAL CONTENT Specific Learning Outcome 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, 	EAMME: HIGHER NATIONAL DIPLOMA SOLA E TITLE: Techno-Economic analysis for Solar PV Semester: I E SPECIFICATION: THEORETICAL AND PRACT This course is design to provide students with knowled AL OBJECTIVE 1.0: Know the technical and econom ETICAL CONTENT Specific Learning Outcome 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,	COURSE COURSE C COURSE C Course is clean provide students with knowledge and skills of Semester: I Pre-requisite SPECIFICATION: THEORETICAL AND PRACTICAL This course is design to provide students with knowledge and skills of AL OBJECTIVE 1.0: Know the technical and economic aspects of sc ETICAL CONTENT Specific Learning Teacher's Activities Outcome Teacher's Activities 1.1 Explain solar PV Explain solar PV technology and market technology and market trends. Computer 1.2 Describe Capital Explain Describe Expenditure (CAPEX) / Capital Expenditure Operational Explain the following Explain the following Key stakeholders in Solar PV Market: ODYSIS etc. • Utilities, ODYSIS etc.	CAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGRAL E TITLE: Techno-Economic analysis for Solar PV COURSE CODE: 322 Credit Unit: 2 Credit Unit: 2 Semester: 1 Pre-requisite: FSPECIFICATION: THEORETICAL AND PRACTICAL This course is design to provide students with knowledge and skills of techno-economic analy AL OBJECTIVE 1.0: Know the technical and economic aspects of solar PV system deployn PRACTICAL CONTENT Specific Learning Outcome 1.1 Explain solar PV Explain solar PV technology and market Resources Specific Learning Outcome 1.1 Explain solar PV Explain solar PV Whiteboard Perform Capital Explain Describe Commuter Market Solar PV systems For PV systems Journals Internet Mag stakeholder's roles in a sample project 1.2 Describe Capital Expenditure (OPEX) for PV systems Explain the following key stakeholders in Solar PV Market: Solar PV Systems Solar PV Market: ODYSIS etc. Mag stakeholde	CAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOI E TITLE: Techno-Economic analysis for Solar PV E TITLE: Techno-Economic analysis for Solar PV COURSE CODE: 322 Contact Hours: 2 Semester: I Pre-requisite: Practical: 1 E SPECIFICATION: THEORETICAL AND PRACTICAL Pre-requisite: Practical: 1 E SPECIFICAL CONTENT Pre-requisite: Practical: 1 Specific Learning Outcome Teacher's Activitics Resources: Specific Learning Outcome Teacher's 1.1 Explain solar PV technology and market trends. Explain Describe Projector Perform Guide the student s to: 1.2 Describe Capital Expenditure (OPEX) for PV systems Explain Describe Projector Map stakcholder's roles in a sample 2. Map stakcholder's roles in a sample 2. Map stakcholder's roles in a sample project 1.3 Explain the following key stakeholders in Solar PV Market: Solar PV Market: Solar PV Market: ODYSIS etc. 2. Map 9 Utilities, Evelopers Evelope







						-
	• Regulators	• Communities				
	• Communities	Financial institutions				
	• Financial institutions					
	etc.					
Genera	l Objective 2.0: Know present	ation of financial modelin	Ig			
	2.1 Define Levelized cost	Explain the concept of	Whiteboard		Guide students to:	1.
	of energy (LCOE) and its	Levelized cost of	Lecture	Perform LCOE		Spreadsheets
4-7	calculation.	energy (LCOE) and its	notes	calculations	1. Perform LCOE	
		calculation.	Computer		calculations	2. Software
	2.2 Explain the NPV/IRR		Marker	Perform NPV/IRR		
	for feasibility.	Explain the NPV/IRR	Projector	calculation	2. Perform	3.
		for feasibility.	Journals	<i>.O</i> [×]	NPV/IRR	Calculators
			Internet	Build financial	calculation	
	2.3 Describe the following		Textbooks	models with		
	Assess risk factors:	Explain the following		appropriate software	3. Build financial	
	Policy	Assess risk factors:		tools	models with	
	Technical	Policy,	\circ		appropriate	
		Technical			software tools	
	2.4 Explain financing		\mathbf{O}^*			
	options in financing Solar	Explain financing				
	Projects	options in financing				
		Solar data Projects				
	2.5 Explain the use of					
	financial models in	Explain the use of				
	evaluating business	financial models in				
	decisions	evaluating business				
		decisions				
	2.6 Explain financial					
	statement analysis	Explain financial				
		statement analysis				





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





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				Load profile etc.	Policies	
					compliance	
					checklist	
					Load profile etc.	
General	Objective 5.0: Know risks as	sessment, incentives, and	policy impacts	on solar PV investment	ts	
14-15	5.1 Explain the key risk	Explain the key risk			Guide the student	5. Computer
	assessments associated	assessments associated			to:	_
	with Solar investments.	with Solar investments.		Perform the SWOT	1. Perform the	6. Marker
	Operational risk	Operational risk		analysis on an	SWOT analysis on	
	Technical risk	Technical risk		existing Nigeria solar	an existing Nigeria	7. Projector
	• Financial risk, etc.	• Financial risk, etc.		project	solar project	
		,				8. Journals
		Explain the		Analyse a failed	Analyse a failed	
	5.2 Explain the	effectiveness of		solar projects and	solar projects and	9. Internet
	effectiveness of financial	financial and		present key lessons	present key	
	and regulatory incentives	regulatory incentives			lessons	10.
	for Solar projects	for Solar projects	0			Textbooks
		Explain the impact of				
	5.3 Explain the impact of	Government policies				
	Government policies on	on Solar energy				
	Solar energy adoption	adoption				
ASSES	SMENT: Continuous Assess					
	Examination: 40%					





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Solar PV System Configuration

	Solar PV System Configuration	
PROGRAMME: HIGHER NATIONAL DIPLOMA		
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 S	Solar PV System Configuration
GENERAL OBJECTIVES: On completion of this course	rse, the students should be able to:	
1.0 Know various grid system configurations		, ,
2.0 Know Mini-grid system configurations	CX	
3.0 Know Off-grid system configurations		
4.0 Know Hybrid system configurations	\sim	
5.0 Know Grid tied system configurations		
	\circ	
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Government of th	ne Netherlands					FEDERAL GOVERNMENT
					10	NIGERIA
				AIC (PV) ENGINEERING		
COURS	E TITLE: Solar PV System	Configuration	COURSE CODE		TACT HOURS: 3	
			CREDIT UNIT:		ORETICAL: 1	
YEAR:			PRE-REQUISIT	TE: NIL PRA	CTICAL: 2	
	E SPECIFICATION: THE				a	
				tills in Solar PV System Cont	figuration	
	AL OBJECTIVE 1.0: Kno	w various solar PV grid sy	ystem configuratio		-	
THEOR	RETICAL 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 	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







CENED	AL ODIECTIVE 2 0. Know	u Solar DV Mini and avet	om configurations			
GENEK	AL OBJECTIVE 2.0: Knov					
1.0	2.1 Explain Solar PV	Explain Solar PV Mini-	Journals		Guide students to:	Charts
4-6	Mini-grid system	grid system	Textbooks	Identify the components of	Identify the	
			Whiteboard	Solar PV Mini-Grid	components of	
			Marker		Solar PV Mini-	
	2.2 Explain the	Explain the component	Internet		Grid	
	component of Solar PV	of Solar PV of Solar PV	Computer			
	mini-grid system	mini-grid system	Projector	Identify the various types	Identify the various	
				of Solar PV mini-grid	types of Solar PV	
	2.3 Explain the effective	Explain the effective		system	mini-grid system	
	steps in Solar PV mini-	steps in Solar PV mini-				
	grid design project	grid design project				
	2.4 List maintenance	Explain maintenance				
	operations in Solar PV	operations in Solar PV				
	mini-grid operations	mini-grid operations				
	2.5 Explain the various	Explain the various				
	types of Solar PV mini-	types of Solar PV mini-				
	grid system:	grid system:				
	Interconnected mini-	• Interconnected				
	grid	mini-grid				
	• Community mini-grid	• Community mini-				
	etc.	grid etc.				
GENER	AL OBJECTIVE 3.0: Knov	U	n configurations			
7-10	3.1 Explain the	Explain the component	Journals		Guide students to:	Charts
-	component of Solar PV	of Solar PV Off-grid	Textbooks	Identify the components of	Identify the	
	Off-grid system	system	Whiteboard	Solar PV Off-grid system	components of	
			Marker		Solar PV Off-grid	
	3.2 Explain the effective	Explain the effective	Internet		system	
	steps in Solar PV Off-grid		Computer		~j ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~	
	design project	grid design project	Projector			
	- acorga project	Brie dougn project	110,00001		1	l







		1				
	3.3 List maintenance	Explain maintenance		Identify the various types of Solar PV Off-grid	Identify the various types of Solar PV	
	operations in Solar PV	operations in Solar PV		0	Off-grid system	
	1	1		system	On-grid system	
	Off-grid operations	Off-grid operations				
	3.4 Explain the various	Explain the various				
	types of Solar PV Off-	types of Solar PV Off-				
	grid system	grid system				
GENER	AL OBJECTIVE 4.0: Kno	w Hybrid system configur	ations			
11-13	4.1 Explain the	Explain the component	Journals		Guide students to:	Charts
	component of Solar PV	of Solar PV	Textbooks	Identify the components of	Identify the	
	• Hybrid system	• Hybrid system	Whiteboard	Solar PV Hybrid system	components of	
	PV/Wind	PV/Wind	Marker		Solar PV Hybrid	
	 PV/Biomass 	 PV/Biomass 	Internet		system	
	 PV/Hydro power etc. 	PV/Hydro power etc	Computer			
	• F V/Hydro power etc.	Explain the various	Projector	Identify the various types	Identify the various	
	4.2 E-mlain the services	types of Hybrid system	Tiojector	of Solar PV Hybrid system	types of Solar PV	
	4.2 Explain the various				Hybrid system	
	types of Hybrid system	• PV/Wind			myond system	
	PV/Wind	PV/Biomass				
	PV/Biomass	PV/Hydro power				
	• PV/Hydro power etc.	etc.				
		Explain the effective				
	4.3 Explain the effective	steps of Hybrid system				
	steps of Hybrid system	design project				
	design project					
	6- F- J					
		Explain maintenance				
	4.4 List maintenance	operations in Hybrid				
	operations in Hybrid	system operations				
	system operations	-				
		1	1	1	1	





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AL OBJECTIVE 5.0: Kno			Т		
					Charts
Grid fied system	system		Grid tied system	-	
5.2 Emploin the annious				Grid tied system	
	-		Lindifie the manipus terms	Identify the merions	
types of Grid fied system					
	system	Projector	of Grid fied system		
5.3 Explain the effective	Explain the effective			system	
	system design project				
5.4 List maintenance	Explain maintenance				
operations in Grid tied	operations in Grid tied				
system operations	system operations				
		$\langle O \rangle$			
		X			
tion: 40%		·			
	Y				
	 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 	5.1 Explain the component of Solar PV Grid tied systemExplain the component of Solar PV Grid tied system5.2 Explain the various types of Grid tied systemExplain the various types of Grid tied system5.3 Explain the effective steps of Grid tied system design projectExplain the effective steps of Grid tied system5.4 List maintenance operations in Grid tied system operationsExplain maintenance operations in Grid tied system operationsMENT: pus Assessment (CA): 60%MENT:	5.1 Explain the component of Solar PV Grid tied systemExplain the component of Solar PV Grid tied systemJournals Textbooks Whiteboard Marker5.2 Explain the various types of Grid tied systemExplain the various types of Grid tied systemInternet Computer Projector5.3 Explain the effective steps of Grid tied system design projectExplain the effective steps of Grid tied system design projectExplain the effective steps of Grid tied system design project5.4 List maintenance operations in Grid tied system operationsExplain maintenance operationsExplain maintenance operationsMENT: pus Assessment (CA): 60%Explain the effective steps of CA): 60%Explain the effective steps of CA):Explain maintenance operations	5.1 Explain the component of Solar PV Grid tied systemExplain the component of Solar PV Grid tied systemJournals TextbooksIdentify the components of Grid tied system5.2 Explain the various types of Grid tied systemExplain the various types of Grid tied systemIdentify the components of Grid tied systemIdentify the components of Grid tied system5.3 Explain the effective steps of Grid tied systemExplain the effective steps of Grid tied systemExplain the effective steps of Grid tied systemIdentify the various types of Grid tied system5.4 List maintenance operations in Grid tied system operationsExplain maintenance operationsExplain maintenance operationsIdentify the various types of Grid tied systemMENT: mus Assessment (CA): 60%Explain the componentIdentify the various types tied systemIdentify the various types of Grid tied system	5.1 Explain the component of Solar PV Grid tied systemExplain the component of Solar PV Grid tied systemJournals Textbooks Whiteboard MarkerIdentify the components of Grid tied systemGuide students to: Identify the components of Grid tied system5.2 Explain the various types of Grid tied systemExplain the various types of Grid tied systemInternet Computer ProjectorIdentify the various types of Grid tied systemIdentify the various types of Grid tied system5.3 Explain the effective steps of Grid tied system design projectExplain the effective steps of Grid tied system design projectExplain the effective steps of Grid tied system operationsExplain maintenance operations in Grid tied system operationsExplain maintenance operationsIdentify the various types of Grid tied systemIdentify the various types of Grid tied systemMENT: mus Assessment (CA): 60%Explain the component of Grid tied systemIdentify the various types of Grid tied systemIdentify the various types of Grid tied system





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.

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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



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PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PV ENGINEERING TECHNOLOGY COURSE TITLE: Research Methodology in Solar PV COURSE CODE: SPE 324 CONTACT HOURS: 2 COURSE CODE: SPE 324 CONTACT HOURS: 2 COURSE CODE: SPE 324 CONTACT HOURS: 2 COURSE SPECIFICAL: 1 COURSE SPECIFICATION: THEORETICAL AND PRACTICAL GOL: 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 PRACTICAL CONTENT PRACTICAL CONTENT WEEK SPECIFIC LEARNING OUTCOME OUTCOME ACTIVITIES 1:1 Define Research Explain the importance of Research of Research Explain the importance of Research such as: National advector of Research etc. Explain the importance of Research such as: Descriptive, and Descriptive, and Descriptive, and Activer Advector Active t							
CREDIT UNIT: 2 THEORETICAL: 1 VYEAR: 1 SEMESTER: 11 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 PRE-REQUISITE: PRACTICAL CONTENT PRACTICAL CONTENT PRECIFIC LEARNING OUTCOME TEACHER'S ACTIVITIES 1-2 1.1 Define Research Explain Research Textbooks Journals TEACHER'S ACTIVITIES RESOURCES 1-2 1.1 Define Research Explain the importance of Research Textbooks Journals Textbooks Journals Textooks Journals Resources 1-2 1.1 Define Research Explain types of Research, such as: Research, such as: Research, such as: Artivitie Board Marker 1.3 Describe types of Research, such as: Experimental, Descriptive, and Descriptive, and Applied research etc. Charks 1.4 Explore existing research and analyze prior findings on solar PV technologies Explain ethical issues prior findings on solar PV technologies Discuss ethical issues Discuss ethical issues </td <td>PROGR</td> <td>AMME: HIGHER NATION</td> <td>AL DIPLOMA SOLAR</td> <td>PV ENGINEERI</td> <td>NG TECHNOLOGY</td> <td></td> <td></td>	PROGR	AMME: HIGHER NATION	AL DIPLOMA SOLAR	PV ENGINEERI	NG TECHNOLOGY		
YEAR: I SEMESTER: II PRE-REQUISITE: PRACTICAL: 1 COURSE SPECIFICATION: THEORETICAL AND PRACTICAL GOAL:	COURSE TITLE: Research Methodology in Solar PV		COURSE CO	DE : SPE 324	CONTACT HOURS	ONTACT HOURS: 2	
YEAR: I SEMESTER: II PRE-REQUISITE: PRACTICAL: 1 COURSE SPECIFICATION: THEORETICAL AND PRACTICAL GOAL:				CREDIT UNIT	: 2	THEORETICAL: 1	
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1.4 Explore existing research and analyze prior findings on solar PV technologiesetc.1.5 Explain ethical issues such as plagiarism, dataDiscuss ethical issues		± '	-				
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falsification, and consent such as plagiarism, data		such as plagiarism, data	Discuss ethical issues				
		falsification, and consent	such as plagiarism, data				







	-	Explain the properties of a good research			ATU	
GENER A	AL OBJECTIVE 2.0: Know	the process of formulating	ng research probl	ems, hypotheses, and objecti	ves specific to solar P	V applications.
3-4	2.1 Explain the essential	Explain the essential parts of a research such	Textbooks	Write a concise and clear		Journals
		as title, background study, problem		title along with background information relevant to	clear title along with background	Internet
	objectives, etc.	statement, objectives,	Projector	solar PV energy	information relevant	
	2.2 Explain problem	etc.	White Board Marker Animations		to solar PV energy	papers on solar PV
	1	Explain problem statement, objectives	Charts	Formulate a research problem relating to solar PV	Formulate a research	
		and Research questions		and derive appropriate objectives for it	solar PV and derive appropriate	
		Discuss Literature	R		objectives for it	
	1	Review citation	$\langle \boldsymbol{\mathcal{C}} \rangle$	Create precise and researchable problem	Create precise and researchable	
	conclusion and	Explain the methodology of the		statements and research questions	problem statements and research	
	research work	research			questions	
		Explain Data interpretation,		Draft a literature review section of a Research	Draft a literature review section of a	
	good abstract	conclusion and recommendation of the		proposal	Research proposal	
		research work		Write an abstract	Write an abstract	
		•		Summarize relevant studies	Summarize relevant	







		Explain the properties		and highlight research gaps	studies and highlight	
		of a good abstract		in solar PV energy	research gaps in	
					solar PV energy	
GENE	RAL OBJECTIVE 3.0: Know	the design and conduct	of experiments/fi	eld studies in solar PV systen	ns using appropriate n	nethodologies
5-6	3.1 Define research	Explain research	Textbooks		Guide students to:	Journals
	objectives for experimental	objectives for	Journals	Select appropriate research	Select appropriate	Internet
	or field study	experimental or field	Internet	design and methodology	research design and	Research
		study	Computer		methodology.	papers on solar
	3.2 Explain appropriate		Projector			PV
	research design and		White Board	Develop experimental or	Develop	Thermal plant
	methodology selection	Explain appropriate	Marker	field procedure for the	experimental or field	
		research design and	Animations	research on any area of your	procedure	simulation if
	3.3 Outline the steps and instruments needed to	methodology selection	Charts	choice on Solar PV		applicable
	carry out the study on	Explain the steps and		Conduct the study using	Conduct the study	
	Solar PV	instruments needed to		tools and techniques in real	using tools and	
		carry out the study on		or simulated environments	techniques in real or	
		Solar PV			simulated	
					environments	
GENE	RAL OBJECTIVE 4.0: Know			pols relevant to solar PV resea		1
	4.1 Explain different data	Explain different data	Textbooks		Guide students to:	Data sets
7-8	collection methods e.g.:	collection methods (e.g.:		Analyse data sets using	Analyse data sets	collected
	Surveys,	Surveys,	Internet	appropriate software tools	using appropriate	
	Experiments,	Experiments,	Computer		software tools	Analysis
	Sensor data collection	Sensor data collection	Projector			software tool
			White Board			(Excel,
	-	Explain data analysis	Marker			MATLAB,
1	methods	methods	Animations			Python)
1			Charts			







	4.3 Describe data analysis	Explain data analysis			NO.	
	software tools e.g.:	software tools e.g.:				
	• Excel,	• Excel,				
	• MATLAB,	• MATLAB,				
	• Python	• Python				
	• SAS etc.	• SAS etc.				
	4.4 Explain the	Explain the				
	Interpretation of results	Interpretation of results				
	from data analysis in the	from data analysis in the				
	context of solar PV energy	context of solar PV				
	systems	energy systems				
GENERA	AL OBJECTIVE 5.0: Know	the compilation, present	ation, and interpr	etation of research findings i	n a standard technical	report format.
10-11	5.1 Explain the structure of	Explain the structure of	Textbooks		Guide students to;	Computer
	a technical report	a technical report	Journals	Compile research data and	Compile research	
				analysis into coherent	2	Printer
		Discuss how to Compile		sections	into coherent	
	compilation and analysis of		Projector		sections	
	research data into coherent		White Board			
	sections	sections		Interpret the implications of	1	
				research results	implications of	
	5.3 Explain the	Discuss the implications	Charts		research results	
	-	of Research results				
	results/findings			Apply correct citation and	Apply correct	
				referencing styles in a	citation and	
	5.4 Explain referencing	Explain referencing and		technical report	referencing styles in	
	and citation in Research	citation in Research			a technical report	
	report	report				
	5 5 Explain power points	Disques nower noint				
	5.5 Explain power point preparation and	Discuss power point preparation and				
	presentation	presentation				
	presentation	presentation				<u> </u>





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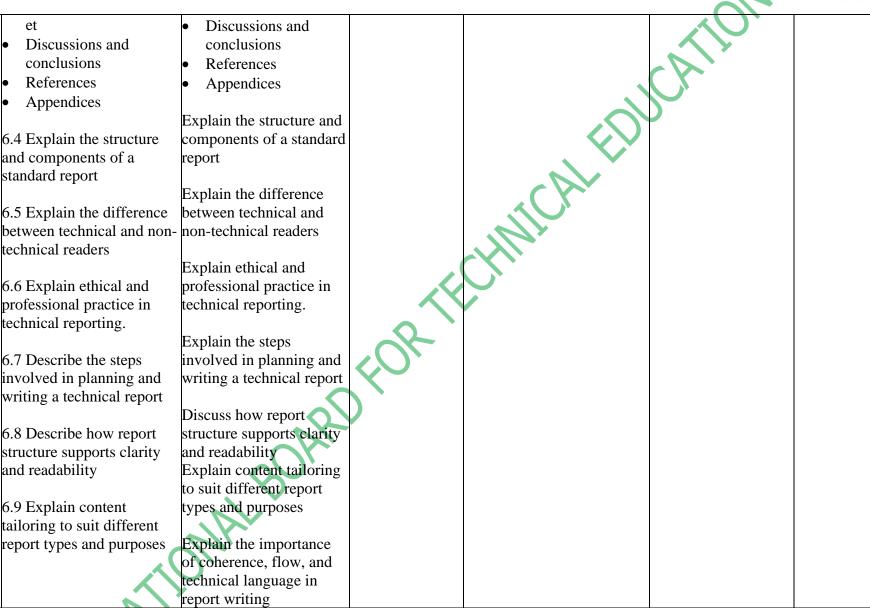
GENER	AL OBJECTIVE 6.0: Unders	tand technical reporting in	RE and engineeri	ng fields		
		L	L		<u> </u>	
12-13	6.1 Explain the importance		Textbooks			
	of technical reporting in	of technical reporting in	Journals		Ú,	
	engineering and RE	engineering and RE	Internet			
	projects	projects	Computer			
			Projector			
	6.2 Explain the role of	Explain the role of	White Board			
	communication,	communication,	Marker			
	documentation and	documentation and	Animations			
	decision making derived	decision making derived	Charts			
	from technical reports in	from technical reports in				
	RE/engineering reports	RE /engineering reports				
	Feasibility reports	Feasibility reports				
	Progress/Interim reports	Progress/Interim reports				
	Research/project reports	Research/project reports				
	Incident or troubleshooting					
	reports	troubleshooting reports				
	Close-out reports	Close-out reports	$\langle \mathcal{O} \rangle$			
		Explain the parts of				
		technical report writing				
	6.3 Explain the parts of	in engineering and				
	technical report writing in	thermal project				
	engineering and RE project	• Title page				
	• Title page	• Abstract/Executive				
	• Abstract/Executive	summary				
	summary	 Introduction 				
	Introduction	 Methodology 				
	Methodology	Results/Findings/Bud				
	• Results/Findings/Budg	get				
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	6.10 Explain the importance of coherence, flow, and technical language in report writing	Explain the common errors in report writing and how to avoid them			CATO	
	6.11 Explain the common errors in report writing and how to avoid them				5	
GENER	AL OBJECTIVE 7.0: Unders	tand Supplementary eleme	ents, reviewing, ed	iting, and presenting technic	al reports	<u>. </u>
14-15	to use visuals	commonly used in technical reports Explain when and how to use visuals	Marker	 Write a/an: Progress/Interim report Feasibility report Incident or troubleshooting report 	 Guide students to write a/an: Progress/Interim report Feasibility report Incident or troubleshooting 	Sample reports Zotero Mendeley
	charts, tables,	charts, tables,	Animations Charts	Demonstrate the use of citation and referencing	report	

tools

diagram diagram 7.3 Explain the importance Explain the importance of source citation and of source citation and referencing referencing 7.4 Explain the different Explain the different

referencing styles

Chicago

IEEE, etc.

APA

citation and referencing Demonstrate the use of citation and Zotero referencing tools Mendeley Zotero Mendeley •



referencing styles APA

Chicago

IEEE, etc.





1	Explain the different			N.	
	tools used for citation				
e	and referencing				
• Zotero	 Zotero 				
Mendeley	• Mendeley				
MS Word Reference	• MS Word Reference				
manager	manager				
• EndNote	• EndNote				
7.6 Explain the importance	-				
of integrating	of integrating				
supplementary elements.	supplementary elements		\mathcal{O}_{λ}		
7.7 Explain the importance	1 1				
of maintaining a consistent					
ſ	consistent and				
0 1	professional layout	\mathbf{O}			
	throughout the report				
7.8 Explain the importance					
of reviewing and editing in		X			
	Explain the importance				
	of reviewing and editing				
	in producing high-quality				
7.9 Explain common errors	reports				
in technical report writing					
	Explain common errors				
	in technical report				
	writing and how to				
of a professional	correct them				
presentation of reports	J'				





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delivering technical reports in academic or workplace settings	a professional	CAL	
ASSESSMENT:			
Continuous Assessment (CA): 60%			
Examination: 40%			
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			OFOR TECH
INCLUDE			
EDGE PLATFORM ON INCLUSIVE DEVELOPMENT POLIC	IES		NBTE





PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR I	PHOTOVOLTAIC (PV) ENGINI	EERING TECHNOLOGY	
COURSE TITLE: SOLAR PV PROJECT MANAGEMENT	COURSE CODE: SPE 325	CONTACT HOURS: 2	
AND TENDERING PROCESS	CREDIT UNIT : 2	THEORETICAL: 1	
YEAR: 1 SEMESTER: II	PRE-REQUISITE: NIL	PRACTICAL: 1	
GOAL: This course is designed to provide students with knowled	ge and skills of Project Managemen	nt and Tendering Process	
GENERAL OBJECTIVES: On completion of this course, the stu	dents should be able to:	*	
1.0 Know the basic concepts of Solar PV Project Management and 2.0 Understand the Solar PV Project Lifecycle	Tendering Process		
3.0 Know Solar PV Project Requirements, Designing and Docume	entation		
4.0 Understand Work Breakdown Structure and Project Estimation			
5.0 Understand Project Quality Management of Solar PV System			
6.0 Understand Project Risk Management of a given Solar PV Sys	tem		
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PROGRA	AMME: HIGHER NATION	AL DIPLOMA SOLAR	PHOTOVOLTA	IC (PV) ENGINEERING	TECHNOLOGY	
	E TITLE : SOLAR PV PROJE		SE CODE: SPE 3		HOURS: 2 Hours	
MANAG	EMENT AND TENDERING	PROCESS CREDI	T UNIT : 2	THEORET	ICAL : 1	
YEAR:	1 SEMESTER: 2	PRE-RI	EQUISITE: NIL	PRACTICA	AL: 1	
COURSE	E SPECIFICATION: THEO	RETICAL AND PRACTI	CAL			
GOAL: 7	This course is designed to prov	vide students with knowled	ge and skills of P	roject Management and Ten	dering Process	
	AL OBJECTIVE 1.0: Know t				~	
	ETICAL CONTENT			PRACTICAL CONTENT	[
WEEK	SPECIFIC LEARNING OUTCOME	TEACHER'S ACTIVITIES	RESOURCES	SPECIFIC LEARNING OUTCOME	TEACHER'S ACTIVITIES	RESOURCES
	1.1 Define Tendering	Explain Tendering	Textbooks,		Guide students to:	Application
	process	process	Journals, Publications,	Create New Solar PV Project using project	Create a New Solar PV Project	packages
1 - 4	1.2 Explain the various types of Tendering process	Explain the various types of Tendering process	Whiteboard, Markers, Internet	management software	using project management software	
	1.3 Define Solar PV Project Management and its importance	Explain Project management and its importance in relation to Solar PV	Computer, Projector	Generate Solar PV project scope and milestones	Generate project scope and milestones	
	1.4 Explain the various types of projects and its characteristics	Explain the various types of projects and its characteristics Explain the differences				
	 1.5 Distinguish between Solar PV project, Solar PV seminar and Solar PV technical team work 	between Solar PV project, Solar PV				







	1.6 List Solar PV Project scope and limitation	Explain Solar PV Project scope and limitation			
	1.7 Explain Solar PV Project	Explain Solar PV Project			
		Management Application		\sim	
	software package,	software package,			
	1 0 1	examples and their uses			
	e.g. MS word, Excel,	e.g. MS word, Excel,			
	spreadsheet etc.	spreadsheet etc.			
GENER	AL OBJECTIVE 2.0: Unders	tand the Solar PV Project	Lifecycle		
	5	Explain Solar PV Project			
	Lifecycle	Lifecycle	Journals,		
			Publications,		
	1 0	Explain the stages of	Whiteboard,		
5 - 8	Solar PV Project	Solar PV Project	Markers,		
			Internet		
	2.3 Explain Solar PV Project	1 0	· · · · · · · · · · · · · · · · · · ·		
	Lifecycle:	Lifecycle:	Projector		
	• Initiation,	• Initiation,			
	• Planning,	• Planning,			
	• Execution,	• Execution,			
	Monitoring/control	 Monitoring/control 			
	• Closure	• Closure			
	2.4 Explain project proposal	Explain Project Proposal			
	•				
	2.5 Explain Solar PV project	Explain Solar PV Project			
	checklist	Proposal checklist			
	2.6 Explain Solar PV	Explain Solar PV			
	project teamwork and role of				
		<u> </u>	•		







	each members in project	role of each members in				
	cycle	project cycle				
GENER	AL OBJECTIVE 3.0: Know S	Solar PV Project Requiren	nents, Designing a	nd Documentation		
9 - 10	3.1 Explain Solar PV project	Explain Solar PV project	Textbooks,		Guide students to:	Computers,
	requirements	requirements	Journals,	Use a Computer	Use a Computer	
			Publications,	Application packages to	11	Software
	3.2 Explain projects	Explain project	Whiteboard,	design and document a	packages to design	
	requirements gathering	requirements gathering	Markers,	project	and document a	
	techniques	techniques	Internet		project	
			Computer,			
	3.3 Explain Solar PV Project	1 5	Projector			
	Requirement Analytical tools	1				
		tools				
	3.4 Explain the components			•		
	requirements of solar PV	Outline the components				
	system project document:	of a requirements solar				
	Technical	PV system document:				
	• Planning	• Technical				
	• Testing	• Planning				
	• Evaluation etc.	• Testing				
		• Evaluation etc				
	3.5 Explain each of the					
	following terms, used in	Describes each of the				
	designing Solar PV system:	following terms, used in				
	• Stakeholder -	Solar PV system:				
	Information	 Stakeholder - 				
	Interpretation	Information				
	• Report	 Interpretation 				
	Procedures	 Report 				
	Timing	 Procedures 				
	• Format	 Timing 				







-	E		•			
	 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 		MCALEDUC		
GENEI	RAL OBJECTIVE 4.0: Unders	stand Work Breakdown Str	ucture and Project	Estimation of Solar PV Sys	tem	
11	 4.1 Define work breakdown structure 4.2 Explain the importance of work breakdown in Solar PV system project management 	Explain work breakdown structure 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 the conventional and non-conventional designs of solar PV System Management. Explain the steps involved in designing Solar PV System e.g.:				







	• Pre installation,	• Pre installation,			N.	
	Installation	Installation			× ×	
	• Post – installation	• Post – installation		C		
	4.5 Explain software usage	Explain software				
	in Solar PV System	usage in Solar PV				
		System				
GENER	RAL OBJECTIVE 5.0: Under	stand Project Quality Mana	gement of Solar P	V System		
12	5.1 Explain project quality	Explain project quality	Textbooks,			
	management of Solar PV	management of Solar PV	Journals,			
	System	System	Publications,			
			Whiteboard,			
	5.2 Explain Quality	Explain Quality	Markers,			
	Assurance and Quality	Assurance and Quality	Internet			
	Control in Solar PV	Control in Solar PV	Computer,			
	System Management	System Management	Projector			
	~ , ~					
	5.3 Explain project	Explain project				
	progress report in Solar	progress report in Solar				
	PV system management.	PV system management.				
CENER	RAL OBJECTIVE 6.0: Under		ment of a given So	lar PV System		
GENER	AE OBJECTIVE 0.0. Onder	stand 1 toject Kisk Manage.	finent of a given se	nai i v System		
13 - 14	6.1 Explain Project Risk	Explain Project Risk and	Textbooks,			
	and Risk Management in	Risk Management in a	Journals,			
	a given Solar PV System	given Solar PV System	Publications,			
	project	project	Whiteboard,			
			Markers,			
	6.2 List the various	Explain the various	Internet			
	categories of Solar PV	categories of Solar PV	Computer,			
	project risks:	project risks:	Projector			
	Business Solar PV	• Business Solar PV	5			
	System risks,	System risks,				
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				NIGERIA
Technical Solar PV	• Technical Solar PV			
System risk;	System risk;			
• Generic and product	• Generic and product		ſ	
Solar PV System risks	Solar PV System			
etc.	risks etc.			
6.3 List the stages in	Explain the stages in			
Risk management process:	Risk management			
Identification,	process:			
Financial analysis,	Identification,			
Ranking etc.	Financial analysis,			
Kanking etc.	Ranking etc.			
	Kunking etc.			
6.4 Explain Risk	Explain Risk mitigation	CX CX		
mitigation in a given	in a given Solar			
Solar PV System	PV System			
tinuous Assessment (CA): 60% mination: 40%		<u>yr</u>		
	nRD'			
	ALBON			
				SED FOR TECHNICA
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Smart Grids & IoT in PV System II

PROGRAMME: HIGHER NATIONAL DIPLOMA SO	LAR 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	e knowledge and skills of Smart C	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 and PV sy 5.0 Know practical applications of IoT in PV systems and S 6.0 Know how to enhance Solar PV Systems with Smart De	mart Grids	



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PROG	RAMME: HIGHER NAT	IONAL DI	PLOMA	SOLAR PHO	TOVOLTAIC (PV)) ENGINEERING '	TECHNOLOGY
	SE TITLE: Smart Grids & Io	oT in PV	COURS	E CODE: SPE	326	Contact Hours:	.3
System	II		Credit U	nit: 3		Theoretical: 1	
Year:	1 Semester: II		Pre-requ	isite: SPE 316		Practical: 2	
COUR	SE SPECIFICATION: THE	ORETICAI	L AND PI	RACTICAL			
GOAL	: The course is designed to e	nable stude	ents to acq	uire knowledg	e and skills of Smart	Grids and IoT in PV	V System
	RAL OBJECTIVE 1.0: Kno						
THEOI	RETICAL 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 	Syster (EMS • Comm n Netv • Dema	key nts of a d PV y ge ns y gement ns) nunicatio works nd nse and	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	 Practical Manual Smart Meters Smart Breakers Routers Android phone
		Syster					





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1.2 Explain Demand	Systems		NO.	1
Response and Distributed	• Cybersecurity			i
Energy Resources (DER)	and Protection			1
	• Power Quality			l
1.3 Explain the	Monitoring			l
Integration of PV				I
systems, storage, and	Explain the			I
demand energy response	Integration of PV			I
programs	systems, storage,			l
	and demand	(I
1.4 Explain advance	energy response			I
control strategies for	programs			I
energy distribution	F Ø			I
	Explain advance	CXV.		I
1.5 List components of a	control strategies			I
Microgrid	for energy			I
	distribution			I
1.6 Explain the role of PV	distribution			I
and IoT in microgrid	Explain			I
management	components of a			I
management				I
	Microgrid			I
1.7 Explain the	Evaluin the value of			I
importance of energy	Explain the role of			I
storage in Smart Grids	PV and IoT in			I
storage in Smart Orlds	microgrid			I
	management			I
1.8 Explain Battery	T			I
technologies and their	Explain the			r
-	importance of			r
management through IoT	energy storage in			r
systems	Smart Grids			r







	 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			ALDU	
		Explain role of blockchain in decentralized energy transactions		~ ECHNI		
Genera	al Objective 2.0: Know Sma	rt Grid Communicat	ion and Cybers	security		
	2.1 Explain the following	Explain the	Textbooks,		Guide students to:	1. Practical Manual
	Communication Networks for Smart Grids: • Wired	following Communication Networks for	Journals, Publications, Whiteboard,	Monitor power consumption by AC loads using	1. Monitor power consumption by AC loads using	2. Smart Meters
4 - 7	Wireless	Smart Grids:	Marker,	smart meter	smart meter	3. Bulbs
	 Supervisory control and Data acquisitions (SCADA) systems 	 Wired Wireless Supervisory control and Data 	Internet, Computer, Projector	Control AC loads using smart circuit breaker	2. Control AC loads using smart circuit breaker	4. Tool box5. Cables
	2.2 Explain the role of	acquisitions		Automate the	3. Automate the	Smart Beakers
	each of the	(SCADA)		operation of AC	operation of AC	
	communication Networks	systems		loads using smart	loads using smart	Routers
	for Smart Grids in 2.1	7		circuit breaker	circuit breaker	







2.3 Explain cybersecurity challenges in smart grids				Ċ	Internet Android phone
 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		CHN	ALDU	
	Explain cybersecurity protocols and encryption of Smart Grids and IoT in PV systems	22408			
	Explain data privacy and integrity in PV systems and smart grids				
General Objective 3.0: Understan	d the Data Analytics	in Smart Grids			
3.1 Define Data	Explain Data	Textbooks,			
Collection and Processing	Collection and	Journals,			





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r			1		r	
		Processing	Publications			
8 - 9	3.2 Explain the following		Whiteboard,			$\langle \rangle$
	types of data collected	Explain the	Marker,			
	from PV systems and	following types of	Internet			
	smart grids;	data collected	Computer,			
	• Energy Generation	from PV systems	Projector			
	Data.	and smart grids;	-			
	• Weather Data.	• Energy				
	• System Performance	Generation				
	Data.	Data.		(
	 Operational Data. 	• Weather Data.				
	 Health and 	• System				
	Diagnostics Data.	Performance				
	 Energy Storage Data. 	Data.		CX Y		
	Power Quality Data.	Operational				
	 Grid Health and 	Data.				
	Stability Data.	• Health and				
	•	Diagnostics				
	 Metering and Billing Data. 	Data.				
		 Energy 				
	Market and Trading	Storage Data.	\mathbf{O}			
	Data.	Power Quality				
	• Cybersecurity Data.	Data.				
		Grid Health				
		and Stability				
		Data.				
		 Metering and 				
		• Wretering and Billing Data.				
		_				
		Market and Trading Data				
		Trading Data.				
		Cybersecurity				







	 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 foracesting			AFDU	
		forecasting				
Genera	al Objective 4.0: Understand	d Machine Learning	in Smart Grids	and PV systems		
10-11	4.1 Explain Machine	Explain Machine	Textbooks,			
10-11	Learning (ML) in Energy	Learning (ML) in	Journals.			
	Systems	Energy Systems	Publications			
	Systems	Energy Systems	Whiteboard,			
	4.2 Evaluin the use of	Evaluin the use of				
	4.2 Explain the use of Machine Learning for;	Explain the use of Machine Learning	Marker, Internet			
		for;	*			
			Computer, Projector			
	maintenance in PV	Predictive	Frojector			
	systems	maintenance in				
	• Energy demand	PV systems				
	forecasting	• Energy				
		demand				
	4.3 Explain Optimization	J forecasting				
	algorithms for					





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	 Smart grid PV system Hybrid PV Grid system Explain the use of Artificial Intelligence (AI) and machine learning (ML) to predict faults in	Explain Optimization algorithms for • Smart grid • PV system • Hybrid PV Grid system Explain the use of Artificial			ALDU	
	PV systems and smart grids	Intelligence (AI) and machine			•	
	gnus	learning (ML) to predict faults in				
		PV systems and smart grids				
Genera	Il Objective 5.0: Know prac	0	IoT in PV syste	ems and Smart Grids		
12-13	5.1 Explain practical	Explain practical	Textbooks,		Guide students to:	1. Practical Manual
	applications of IoT in PV	applications of	Journals,	Implement a	1. Implement a	2. Software
	systems and Smart Grids	IoT in PV systems	Publications	small-scale Smart	small-scale Smart	3. Computer
	5.2 Emploin the	and Smart Grids	Whiteboard,	Grid using IoT-	2. Grid using IoT-	4. Smart device
	5.2 Explain the	Explain the	Marker,	enabled PV	enabled PV	5. Domestic
	implementation of IoT in existing PV systems	implementation of	Internet	systems	systems	
	existing PV systems	IoT in existing PV systems	Computer, Projector	Connect a smart	3. Connect a	appliance 6. PV systems
		systems	1 10 jector	energy meter to a	smart energy	0. 1 v systems
				PV inverter	meter to a PV	
		J			inverter	
				Use a smart plug		







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





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systems for improved		
General Objective 6.0: Know how to enhance Solar PV Sys	ems with Smart Devices	
14-156.1 Explain the following categories of smart devices:Explain the following 	books, nals,Demonstrate how to control Smart plug scheduling ker,Guide stud 1. Demonst how to con Smart plug scheduling	trol2. Softwarefor3. Computerfor4. Smart devicefor5. Domestic appliancetrate6. PV systems7. Smart thermostats8. Smart plugs/socketsfor





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code compliance	integration		
• Tools and apps	planning		
required (e.g., Home	procedures to		
Assistant,	enhance		\$
SmartThings, Sense)	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%)	<u>10, 10, 10, 10, 10, 10, 10, 10, 10, 10, </u>	
	BOARD		
	MAL		
			4
INCLUDE			1





YEAR TWO SEMESTER ONE



INCLUDE KNOWLEDGE PLATFORM ON INCLUSIVE DEVELOPMENT POLICIES



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

 Year: II
 Semester: I
 Pre-requisite:
 Pre-requisite: 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)

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6.0 Understand current trends, innovations, and future prospects in solar PV technologies.



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PROGI	RAMME: HIGHER NAT	TIONAL DIPLOMA SO	DLAR PHOT	DVOLTAIC (PV) EN	IGINEERING TECH	HNOLOGY
COURS	SE TITLE: Advanced Sola	ar PV Technologies	COURSE COI	DE : SPE 411	Contact Ho	ours: 2
		(Credit Unit: 2		Theoretical	1: 1
Year:	II Semester: I]	Pre-requisite:		Practical:	1
	SE SPECIFICATION: TH					
	This course is designed to					hnologies
GENE	RAL OBJECTIVE 1.0: K	Lnow the working principation of the second se	ples of an advar	nced solar PV system		
THEOI	RETICAL CONTENT			PRACTICAL CON	ITENT	
Week	Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
	1.1 Explain the concept	Explain the concept of	Whiteboard		Guide Students to:	1. Solar
	advanced Solar PV	advanced Solar PV	Lecture	Demonstrate the	1. Demonstrate the	simulator
1.0	System	System	notes	working principles	working principles	A T T
1-2		F 1 ' (1 1'CC	Computer	of a traditional and	of a traditional and	2. I-V curve
	1.2 Explain the differences between	Explain the differences between traditional and		advanced Solar PV modules	advanced Solar PV modules	tracer
	traditional and	advanced Solar PV	Journals	modules	modules	3. PV module
	advanced Solar PV	Modules.	Internet	Measure I-V	2. Measure I-V	Multimeters
	Modules.		Textbooks	characteristics	characteristics	
			1	under the following	under the following	4. Data logge
	1.3 Explain efficiency	Explain efficiency		conditions:	conditions:	
	factors in advanced	factors in advanced		5. Irradiance
	Solar PV systems.	Solar PV systems.		Load	Load	Meter
	1.4 Explain Building-	Explain Building-		Temperature Irradiance	Temperature Irradiance	6. Digital
	Integrated	Integrated		maurance	maurance	Thermometer
	Photovoltaics (BIPV)	Photovoltaics (BIPV)				incritionicter
	panels	panels		Measure the	3. Measure the	7.Resistive
		-		characteristics of	characteristics of	Load
				Solar PV using	Solar PV using	







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







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







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			Marker	charge controllers	charge controllers	Charge
	4.2 Explain the concept	Explain the concept of	Projector	-		controller
	of advanced PWM	advanced PWM charge	Journals			
	charge controllers	controllers	Internet			
			Textbooks			
	4.3 Explain Battery	Explain Battery			\sim	
	Charging Algorithms,	Charging Algorithms,				
	control features,	control features,				
	limitation and	limitation and				
	optimization in PWM	optimization in PWM				
	Controllers	Controllers				
	Condoners	Controllers				
	4.4 Explain advanced	Explain advanced				
	MPPT charge	MPPT charge				
	controllers	controllers				
General	Objective 5.0: Understan		of Battery M	anagement Systems ()	BMS)	
General	5.1 Explain Battery	Explain Battery	Whiteboard	inagement bystems (i		
	Management systems	Management systems	Lecture			
	operation based on:	operation based on:	notes			
	-	1				
	• State of charge	• State of charge	Computer Marker			
	(SoC)	(SoC)				
	• State of health	• State of health	Projector			
	(SoH) monitoring	(SoH) monitoring	Journals			
10-13	techniques.	techniques.	Internet			
10 10	• Depth of discharge	• Depth of discharge	Textbooks			
	• Number of cycles.	• Number of cycles.				
	5.2 Explain battery	Explain battery Storage				
	Storage Systems	Systems				
	Battery technologies	Battery technologies				
	and chemistries	and chemistries				
	• Battery	• Battery				
L		J	1			







					C	
	characteristics and	characteristics and)
	ratings	ratings				
	• Battery charging	• Battery charging				
	cycles and states	cycles and states				
	5.3 Explain critical	Explain critical				
	parameters affecting	parameters affecting				
	battery life and	battery life and				
	performance	performance				
General	Objective 6.0: Understand	current trends, innovatio	ns, and future	prospects in solar PV	technologies.	
	6.1 Explain global	Explain global trends				
	trends in PV	in PV technologies.				
	technologies.	Bifacial Solar				
	Bifacial Solar	Technology				
	Technology	• Dye-Synthesize				
	• Dye-Synthesize	Solar cells DSSC				
	Solar cells DSSC	etc.	\mathbf{O}			
13 - 15	etc.					
15 - 15						
	6.2 Explain innovations	Explain innovations				
	like smart and IoT-	like smart and IoT-	•			
	based monitoring.	based monitoring.				
	6.3 Explain future	Explain future				
	prospects in solar PV	prospects in solar PV				
	technologies	technologies				
EVALU	ATION: CA 60%	N				
EXAMI	NATION: 40%					





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	and Commissioning of Solar	
PROGRAMME: HIGHER NATIONAL DIPLOMA S	SOLAR PHOTOVOLTAIC (1	PV) ENGINEERING TECHNOLOGY
COURSE TITLE: Installation and Commissioning of	Course Code: SPE 412	Contact Hours: 3
Solar PV System	Credit Unit: 3	Theoretical: 1
Year: II Semester: I	Pre-requisite: NIL	Practical: 2
GOAL: This course is designed to enable the students de systems.	evelop knowledge and skills for	installing and commissioning of Solar PV
GENERAL OBJECTIVES: On completion of this course	e, 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 S 4.0 Maintain and Troubleshoot Solar PV Systems 	ystems	*
4.0 Maintain and Troublesnoot Solar PV Systems	FOR	
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PROG	PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY									
COUR	SE TITLE: Installation and	d Commissioning of	COURSE CODE: SPE 412		CONTACT HOURS: 3					
Solar P	V System		CREDIT UNIT	3	THEORETICAL:	1				
YEAR	: II SEMESTER: I		PRE-REQUISI	FE: NIL	PRACTICAL:	2				
COUR	SE SPECIFICATION: T	HEORETICAL AND PRA	CTICAL							
GOAL	: This course is designed to	enable the students develo	p knowledge and	skills for installing and	commissioning of Sol	ar PV systems.				
	RAL OBJECTIVE 1.0: Ki		* *			•				
	RATICAL			PRACTICAL						
Week	Specific Learning	Teacher's Activities	Resources	Specific Learning	Teacher's	Resources				
	Outcome			Outcome	Activities					
1-3	1.1 Explain the required	Explain the required	Journals		Guide students to:	1. Load				
	steps in performing site	steps in performing site	Textbooks	Performing load						
	load analysis	load analysis	Whiteboard	calculations.	1. Performing load	2. Calculators				
			Marker		calculations.					
	1.2 Explain site	Explain site assessment	Internet	Provide hands-on		3. Design				
	assessment and load	and load analysis.	Computer	training in system	2. Provide hands-					
	analysis.		Projector	design software.	on training in	4. Software.				
		Emploin the colorador		Deriver et alier	system design	5 Wine				
	1.3 Explain calculations on system sizing for	Explain the calculations on system sizing for	D	Review case studies	software.	5. Wire				
	different applications	different applications		of existing solar PV installations.	3. Review case	6. Diagrams				
	different applications	unrerent applications		instantations.	studies of existing	0. Diagranis				
	1.4 Explain component				solar PV	7. Technical				
	selection for optimized	Explain component			installations.	datasheets.				
	system performance	selection for optimized								
		system performance								
	1.5 Explain system									
	layouts and wiring	Explain system layouts								
	diagrams.	and wiring diagrams.								







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







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





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	term efficiency.	Installation		resolve common	5. Faulty system
		guides		faults in solar PV	components
4.3 Explain how to adher			Identify and repair	setups.	
to local and international	Explain how to adhere	Standards and	faults in solar PV		6. Maintenance
electrical and safety	to local and	codes	setups.	3. Identify and	checklists
regulations.	international electrical	Instructional		repair faults in	7.
	and safety regulations.	videos	Mount modules and	solar PV setups.	Troubleshooting
4.4 Explain basic system			connect components.	1	guides.
operation and	Explain basic system		1	4. Mount modules	
maintenance.	operation and		Perform	and connect	8. Simulation
	maintenance.		commissioning	components.	tools
4.5 Describe installation	munitentitiee.		checklist activities.	components.	10015
procedures and standards	. Describe installation		checklist detryffies.	5. Perform	9. Mounting
procedures and standards	procedures and				structures
	standards.			commissioning checklist activities.	structures
	standards.			checklist activities.	10 DDE
4.6 Explain					10. PPE
commissioning steps and	1 0				
quality checks.	steps and quality				
	checks.				
4.7 Explain emerging					
trends and innovations in	Explain emerging trends				
solar PV technology.	and innovations in solar				
	PV technology.				
ASSESSMENT:		1	1	1	1
Continuous Assessment (CA): 60	%				
Examination: 40%					





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ADVANCE PV SYSTEM PERFORMANCE AND TROUBLESHOOTING

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY

COURSE TITLE: ADVANCE PV SYSTEM PERFORMANCE AND	Course Code: SPE 413	Contact Hours: 2
TROUBLESHOOTING	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 and Maintenance	skills in Advance PV Syste	em Performance Troubleshooting
GENERAL OBJECTIVES : On completion of this course, the students s 1.0 Know the troubleshooting techniques for PV system performance 2.0 Know the factors affecting the performance PV system components per 3.0 Know the advance method for diagnosing and troubleshooting perform 4.0 Know the advance method for monitoring and optimization of PV sys 5.0 Know the process of solving real-world problems in PV systems.	erformance nance of PV systems	
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PROG	RAMME: HIGHER NATION	ONAL DIPLO	OMA SOLAR	PHOTOVOL	TAIC (PV) EN	NGINEE	RING TECHNOLOG	GY
	SE TITLE: Advance PV Sys		COURSE CODE: SPE 413 Contact I			Hours: 2 Hours		
Perform	nance and Troubleshooting		Credit Unit: 2	2		Theoretic	cal: 1	
Year:	II Semester: I		Pre-requisite:			Practical		
	SE SPECIFICATION: THE	EORETICAL	A			Tractical		
	: This course is designed to e				s in Advance P	V System	Performance Troubles	shooting and
	RAL OBJECTIVE 1.0: Kn	ow the trouble	shooting techr	niques for PV s	ystem performa	ance		
THEO	RETICAL CONTENT				PRACTICAL	CONTE	CNT	
Week	Specific Learning Outcome	Teacher's A	ctivities	Resources	Specific Lear 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. 	in relation to Explain tradi troubleshooti Multimet Clamp m	es and safety PV systems ctured ing approach PV systems tional ing tools; er, eter, imaging,	Textbooks, Publications Journals, Whiteboard, Marker, Internet Computer, Projector	Identify comm faults in PV sy and troublesho using tools: • Module-le • Inverter-le • Wiring Identify traditi troubleshootin • Multimete • Clamp met • Solar PV i • Power ana	non ystems boting vel, evel, ional ng tools; r, ter, maging,	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





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







Genera	 2.3 Explain diagnosing and troubleshooting of the following electrical faults; Module Faults Inverter Faults Cabling and Connections Grounding IObjective 3.0: Know the additional context of the following the fault of the following electrical faults; Module Faults Inverter Faults 	 Explain diagnosing and troubleshooting of the following electrical faults; Module Faults Inverter Faults Cabling and Connections Grounding 	and troubles	hooting performance of	PV systems	
General	-	-	-	nooting performance of	-	Terrortor
	3.1 Explain the role of Manufacturer Manuals in	Explain the role of Manufacturer Manuals in	Textbooks, Journals,	Diagnose the	Guide students to Diagnose the	Inverter Controller
	fault diagnosing and	fault diagnosing and	Publications,	following component	following	Battery
	troubleshooting	troubleshooting	Whiteboard,	faults based on codes;	component faults	Dattery
<i>y</i> 11	component performance	component performance	Marker,	Inverter	based on codes;	Manufacturer
		r r r	Internet,	.controller and	Inverter	Manuals
	3.2 Explain advanced		Computer,	battery	.controller and	
	inverter diagnostics using;	Explain advanced inverter	Projector		battery	
	• Inverter Fault Codes	diagnostics using;				
	• Inverter Parameters:	Inverter Fault Codes				
	• Voltage,	• Inverter Parameters:				
	• Current,	• Voltage,				
	• Frequency, and power	• Current,				
	checks.	• Frequency, and power				
		checks.				
	3.4 Explain advanced charge controller	Explain advanced charge				
	diagnostics using:	controller diagnostics				
	 Fault Codes 	using:				
	Parameters	• Fault Codes				
		Parameters				
	\sim	•				





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 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 		CHNI-CAL-		
General Objective 4.0: Know the adv		g and optimizat	ion of PV systems perfo		
 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





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4.5 Explain the calculation	Explain the calculation of				
of performance Ratio (PR)	performance Ratio (PR)				
in PV system	in PV system				
	Explain how to improve				
4.6 Explain how to	PV system performance				
improve PV system	by replacing			\sim	
performance by replacing	underperforming				
underperforming	components.				
components.					
eneral Objective 5.0: Know the p	process of solving real-world	problems in PV	V systems.		
5.1 Explain the process	Explain the process	Textbooks,		Guide student to:	Inverter
required to solve low	required to solve low	Journals,	Measure solar power	Measure solar	
energy yield due to module	energy yield due to	Publications,	generated due to	power generated due	Tool box
degradation	module degradation	Whiteboard,	panels dust and solve	to panels dust and	
	_	Marker,	the problem	solve the problem	Solar powe
5.2 Explain the process	Explain the process	Internet,		-	meter
required to solve inverter	required to solve inverter	Computer,	Repair a faulty	Repair a faulty	
malfunction leading to	malfunction leading to	Projector	inverter with error	inverter with error	Solar panel
system downtime.	system downtime.		code 4, and solve the	code 4, and solve	
			problem	the problem	
5.3 Explain the process	\sim		1	1	
required to solve	Explain the process				
environmental issues	required to solve				
affecting system	environmental issues				
performance.	affecting system				
L	performance.				
5.4 Explain the process					
required to solve Battery	Explain the process				
failures in hybrid systems.	required to solve Battery				
	failures in hybrid systems.				
	*				





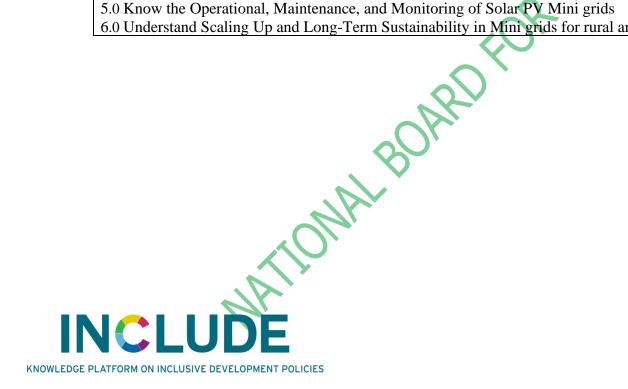


Government of the Nethenands			FEDER
troubleshooting techniques to diagnose complex PV	Explain troubleshooting techniques to diagnose complex PV system		
ASSESSMENT: Continuous Assess	problems. sment (CA): 60%		
ASSESSMENT: Continuous Assess Examination: 40%	sment (CA): 60%		5
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Solar Mini-Grid and Rural Electrification

COURSE TITLE: Solar Mini-Grid and Rural Electrification				
COUNSE ITTLE. Solar Mini-One and Kurar 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	l skills in Solar PV Mini-Grid and Ru	ral Electrification		
GENERAL OBJECTIVES: On completion of this course, the students s	should be able to:			
	, XIA.			
1.0 Know the basics of solar PV Mini grids for rural electrification.	CX Y			
2.0 Know factors to consider for Mini grid site selection and deployment i				
3.0 Know the system design and sizing of solar PV Mini grids for rural ele	ectrification			
4.0 Know the implementation of solar PV Mini grids for rural electrification	on.			
5.0 Know the Operational, Maintenance, and Monitoring of Solar PV Min	ni grids			
6.0 Understand Scaling Up and Long-Term Sustainability in Mini grids fo	or rural areas			







PROGI	RAMME: HIGHER NATIONAL	DIPLOMA SOLAR PH	ΟΤΟΥΟΙ ΤΑΙ	C (PV) ENGINEERIN	GTECHN		FEDERAL GOVERNMENT NIGERIA
	SE TITLE : Solar Mini-Grid and	COURSE CODE: SPE					ours: 3 Hours
Rural E	lectrification	Credit Unit: 2			Г	Theoretica	J. 1
Year:	II Semester: I	Pre-requisite: NIL				Practical:	
	SE SPECIFICATION: THEORET	1					
GOAL:	The course is designed to enable st	udents acquire knowledge	and skills in S	olar Mini-Grid and Rura	al Electrifica	ation	
GENE	RAL OBJECTIVE 1.0: Know the	basics of solar PV mini gr	ids for rural ele	ectrification.			
THEOI	RETICAL CONTENT			PRACTICAL CONT	ENT		
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 stud Identify typ mini grids community	pes of in your	Charts







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







	2.5 Explain economic benefits	Explain socio-economic				
	of mini grid to rural	impacts of electricity				
	communities	supply.				
				. (X	
	2.6 Explain the social impacts of	Explain economic				
	mini grids in rural areas.	benefits of mini grid to				
		rural communities		ICALED		
	2.7 Explain the importance of					
	community engagement.	Explain the social				
		impacts of mini grids in				
		rural areas.		ζŲ'		
		Explain the importance				
		of community		* 		
		engagement.				
Genera	l Objective 3.0: Know the system of	lesign and sizing of solar I	2V mini grids f	or rural electrification		
	3.1 Explain Mini grid design	Explain Mini grid	Textbooks,		Guide students to;	Software tools
	process.	design process.	Journals,	Design a small solar	Design a small	
			Publications,	PV Mini grid	solar PV Mini grid	Simulation
9 - 10	3.2 Explain the use of	Explain the use of	Whiteboard,			tools
	simulation software for solar	simulation software for	Marker,			
	mini-grid design	solar mini-grid design	Internet,			
			Computer,			
	3.3 Explain solar PV system	Explain solar PV	Projector			
	design	system design				
		Explain solar PV				
	3.4 Explain solar PV system	system sizing				
	sizing	• Solar Arrays,				
	• Solar Arrays,	• Battery Storage,				
	Battery Storage,	• Inverters,				
	• Inverters,	Balance of System				





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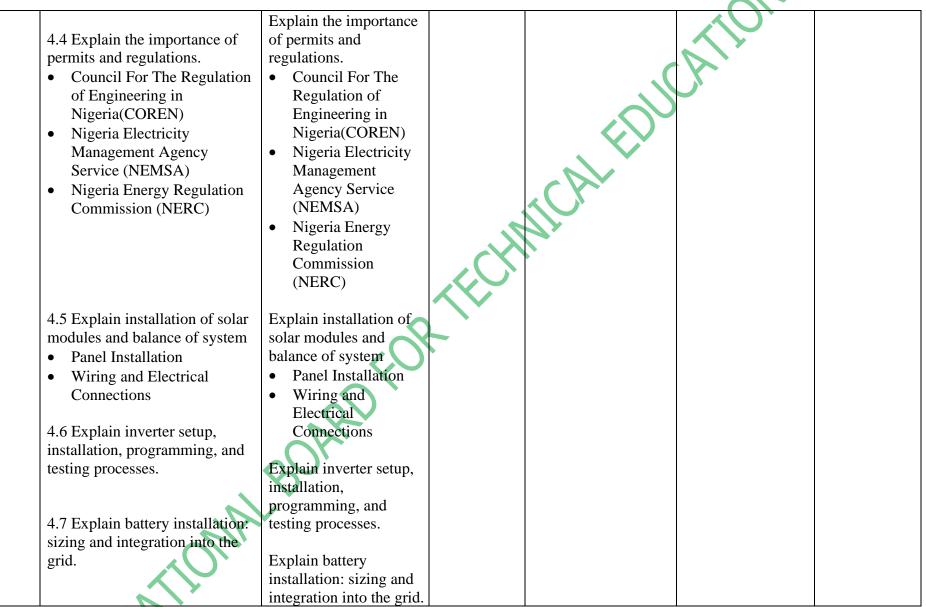
	• Balance of System (BoS).	(BoS).				
	3.5 Explain the importance of	Explain the importance				
	power and energy calculations	of power and energy				
	based on:	calculations based on:				
	Peak Demand,	• Peak Demand,				
	 Energy Yield, 	• Energy Yield,		CHED		
	 Battery Sizing for the 	• Battery Sizing for				
	Desired Autonomy.	the Desired				
	ja in statistica gr	Autonomy.				
	3.6 Explain technical standards					
	and guidelines for mini grid	Explain technical	2.			
	systems.	standards and				
	Nesis Code	guidelines for mini grid				
		systems.				
		Nesis Code	$\overline{\mathbf{A}}$			
Genera	l Objective 4.0: Know the impleme	entation of solar PV mini g	rids for rural e	lectrification.		
	4.1 Explain installation planning	Explain installation	Textbooks,		Guide students to:	PV module
11-13	and site assessment	planning and site	Journals,	Carryout installation	Carryout	
		assessment	Publications,	setting of a small-	installation setting	Cables
			Whiteboard,	scale solar PV mini	of a small-scale	
	4.2 Explain site selection and	Explain site selection	Marker,	grid	solar PV mini grid	Inverter
	surveying	and surveying	Internet,			
			Computer,	•	•	Battery
	4.3 Explain civil works and	Explain civil works and	Projector			
	infrastructure setup e.g.	infrastructure setup e.g.				Tools Box
	Mounting Systems	Mounting Systems				
	Battery Storage Area,	Battery Storage				
	• Inverter Placement.	Area,				
		• Inverter Placement.				





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





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	Repairing Faults	Explain the importance				
	• Repairing Faults	of preventative and				
		corrective maintenance			× Y	
		through;		(
		U ,				
		Routine				
		Maintenance				
		Repairing Faults				
Genera	al Objective 6.0: Understand Scaling			ini grids for rural areas		
	6.1 Explain the importance of	Explain the importance	Whiteboard,			
15	scaling up and long-term	of scaling up and long-	Marker,			
	sustainability in solar PV	term sustainability in	Internet,			
	systems.	solar PV systems.	Computer,			
			Projector			
	6.2 Explain the challenges in	Explain the challenges		·		
	scaling mini grids to larger rural	in scaling mini grids to				
	areas	larger rural areas				
	6.3 Explain the challenges of	Explain the challenges				
	integrating mini grids with the	of integrating mini grids				
	national grid.	with the national grid.				
		\circ				
	6.4 Explain Sustainability	Explain Sustainability				
	Challenges such as;	Challenges such as;				
	• Financial Sustainability,	Financial				
	• System Durability,	Sustainability,				
	• Community ownership.	• System Durability,				
		• Community				
		Ownership.				

Examination: 40%







MINI – PROJECT ON SOLAR PV SYSTEM INSTALLATION

PROGRAMME: HIGHER NATIONAL DIPLOMA SOL	AR PHOTOVOLTAIC (PV) ENGI	EERING TECHNOLOGY
COURSE TITLE: MINI – PROJECT ON SOLAR PV	COURSE CODE: SPE 415	CONTACT HOURS: 3
SYSTEM INSTALLATION	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

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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 PHO	DTOVOLTAIC (PV) ENGINEERI	NG TECHNOLOGY
COURSE TITLE: Solar PV Policy, Climate Adaptation & Energy	Course Code: SPE 416	Contact Hours: 2
Fransition	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 ransition	d skills of solar PV policies, climate a	daptation, and energy
GENERAL OBJECTIVES: On completion of this course, the students	s 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 s	systems	
4.0 Understand implement and promotion of solar PV systems		
\circ		
MALBORI		
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ATFORM ON INCLUSIVE DEVELOPMENT POLICIES		0





PROGR	AMME: HIGHER NATIO	ONAL DIPLOMA SOLA	R PHOTOVOLT	AIC (PV) ENGINEERIN	G TECHNOLOGY	Y
	E TITLE: Solar PV Policy,		COURSE CODE		CONTACT HOURS: 2	
	Transition	1	CREDIT UNIT :	2 TH	EORETICAL:	2
YEAR:			PRE-REQUISIT	E: NIL PRA	CTICAL:	0
COURS	E SPECIFICATION: THE	EORETICAL& PRACTIC	AL			
GOAL:	This course is designed to ec	uip students with knowle	dge and skills of so	lar PV policies, climate ad	aptation, and energy	v transition
GENER	AL OBJECTIVE 1.0: Kno	w Solar PV Policies and I	Regulations			
THEOR	ETICAL CONTENT			PRACTICAL CONTEN	T	
WEEK	SPECIFIC LEARNING OUTCOME	TEACHER'S ACTIVITIES	RESOURCES	SPECIFIC LEARNING OUTCOME	TEACHER'S ACTIVITIES	RESOURCES
1-4	1.1 Explain renewable energy policies and regulations1.2 Explain policies governing solar PV at	Explain renewable energy policies and regulations Explain policies governing solar PV at	Journals Textbooks Whiteboard Marker Internet Computer	Participate in group discussions and class presentations	Guide students on how to: Organize group discussions and class presentations	Journals Textbooks Whiteboard Marker Internet Computer
	national and global levels.	national and global levels.	Projector Policy documents	Participate in Seminars	Organise Seminars	Projector Policy documents
	1.3 Explain government incentives, subsidies, and tariff structures towards solar PV systems	Explain government incentives, subsidies, and tariff structures towards solar PV systems				
	1.4 Explain compliance requirements for solar PV projects.	Explain compliance requirements for solar PV projects.				







	1.5 Explain policy	Explain policy influence			XO.	
	influence on investment	on investment and				
	and market growth in	market growth in solar				
	solar PV system	PV system				
	1.6 Explain the role of	Explain the role of				
	policy in achieving solar	policy in achieving				
	PV system targets.	solar PV system targets.				
GENE	RAL OBJECTIVE 2.0: Und	erstand Climate Adaptation	n Strategies for sola	ar PV systems	1	
	2.1 Explain the impact of	Explain the impact of	Journals			
	climate change on energy	climate change on	Textbooks			
5-7	demand and supply.	energy demand and	Whiteboard	<i>'O</i> ,		
		supply.	Marker			
			Internet			
	2.2 Explain how solar PV	Assess how solar PV	Computer			
	can support climate	can support climate	Projector			
	adaptation and resilience.	adaptation and	\circ			
		resilience.				
	2.3 Explain case studies	Explain case studies of				
	of renewable energy integration in climate	renewable energy integration in climate				
	action plans.	action plans.				
	action plans.	action plans.				
	2.4 Explain innovations in	Discuss innovations in				
	solar PV to address	solar PV to address				
	environmental challenges.	environmental				
		challenges				
		P				





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





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		investment.						
	4.3 Explain regulatory	Explain regulatory						
	frameworks supporting	frameworks supporting				(\mathbf{x})		
	solar energy growth.	solar energy growth.						
	4.4 Europein the impact of	Eurlain the impact of						
	4.4 Explain the impact of innovation on solar PV	Explain the impact of innovation on solar PV						
	adoption.	adoption.						
	1	1		C				
	4.5 Explain strategies for	Explain strategies for			•			
	increasing solar PV	increasing solar PV						
	accessibility and affordability.	accessibility and affordability.						
	anordaointy.	anoruaointy.						
	SMENT: Continuous Assess	ment (CA): 40%						
Examina	ation: 60%		\sim					
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Solar PV Policy, Regulation, and Standards

PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY Contact Hours: 2 Course Code: SPE 421 COURSE TITLE: Solar PV Policy, Regulation, and Standards Theoretical: 1

Credit Unit: 2

Semester: II Year: Π

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







PROGR	PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOVOLTAIC (PV) ENGINEERING TECHNOLOGY								
	E TITLE: Solar PV Policy,		COURSE CODE: 421		CONTACT HOURS: 2				
Standard		6 /	CREDIT UNIT: 2		THEORETICAL: 1				
YEAR:	YEAR: II SEMESTER: II			FE: NIL	PRACTICAL:	1			
COURS	E SPECIFICATION: THE	EORETICAL & PRACTIC	CAL		1				
GOAL:	GOAL: This course is designed to enable students acquire knowledge and Skills of solar PV policies, regulations, and standards.								
GENER	AL OBJECTIVE 1.0: Kno	w Policy Frameworks for	solar PV systems	× ×					
THEOR	RETICAL CONTENT			PRACTICAL CONT	ENT				
WEEK	SPECIFIC LEARNING OUTCOME	TEACHER'S ACTIVITIES	RESOURCES	SPECIFIC LEARNIN OUTCOME	NG 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 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	Journals Textbooks Whiteboard Marker Internet Computer Projector Policy documents			







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		 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, 			SCATE	
			• IEC, etc.				
(GENERA	AL OBJECTIVE 2.0: Unde		ms and Incentives	for Solar PV System	1	L
		2.1 Explain financial	Explain financial	Journals			
		models and incentives	models and incentives	Textbooks			
4	4-6			Whiteboard			
		2.2 Explain financial	Explain financial	Marker			
		models, incentives, and	models, incentives, and	Internet			
		investment opportunities	investment	Computer			
		in Nigeria's solar energy	opportunities in	Projector			
		sector	Nigeria's solar energy				
			sector				
		2.3 Explain the following					
		financial model-	Explain the following				
		Power Purchase	financial model-				
		Agreements (PPA)	Power Purchase				
		Leasing models	Agreements (PPA)				
			Leasing models				





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	2.4 Explain the following	Explain the following				
	financial incentives	financial incentives				
	• Feed-in-tariff	• Feed-in-tariff				
	• Tax incentives	• Tax incentives			(X^{*})	
	2.5 Explain the following	Explain the following			5	
	financial investment	financial investment				
	opportunities:	opportunities:				
	• Large scale solar	• Large scale solar				
	project	project		C V		
	• Off-Grid and Mini-	• Off-Grid and Mini-				
	grid systems	grid systems				
	• Solar component	• Solar component				
	Manufacturing	Manufacturing				
	2.6 Explain the use of	Explain the use of PPA				
	PPA and leasing for solar	and leasing for solar PV				
	PV projects	projects				
GENER	AL OBJECTIVE 3.0: Unde	erstand the Regulations Go	overning Solar PV	Systems		
7-9	3.1-Define regulation	Explain regulation	Journals			
			Textbooks			
	3.2 Explain legal and	Explain legal and policy	Whiteboard			
	policy framework for	frame work for solar PV	Marker			
	solar PV sector in Nigeria	sector in Nigeria	Internet			
			Computer			
	3.3 Explain Electricity act	Explain Electricity act	Projector			
	2023 and its implications	2023 and its				
	in Nigeria PV sector	implications in Nigeria				
		PV sector				
		J				
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	3.4-Explain the levels of	Explain the levels of				
	policies implementation	policies implementation				
	and their roles in solar PV	and their roles in solar				
	deployment.	PV deployment.				
	3.5 Explain the roles and	Explain the roles and			5	
	mandate of the following	mandate of the				
	regulatory bodies in	following regulatory				
	Nigeria:	bodies in Nigeria:				
	• NERC	• NERC				
	COREN	COREN				
	• REA	• REA				
	• NEMSA	NEMSA				
	• SON	• SON				
	• ECN	• ECN				
	Federal Ministry of	• Federal Ministry of				
	Power	Power				
	NESREA	 NESREA 				
	• SERCs	• SERCs				
GENER	AL OBJECTIVE 4.0: Unde		latory compliance	for solar PV installation		
011111	4.1 Explain licencing	Explain licencing	Journals			
10-12	···		Textbooks			
	4.2 Explain procedures	Explain procedures and	Whiteboard			
	and requirements for	requirements for	Marker			
	obtaining necessary	obtaining necessary	Internet			
	licenses	licenses	Computer			
			Projector			
	4.3 Explain the types of	Explain the types of	5			
	licenses for :	licenses for :				
	• Generation;	• Generation;				
	• Distribution,	• Distribution,				





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	-		•			<u> </u>
	• Embedded generation	• Embedded				
		generation				
	4.4 Explain the procedure	1 1				
	for compliance with	for compliance with				
	regulation for mini-grid	regulation for mini-grid				
	PV installations for:	PV installations for:				
	NERC	• NERC				
	NEMSA	NEMSA				
				C V		
	4.5 Explain strategies for	Explain strategies for		MCALED		
	maintaining compliance	maintaining compliance				
	throughout project	throughout project				
	lifecycles.	lifecycles.				
GENER	AL OBJECTIVE 5.0: Under	erstand Technical Standard	ls and Quality As	surance for solar PV systems	6	
13-15	5.1 Explain Technical	Explain Technical	Journals			
	Standards	Standards	Textbooks			
			Whiteboard			
	5.2 Explain Quality	Explain Quality	Marker			
	Assurance	Assurance	Internet			
			Computer			
	5.3 Explain quality	Explain quality	Projector			
	assurance measures	assurance measures				
	essential for solar PV	essential for solar PV				
	system integrity and	system integrity and				
	performance	performance				
	1					
	5.4 Explain technical	Explain technical				
	standards essential for	standards essential for				
	solar PV system integrity	solar PV system				
	and performance	integrity and				
		performance				







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





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	Documentation and			
	Continuous			
	Improvements			
ASSESSMENT:				
Continuous Assessment (CA): 40%				
Examination: 60%			<u> </u>	
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Maintenance of Solar PV Systems

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Maintena PROGRAMME: HIGHER NATIONAL DIPLOMA SOLA	nce of Solar PV Systems	
COURSE TITLE: Maintenance of Solar PV Systems	Course Code: SPE 422 Credit Unit: 3	Contact Hours: 3 Theoretical: 1
Year: II Semester: II	Pre-requisite:	Practical: 2
GOAL: This course is designed to equip students with knowle	dge and skills of maintenance of sol	lar PV systems
GENERAL OBJECTIVES: On completion of this course, the s	tudents should be able to:	
1.0 Know Solar PV System Components and Configurations2.0 Know maintenance techniques for optimized PV system3.0 Know Routine Maintenance of Solar PV Systems4.0: Know the Operational, Maintenance, and Monitoring of Solar	olar PV Mini Grids	
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PROGRAMME: HIGHER NATIONA COURSE TITLE : Maintenance of	COURSE CODE: SP		Contact Hours: 3		
Solar PV Systems	Credit Unit: 3			Theoretical: 1	
Year: I Semester: I	Pre-requisite:			Practical: 2	
COURSE SPECIFICATION: THEOR					
GOAL: This course is designed to equip GENERAL OBJECTIVE 1.0: Know S				systems	
THEORETICAL CONTENT	Sour I + System Compo		PRACTICAL CONT	ENT	
Week Specific Learning Outcome	Teacher's Activities	Resources	Specific Learning Outcome	Teacher's Activities	Resources
 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





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• Pulse Width Modulation	Explain different		Identify the flow of	different PV system	(PWM)
(PWM)Maximum Power Point	charging algorithms:Pulse Width		Identify the flow of energy through	configurations.	MPPT
			0.		
Hacking (MFFT).			2		Batteries
			e on ingen without of	\sim	2
1.5 Explain the principle of				$\mathbf{\nabla}$	Cables
	0				
1.1	× ,			Demonstrate how to	Screwdrive
	Explain the principle			configure PV	
1.6 Define Configuration	of operation of each			systems	Pliers
	component in 1.1				
					Insulation
system configurations	Explain Configuration		System		tapes
					MC4
					connector
	•				connector
	configurations				Cable lug
					8
Objective 2.0: Know maintenance	te techniques for optimiz	zed PV system			
21 Define Maintenance	D.C. Maintenance	T		Carilla attachanta ta	Cleaning
2.1 Define Maintenance	Define Maintenance		Commont routing		Cleaning materials
2.2 Explain types of	Explain types of				materials
1 11	· · · ·		,	· · · · · · · · · · · · · · · · · · ·	Data logger
Preventive	Preventive	Internet	Cleaning,	Cleaning,	
	Corrective	Computer	Visual	Visual	Hydro phob
	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	Tracking (MPPT).Modulation (PWM)1.5 Explain the principle of operation of each component in 1.1Modulation (PWM)1.6 Define Configuration 1.7 Explain types of Solar PV system configurationsExplain the principle of operation of each component in 1.11.7 Explain types of Solar PV system configurationsExplain the principle of operation of each component in 1.1Define ConfigurationExplain types of Solar PV system configurationObjective 2.0: Know maintenanceExplain types of optimiz2.1 Define MaintenanceDefine Maintenance2.2 Explain types ofExplain types of	Tracking (MPPT).Modulation (PWM)1.5 Explain the principle of operation of each component in 1.1Maximum Power Point Tracking (MPPT).1.6 Define Configuration 1.7 Explain types of Solar PV system configurationsExplain the principle of operation of each component in 1.11.7 Explain types of Solar PV system configurationsExplain Configuration Explain types of Solar PV system configurations0bjective 2.0: Know maintenance 2.1 Define MaintenanceDefine Maintenance Explain types of Solar PV system2.1 Define Maintenance 2.2 Explain types ofDefine Maintenance Explain types ofJournals Textbooks Whiteboard	Tracking (MPPT).Modulation (PWM)different PV system configurations.1.5 Explain the principle of operation of each component in 1.1Maximum Power Point Tracking (MPPT).different PV system configurations.1.6 Define Configuration 1.7 Explain types of Solar PV system configurationsExplain the principle of operation of each component in 1.1Identify how to configure PV System1.7 Explain types of Solar PV system configurationsExplain Configuration Explain types of Solar PV system configurationsIdentify how to configure PV SystemObjective 2.0: Know maintenance 2.1 Define Maintenance 2.2 Explain types ofDefine Maintenance Explain types ofJournals Textbooks WhiteboardCarryout routine maintenance checks, Whiteboard	Tracking (MPPT).Modulation (PWM)1.5 Explain the principle of operation of each component in 1.1Maximum Power Point Tracking (MPPT).different PV system configurations.1.6 Define Configuration 1.7 Explain types of Solar PV system configurationsExplain the principle of operation of each component in 1.1Demonstrate how to configure PV System1.7 Explain types of Solar PV system configurationsExplain Configuration Explain types of Solar PV system configurationsIdentify how to configure PV System0bjective 2.0: Know maintenance 2.1 Define MaintenanceDefine Maintenance Explain types ofJournals Textbooks WhiteboardGuide students to Carryout routine maintenance checks,



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2.3 Explain different types of		Projector	inspections, and		inspections, and	solution
Maintenance actions			System health	٠	System health	
• Perfect	Explain different		assessments.		assessments.	Anti-soiling
Minimal repair	types of Maintenance					coating
• Imperfect	actions					
	• Perfect					
	Minimal repair					
2.4 Explain preventative maintenance in PV system	• Imperfect					
• Systematic	Explain preventative					
Conditional	maintenance in PV					
• Predictive	system					
	• Systematic					
	Conditional					
2.5 Explain corrective maintenance	• Predictive					
• Deferred	Explain corrective					
• Emergency	maintenance					
	Deferred					
	Emergency	K				
	Explain dust and					
2.6 Explain dust and debris	debris management in					
management in PV system	PV system					
	Explain electrical and					
2.6 Explain electrical and	mechanical integrity					
mechanical integrity checks	checks in PV system					
in PV system						
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General Objective 3.0: Know Routine Ma	vintenance of Solar PV S	veteme			
3.1 Explain Faults in PV system 3-10	Explain Faults in PV system	Journals Textbooks Whiteboard	Identify faults in solar PV System	Guide students to: Identify faults in solar PV System	PPE Solar PV
 3.2 Explain Failure in PV System 3.3 Explain Failure and its characteristics Human error Natural event Design flows Failure related to 	 Explain Failure in PV System Explain Failure and its characteristics Human error Natural event Design flows Failure related to component etc. 	Marker Internet Computer Projector	components Simulate the effect of shading on a small PV array (using opaque materials), power curve Identify potential areas where	components Simulate the effect of shading on a small PV array (using opaque materials), power curve Identify potential areas where	System components Multimeter, Ladder Imaging camera Inspection
 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 failure causes Interconnector failure Corrosion Delamination Hotspot Potential Induced Degradation (PID) Cables etc. Explain the impact of shading on PV system performance Describe environmental 		environmental degradation might occur on a physical system. Carry Out Repairs/ Replacements on Solar PV system components Demonstrate record- keeping for maintenance activities	environmental degradation might occur on a physical system. Carry Out Repairs/ Replacements on Solar PV system components Demonstrate record- keeping for maintenance activities	mirror Cleaning materials







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	 3.6 Describe environmental degradation factors affecting PV systems UV radiation Temperature cycling Humidity Dust accumulation 	 degradation factors affecting PV systems UV radiation Temperature cycling Humidity Dust accumulation Explain the importance of record- 		NICAL	DUCATIO	
	3.7 Explain the importance of	keeping for				
	record-keeping for maintenance activities	maintenance activities				
	activities					
Genera	l Objective 4.0: Know the Operati	ional, Maintenance, and	Monitoring of S	olar PV systems	I	<u> </u>
11-15	4.1 Explain operations of solar	Explain operations of	Journals		Guide students to:	PV system
	PV systems	solar PV systems	Textbooks	Carryout system	Carryout system	DDE
	4.2 Explain maintenance, and	Explain maintenance,	Whiteboard Marker	maintenance and troubleshooting	maintenance and troubleshooting	PPE
	monitoring of solar PV systems	and monitoring of	Internet	troubleshooting	uouoiesiiootiiig	Solar PV
		solar PV systems	Computer	Simulation of	Simulation of	System
	4.3 Explain monitoring and		Projector	common failures,	common failures,	components
	control tools use for solar PV	Explain monitoring		troubleshooting and	troubleshooting and	
	systems	and control tools use for solar PV systems		repairing the system.	repairing the system.	Multimeter,
		for solar r v systems		system.	system.	Imaging
	4.4 Explain Key Performance	Explain Key				camera
	Indicators (KPIs) to consider	Performance				
	while assessing the efficiency	Indicators (KPIs) to				Inspection
	and health of the system: e.g.:	consider while				mirror
	Performance ratio, Battery efficiency,	assessing the efficiency and health				Cleaning
	Duttery enforciety,	enterency and nearth				Cicumiz





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Power output4.5 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		materials Demonstratio n board
EVALUATION: CA 70%	Data Loggers Sensors etc.		
EXAMINATION: 30%		<u>CHUr</u>	
	for	-	
	ORE		
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NALL			. Antin
EDGE PLATFORM ON INCLUSIVE DEVELOPMENT POLICIES			



HIGH – VOLTAGE SOLAR PV AND INDUSTRIAL APPLICATION							
PROGRAMME: HIGHER NATIONAL DIPLOMA SOLAR PHOTOV	OLTAIC (PV) ENGINEERING TECHNOLOGY						
COURSE TITLE: HIGH – VOLTAGE SOLAR PV AND INDUSTRIAL	COURSE CODE: SPE 423 CONTACT HOURS: 3						
APPLICATION	CREDIT UNIT: 3 THEORETICAL: 1						
YEAR: II SEMESTER: II	PRE-REQUISITE: PRACTICAL: 2						
GOAL: This course is designed to enable students acquire knowledge and sk	kills in high – voltage solar PV and industrial application						
GENERAL OBJECTIVE: On completion of this course, the students should	ld 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 							







Government of t	he Netherlands				4	FEDERAL GOVERNMENT OF
					TION	
PROGR	AMME: HIGHER NATIO	NAL DIPLOMA SOLAI	R PHOTOVOLT.	AIC (PV) ENGINEERING	TECHNOLOGY	
COURS	E TITLE : HIGH – VOLTAO	GE SOLAR PV AND	COURSE CODE	: SPE 423 CON'	TACT HOURS: 3	
INDUST	RIAL APPLICATION		CREDIT UNIT: 1	3 THE	ORETICAL: 1	
YEAR:	II SEMESTER: II		PRE-REQUISIT	E: PRAC	CTICAL: 2	
COURS	E SPECIFICATION: THE	ORETICAL AND PRACT	ΓICAL			
GOAL:	This course is designed to ena	able students acquire know	vledge and skills in	n high – voltage solar PV and	d industrial application	
GENER	AL OBJECTIVE 1.0: Know	v the principles of high vo	oltage solar PV			
THEOR	ETICAL CONTENT			PRACTICAL CONTENT		
WEEK	SPECIFIC LEARNING	TEACHER'S	RESOURCES	SPECIFIC LEARNING	TEACHER'S	RESOURCES
	OUTCOME	ACTIVITIES		OUTCOME	ACTIVITIES	
	1.1 Define high voltage PV	Explain high voltage PV	Textbooks,		Guide students to:	Charts
			Journals,	Demonstrate the use of the	Demonstrate the use	
	1.2 Explain the operational		Publications,	following devices:	of the following	Pictorials
	components of high	components of high	Whiteboard,	Transformers	devices:	
1 4	0	voltage PV in 1.2	Markers,	Blocking Diodes	Transformers	Videos
1 - 4	6 6 65	High voltage energy	Internet	Transmission towers and	Blocking Diodes	
	6	storage devices: Battery bank	Computer,	lines Grid	Transmission towers and lines	
	- Inghei vonuge	System balancing	Projector, Charts,	Battery bank	Grid	
		component:	Cilarts,	Inverter/ Charge controller	Battery bank	
	 System balancing 	Transformers, Blocking			Inverter/ Charge	
	• System balancing component	diodes			controller	
	 High voltage solar 	High voltage solar panel:				
		above 48 volts				
	 Monitoring system (Monitoring system:				
	High voltage power	Computers				
	system network	High voltage power				
		system network:				





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 1.3 List the Application of components in 1.2 1.4 List the main types of high voltage solar PV system Standalone System System Standalone System System Standalone System System Standalone System System System System System System Textbooks, Journals, Journale							
components in 1.2 Explain the Application of high voltage solar PV 1.4 List the main types of high voltage solar PV Explain the main types of high voltage solar PV 9 Standalone System • Standalone PV system System • Standalone System • Standalone System 2.1 Explain the working mechanism of high voltage Standalone PV System Textbooks, Journals, Demonstrate on the categorizes of High Voltage Standalone PV System 5 - 9 of high voltage Standalone PV System Explain the categorization of high voltage Standalone PV System • Direct coupled: • With battery storage • With battery storage • with battery storage • With battery storage • With battery storage • With AC and DC Loads • With Battery storage • With Battery storage • With AC and DC Loads • With Battery storage • With Battery storage • With AC and DC Loads • With Battery storage <td< td=""><td></td><td></td><td>Transmission towers and</td><td></td><td></td><td>NO.</td><td></td></td<>			Transmission towers and			NO.	
 Explain the Application of high voltage solar PV system Standalone System Standalone System Standalone PV Systems Standalone PV Systems Standalone PV Systems Standalone PV Systems Standalone PV System Direct coupled: with batteries and Charge controller With AC and DC Loads Hybrid Standalone System Standalone System Standalone System 		1.3 List the Application of	lines				
1.4 List the main types of high voltage solar PV system of high voltage PV system Explain the main types of high voltage solar PV system Explain the main types of high voltage solar PV system Explain the main types of high voltage solar PV system Image: Complete integration of the integration of high voltage solar PV System Image: Complete integration of the integration of the integration of high voltage solar PV System GENERAL OBJECTIVE 2.0: Know working mechanism of high voltage solar PV System Explain the working mechanism of high voltage standalone PV System Textbooks, Journals, System Demonstrate on the categorizes of High Voltage standalone PV system Guide students to: Demonstrate on the categorizes of High Voltage standalone PV system Charts 5 - 9 of high voltage Standalone PV System: Explain the categorization of high voltage Standalone PV System Direct coupled: With battery storage System Computer, Voltage Standalone PV system Videos • Direct coupled: • with AC and DC Loads · Hybrid Standalone System Direct coupled: • with AC and DC Loads Direct oupled: • With AC and DC With AC and DC Loads With AC and DC Loads Hybrid Standalone Hybrid Standalone		components in 1.2					
high voltage solar PV system • Standalone System • Grid – connected System • Standalone System • Standalone PV Systems Standalone PV Systems 5 - 9 • Direct coupled: • with Act and DC Loads • Hybrid Standalone Standalone System • Direct coupled: • with Act and DC Loads • Hybrid Standalone Standalone System • Direct coupled: • with Act and DC Loads • Hybrid Standalone • Standalone System • Direct coupled: • with Act and DC Loads • Hybrid Standalone • Hybrid Standalone • With AC and DC Loads • Hybrid Standalone • Hybrid Standalone			Explain the Application				
 system Standalone System Standalone System Grid - connected System Grid - connected System Grid - connected System Grid - connected System Standalone System Grid - connected System Standalone System Grid - connected System Standalone System Standalone PV Systems Standalone PV Systems Standalone PV Systems Standalone PV System System System Standalone PV Systems System System System System System System Textbooks, Journals, Publications, System System System System System System System Charts Demonstrate on the categorizes of High Voltage standalone PV system Vidage Standalone PV System: Direct coupled: With batterise and Charge controller With batterises and Charge controller With batterises and Charge controller With Act and DC System System System Standalone Piper coupled: With Act and DC System System Hybrid Standalone 		1.4 List the main types of	of high voltage PV				
 Standalone System Grid - connected System Grid - connected System Standalone System Grid - connected System Standalone System Grid - connected System Standalone System Grid - connected System I. Explain the working mechanism of high voltage Standalone PV Standalone PV System System Syst		high voltage solar PV				\mathbf{P}	
System • Standalone System • Grid – connected System • Grid – connected System GENERAL OBJECTIVE 2.0: Know working mechanism of high voltage mechanism of high voltage Explain the working mechanism of high voltage Standalone PV Explain the working mechanism of high voltage Standalone PV Guide students to: Demonstrate on the categories of High Voltage standalone PV system Guide students to: Demonstrate on the categories of High Voltage standalone PV system Charts 5 - 9 of high voltage Standalone PV System: Explain the categorization of high voltage Standalone Explain the categorization of high voltage Standalone Computer, Projector, System Porjector, Charts System Videos • Direct coupled: • with battery storage • with battery storage • With batteries and Charge controller • with battery storage • with battery storage • with battery storage • with AC and DC Loads • With Cand DC • Loads • With Cand DC 2.3 Explain each of the Standalone System • Hybrid Standalone • Hybrid Standalone • Hybrid Standalone • Hybrid Standalone		system	Explain the main types of				
System • Standalone System • Grid – connected System • Grid – connected System GENERAL OBJECTIVE 2.0: Know working mechanism of high voltage mechanism of high voltage Explain the working mechanism of high voltage Standalone PV Explain the working mechanism of high voltage Standalone PV Guide students to: Demonstrate on the categories of High Voltage standalone PV system Guide students to: Demonstrate on the categories of High Voltage standalone PV system Charts 5 - 9 of high voltage Standalone PV System: Explain the categorization of high voltage Standalone Explain the categorization of high voltage Standalone Computer, Projector, System Projector, Charts System Videos • Direct coupled: • with battery storage • with battery storage • Hybrid Standalone • Direct coupled: • with battery storage • with battery storage • with battery storage • Hybrid Standalone • Direct coupled: • With AC and DC Loads • With Battery storage • With AC and DC Loads • With Battery storage • With AC and DC • With Battery storage • With AC and DC • With Battery storage • With AC and DC • Used Loads • With AC and DC		Standalone System	high voltage solar PV				
Grid - connected System • Contral • Connected System • Contral • Connected System • Contral • Contral • Contral • Contral • Constant on the categorization of high voltage Standalone • Direct coupled: • with battery storage • Direct coupled: • with battery storage • Direct coupled: • with battery storage • With battery storage • With battery storage • With AC and DC Loads		• Grid – connected	system				
GENERAL OBJECTIVE 2.0: Know working mechanism of high voltage solar PV SystemGuide students to: Demonstrate on the categories of High Voltage standalone PV SystemGuide students to: Demonstrate on the categories of High Voltage standalone PV systemCharts2.2 List the categorization of high voltage Standalone PV System:Explain the woltage Standalone PV SystemMarkers; Projector, SystemDemonstrate on the categories of High Voltage standalone PV systemGuide students to: Demonstrate on the categories of High Voltage standalone PV systemCharts5 - 9of high voltage Standalone PV System:Explain the categorization of high voltage Standalone PV system:Internet Projector, SystemProjector, Projector, SystemVideos6Direct coupled: with batteries and Charge controller P with AC and DC Loads SystemDirect coupled: with batteries and Charge controller With AC and DC LoadsDirect coupled: with batteries and Charge controller With AC and DC LoadsDirect coupled: With AC and DC LoadsWith batteries and Charge controller With AC and DC LoadsHybrid StandaloneHybrid Standalone2.3 Explain each of the Standalone SystemHybrid StandaloneHybrid StandaloneHybrid StandaloneHybrid Standalone		System	Standalone System		C V		
GENERAL OBJECTIVE 2.0: Know working mechanism of high voltage solar PV System 2.1. Explain the working mechanism of high voltage mechanism of high voltage standalone PV Systems Explain the working mechanism of high voltage Standalone PV System Explain the working mechanism of high voltage Standalone PV System Guide students to: Demonstrate on the voltage Standalone PV System Charts 5 - 9 of high voltage Standalone PV System: Explain the categorization of high voltage Standalone PV System Internet Computer, voltage Standalone PV System Videos 5 - 9 Direct coupled: System Explain the categorization of high voltage Standalone Projector, System System Videos 6 Direct coupled: Nith batteris and Charge controller Oil the the tories and Charge controller Direct coupled: Nith batteris and Charge controller Nith batteris standalone Nith batteries and Charge controller Nith AC and DC Loads Nith AC and DC <t< td=""><td></td><td></td><td>• Grid – connected</td><td></td><td></td><td></td><td></td></t<>			• Grid – connected				
 2.1. Explain the working mechanism of high voltage Standalone PV Systems 5 - 9 5 - 9 5 - 9 2.2 List the categorization of high voltage Standalone PV System 2.2 List the categorization of high voltage Standalone PV System 5 - 9 5 - 9 5 - 9 6 List the categorization of high voltage Standalone PV System 6 List the categorization of high voltage Standalone 6 List the categorization of high voltage Standalone 6 List the categorization of high voltage Standalone 7 - 9 9 10 List the categorization of high voltage Standalone 9 10 List the categorization of high voltage Standalone 10 List the categorization of high v			System				
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Standalone PV Systemsvoltage Standalone PV SystemPublications, Whiteboard, Markers,eategories of High Voltage standalone PV systemPictorials5 - 9of high voltage Standalone PV System:Explain the categorization of high voltage Standalone Projector,Internet Computer, Projector,Videos6Direct coupled: with battery storage with AC and DC Loads Hybrid Standalone SystemDirect coupled: with batteries and Charge controllerDirect coupled: with batteries and Charge controllerDirect coupled: with batteries and Charge controllerDirect coupled: with batteries and Charge controllerWith batteries and Charge controllerInternet Projector, Projector, With adderies and Charge controllerInternet Projector, Projector, Projector, Projector, With adderies and Charge controllerInternet Projector, Proj		2.1. Explain the working	Explain the working	Textbooks,		Guide students to:	Charts
5 - 9SystemWhiteboard, Markers,standalone PV systemVoltage standalone PV system5 - 90 f high voltage Standalone PV System:Explain the categorization of high voltage StandaloneInternet Computer, Projector,Videos• Direct coupled: • with battery storage • with batteries and Charge controller • Mith battery storage • With batteries and Charge controller• Direct coupled: • With battery storage • with batteries and Charge controller • With AC and DC Loads • Hybrid Standalone • Hybrid Standalone • Hybrid Standalone• Direct coupled: • With AC and DC Loads • Hybrid Standalone• Direct coupled: • With AC and DC Loads • Hybrid Standalone		mechanism of high voltage	mechanism of high	Journals,	Demonstrate on the	Demonstrate on the	
 2.2 List the categorization of high voltage Standalone Explain 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 Standalone System Hybrid Standalone 		Standalone PV Systems	voltage Standalone PV	Publications,	categories of High Voltage	categories of High	Pictorials
5 - 9 of high voltage Standalone Explain the categorization of high voltage Standalone Internet PV System: categorization of high voltage Standalone Projector, • Direct coupled: System Charts • with battery storage • Direct coupled: • Direct coupled: • with batteries and Charge controller • Direct coupled: • With battery storage • with AC and DC Loads • with batteries and Charge controller • with batteries and Charge controller • Mybrid Standalone System • With AC and DC Loads • With AC and DC Loads • Hybrid Standalone System • Hybrid Standalone • With AC and DC			System	Whiteboard,	standalone PV system	Voltage standalone	
PV System: categorization of high voltage Standalone Computer, Projector, Projector, System Direct coupled: System Charts with battery storage Direct coupled: Charts with batteries and Charge controller Direct coupled: Charts with AC and DC Loads with battery storage with batteries and Charge controller With AC and DC Loads with batteries and Charge controller With batteries and Charge controller With AC and DC Loads With AC and DC Loads Standalone System Hybrid Standalone Hybrid Standalone		0		Markers,		PV system	Videos
 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 Voltage Standalone Multiple Standalone Projector, Charts Projector, Projector, Charts Projector, Projector, Charts Projector, Projector, Charts Projector, Projector, Charts Projector, Projector, Charts Projector, Projector, Charts Projector, Projector, Charts Projector, Projector, Charts Projector, Projector, Charts 	5 - 9	0					
 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 Hybrid Standalone Hybrid Standalone Hybrid Standalone Hybrid Standalone 		PV System:		-			
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 with batteries and Charge controller with AC and DC Loads Hybrid Standalone System 2.3 Explain each of the Standalone System Hybrid Standalone Hybrid Standalone Hybrid Standalone 		• Direct coupled:	System	Charts			
 Charge controller with AC and DC Loads Hybrid Standalone System 2.3 Explain each of the Standalone System Direct coupled: with battery storage with batteries and Charge controller With AC and DC Loads Hybrid Standalone Hybrid Standalone 		• with battery storage					
 with AC and DC Loads Hybrid Standalone System 2.3 Explain each of the Standalone System with battery storage with batteries and Charge controller With AC and DC Loads Hybrid Standalone 		• with batteries and					
 Hybrid Standalone System With batteries and Charge controller With AC and DC Loads Loads Hybrid Standalone 		Charge controller					
System Charge controller • With AC and DC 2.3 Explain each of the Standalone System • Hybrid Standalone		• with AC and DC Loads					
with AC and DC Loads Standalone System Hybrid Standalone		Hybrid Standalone					
2.3 Explain each of the Loads Standalone System • Hybrid Standalone		System					
Standalone System • Hybrid Standalone		(
		-					
categorization in 2.2 System		-					
		categorization in 2.2	System				



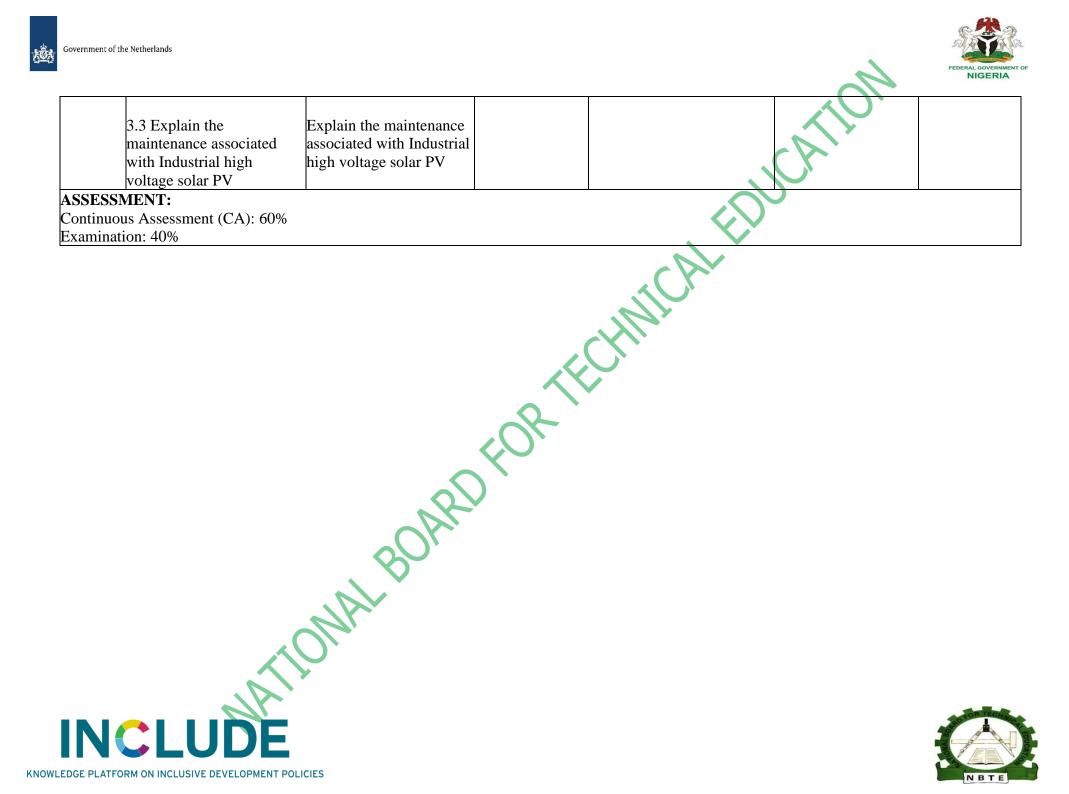




 2.4 Explain the working mechanism of Grid connected high voltage PV System in 2.2 based on: Dependency Usage Connection 2.5 Explain the merits and demerits of Standalone System categorization in 2.2 	 Explain each of the Standalone System categorization in 2.2 Explain the working mechanism of Grid connected 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		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 	Textbooks, Journals,	Visit an industrial high voltage PV plants	Guide students to: Visit an industrial high voltage PV plants	









Application of AI for Energy Trading

PROGRAMME: HIGHER NATIONAL DIPLOM	A SOLAR PHOTOVOLTAIC (I	PV) ENGINEERING TECHNOLOGY
COURSE TITLE: Application of AI for Energy	Course Code: SPE 424	Contact Hours: 3
Trading	Credit Unit: 3	Theoretical: 1
Year: II Semester: II	Pre-requisite: Python	Practical: 2Hour/week:
GOAL: This course is designed to provide students w	vith knowledge and Application of	AI for energy trading.
GENERAL OBJECTIVES: On completion of this c	ourse, the students should be able t	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,	1 1 0 1	
3.0 Understand smart contracts for automated P2P ene		
4.0 Know Decentralized Applications (DApps) for En		
5.0 Know energy trading using reinforcement learning 6.0 Know security, privacy, and regulatory challenges		m a
0.0 Know security, privacy, and regulatory chanenges	a in biockenam-based energy system	115
TIONAL BON		
ICLUDE LATFORM ON INCLUSIVE DEVELOPMENT POLICIES		





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	SE TITLE: Application of AI for	COURSE CODE: SPE424	1	C	ontact Hours: 3	
Energy	Trading	Credit Unit: 3	Theoretical: 1			
Year:	II Semester: II	Pre-requisite: Python		P	ractical: 2	
COUR	SE SPECIFICATION: THEORETI	CAL AND PRACTICAL				
	: This course is designed to provide s					
GENE market	RAL OBJECTIVE 1.0: Know the funst s	damentals of blockchain te	chnology, mach	ine learning algorith	ms and their applicat	ion in energ
THEO	RETICAL CONTENT			PRACTICAL CON	ITENT	
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 	Explain blockchain technology and distributed ledgers for energy markets Explain peer- to -peer (P2P) energy market fundamentals	Whiteboard Marker Internet Computer Projector Textbooks Videos USB drives	Use machine learning to forecast: Energy demand Energy Market Energy output etc.	Guide student to: Use machine learning to forecast: Energy demand Energy Market Energy output etc. Write a simple	Computer system Software
	1.3 Explain AI and its application in energy market.	Explain AI and its application in energy market.		Write a simple machine learning language: Python	machine learning language: Python	
	1.4 Explain Machine learning (ML) basics with a focus on energy applications	Explain Machine learning (ML) basics with a focus on energy applications				







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	1.5 Explain Data structures and	Explain Data structures				
	cryptography for blockchain	and cryptography for				
	systems	blockchain systems				
Gener	cal Objective 2.0: Know models that ca	an predict energy productio	n, consumption	, and pricing		
	2.1 Explain Time series forecasting	Explain Time series	Whiteboard	Demonstrate Time	Guide students	Software:
4-6	for energy production and	forecasting for energy	Marker	series forecasting	to:	MATLAB
	consumption using the following	production and	Internet	for energy		Python
	economic indicators:	consumption using the	Computer	production and	Demonstrate	RETScreen
	• GDP,	following economic	Projector	consumption using	Time series	SQL
	• Unemployment,	indicators:	Textbooks	the following	forecasting for	Pandas
	 Inflation 	• GDP,	Videos 🗸	Software:	energy	
		• Unemployment,	USB drives	MATLAB	production and	
	2.2 Explain Price forecasting	• Inflation		Python	consumption	
	models and market dynamics		CX Y	•	using the	
		Explain Price forecasting			following	
	2.3 Explain Anomaly detection in	models and market	\sim		Software:	
	energy data streams	dynamics 🔨			MATLAB	
		Explain Anomaly			Python	
		detection in energy data				
		streams				
Gener	al Objective 3.0: Understand smart con		nergy transaction	ns		
	3.1 Explain Smart contract	Explain Smart contract	Whiteboard			
	development for automated energy	development for	Marker			
	transactions	automated energy	Internet			
	uansactions	transactions				
	2.2 Eurlain Takan accommiss and		Computer			
6-9	3.2 Explain Token economics and	Explain Token economics and incentive	Projector Textbooks			
0-9	incentive design for energy markets		Videos			
		design for energy markets	USB drives			
	3.3 Explain Interoperability	markets	USD unves			
		Explain Intoronarchility				
	between energy trading platforms	Explain Interoperability				





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		between energy trading				
		platforms				
	3.4 Explain the intersection of AI				. 0 .	
	and energy systems	Explain the intersection				
		of AI and energy systems				
	3.5 Explain different types of					
	energy data:	Explain different types of		COL ED		
	Production,	energy data:				
	Consumption,	Production,				
	Pricing, etc.	Consumption,		$\mathbf{C}\mathbf{V}$		
		Pricing. Etc.				
	3.6 Explain smart contract writing					
	specifically for energy transactions	Explain smart contract				
		writing specifically for	CX Y			
		energy transactions				
			$\overline{\mathbf{X}}$			
Genera	al Objective 4.0: Know Decentralized	Applications (DApps) for	Energy Trading	Platforms		
10-11	4.1 Explain the concept of	Explain the concept of	Whiteboard	Simulate stability	Guide student to:	Software:
	decentralized energy trading.	decentralized energy	Marker	in decentralized	Simulate grid	Python
		trading.	Internet	grid control	stability in	
	4.2 Explain how different	\circ	Computer	systems	decentralized grid	Prophet
	decentralized energy trading	Explain how different	Projector		control systems	
	platforms works	decentralized energy	Textbooks			Cloud base
	Transparency	trading platforms works	Videos			platform
	Efficiency	Transparency	USB drives			(AWS,
	Security, etc.	Efficiency				google
		Security, etc.				colab)
	4.3 Explain the benefits of					Siemens
	decentralized energy trading	Explain the benefits of				spectrum
		decentralized energy				power
		trading				







	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				
Genera	al Objective 5.0: Know energy trading	g using reinforcement learn	ing			
12-13	5.1 Explain Reinforcement learning.	Explain Reinforcement learning.	Whiteboard Marker Internet	Simulate energy	Guide students to: Simulate energy	MATLAB Video clips
	5.2 Explain multi agant quatama for	Explain multi agant				video crips
	5.2 Explain multi-agent systems for		Computer	trading using MDPs software	trading using MDPs software	
	decentralized energy coordination	systems for decentralized energy coordination	Projector Textbooks Videos USB drives	MDPs software	MDPs software	
	5.4 Explain the impact of energy	Explain the impact of	•			
	market volatility, and the need for	energy market volatility,				
	automated strategies	and the need for automated strategies				
	Explain the concept of Markov					
	Decision Processes (MDPs)	Explain the concept of				
	through a simplified game with	Markov Decision				
	states, actions, rewards, and	Processes (MDPs)				
	transitions.	through a simplified				
		game with states, actions,				
		rewards, and transitions.				
Genera	General Objective 6.0: Know security, privacy, and regulatory challenges in blockchain-based energy systems					

General Objective 6.0: Know security, privacy, and regulatory challenges in blockchain-based energy systems







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





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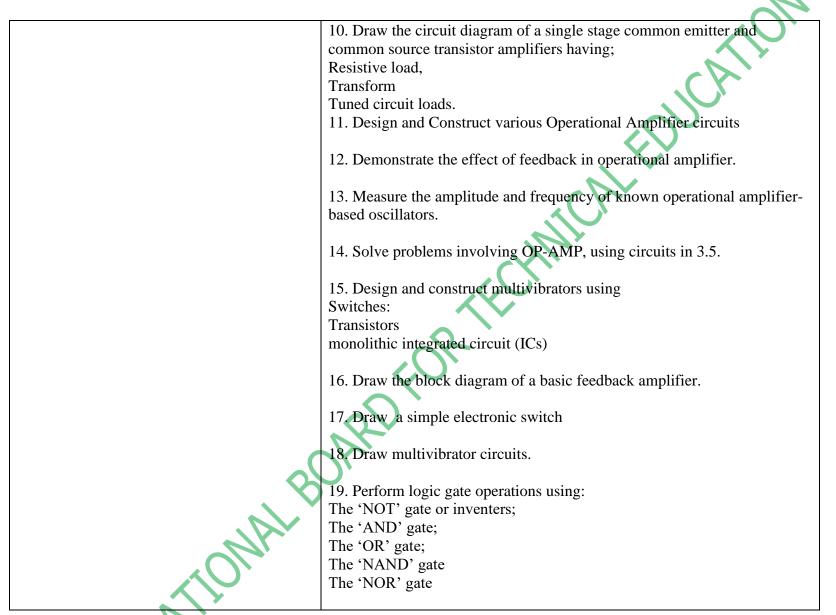
PRACTICAL MANUALS

	TION
RACTICAL MANUALS	
SPE 311 PRINCIPLES OF ELECTRONICS	1. Identify different types of diodes
River EES of EEECTRONICS	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.
<i>.</i>	Junction FET simple bias
Chr.	8. Illustrate using diagrams activities 2.2 to 2.8
	9. Calculate the voltage and power gains of the amplifiers in 2.8.













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	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	Form and guide in group discussions, and class presentations on different
PRINCIPLES OF RENEWABLE ENERGY	types of energy transformation
	Demonstrate using visual aids on how energy been transform
SPE 313	1. Illustrate the Electromagnetic spectrum, waves, fields on various semi –
FUNDAMENTALS FOR SOLAR	conductors
PHOTOVOLTAIC (PV) SYSTEM	
	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
	A Lie of Galax DV installation Grateman
	4. Identify types of Solar PV installation Systems
SPE 314	1. Identify the types of solar radiation (DNI, GHI, DHI).
SOLAR RESOURCE ASSESSMENT	2. Demonstrate how sunlight is converted into electricity and heat
	2. Demonstrate now summent is converted into electricity and near
	3. Demonstrate how solar energy is measured with simple tools
NAL	4. Measure temperature, tilt angle and irradiance as factors affecting solar energy availability.
	5. Compare solar radiation levels in different directions
	1







4
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





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	Climatic condition, etc.
	17. Demonstrate the effect of solar collector orientation and tilt angle.
SPE 315 WORKSHOP PRACTICE AND SAFET	1.Demonstrate the use of PPE.
PROCEDURE	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.
2	8. Maintain tools and equipment appropriately.
ONA	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	1. Identify a mini traditional grid and mini smart grid
SMART GRIDS & IoT IN PV SYSTEM I	
	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







	4
	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	1. Identify types of energy storage (batteries, thermal, mechanical).
ENERGY STORAGE TECHNOLOGIES IN	
SOLAR PV SYSTEMS	2. Implement sustainable practices to minimize solar PV waste and extend
	battery life.
SPE 318	1. Design the layout of a basic solar PV system
MODELLING AND SIMULATION OF	
SOLAR PV SYSTEMS	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 methometical models to calculate the behavior of best storage
	5. Use mathematical models to calculate the behavior of heat storage systems
XU'	Heat losses
	Charging/ discharging cycle





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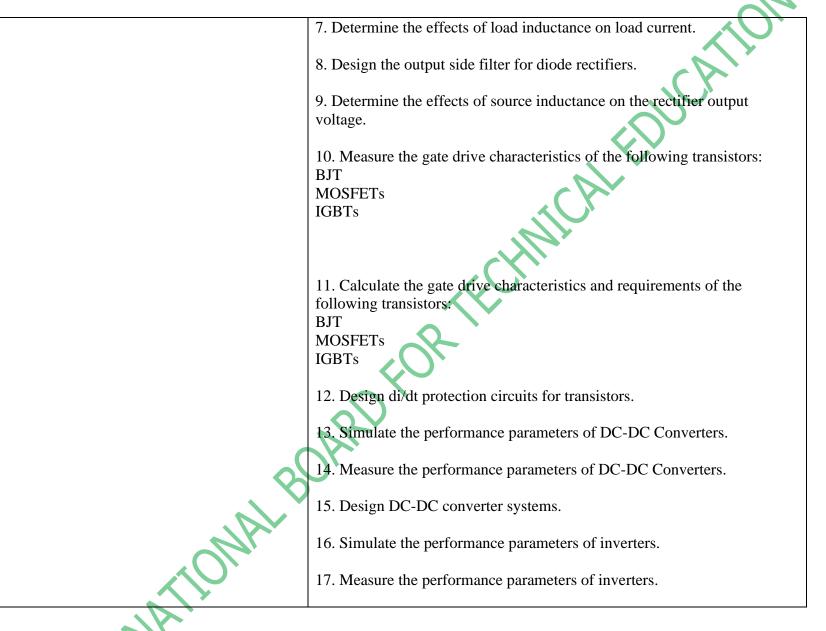


nent of the Netherlands	
	6. Identify commonly used software for solar PV system simulation
	7. Navigate user interface and set up basic simulation models in any available software
	8. Input system parameters and environmental data into simulation software
SDE 201	9. Interpret software-generated outputs and simulation graphs
SPE 321 POWER ELECTRONICS	 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.
NAL	5. Calculate the performance parameters of diode rectifiers.
	6. Design a diode rectifier circuit.
	I











KNOWLEDGE PLATFORM ON INCLUSIVE DEVELOPMENT POLICIES



	Carryout CAPEX/OPEX spreadsheet modelling for 10 kW system.
SPE 322	
TECHNO-ECONOMIC ANALYSIS FOR	Map stakeholder's roles in a sample project.
SOLAR PV SYSTEM	Perform LCOE calculations.
	Perform NPV/IRR calculation.
	Build financial models with appropriate the software tools.
	6. Contrast PPAs vs. leasing models.
	0. Contrast I I As 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
0	
	12. Analyse a failed solar projects and present key lessons
SDE 202	1. I dentifie the cost of following or identified and
SPE 323	1. Identify the each of following grid systems:
SOLAR PV SYSTEM CONFIGURATION	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	1. Write a concise and clear title along with background information
RESEARCH METHODOLOGY IN SOLAR	relevant to solar PV energy.
PV	
	2. Formulate a research problem relating to solar PV and derive
	appropriate objectives for it.
	2 Create and researchable methods statements and research
	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.
AA	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	1. Create New Solar PV Project using project
SOLAR PV PROJECT MANAGEMENT AND TENDERING PROCESS	management software.
	2. Generate Solar PV project scope and milestones.
	3. Use a Computer Application packages to design and document a project.
SPE 326	1. Identify Smart grid devices such as Smart Meters and End-User
SMART GRIDS & IoT IN PV SYSTEM II	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.
Ar.	6. Connect a smart energy meter to a PV inverter.
	7. Use a smart plug to automate a domestic appliance based on PV output.





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	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	1. Demonstrate the working principles of a traditional and advanced Solar
ADVANCED SOLAR PV TECHNOLOGIES	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	1) Perform calculations related to load analysis.
INSTALLATION AND COMMISSIONING	
OF SOLAR PV SYSTEM	2. Provide hands-on training in system design software.
ahr.	3. Review case studies of existing solar PV installations.
	4. Perform pre- commissioning tests.
	1







	4 A
	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	1. Identify the common faults in PV systems and troubleshoot using the
ADVANCE PV SYSTEM PERFORMANCE	following tools:
AND TROUBLESHOOTING	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.
\sim	8. Measure solar power generated due to panels dust and provide solution.
	9. Repair a faulty inverter with error code 4.
SPE 414	1. Identify the types of mini grids in your community.
SOLAR MINI-GRID AND RURAL	
ELECTRIFICATION	2. Carryout solar resource assessment of a rural community.
Y	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	Organize in group discussions and class presentations
Solar PV Policy, Climate Adaptation &	Organise Seminars
Energy Transition	
SPE 421	Organize class group discussion
Solar PV Policy, Regulation, and Standards	
	Evaluate the level of policies implementation
	Organise Seminars
SPE 422	1. Identify the following Solar PV System Components:
MAINTENANCE AND REPAIRS OF	Solar panels
SOLAR PV SYSTEMS	Inverters
SOLAR F V STSTEWIS	
	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





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	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	Illustrate on:
HIGH – VOLTAGE SOLAR PV AND	Transformers
INDUSTRIAL APPLICATION	Blocking Diodes
INDUSTRIAL ATTEICATION	Transmission towers and lines
	Grid
	Battery bank
	Inverter/ Charge controller
	inverter, charge controller
	Demonstrate on the categories of High Voltage standalone PV system
	Visit an industrial high voltage PV plant
SPE 424	1. Use machine learning technique to forecast the following:
Application of AI for Energy Trading	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. 	
 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. 	
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Blockchain energy security model. Threat model. Blockchain system optimization.	
Threat model. Blockchain system optimization.	
Blockchain system optimization.	Blockchain energy security model.
	Threat model.
Blackout prevention.	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	







ent of the Ne	thenands			
	D:		1	
9	Diagrams	Assorted		
10	Digital Thermometers	10		
11	Faulty system components (Inverters, charge controllers, panels, batteries, breakers, diodes)	Assorted		CATION
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	<i>'U</i> ,	
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 resistance tester 1 61 Insulation resistance tester 1 62 Earth resistance tester 1	ent of the N	etherlands			
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57MC4 connectorAssorted58Cable lugAssorted59Insulation tapes(Different color)Assorted60Cable ties/clamsAssorted61Insulation resistance tester(megger)162Earth resistance tester163Cleaning materialsAssorted64Component datasheets1065Fire AlarmAssorted66Sand bucketAssorted67Fire BlanketAssorted68Smoke DetectorsAssorted	55	Thermal cameras	5		
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63Cleaning materialsAssorted64Component datasheets1065Fire AlarmAssorted66Sand bucketAssorted67Fire BlanketAssorted68Smoke DetectorsAssorted	61	Insulation resistance tester(megger)	1		
64Component datasheets1065Fire AlarmAssorted66Sand bucketAssorted67Fire BlanketAssorted68Smoke DetectorsAssorted	62	Earth resistance tester	1		
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66Sand bucketAssorted67Fire BlanketAssorted68Smoke DetectorsAssorted	64	Component datasheets	10		
67Fire BlanketAssorted68Smoke DetectorsAssorted	65	Fire Alarm	Assorted		
68 Smoke Detectors Assorted	66	Sand bucket	Assorted		
	67	Fire Blanket	Assorted		
69 Gas Detectors Assorted	68	Smoke Detectors	Assorted		
	69	Gas Detectors	Assorted		





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70	Safety signs	Assorted	
71	Fabrication Materials	Assorted	

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70	Safety signs	Assorted	
71		Assorted	
	LADODATODX TOOLS//FOLUDMENT		
S/N	LABORATORY TOOLS//EQUIPMENT EQUIPMENT	QUANTITY	REMARKS
<u>5/N</u> 1	BJT Transistors	Assorted	KEWIAKAS
2	Breadboard	Assorted	
3	Capacitors	Assorted	
4	Integrated Circuit (e.g. 555 timer, LM 74, 7805. 7812		
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	





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22	Smart plugs/sockets	Assorted		CATION
23	Smart thermostats	Assorted		
24	Switches	Assorted		
25	System monitoring dashboard	1		
26	Audio visual	Assorted		
27	Ammeter	12		
28	Anemometers	5		\sim
29	AC Bulbs	Assorted		
30	Charts	Assorted		
31	Controller (PWM, MPPT)	5 each		
32	Data logger	5	NU.	
33	Dataset	Assorted	ν	
34	DC Bulbs	Assorted		
35	Diagrams	Assorted		
36	Digital Thermometers	10		
37	Faulty system components (Inverters, charge	Assorted		
	controllers, panels, batteries, breakers, diodes)	\mathbf{O}		
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]







nt of the N	letherlands	
52	Solar PV meter	10 Assorted Assorted Assorted Assorted
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	1 each
	Grid)	
78	Solar PV installation kits.	5
79	Test board (MBF)	Assorted
80	Thermal cameras	1
81	Concave mirror	5







82	Light beam	5	\mathbf{V}
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	
	ALBOAR		
	CLUEE M ON INCLUSIVE DEVELOPMENT POLICIES		







	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	NICA
~ ~ ~	SOLAR FARM		
S/N	EQUIPMENT		QUANTITY REMAR
1	Demonstration Solar PV farm (5KW)		1
	BOAR		
	LUDE		



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