West Bengal State Council of Technical & Vocational Education and Skill Development

TEACHING AND EXAMINATION SCHEME FOR DIPLOMA COURSES

COURSE NAME: RENEWABLE ENERGY ENGINEERING

COURSE CODE : REE

DURATION OF COURSE : 6 SEMESTERS

SEMESTER - V

Sl. No.	Course Code	Course Title	Hours Per Week			Total Contact Hours /Week	Credit	MARKS	
			L	T	P			IA	ESE
1.	REEPC301	Distributed Generation Systems	3	0	0	3	3	40	60
2.	REEPC303	Energy Efficiency, Economics and Audit	3	0	0	3	3	40	60
3.	REEPC305	Energy Efficiency, Economics and Audit Laboratory	0	0	3	3	1.5	60	40
4.	REEPC307	Energy Conversion Devices & Methodologies	3	0	0	3	3	40	60
5.	REEPC309	Energy Storage Laboratory	0	0	3	3	1.5	60	40
6.	REEPE301	Elective –III (Any one from Program Elective list)	3	0	0	3	3	40	60
7.	REEPE303	Elective –IV (Any one from Program Elective list)	3	0	0	3	3	40	60
8.	REEOE301	Open Elective – I (Any one from Open Elective list)	3	0	0	3	3	40	60
9.	SI301	Summer Internship – II (4 – 6 weeks after 4th.Semester)	0	0	0	0	3	60	40
10.	PR301	Major Project	0	0	2	2	^	--	--
		Total	**18**	**0**	**8**	**26**	**24**	**420**	**480**

L- Lecture, T-Tutorial, P-Practical, IA-Internal Assessment , ESE-End Semester Exam

Total Marks : 900

The student has to obtain 40% marks individually both in Internal Assessment and End Semester Examination to pass.

^ Note: one credit is carried forward from the 5th. Semester to 6th. Semester for major project evaluation.

Semester : Fifth	
Course Code : REEPC301	
Course Title : Distributed Generation Systems	
Number of Credit: 3 (L- 3; T- 0; P- 0)	
Prerequisite: Nil	
Course Category: PC	
Course Objectives: 1. To get the concept of distributed generation. 2. To learn concept of Microgrid for power distribution. 3. To know the distributed energy sources and their integration to Microgrid. 4. To know the power monitoring system.	
Course Contents (Theory):	
Unit : 1	1. Distributed Generation and Microgrid: 1.1 Introduction. 1.2 Integration of distributed generation to Grid. 1.3 Concepts of Micro Grid. 1.4 Typical Microgrid configurations, AC and DC micro grids. 1.5 Interconnection of Microgrids. 1.6 Technical and Economical advantages of Microgrid. 1.7 Concept of Electric Grid.
Unit : 2	2. Distributed Energy Resources: 2.1 Introduction. 2.2 Combined heat and power (CHP) generation. 2.3 Solar photovoltaic (PV) systems. 2.4 Wind energy conversion systems (WECS). 2.5 Small-scale hydroelectric power generation. 2.6 Storage devices – Batteries, Ultra capacitors, Flywheel energy storage system in Microgrids. 2.7 Functions of Central Controller (CC) and Microsource Controllers (MCs).

	2.8 Active and reactive power control, Voltage control. 2.9 Load sharing through power-frequency control.
Unit : 3	3. Protection Issues for Microgrids: 3.1 Introduction. 3.2 Islanding, Different islanding scenarios. 3.3 Major protection issues of standalone Microgrid. 3.4 Adaptive protection for Microgrid. 3.5 Impact of DG integration on electricity market, environment and distribution system. 3.6 Communication standards and protocols.
Unit : 4	4.1 Electricity tariff – one part tariff, two part tariff, maximum demand tariff, power factor tariff. 4.2 Concept of Dynamic pricing, Time of-use (TOU) pricing, Critical-peak pricing (CPP), Real Time Pricing. 4.3 Automatic Meter Reading (AMR). 4.4 Plug in Hybrid Electric Vehicles (PHEV). 4.5 Intelligent Electronic Devices (IED) and their application for monitoring & protection.
Unit : 5	5.1 Energy efficient end use devices. 5.2 Load Curves, Load Shaping Objectives, Load Shaping methodologies. 5.3 Types of power quality disturbances – Voltage sag (or dip), Transients, Short and Long duration voltage variation, Voltage imbalance, Waveform distortion, Harmonic sources. (Numerical Problems)
Unit : 6	6.1 Advanced Metering Infrastructure (AMI). 6.2 Sensor and Actuator Networks (SANETs). 6.3 Substation Architecture. 6.4 Substation Automation, Feeder Automation.

Text / Reference Books:

Sl. No.	Titles of Book	Name of Author	Name of Publisher
1.	Design of Smart Power Grid Renewable Energy Systems	Ali Keyhani	Wiley

2.	Smart Grid: Fundamentals of Design and Analysis	James Momoh	Wiley
3.	Electrical Power System Quality	R. C. Durgan, M. F. Me Granaghen, H. W. Beaty	McGraw-Hill
4.	Grid Converters for Photovoltaic and Wind Power Systems	Remus Teodorescu, Marco Liserre, Pedro Rodriguez	Wiley
5.	Microgrids and Active Distribution Networks	S. Chowdhury, S.P. Chowdhury and P. Crossley	ISBN 978-1-84919-014-5, IET, 2009
6.	Power System	J.B.Gupta	S.K.Kataria & Sons

Course Outcomes:

After completing the course the student will be able to:

1. Explain the concept of distributed generation systems.
2. Understand the Microgrid system and their control schemes.
3. Identify distributed energy sources and their monitoring in Microgrid.
4. Learn the way of efficient use of distributed sources and power.

END SEMESTER EXAMINATION SCHEME (Distributed Generation Systems) – 60 Marks

GROUP	UNIT	OBJECTIVE QUESTIONS (20) (One/Two Sentences, MCQ)				SUBJECTIVE QUESTIONS (40)			
		TO BE SET	TO BE ANSWERED	MARKS PER QUESTION	TOTAL MARKS	TO BE SET	TO BE ANSWERED	MARKS PER QUESTION	TOTAL MARKS
A	1,2,3	11	20	1	1 X 20 =20	5	5 (Taking at least two from each group)	8	8 X 5 = 40
B	4,5,6	11				4			

Note: Paper-setter should take into account of each unit and set the paper accordingly so that all units get equal importance.

Semester : Fifth	
Course Code : REEPC303	
Course Title : Energy Efficiency, Economics and Audit	
Number of Credit: 3 (L- 3; T- 0; P- 0)	
Prerequisite: Nil	
Course Category: PC	
Course Objectives: 1. To learn energy efficiency and energy conservation opportunities for different load conditions. 2. To select appropriate tariff system and methods for reducing electricity consumption and energy saving. 3. To know methods of energy conservation in buildings. 4. To apply tools for energy audit and recommend measures for energy conservation.	
Course Contents (Theory):	
Unit : 1	**1. Introduction to Energy Efficiency:** 1.1 Concepts of Energy Efficiency and Energy Conservation. 1.2 Indian Electricity Act 2001. 1.3 Relevant clauses of energy conservation. 1.4 Star Labelling – Need and its benefits.
Unit : 2	**2. Energy Conservation:** 2.1 Lighting Energy: Techniques of energy efficient lighting, Components of energy efficient lighting system. Periodic survey and adequate maintenance programs. 2.2 Heating: Techniques of energy saving in Furnaces, Ovens and Boilers. 2.3 Cooling: Techniques of energy saving in Ventilating systems and Air Conditioners. 2.4 Motive power. 2.5 Energy Efficient Motors. 2.6 Energy Conservation Equipment: Soft starters, Automatic star delta convertor. 2.7 Variable Frequency Drives. 2.8 Automatic p. f. controller (APFC).

	2.9 Energy efficient transformers, amorphous transformers, epoxy Resin cast transformer / Dry type of transformer. 2.10 Energy conservation opportunities in Fans & blower systems. 2.11 Energy conservation opportunities in Pumping systems. 2.12 Cogeneration – Definition and Advantages.
Unit : 3	**3. Energy Conservation in Buildings:** 3.1 Introduction. 3.2 Orientation and Planning for Environment. 3.3 Indoor Air Quality (IAQ) requirements. 3.4 Thermal Comfort of Building, Thermal Comfort Improvement Methods, Thermal Insulation, Control of Humidity and Condensation. 3.5 Thermal Admittance Method. 3.6 Building energy Simulation, Load Calculation. 3.7 Use of daylighting integrated artificial lighting system.
Unit : 4	**4. Tariff and Energy Conservation in Industries:** 4.1 Energy cost and Recent WBSEB/CESC tariffs. 4.2 Application of Tariff System to reduce Energy bill. 4.3 Prosumer tariff. 4.4 Availability Based Tariff (ABT). 4.5 Time of Day (TOD) tariff. 4.6 Indian Energy Exchange (IEX). 4.7 Energy conservation by improving load factor and power factor. (Numerical)
Unit : 5	**5. Energy Conservation In Transmission and Distribution Systems:** 5.1 Reactive power compensation. 5.2 Demand side management, system voltage optimization and phase current balancing. 5.3 Losses in transmission and distribution system and its minimization.
Unit : 6	**6.1 Energy Economics:** 6.1.1 Economics of Energy Demand. 6.1.2 Energy Poverty and the Energy Ladder. 6.1.3 Economics of Exhaustible Resources. 6.1.4 Taxation of Resource Rents. 6.1.5 Electricity Supply, Energy Demand Management. 6.1.6 Regulation and Reform of Electricity Markets. 6.1.7 Economics of Climate Change.

	6.2 Energy Audit: 6.2.1 Need of Energy Audit. 6.2.2 Procedure of Energy audit. 6.2.3 ABC analysis, Energy. 6.2.4 Flow Diagram and its importance. 6.2.5 Various measuring instruments used for measurements in energy audit. 6.2.6 Questionnaires for the energy audit, Internal energy audit checklist, Equipment used for energy conservation. 6.2.7 Calculation of payback period for energy conservation equipment. 6.2.8 IE rules and regulations for energy audit, Electricity Act 2003. (Numerical).

Text / Reference Books:

Sl. No.	Titles of Book	Name of Author	Name of Publisher
1.	Generation Distribution and Utilization of Electrical Energy	C.L. Wadhawa	New Age 2004
2.	Economy Loading of Power plant and Electric system	M.J. Steinburg and T.H. Smith	John Willey and sons
3.	Energy conservation Guide book	Steven R. Patrick, Dale R. Patric Stephen W. Fardo	Fairmont Press
4.	Industrial Energy Management: Principles and applications	Giovanni Petrecca	Kluwer Academic Publisher
5.	General Aspect of Energy Management and Energy Audit, 2010	BEE Guide book	
6.	Energy Efficiency in Electrical Utilities, 2010	BEE guide book	
7.	Handbook of Energy Engineering. Fifth ed.	Thumann, Mehta.	The Fairmount Press, 2001

Course Outcomes:

After completing the course the student will be able to:

1. Select energy conservation methods for different load conditions.
2. Identify methods of energy conservation in buildings.
3. Propose appropriate tariff system and methods for reducing electricity consumption and energy saving.
4. Analyse the economy of power distribution and efficient use of energy consumption.
5. Apply tools for energy audit and recommend measures for energy conservation for different load conditions.

END SEMESTER EXAMINATION SCHEME (Energy Efficiency, Economics and Audit) – 60 Marks									
GROUP	**UNIT**	**OBJECTIVE QUESTIONS (20) (One/Two Sentences, MCQ)**				**SUBJECTIVE QUESTIONS (40)**			
		TO BE SET	**TO BE ANSWERED**	**MARKS PER QUESTION**	**TOTAL MARKS**	**TO BE SET**	**TO BE ANSWERED**	**MARKS PER QUESTION**	**TOTAL MARKS**
A	1,2,3	11	20	1	1 X 20 =20	4	5 (Taking at least two from each group)	8	8 X 5 = 40
B	4,5,6	11				5			
Note: Paper-setter should take into account of each unit and set the paper accordingly so that all units get equal importance.									

Semester : Fifth
Course Code : REEPC305
Course Title : Energy Efficiency, Economics and Audit Laboratory
Number of Credit: 1.5 (L- 0; T- 0; P- 3)
Prerequisite: Nil
Course Category: PC
Course Objectives: 1. To learn energy efficiency and energy conservation opportunities for different load conditions. 2. To select appropriate tariff system and methods for reducing electricity consumption and energy saving.

3. To know methods of energy conservation in buildings. 4. To apply tools for energy audit and recommend measures for energy conservation.
List of Practicals: (At least Eight experiments are to be performed)
1. Study the construction and operation of energy efficient lamps – CFL, LED, Fluorescent lamp.
2. Experiment to calculate power and energy consumed by a florescent lamp using electronic ballast and magnetic ballast.
3. Identify energy saving equipments for domestic and commercial applications.
4. Study the energy consumption of energy efficient domestic appliances and commercial appliances and make a report on it.
5. Experiment to compute energy consumption of an air-conditioning machine using different refrigerant.
6. Study the parameters of an energy efficient motor in comparison with a commercial motor.
7. Study the components of a Solar Water Heating system and compute its energy efficiency.
8. Experiment to compare temperature of a model room using normal glass window and heat insulated tinted glass window.
9. Experiment to compare lighting energy consumption of a model room using only artificial lighting and artificial lighting integrated with natural daylighting.
10. Identify different equipments required for energy audit of your Institute (Classroom, Workshop & Laboratory).
11. Prepare an energy audit report of your Institute (Classroom, Workshop & Laboratory).
12. To Collect the Standard tariff rates of CESC / WBSEB and suggest suitable tariff for given industry/Lab/Institute/Commercial establishment.
Course Outcomes: After completing the course the student will be able to: 1. Select energy conservation methods for different load conditions. 2. Identify methods of energy conservation in buildings. 3. Propose appropriate tariff system and methods for reducing electricity consumption and energy saving. 4. Analyse the economy of power distribution and efficient use of energy consumption. 5. Apply tools for energy audit and recommend measures for energy conservation for different load conditions.

EXAMINATION SCHEME (Energy Efficiency, Economics and Audit Laboratory) – 100 Marks
1. Internal Assessment (60 Marks): Evaluation is based on – **Work done-30, Quality of report & Presentation-15, Performance in Viva-voce-15.**
2. End Semester Examination (40 Marks): Evaluation is based on – **Work done -15, Quality of report & Presentation-15, Performance in Viva-voce-10.**

Semester : Fifth	
Course Code : REEPC307	
Course Title : Energy Conversion Devices & Methodologies	
Number of Credit: 3 (L- 3; T- 0; P- 0)	
Prerequisite: Nil	
Course Category: PC	
Course Objectives: 1. To learn about different conventional & non conventional energy sources and their conversion to other systems. 2. To know about different parts of thermal, hydro, nuclear & other renewable power plants.	
Course Contents (Theory):	
Unit : 1	**1.1 Thermal Science:** 1.1.1 Thermal systems, Thermal circuit analysis and terminology. 1.1.2 Heat transfer methodologies – Conduction, Convection and Radiation. 1.1.3 Properties of heat transparent materials. 1.1.4 Heat transfer by mass transfer. **1.2 Electro-Mechanical Energy Conversion:**

	1.2.1 Introduction. 1.2.2 Salient aspects of conversions. 1.2.3 Energy – Balance, Magnetic-field System, Energy and Co-energy. 1.2.4 A Simple Electromechanical System. 1.2.5 Energy in Terms of Electrical Parameters, Rotary Motion, Dynamic Equations and system-model of a simple system.
Unit : 2	**2.1 Steam Power Unit:** 2.1.1 Layout of the unit. 2.1.2 Coal burning methods, Disposal of ash and dust. 2.1.3 Combined cycle power plants, Integrated coal gasification. 2.1.4 Plant components: Condenser, Economiser, Cooling tower. **2.2 Boilers and Fired Systems:** 2.2.1 Fundamentals of Boilers, Materials and construction of boilers. 2.2.2 Types of boilers, Firing systems. 2.2.3 Efficiency of boilers, Elements for maximum efficiency of boilers. 2.2.4 Excess air, Stack temperature control, Utilization of waste heat. 2.2.5 Load balancing, Boiler blow down. 2.2.6 Condensate return methodologies. 2.2.7 Fuel consideration, Coal, Oil and Natural Gas. **2.3 Steam and Condensate Systems:** 2.3.1 Thermal properties of steam. 2.3.2 Saturated steam, Super heated steam. 2.3.3 Heat transfer characteristics of steam. 2.3.4 Estimating steam usage, Steam traps and their applications.
Unit : 3	**3.1 Hydro-electric Units:** 3.1.1 Classification. 3.1.2 Layout of the unit. 3.1.3 Components and auxiliaries of hydro power plant. 3.1.4 Selection of turbines, Micro hydro plants, Pumped storage. **3.2 Hydro-Power:** 3.2.1 Components for hydroelectric generators. 3.2.2 Ram pump, Impulse turbine, Reaction turbine, Hydroelectric Systems. 3.2.3 Small and large hydro-power plants.
Unit : 4	**4.1 Diesel and Gas Turbine Units:** General Layout, Components of Plant, Comparison with steam power plant.

	4.2 Nuclear Power Plants: 4.2.1 Location of plant. 4.2.2 Components of nuclear plants, Types of reactors, Uranium enrichment, Safety factors, Disposal of nuclear waste. 4.2.3 Comparison with thermal power plant.
Unit : 5	**5. Other Conversion Units:** Renewable Power Plants – Solar power plant, Wind power plant, Biogas power plant, Geothermal energy, Ocean thermal energy.

Text / Reference Books:

Sl. No.	Titles of Book	Name of Author	Name of Publisher
1.	Non-Conventional Energy Resources	B. H. Khan	The McGraw Hill Publications.
2.	Non-Conventional Energy Sources	G.D. Ray	Khanna Publications
3.	Power Plant Engineering	P.K.Nag	Tata McGraw-Hill Education
4.	Solar Energy – Principles of Thermal Collection and Storage	S. P. Sukhatme and J.K. Nayak	Tata McGraw-Hill, New Delhi
5.	Solar Energy, Fundamentals and Applications	Garg, Prakash	Tata McGraw Hill.
6.	A Text Book on Power Plant Engineering	K.K. Ramalingam	Scitech Publications (India) Pvt. Ltd.
7.	Power Plant Engineering	R.K. Hegde	Pearson

Course Outcomes:

After completing the course the student will be able to:

1. Identify different sections of conventional & non conventional energy power plants.
2. Learn energy conversion systems from conventional & non conventional sources.
3. Compare merits & demerits of different conversion systems.
4. Compute economy of the different energy conversion process.

END SEMESTER EXAMINATION SCHEME (Energy Conversion Devices & Methodologies) – 60 Marks									
GROUP	**UNIT**	**OBJECTIVE QUESTIONS (20) (One/Two Sentences, MCQ)**				**SUBJECTIVE QUESTIONS (40)**			
		TO BE SET	**TO BE ANSWERED**	**MARKS PER QUESTION**	**TOTAL MARKS**	**TO BE SET**	**TO BE ANSWERED**	**MARKS PER QUESTION**	**TOTAL MARKS**
A	1,2	11	20	1	1 X 20 =20	4	5 (Taking at least two from each group)	8	8 X 5 = 40
B	3,4,5	11				5			
Note: Paper-setter should take into account of each unit and set the paper accordingly so that all units get equal importance.									

Semester : Fifth
Course Code : REEPC309
Course Title : Energy Storage Laboratory
Number of Credit: 1.5 (L- 0; T- 0; P- 3)
Prerequisite: Nil
Course Category: PC
Course Objectives: 1. To learn the characterization of different types of battery. 2. To know about thermal storage and pumped storage systems. 3. To maintain efficient use of battery & other solar power storage systems generating electrical power.
List of Practicals: (At least Eight experiments are to be performed)

1. Study the parts of a Lead-Acid battery, Ni-Cd battery and Li-ion battery.
2. Connect batteries in different connections to verify its Voltage & Ampere-hour.
3. Experiment for Charging & Discharging characterisation of a Lead-Acid battery and its parameters.
4. Experiment for Charging & Discharging characterisation of a Ni-Cd battery and its parameters.
5. Experiment for Charging & Discharging characterisation of a Li-ion battery and its parameters.
6. Experiment to study different parts of a thermal storage system.
7. Experiment to apply thermal storage principle for solar collector.
8. Experiment to apply thermal storage principle for solar water heater.
9. Experiment to study different parts of a pumped storage system.
10. Experiment to run a turbine from pumped storage system generating electricity.
11. Experiment to study different parts of a compressed gas storage system.
12. Experiment to use compressed gas from storage system to run a turbine and generating electricity.
Course Outcomes: After completing the course the student will be able to: 1. Use different batteries knowing their electrical characteristics. 2. Apply thermal storage systems storing energy and to generate electrical power. 3. Apply pumped storage systems storing energy and to generate electrical power. 4. Apply compressed gas storage systems storing energy and to generate electrical power. 5. Compare the energy storage suitability between different storage methods.

EXAMINATION SCHEME (Energy Storage Laboratory) – 100 Marks
1. Internal Assessment (60 Marks): Evaluation is based on – **Work done-30, Quality of report & Presentation-15, Performance in Viva-voce-15.**
2. End Semester Examination (40 Marks): Evaluation is based on – **Work done -15, Quality of report & Presentation-15, Performance in Viva-voce-10.**

Semester : Fifth
Course Code : REEPE301
Course Title : Elective – III (To be chosen from Program Elective List)
Number of Credit: 3 (L- 3; T- 0; P- 0)
Prerequisite: Nil
Course Category: PE

Semester : Fifth
Course Code : REEPE303
Course Title : Elective – IV (To be chosen from Program Elective List)
Number of Credit: 3 (L- 3; T- 0; P- 0)
Prerequisite: Nil
Course Category: PE

Semester : Fifth
Course Code : REEOE301
Course Title : Open Elective – I (To be chosen from Open Elective List)
Number of Credit: 3 (L- 3; T- 0; P- 0)
Prerequisite: Nil
Course Category: OE

Semester : Fifth
Course Code : SI301
Course Title : Summer Internship-II
Number of Credit: 3
Duration: 4 – 6 weeks after 4th.Semester.
Course Category: SI
Course Contents:
Summer Internship will be undertaken in an industry only. The industry is preferably related with renewable power industry or its allied industry.

EXAMINATION SCHEME (Summer Internship-II) – 100 Marks
1. Internal Assessment (60 Marks): Evaluation is based on – **Work done-30, Quality of report & Presentation-15, Performance in Viva-voce-15.** **Internal Assessment by the internal teacher will be based on reports of industry visit & job done there.**
2. End Semester Examination (40 Marks): Evaluation is based on – **Work done -15, Quality of report & Presentation-15, Performance in Viva-voce-10.** **End Semester Examination will be based on evaluation by the supervisor of the concerned industry/organization.**

Semester : Fifth
Course Code : PR301
Course Title : Major Project
Number of Credit: ^ (L- 0; T- 0; P- 2)
Course Category: PR
Course Contents :
Major Project will be based on real/ live problems of the Industry/Govt./NGO/ MSME/Rural Sector or an innovative idea having the potential of a Startup. **Evaluation of the Job of 5th. Semester will be carried over in 6th. Semester examination.** **^ Note: One credit will be carried forward from the 5th. Semester to 6th. Semester for major project evaluation.**
