Syllabus for

Post Graduate Diploma in Renewable Energy and Energy Management

Department of Physics
SNCW, Kollam

Syllabus Structure

POST GRADUATE DIPLOMA
IN
RENEWABLE ENERGY AND ENERGY MANAGEMENT (REEM)

Semester I			
Course code	**Course Name**	**CH**	**Credits**
DRE101	Energy and Environment	12	6
DRE102	Solar Energy	12	6
DRE103	Biomass Energy	12	6
DRE104	Wind and Hydro Energy	12	6
DRE105	New Energy Resources	12	6
		Total credits	**30**
Semester II			
DRE201	Energy Management and Auditing	12	6
DRE202	Energy Efficiency in Thermal Utilities	12	6
DRE203	Energy Efficiency in Electrical Utilities	12	6
DRE204P	Practical and Project work	24	12
		Total credits	**30**

Total credits requirement: 60

Course code	Course Name	Credits	CH
DRE 101	**Energy and Environment**	**3**	**12**

Unit 1 Ecological principles and energy flow

Ecological principle of nature
Concept of ecosystems
Different types of ecosystems; ecosystem theories
Energy flow in the ecosystems; biodiversity

Unit 2 Energy scenario and development

Overview of world energy scenario
Overview of India's energy scenario
Overview of Energy Scenario of North East India and in particular to Assam
Energy and development linkage
Energy Sources: classification of energy sources
Quality and concentration of energy sources

Unit 3 Major energy resources

Units of various Energy sources, Conversion, calorific value
Coal-sources, formation, important properties & conversion
Petroleum-sources, genesis, important properties & uses
Natural gas- sources, genesis, important properties & uses

Unit 4 Environment concerns of energy extraction

Environment effects of energy extraction, conversion and use
Sources of pollution; primary and secondary pollutants.
Consequences of pollution growth; air, water, soil, thermal, noise pollution-cause and effect
Pollution control methods
Environmental laws on pollution control

Unit 5 Energy use & climate change

Global warming
Green house gas emission, impacts, mitigation.
Causes of global, regional and local climate change

Unit 6 Sustainability issues of energy use

Externalities
Future Energy Systems
Clean Energy Technologies

Unit 7Socio-Economical aspects of Energy resources

General concepts
Socio-economical impacts
Rural development, Poverty alleviation, Employment; Security of supply and use
Environmental and ethical concerns
Economical aspects of renewable energy systems vs large hydro and thermal power projects

Unit 8 International treaties & convention on environmental mitigation

United Nations Frameworks Convention on climate change (UNFCC)
Various convention and treaties at international level aiming at CO_2 mitigation

Suggested reading references

1. Ristinen RA. Kraushaar JJ. *Energy and the Environment*, 2nd edition, John Willey & Sons, 2006
2. Banerjee BP. *Handbook of Energy and Environment in India*, Oxford University Press, 2005, India
3. MC Dass, *Fundamentals of Ecology*, Tata McGraw Hill, 1994

4. Kaushik ND. Kaushik K. *Energy, Ecology & Environment*, Capital Publishing, 2004
5. De AK. *Environmental Chemistry*, New Age International Publishers, 2005

Course code	Course Name	Credits	CH
DRE 102	**Solar Energy**	**3**	**12**

Unit 1 Solar Radiation

Solar radiation: extra-terrestrial and terrestrial
Radiation measuring instruments
Radiation measurements and predictions

Unit 2 Basics of Solar Thermal Conversion

Solar thermal conversion: basics
Flat plate collectors-liquid and air type, Theory of flat plate collectors
Selective coatings

Unit 3 Solar thermal systems and applications

Advanced collectors: ETC, Solar Pond
Concentrators: optical design of concentrators
Solar water heaters, Solar dryers, Solar stills
Economics of solar thermal conversion systems

Unit 4 Solar thermal Energy conversion

Solar cooling and refrigeration
Thermal storage
Conversion of heat into mechanical energy
Active and passive heating of buildings
Solar thermal power generation

Unit 5 Basics of Solar Photovoltaics

Principle of photovoltaic conversion
Technology for fabrication of photovoltaic devices

Unit 6 Solar Photovoltaic energy conversion and utilization

Photovoltaic power generation systems.
Off-grid systems
Grid connected systems
Organic solar cells
Electrochemical energy storage: Batteries
Economics of solar photovoltaic systems

Unit 7 Power electronics for Photovoltaic systems

Off-grid power control and management systems
Grid-connected power control and management systems

Unit 8 Solar Photo-catalysis

Solar photocatalysis: mechanism, Kinetics
Nano-catalysts: system design, Performance parameters
Applications of solar photo-catalysis

Suggested reading references

1. Goswami DY. Kreith F. Kreider JF. *Principles of Solar Engineering*, Taylor & Francis, 1999
2. Tiwari GN. *Solar Energy, Fundamentals design, modeling and Applications*. Narosa, 2002
3. Duffie JA. Beckman WA. *Solar Engineering of Thermal Processes*, John Wiley, 2006
4. Kishore VVN. *Renewable Energy Engineering and Technologies*, TERI, 2009

Course code	Course Name	Credits	CH
DRE 103	**Biomass Energy**	**3**	**12**

Unit 1 Introduction

Overview of biomass as energy source; *Biomass availability in North Eastern States of India*
Production of biomass, Photosynthesis, efficiency of C_3 & C_4 plants on biomass production.
Classification of biomass.

Unit 2 Biomass as fuel

Physicochemical characteristics of biomass as fuel
Thermal characteristics of biomass as fuel
Biomass conversion routes: biochemical, chemical and thermo-chemical

Unit 3 Biochemical conversion of biomass for energy production

Anaerobic digestion, biogas production mechanism
Types of digesters, installation, operation and maintenance of biogas plants
Biogas plants manure-utilization and manure values.
Biogas utilization and storage
Biogas for motive power generation etc.

Unit 4 Liquid biofuel

Biodiesel – the mechanism of transesterification, fuel characteristics of biodiesel, technical aspects of biodiesel engine utilization
Alcohol production from biomass - types of materials of alcohol production - process description, utilization

Unit 5 Chemical conversion of biomass for energy production

Chemical conversion processes
Hydrolysis and hydrogenation

Unit6 Synthesis biofuel

Modern biofuel synthesis
Bio- refinery

Unit7 Thermo-chemical conversion of biomass

Combustion in excess oxygen and oxygen deficient atmosphere
Pyrolysis, Carbonization, Charcoal production
Biomass gasification--different types--power generation from gasification
Biomass based power generation

Unit 8 Energy plantation

Overview on energy plantation
Basis of selecting the plants for energy plantation
Waste land utilization through energy plantation

Suggested reading references

1. Mukunda HS. *Understanding Clean Energy and fuels from biomass*. Wiley-India Pvt. Ltd, 2011
2. Pandey A. *Hand book of plant-based bio-fuel*. CRC Press, Taylor & Francis, 2008
3. Mital KM. *Biogas Systems, Principle and Applications.* New Age International Ltd. 1996
4. Rai GD. *Non-conventional energy sources*. Khanna Publication, 2001
5. Ravindranath NH. Hall DO. *Biomass, Energy and Environment, A developing country perspective from India*. Oxford University Press, 1995

Course code	Course Name	Credits	CH
DRE 104	**Wind and Hydro Energy**	**3**	**12**

Unit 1 Wind resource assessment

History of wind energy, Current status and future prospects, Wind Energy in India.
Power available in the wind, Wind Turbine power and torque characteristics, Types of rotors: Horizontal and Vertical axis wind turbine, Characteristics of wind rotor.
Analysis of wind regimes
Local effects, wind shear, Turbulence and acceleration effects
Measurement of wind: Ecological indicator, Anemometers and wind directions.
Wind speed statistics: Time and Frequency distribution, Mean wind speed and distribution of wind velocity.
Statistical model for wind data analysis : Weibull distribution
Energy estimation of wind regimes, capacity factor.

Unit 2 Aerodynamics of wind turbine

Airfoil, lift and drag characteristics
Aerodynamic theories
Axial momentum theory
Blade element theory
Strip theory
Power coefficient and tip speed ratio characteristics, Rotor design and Performance analysis

Unit 3 Wind energy conversion systems

Wind electric generators
Tower, rotor, gearbox, power regulation, safety mechanisms
Generator: Induction and synchronous generator
Grid integration
Wind pumps
Wind driven piston pumps, limitations and performance analysis

Unit 4 Wind energy systems: Environment and Economics

Environmental benefits and problems of wind energy
Economics of wind energy
4.21 Factors influence the cost of energy generation: Site specific parameters, machine parameters
4.2.2 Life cycle cost analysis

Unit 5 Hydro-power

Introduction to Hydropower, Classification of Hydropower Plants, Small Hydropower Systems: Overview of micro, mini and small hydro systems, Status of Hydropower Worldwide, Advantages and Disadvantages of Hydropower
Selection of site for hydroelectric plant, Hydrological cycle
Essential elements of a hydroelectric power plant

Unit 6 Basics of Fluid Mechanics

Classification of Fluids, Characteristic of Water, units of Pressure, Pascal's law, applications of Pascal's law, Hydraulic press, Pressure measurement
Types of fluid flow, stream line and turbulent flow
Velocity Equation, Bernoulli's Equation, Power Equation, Continuity Equation, Cavitations, venturi meter, orifice meter, Pitot tube

Unit 7 Components of Hydropower Plants

Components of hydropower plants Hydraulic Turbines: Types and Operational Aspects

Classification of Hydraulic Turbines, Theory of Hydroturbines; Francis, Pelton, Kaplan and Propeller Turbine; differences between impulse and reaction turbines; Operational Aspects of Turbines

7.2.3 Efficiency and selection of turbines

Types of generators - synchronous and induction, transformers, protection & control, transmission and distribution system.

7.3 Dam and Spillway, Surge Chambers, Penstock, Tailrace

Unit 8 Hydropower plant development

Site selection, environmental aspect, run-of-the-river and storage schemes; diversion structures, power channels, desilting arrangements, forebay tank and balancing reservoir, penstock and power house; transmission and distribution system.

Economics: cost structure, Initial and operation cost. Environmental issues related to small and large hydropower plants

Potential of hydro power in North East India

Suggested reading references

1. Johnson GL. *Wind Energy Systems,* (Electronic Edition), Prentice Hall Inc, 2006
2. Mathew S. *Wind Energy: Fundamentals, Resource Analysis and Economics*. Springer, 2006
3. Burton T. Sharpe D. Jenkins N. Bossanyi E. *Wind Energy Handbook*. John Wiley, 2001
4. Jha AR. *Wind Turbine Technology,* CRC Press, Taylor & Francis, 2011
5. Jain P. *Wind Energy Engineering*. McGraw-Hill 2011
6. Nag P K. *Power Plant Engineering,* 3rd Edition, Tata McGraw Hill, 2008.
7. Bansal RK. A textbook of fluid mechanics and hydraulic machines. Laxmi Publications, 2005, New Delhi
8. Hussian Z. Abdullah MZ. Alimuddin Z. *Basic Fluid Mechanics and Hydraulic Machines*. CRC Press, 2009.
9. Jiandong T. *Mini hydropower*. John Wiley, 1997
10. Wagner H. Mathur J. *Introduction to Hydro energy Systems : Basics, Technology and Operation*, Springer, 2011

Course code	Course Name	Credits	CH
DRE 105	**New Energy Resources**	**3**	**12**

Unit 1 Background

Need of energy systems and materials
Application to supplement and expedite energy conservation efforts
Addressing environmental concern
Suitability as CDM

Unit 2 Hydrogen Energy

2.1 Basics of Hydrogen Energy
Production methods
Storage and transportation
Applications

Unit 3 Fuel Cell

Principle of working
Basic thermodynamic and electrochemical principles
Classifications
Applications for power generations

Unit 4 Ocean Energy

Ocean energy resources
Ocean energy routes
Ocean thermal energy conversion
Wave energy conversion
Tidal energy conversion

Unit 5 Geothermal Energy

Origin
Types of geothermal energy sites
Geothermal Power plants

Unit 6 Magneto-hydro-dynamic (MHD) energy conversion

Principle of operation
Classifications
Features of MHD Systems

Unit 7 Electrochemical Energy Storage System

Batteries
Types
Working principles
Role of carbon nanotubes in electrode

Unit 8 Magnetic and Electric Storage System

Super conducting magnetic energy storage (SMES) systems
Capacitor and super capacitor

Suggested reading references

1. Narayan R. Biswanathan B. *Chemical and Electrochemical Energy Systems*, University Press (India) Ltd. 1998.
2. J W Twidell & A D Weir, *Renewable Energy Resources*, ELBS, 2006
3. Tiwari GN. Ghoshal MK. *Fundamental of Renewable Energy Sources*, Narosa, 2007.

Course code	Course Name	Credits	CH
DRE 201	**Energy Management and Auditing**	**3**	**12**

Unit 1 Energy and its various forms

Commercial and Non-commercial energy, primary energy resources, commercial energy production
Energy pricing, energy security, energy conservation and its importance
Electricity tariff, load management and maximum demand control
Thermal energy contents of fuel, heat capacity, sensible and latent heat, heat transfer
Stochiometric air-fuel ratio, Flue gas analysis

Unit 2 Energy management and auditing

Concept of energy management programme, Energy auditing services; basic components of an
Energy audit, types of energy audit, Industrial, commercial and residential audit planning
Understanding energy costs, bench marking, energy performance index
Understanding energy used pattern, system efficiencies, input energy requirements optimization
Fuel & energy substitution
Energy conservation act and its features
Duties and responsibilities of energy managers and auditors
Energy audit instruments/ tools

Unit 3 Material and Energy Balance

Basic Principles, Sankey diagrams
Material balances for different processes
Energy balances, heat balances
Methods for preparing process flow chart
Procedure to carry out the material and energy balance in different processes

Unit 4 Energy Action Planning

Energy management systems, Management commitment and energy conservation policy
Energy performance assessment: Data collection and management, analysis of data, baseline and benchmarking, Estimation of energy savings potential
Action planning, training planning.

Unit 5 Monitoring and Targeting

Defining monitoring & targeting, elements of monitoring & targeting,
Data and information-analysis, various techniques
Energy consumption, production, cumulative sum of differences (CUSUM), case studies.

Unit 6 Electrical Energy Management

Reactive power management
Energy conservation in domestic and industrial sectors
Energy conservation in lighting, motors, pumps and fan systems

Unit 7 Thermal Energy Management

Energy conservation in boilers and Furnaces
Waste heat recovery
Thermal insulation
Energy conservation in buildings, Building heating and cooling load management, Buildings code, solar passive and green building concepts

Unit 8 Financial and Project Management

Financial analysis techniques: simple payback period, return on investment, net present value, internal rate of return, cash flows and sensitivity analysis Financing options, energy

performance contracts and role of ESCOs. Project definition and scope, Technical design and Financing Project planning techniques; CPM and PERT, case studies

Course code	Course Name	Credits	CH
DRE 202	Energy Efficiency in Thermal Utilities	3	12

Unit 1 Fuels and Combustion

Introduction to Fuels
Properties of Fuel oil, Coal and Gas, Storage, handling and preparation of fuels
Principles of Combustion, Combustion of Oil, Coal, and Gas
Stoichiometric air fuel ratio, Theoretical and excess air

Unit 2 Energy conservation in boilers

Boiler systems, Types of boilers
Combustion in boilers
Performances evaluation; Analysis of losses
Feed water treatment, Blow down
Energy conservation opportunities

Unit 3 Steam Systems

Steam Properties
Steam distribution
Steam pipe sizing and designing
Steam traps: Operation and maintenance, Performance assessments
Energy conservation opportunities

Unit 4 Furnaces

Types and classifications of different furnaces
Performance analysis of furnaces; Analysis of losses
General fuel economy measures in furnaces; Case study
4.3 Energy conservation opportunities

Unit 5 Cogeneration

Principle and need for cogeneration
Technical options of cogeneration; Classifications of cogenerations
Factors influences cogeneration cycle
Cogeneration performance parameters, Case study

Unit 6 Waste Heat Recovery

Classifications and Applications
Benefits of waste heat recovery
Commercial waste recovery systems, Case study

Unit 7 Insulations and Refractories

Purpose of insulations, Types and applications
Calculation of insulation Thickness; Economic thickness of insulations
Types and properties of refractories; Industrial use of refractories
Heat losses from furnace walls

Unit 8 Energy Performance assessment of heat exchangers

Performance terms and Methodology of performance assessment;
Case study

Course code	Course Name	Credits	CH
DRE 203	**Energy Efficiency in Electrical Utilities**	**3**	**12**

Unit 1 Electrical systems

Introduction of Electrical systems, Tariff and economic considerations; T & D losses
Electrical load management; Maximum demand management
Role of Power factor and its improvement
Electric Power systems analysis
Energy Efficient Technologies in Electrical Systems

Unit 2 Electric Motors

Motor Types, Characteristics, Efficiency
Energy Efficient Motors
Factors affecting Energy efficiency of a motor
Soft starters, Variable speed drives

Unit 3 Compressed Air systems

Introduction, Compressor types and performance; Compressed air systems components;
Efficient operation of compressed air systems, Systems capacity assessment
Energy conservation opportunities

Unit 4 HVAC and Refrigeration systems

Introduction: Types of Refrigeration systems; Common Refrigerant and Properties
Compressor types and applications
Performance assessment of Refrigeration plants
Energy conservation opportunities

Unit 5 Fans and blowers

Types, Performance evaluation, efficient system operation, Capacity selections
Performance assessment of fans and blowers
Energy conservation opportunities

Unit 6 Pumping systems and cooling towers

Types, Performance evaluation, efficient system operation
Energy conservation opportunities in pumping systems
Introduction to cooling towers; cooling tower performance, efficient system operation
Energy conservation opportunities in cooling towers

Unit 7 Lighting systems

Basic terms of lighting systems; Lamp and Luminaries types, recommended illumination level
Methodology of lighting systems energy efficiency study
Cast study, Energy conservation opportunities

Unit 8 DG Set systems

Introduction, Selection and capacity factor, Operational parameters
Performance assessment of DG Systems
Energy conservation opportunities

Suggested reading references (DRE 201, 202 and 203)

[1]. *General Aspect of Energy Management and Energy Audit*, 2010, BEE Guide book
[2]. *Energy Efficiency in Thermal Utilities*, 2010, BEE guide book
[3]. *Energy Efficiency in Electrical Utilities*, 2010, BEE guide book
[4]. Turner WC. *Energy Management Handbook*, 5th Edition, The Fairmont Press, 2005
[5]. Capehart, Turner, Kennedy. *Guide to Energy Management*. Fifth Ed. The Fairmount Press, 2006.

[6]. Thumann, Younger. *Handbook of Energy Audit*. Sixth Ed. The Fairmount Press, 2003.
[7]. Thumann, Mehta. Handbook of Energy Engineering. Fifth Ed. The Fairmount Press, 2001

****

Practical and Project work

1. Evaluation methods of solar power plants
2. study of V-I characteristics of solar PV system
3. Study of different batteries used in PV system
4. Study of different methods of solar power tracking
5. Identification of defects in biogas plant and repair
6. Study of biogas pressure variation with time
7. Variation of electric power output based on wind power
8. Variation of electric power output related to shape of blade
9. Efficiency test of mini hydropower station
10. Recharging of hydral power plant using renewable energy.

Major Project

1. AIM:

   To expose student to industry-standard project practices, through a real-life project work under timeand deliverable constraints, applying the knowledge acquired through various courses.

2. OBJECTIVES:

   To provide an opportunity to apply the knowledge gained through various courses in solving a real life problem
   To provide an opportunity to practice different phases of software/system development life cycle
   To introduce the student to a professional environment and/or style typical of a global industry
   To provide an opportunity for structured team work and project management
   To provide an opportunity for effective, real-life, technical documentation
   To provide an opportunity to practice time, resource and person management.

3. PROJECT GUIDELINES

   Group Size – Maximum 3
   No. of records – No. of group members + 1 (Department copy) Certificate should include the names of all members
   The minimal phases for the project are: Project search, finalization and allocation, Investigation of system requirements, System Design, System implementation and acceptance testing.

   3.1 Planning the Project: The Major Project is an involved Exercise which has to be planned well in advance. The topic should be chosen in Semester 4 itself and the case study of Course should as far as possible, be based on the project topic, though on Exceptional cases, for valid reasons, the project guide may waive this condition. Related reading, training and discussions should start from first semester itself.

4. Selection of project work:
   a) Developing solution for a real-life problem
   (b) Innovative Product development:
   (c) Research level project

Teaching Methodology

- Familiarize some Technologies of Energy conversion
- Interact with some Industry people
- writing project proposals
- Writing assignments
- Quizzes, test papers
- Case studies and feasibility studies of various energy conversion systems
- Mock Energy auditing

Scheme of Evaluation

The course shall have eight theory papers of 100 marks each, that is a total of 800 marks. Second semester contains a Practical and project paper of 100 marks each. Total 1000 marks for the entire course.

Each theory paper of 100 marks shall have two components of evaluation:

a) Continuous evaluation of 20 marks, comprising of quizzes, assignments, test papers etc.

b) Final Written Examination of 80 marks.

The practical paper shall be a practical examination of experiments and viva-voce of 100 marks.

Final Score for 1000 Marks shall be calculated for the continuous evaluation and final examination; and grade shall be as per the grading system below.

Grading System

Based on the student's performance in all the five papers, a final letter grade will be awarded at the end of the PG Diploma course. The letter grades and the corresponding grade points are as given in Table

Table: Grades and Grade Points

S.No.	Grade	Grade Points	Absolute Marks
1	O (Outstanding)	10	90 and above
2	A+ (Excellent)	9	80 to 89
3	A (Very Good)	8	70 to 79

4	B+ (Good)	7	60 to 69
5	B (AboveAverage)	6	50 to 59
6	C (Average)	5	45 to 49
7	P (Pass)	4	40 to 44
8	F (Fail)	0	Less than 40
9	Ab (Absent)	0	

Grade Point Average

A Grade Point Average (GPA) for the course will be calculated according to the formula:

$$GPA = \frac{\Sigma[\ C\text{-}G\ ]}{\Sigma\ C}$$

A student, who earns a minimum of 4 grade points (P grade) in the final exam and continuous evaluation put together in each of the eight papers, is declared to have successfully completed the course, subject to securing a GPA of 8 for a pass in the course.