Post Graduate Diploma in Renewable Energy and Energy Management

Course Structure

(Distance Mode)

Department of Energy
School of Engineering
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Preamble of the course

Energy is a vital input for the development and economic growth of a country. The growth for energy sector is critical for socio-economic development particularly for rural areas. In the Indian context, it is a great challenge to provide affordable energy services to the population. At present, 80% of the total villages and 44% of rural households has access to grid electricity. The development of energy systems is also constrained by the depletion of fossil fuel, local environmental impacts and the problem of global warming and associated climate change. The energy sector is in transition and there is significant need to understand the various energy conversion and efficient utilization process. In view of the problem of climate change and scarcity of fossil fuels, the field of energy engineering offers significant challenges and opportunities. The Department of Energy is going to offer a Post Graduate Diploma Programme in Renewable Energy and Energy Management under distance education mode to enable students with different backgrounds to understand the different aspects of energy engineering. Students will be exposed to the status of energy resources, its interaction with environment, different renewable energy sources technologies, different techniques and technologies for energy management and energy conservation along with the economic aspects of renewable energy based power generation. The objective of the programme is to provide specialist manpower to meet the challenges of the energy sector.

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	3
DRE102	Solar Energy	12	3
DRE103	Biomass Energy	12	3
DRE104	Wind and Hydro Energy	12	3
DRE105	New Energy Resources	12	3
		Total credits	**15**
Semester II			
DRE201	Energy Management and Auditing	12	3
DRE202	Energy Efficiency in Thermal Utilities	12	3
DRE203	Energy Efficiency in Electrical Utilities	12	3
DRE204P	Project work	24	6
		Total credits	**15**

Credit Requirements: Total credits requirement: 30

Duration: Minimum duration of the course: 2 semesters
Maximum duration of the course: 4 semesters

Eligibility Qualification: B.E. /B. Tech. or M.Sc. in Physics and Chemistry

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

Unit 1 Ecological principles and energy flow

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

Unit 2 Energy scenario and development

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

Unit 3 Major energy resources

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

Unit 4 Environment concerns of energy extraction

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

Unit 5 Energy use & climate change

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

Unit 6 Sustainability issues of energy use

6.1 Externalities
6.2 Future Energy Systems
6.3 Clean Energy Technologies

Unit 7Socio-Economical aspects of Energy resources

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

Unit 8 International treaties & convention on environmental mitigation

8.1 United Nations Frameworks Convention on climate change (UNFCC)
8.2 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

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

Unit 2 Basics of Solar Thermal Conversion

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

Unit 3 Solar thermal systems and applications

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

Unit 4 Solar thermal Energy conversion

4.1 Solar cooling and refrigeration
4.2 Thermal storage
4.3 Conversion of heat into mechanical energy
4.4 Active and passive heating of buildings
4.5 Solar thermal power generation

Unit 5 Basics of Solar Photovoltaics

5.1 Principle of photovoltaic conversion
5.2 Technology for fabrication of photovoltaic devices

Unit 6 Solar Photovoltaic energy conversion and utilization

6.1 Photovoltaic power generation systems.
    6.1.1 Off-grid systems
    6.1.2 Grid connected systems
6.2 Organic solar cells
6.3 Electrochemical energy storage: Batteries
6.4 Economics of solar photovoltaic systems

Unit 7 Power electronics for Photovoltaic systems

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

Unit 8 Solar Photo-catalysis

8.1 Solar photocatalysis: mechanism, Kinetics
8.2 Nano-catalysts: system design, Performance parameters
8.3 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

1.1 Overview of biomass as energy source; *Biomass availability in North Eastern States of India*

1.2 Production of biomass, Photosynthesis, efficiency of C_3 & C_4 plants on biomass production.

1.3 Classification of biomass.

Unit 2 Biomass as fuel

2.1 Physicochemical characteristics of biomass as fuel

2.2 Thermal characteristics of biomass as fuel

2.3 Biomass conversion routes: biochemical, chemical and thermo-chemical

Unit 3 Biochemical conversion of biomass for energy production

3.1 Anaerobic digestion, biogas production mechanism

3.2 Types of digesters, installation, operation and maintenance of biogas plants

3.3 Biogas plants manure-utilization and manure values.

3.4 Biogas utilization and storage

3.5 Biogas for motive power generation etc.

Unit 4 Liquid biofuel

4.1 Biodiesel – the mechanism of transesterification, fuel characteristics of biodiesel, technical aspects of biodiesel engine utilization

4.2 Alcohol production from biomass- types of materials of alcohol production-process description, utilization

Unit 5 Chemical conversion of biomass for energy production

5.1 Chemical conversion processes

5.2 Hydrolysis and hydrogenation

Unit6 Synthesis biofuel

6.1 Modern biofuel synthesis

6.2 Bio- refinery

Unit7 Thermo-chemical conversion of biomass

7.1 Combustion in excess oxygen and oxygen deficient atmosphere

7.2 Pyrolysis, Carbonization, Charcoal production

7.3 Biomass gasification--different types--power generation from gasification

7.4 Biomass based power generation

Unit 8 Energy plantation

8.1 Overview on energy plantation

8.2 Basis of selecting the plants for energy plantation

8.3 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

1.1 History of wind energy, Current status and future prospects, Wind Energy in India.

1.2 Power available in the wind, Wind Turbine power and torque characteristics, Types of rotors: Horizontal and Vertical axis wind turbine, Characteristics of wind rotor.

1.3 Analysis of wind regimes

1.3.1 Local effects, wind shear, Turbulence and acceleration effects

1.3.2 Measurement of wind: Ecological indicator, Anemometers and wind directions.

1.3.3 Wind speed statistics: Time and Frequency distribution, Mean wind speed and distribution of wind velocity.

1.3.4 Statistical model for wind data analysis : Weibull distribution

1.3.5 Energy estimation of wind regimes, capacity factor.

Unit 2 Aerodynamics of wind turbine

2.1 Airfoil, lift and drag characteristics

2.2 Aerodynamic theories

2.2.1 Axial momentum theory

2.2.2 Blade element theory

2.2.3 Strip theory

2.3 Power coefficient and tip speed ratio characteristics, Rotor design and Performance analysis

Unit 3 Wind energy conversion systems

3.1 Wind electric generators

3.1.1 Tower, rotor, gearbox, power regulation, safety mechanisms

3.1.2 Generator: Induction and synchronous generator

3.1.3 Grid integration

3.2 Wind pumps

3.2.1 Wind driven piston pumps, limitations and performance analysis

Unit 4 Wind energy systems: Environment and Economics

4.1 Environmental benefits and problems of wind energy

4.2 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

5.1 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

5.2 Selection of site for hydroelectric plant, Hydrological cycle

5.3 Essential elements of a hydroelectric power plant

Unit 6 Basics of Fluid Mechanics

6.1 Classification of Fluids, Characteristic of Water, units of Pressure, Pascal's law, applications of Pascal's law, Hydraulic press, Pressure measurement

6.2 Types of fluid flow, stream line and turbulent flow

6.3 Velocity Equation, Bernoulli's Equation, Power Equation, Continuity Equation, Cavitations, venturi meter, orifice meter, Pitot tube

Unit 7 Components of Hydropower Plants

7.1 Components of hydropower plants

7.2 Hydraulic Turbines: Types and Operational Aspects

7.2.1 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

7.3 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

8.1 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.

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

8.3 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

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

Unit 2 Hydrogen Energy

2.1 Basics of Hydrogen Energy
2.3 Production methods
2.4 Storage and transportation
2.5 Applications

Unit 3 Fuel Cell

3.1 Principle of working
3.2 Basic thermodynamic and electrochemical principles
3.3 Classifications
3.4 Applications for power generations

Unit 4 Ocean Energy

4.1 Ocean energy resources
4.2 Ocean energy routes
4.3 Ocean thermal energy conversion
4.4 Wave energy conversion
4.5 Tidal energy conversion

Unit 5 Geothermal Energy

5.1 Origin
5.2 Types of geothermal energy sites
5.3 Geothermal Power plants

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

6.1 Principle of operation
6.2 Classifications
6.3 Features of MHD Systems

Unit 7 Electrochemical Energy Storage System

7.1 Batteries
7.2 Types
7.3 Working principles
7.4 Role of carbon nanotubes in electrode

Unit 8 Magnetic and Electric Storage System

8.1 Super conducting magnetic energy storage (SMES) systems
8.2 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

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

Unit 2 Energy management and auditing

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

Unit 3 Material and Energy Balance

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

Unit 4 Energy Action Planning

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

Unit 5 Monitoring and Targeting

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

Unit 6 Electrical Energy Management

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

Unit 7 Thermal Energy Management

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

Unit 8 Financial and Project Management

5.1 Financial analysis techniques : simple payback period, return on investment, net present value, internal rate of return, cash flows and sensitivity analysis
5.2 Financing options, energy performance contracts and role of ESCOs.
5.3 Project definition and scope, Technical design and Financing
5.4 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

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

Unit 2 Energy conservation in boilers

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

Unit 3 Steam Systems

3.1 Steam Properties
3.2 Steam distribution
3.3 Steam pipe sizing and designing
3.4 Steam traps: Operation and maintenance, Performance assessments
3.5 Energy conservation opportunities

Unit 4 Furnaces

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

Unit 5 Cogeneration

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

Unit 6 Waste Heat Recovery

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

Unit 7 Insulations and Refractories

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

Unit 8 Energy Performance assessment of heat exchangers

8.1 Performance terms and Methodology of performance assessment;
8.2 Case study

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

Unit 1 Electrical systems

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

Unit 2 Electric Motors

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

Unit 3 Compressed Air systems

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

Unit 4 HVAC and Refrigeration systems

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

Unit 5 Fans and blowers

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

Unit 6 Pumping systems and cooling towers

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

Unit 7 Lighting systems

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

Unit 8 DG Set systems

8.1 Introduction, Selection and capacity factor, Operational parameters
8.2 Performance assessment of DG Systems
8.3 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

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