"Heaven's Light is Our Guide"

Rajshahi University of Engineering & Technology (RUET)

Institute of Energy and Environmental Studies (IEES)

Course Structure and Outline for Postgraduate Diploma in Energy Technology (PGD in ET) and Postgraduate Diploma in Environmental Engineering (PGD in Env.E)

1. Academic Requirements and Regulations

1.1 The minimum duration of the PGD in ET/ PGD in Env.E will normally be two (2) semesters. A candidate for the PGD in ET & PGD in Env.E must complete all the requirements for the diploma within three academic years from the date of his/her first admission in the program. In an academic year there will be normally two semesters.

1.2 Academic progress will be measured in terms of credits earned by a student. One credit for theory course will normally require 14 hours of lecture for one semester; while one credit for project/ laboratory should normally require 42 hours of work for one semester. The number of courses for each subject will be specified in the syllabus of the institute.

1.3 For the PGD in ET/ PGD in Env.E a student must earn a minimum of 40 credits including 10 credits in a project, 15 credits in 5 core coures and 15 credits in 5 optional courses.

1.4 There shall be two categories of students, namely, full-time students and part-time students. A student may be enrolled as a full-time student directly. Students, serving in different organizations, may also be admitted as a part-time student with a written consent of the employer.

(a) In the case of PGD in ET/ PGD in Env.E, a full-time student must register a minimum of 15 credits and a maximum of 20 credits per semester. A full-time student shall not be allowed to be in the employment of any organization (even as a part time employee). However, they may be employed as Teaching/ Research assistant at the university. If a full-time student becomes an employee (full time or part time) of any other organization in the middle of a semester, he/she may, with the approval of the Director of the Institute and his/her Employer, be allowed to continue as a full-time student for that semester.

(b) In the case of PGD in ET/ PGD in Env.E, a part-time student may be assigned a maximum of 11 credits of course work in any semester.

(c) The student may be allowed to switch from part-time to full-time or vice versa on the recommendation of the RAC before the commencement of a semester.

Summary of the Courses for PGD in ET:

First Semester

Sl. No.	Course Code	Course Title	Credit	Hours/ Week Lecture+Lab
1	DET 6000	Project	5.00	0+5
2	DET 6101	Fundamentals of Energy Engineering	3.00	2+2
3	DET 6102	Energy Policy and Planing	3.00	2+2
4	DET 6103	Energy Auditing and Management	3.00	2+2
5	DET 61**	Optional I	3.00	2+2
6	DET 61**	Optional II	3.00	2+2
		Total	20.00	10+15

Second Semester

Sl. No.	Course Code	Course Title	Credit	Hours/ Week Lecture+Lab
1	DET 6000	Project	5.00	0+5
2	DET 6201	Energy Efficiency in Engineering Systems	3.00	2+2
3	DET 6202	Project Planning and Management	3.00	2+2
4	DET 62**	Optional I	3.00	2+2
5	DET 62**	Optional II	3.00	2+2
6	DET 62**	Optional III	3.00	2+2
		Total	20.00	10+15

Optional Courses:

SI. No.	Course Code	Course Title	Credit	Hours/ Week Lecture+Lab
1	DET 6104	Solar Cell Operation and Technology	3.00	2+2
2	DET 6105	Wind Energy Engineering	3.00	2+2
3	DET 6106	Bio-Energy Engineering	3.00	2+2
4	DET 6107	Fuels and Combustion	3.00	2+2
5	DET 6108	Natural Gas Engineering	3.00	2+2
6	DET 6109	Clean Coal Technologies	3.00	2+2
7	DET 6110	Nuclear Engineering	3.00	2+2
8	DET 6111	Energy Systems Modeling and Simulation	3.00	2+2
9	DET 6112	Materials for Energy Application	3.00	2+2
10	DET 6113	Hydrogen Energy	3.00	2+2
11	DET 6114	Smart Grid Technology	3.00	2+2
12	DET 6203	Solar Thermal Systems	3.00	2+2
13	DET 6204	Solar PV System and Net Metering	3.00	2+2
14	DET 6205	Hydro Power Engineering	3.00	2+2
15	DET 6206	Geothermal and Ocean Energy	3.00	2+2
16	DET 6207	Waste to Energy Conversion	3.00	2+2
17	DET 6208	Fuel Cells	3.00	2+2
18	DET 6209	Heating Ventilation and Air Conditioning Systems	3.00	2+2
19	DET 6210	Energy Management in Smart Buildings	3.00	2+2
20	DET 6211	Instrumentation in Energy Systems	3.00	2+2
21	DET 6212	Numerical Computation and Analysis	3.00	2+2
22	DET 6213	Energy Storage Technologies	3.00	2+2
23	DET 6214	Power Plant Engineering	3.00	2+2
24	DET 6215	Power System Planning and Operation	3.00	2+2
25	DET 6216	Pollution Control in Power Plants	3.00	2+2
26	DET 6217	Solar Refrigeration and Air Conditioning	3.00	2+2

Core Courses for First Semester

DET 6000: Project

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 5.0)

The project work as guided by the supervisor.

DET 6101: Fundamentals of Energy Engineering

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Types of energy and their sources, Energy transfer and their usage, Energy scenario, Nodal agencies for power generation and their roles, Role of energy in economic development and social transformation, National energy policy, Environmental impacts of energy production and consumption, Standardization and certification of energy systems, Application of energy systems; Different types of technologies for energy conversion & conservation, Laws and principles related to electrical, thermal and mechanical energy.

DET 6102: Energy Policy and Planning

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Energy (and power) policies in the country, Tariffs and subsidies, Energy utility interface, Private sector participation in power generation, State role and fiscal policy, Energy and development, National energy plan, Role of modeling in energy policy analysis, Energy data base, Energy balances, Flow diagrams, Reference energy system, Energy demand analysis, Trend analysis, Econometric models, Elasticities approach, Input-output models, Simulation/process models, Energy supply analysis, Costs of exploration and economics of utilization of depletable and renewable resources, Scarcity rent, International energy supply, Energy demand supply balancing, Energy -economy interaction, Energy investment planning, Energy environment interaction, Energy Pricing.

DET 6103: Energy Auditing and Management

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Energy Overview – Energy Management Techniques, Role of Energy Managers in Industries- Energy monitoring, auditing & targeting – Economics of various Energy Conservation schemes. Total Energy Systems, Energy Audit -various Energy Conservation Measures in Steam -Losses in Boiler. Energy Conservation in Steam Systems -Case studies. Energy conservation in Centrifugal pumps, Fans & Blowers, Air compressors– energy consumption and energy saving potentials – Design consideration. Refrigeration & Air conditioning - Heat load estimation -Energy conservation in cooling towers & spray ponds – Case studies, Electrical Energy -Energy Efficiency in Lighting – Case studies. Organizational background desired for energy management, motivation, detailed process of M&T-Thermostats, Boiler controls- proportional, differential and integral control, optimizers; compensators.

First Semester Optional Courses

DET 6104: Solar Cell Operation and Technology

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Introduction: History and development of solar cell technology, Different generation of solar cell; Solar photovoltaic basic, Sunlight, Semiconductor material for solar photovoltaic, Electron-hole pair generation, Recombination and the basic equation of device physics, Carrier injections in photovoltaic p-n junction, Dark characteristic, Illuminated characteristic, Solar cell output parameters, Solar cell efficiency limits, Losses and measurement, Standard silicon solar cell technology, Improved silicon cell technology, Design of silicon solar cells, MIS solar cells, Photo-electrochemical cells.
Thin Film Solar Cell: CdTE, CIGS, CZTS, amorphous Si and CTS solar cells.

DET 6105: Wind Energy Engineering

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Wind Resource Assessment*:* History of wind energy, Current status and future prospects, Power available in wind; Power and torque characteristics, Types of wind turbine; Characteristics of wind rotor; analysis of wind regimes; Local effects, Wind shear, Turbulence and acceleration effects; Measurement techniques of wind energy.
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.

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.

Wind Energy Conversion System: Wind electric generators, tower, rotor, gearbox, power regulation, safety mechanisms, Induction and synchronous generators.

DET 6106: Bio-Energy Engineering

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Fundamentals: Biomass resources, Modes of biomass utilization for energy, Routes of biomass conversion processes and biofuels production technologies, History and success stories of energy from biomass.

Characteristics of Biomass Fuels: Fuel analyses, Sample preparation, Characterization and chemical analyses, Relevance of feed properties for anaerobic digestion and thermochemical processes.

Thermochemical Conversion: Pyrolysis- torrefaction, Slow and fast pyrolysis, Charcoal production, Gasification- fundamentals, Fixed bed gasifiers, Technical and operations problems with fixed bed gasifiers, Fluidized bed gasifiers, Entrained bed gasifiers, Gas treatment.

Anaerobic-Aerobic Digestion: Types of biogas plants, Kinetics and mechanism of high-rate digesters for industrial waste water treatment, Design, Installation, operation and management of fixed dome and floating drum biogas plants, Power generation from biogas plants, Purification of biogas for grid quality methane/natural gas, Digester effluent utilization strategies.

Combined Heat and Power Production from Biomass: Concept of CHP in energy production, Poly-generation process (heat, electricity and chemical production), Drawing up of mass and energy balances, Evaluation of the techno- and eco-efficiency, Economic evaluation/preparation of business plan.

DET 6107: Fuels and Combustion

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Fuels and classification of fuels, Merits & demerits of different kinds of fuel, Determination of fuel properties, Physics, Chemistry and thermodynamics of combustion processes, Pollution generation and its environmental effects. Laminar and turbulent premixed and diffusion flames, Determination of flame velocity and length.
Empirical correlation, Flammability limits and flame stability, Combustion of solid and liquid fuels, diffusion and kinetically controlled combustion, Combustion applications.

DET 6108: Natural Gas Engineering

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Introduction, Gas Production: Upstream, Reservoir- Well Completion.

Properties of Natural Gas: Phase Behaviour, Well inflow performance relationship (IPR), Skin factor, Productivity Index, Gas well testing.

Wellbore Performance: TPR Curve, Single Phase & Multi Phase flow, Choke Performance: CPR Curve, Sonic and Subsonic Flow, Well Deliverability: Nodal Analysis.

Natural Gas Production: Downstream, Surface Facilities, Principle of Separator, Design of Separator: Vertical, Horizontal; Two Phase Separation, Three Phase Separation.

Natural Gas Processing: Dehydration of Natural Gas, Design of Dehydration, Sweeting Processes, Compressor design and energy calculation.

Transportation and Measurement, Pipeline Design, Flow through pipeline, issues and solutions, Unconventional Production of Natural Gas: Shale Gas, Gas Hydrates, Coal bed Methane, Oil Shale, Pyrolysis of Carbonaceous Materials etc.

DET 6109: Clean Coal Technologies

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

An overview of combustion fundamentals, Reaction kinetics, Combustion chemistry, Flames, Power generation systems such as, gas-fired furnaces, Premixed-charged engines, oil-fired furnaces, gas-turbines, direct injection engines, Fixed-bed combustors, Pulverized fuel combustors, and Fluidized bed combustors.

Conventional Technologies: Coal washing, Wet scrubbers, Low NOx (nitrogen oxide) burners, Electrostatic precipitators, Oxy-fuel combustion, Flue-gas separation, Carbon dioxide capture technologies, Carbon dioxide sequestration, Environmental impact of advanced clean coal technologies.

DET 6110: Nuclear Engineering

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Radioactivity: Alpha, Beta and Gamma rays, Radioactive Decay, Units of radioactivity, Interaction of gamma rays, Neutrons and charged particles with matter, The basis of the theory of radioactive disintegration, The disintegration constant, Radioactive decay, Half-life and Mean Life.

Nuclear Reaction: Possible type of nuclear interactions, Nuclear fission and fusion.

Nuclear Power Development: Difference between PWR and BWR, Safety features of VVER (Russian PWR, which the Bangladesh Govt. is going to establish at Ruppur site), Fast breeder reactor, Bangladesh.

Nuclear Power Generation: Basics of nuclear power generation, Design, analysis and fabrication of nuclear power systems, Energy conversion in nuclear power systems, Corrosion in nuclear power systems: structural metals in nuclear power plants, operation and maintenance of nuclear power plant, Reactor Controls, Rector Coolants and Radioactive waste disposal.

Nuclear Fuel Cycle and Waste Management: Components of Nuclear Fuel Cycle (NFC), types of NFC, components of the NFC with diagram, differences between closed and open NFCs, classification of radioactive wastes, types of wastes associated with PWR operations.

Water Management of Nuclear Power Plant: Different types of cooling systems, once through, Wet cooling tower, Dry cooling tower etc.

DET 6111: Energy Systems Modeling and Simulation

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

The basic concept of simulation, System modeling simulation of continuous and time discrete system, Queuing simulation, Pert network, Simulation software, Simulation examples of some real-life energy system.

DET 6112: Materials for Energy Application

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Geologic/Alternative fuels: Geology and infrastructure of the current hydrocarbon economy. Alternative sources: shale oil, Tar sands, Methane clathrates.

Thermoelectric Materials: Introduction to thermoelectric materials, Thermal and electrical transport properties, Synthesis of TE material, Aspects of TE devices.

Inorganic Photovoltaic Materials: Introduction of Inorganic photovoltaic materials, Inorganic semiconductors for solar cell applications.

Organic Photovoltaic Materials: Dye sensitized and polymer solar cells, POLEDS, Small molecule solar, OLEDS, and other organic electronics.

Materials Related to Hydrogen Technologies: Hydrogen production, Transportation, Storage, and use fuel cells.

Materials for Electrical Energy Storage: Batteries, Ultracapacitors.

Materials Issues for Future Nuclear Energy: Radiation damage, Recovery mechanisms, and Creep-rupture.

DET 6113: Hydrogen Energy

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Introduction of Hydrogen Energy Systems 183 Energy Studies Hydrogen pathway's introduction – current uses, General introduction to infrastructure requirement for hydrogen production, Storage, dispensing and utilization, and Hydrogen production power plants. Hydrogen Production Processes Thermal – Steam Reformation – Thermo chemical Water Splitting – Gasification – Pyrolysis, Nuclear thermo catalytic and partial oxidation methods. Electrochemical – Electrolysis – Photo electrochemical. Biological - Anaerobic - Digestion – Fermentative Micro- organisms. Hydrogen Storage - Physical and chemical properties – General storage methods, compressed storage –

Composite cylinders – Glass micro sphere storage – Zeolites, Metal hydride storage, chemical hydride storage and cryogenic storage. Hydrogen Utililzation-Overview of Hydrogen utilization: I.C. Engines, gas turbines, Hydrogen burners, Power plant, Refineries, Domestic and marine applications. Hydrogen fuel quality, performance, COV, Emission and combustion characteristics of Spark lgnition engines for hydrogen, Back firing, Knocking, Volumetric efficiency, Hydrogen manifold and direct injection, Fumigation, NOx controlling techniques, Dual fuel engine, Durability studies, Field trials, emissions and climate change.

DET 6114: Smart Grid Technology

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Introduction: - Smart Grid an overview, Components of Smart Grid; Intelligent Appliances, Smart Substations, Smart Distributions Generations, Smart Power meters, Universal Access (wind, solar, hydro etc.) Smart Grid Technologies, Integrated Communications.

Sensing and Measurement, Advance Control Methods, Advance components and Improved Interfaces and Decision Support.

Benefits of Smart Grid: Self-Healing, Power Quality Improvement, Utilization of all generation and storage options, Optimized use of assets and efficient Operation. Miscellaneous: Smart Grid Challenges, Smart Grid Projects, Contribution of Microgrid in development of Smart Grid.

Core Courses for Second Semester

DET 6201: Energy Efficiency in Engineering Systems

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Fundamentals: Tariff and economic considerations, Transmission and distribution losses, Mechanical losses in power production, Electrical load and demand management, Role of power factor and improvement, Electrical power systems analysis.

Energy assessment in mechanical systems: Types of pumps and turbines and their classification, Performance and characteristics of turbines, Pumps and compressors, Types of IC engines and performance analysis. Different thermodynamic cycle and efficiency analysis.

Energy assessment in electrical systems*:* Motors- Fundamentals and types, characteristics, efficiency, factors affecting energy efficiency, soft starters, variable speed drives, Lighting systems- Fundamentals, types, capacity selections, performance assessment; energy conservation opportunities, Generators- Fundamentals, types, capacity selections, performance assessment; energy conservation opportunities; Transformer systems- Fundamentals; types, capacity selections, performance assessment; energy conservation opportunities.

DET 6202: Project Planning and Management

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Introduction to Energy Projects: Features of energy projects, Project cycle and Context of energy projects.

Project Preparation and Development: Project Identification, Project proposal preparation, Pre-feasibility and Feasibility studies, Budgeting and Project approval and implementation.

Cost Concepts and Financial Calculations: Cost concepts, Time value of money, Interest formulas and equivalence, Inflation and Depreciation.

Economic Evaluation of Energy Projects: Alternative methods of project evaluation, Economic vs. financial evaluation, Valuation of costs and benefits, Sensitivity analysis and break-even analysis.

Financial Evaluation of Energy Projects: Elements of financial costs, Financial structure and project feasibility, Revenue streams: Effects of assumptions and pricing, Sensitivity analysis. Sources of funds and the cost of capital, Project financing and Raising funds in the international market.

Environmental Issues in Energy Projects: Evaluation of Environmental Impacts, Methods of Economic Evaluation of Environmental Impacts and Effects of Environmental Regulations in Project Evaluation.

Risk Analysis in Project Development: Origins of project risk, Methods of describing project risk, Measurement of investment worth under risk.

Life Cycle Analysis (LCA) of Energy Projects: Life cycle cost analysis, Other aspects of life cycle analysis, LCA applications in energy projects.

Optional Courses for Second Semester

DET 6203: Solar Thermal Systems

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Introduction: Sun-earth geometry relationship, Variation of extraterrestrial radiation, Beam and diffuse radiation, Solar time and Solar angle.

Flat Plate Collector*:* Construction methodology and classification, Flat-plate energy balance equation, Temperature distributions in FPC, Collector overall heat transfer coefficient, Testing of collector, Collector efficiency factors, Collector heat removal factor and flow factor, Selective coating, Effective transmittance-absorptance product, Heat capacity effects in FPC, Optimum inclination of FPC, Evacuated tube cover collector, Evacuated-tubular collector, Evacuated tube of heat pipe.

Concentrating Collectors: Fundamentals, Characteristics parameters, Concentration ratio, Optical efficiency, Classification of concentrators, Tracking of concentrators, Tracking methods, Thermal analysis, Materials for concentrators.

Applications: Solar water heating, Heat collection in storage tank, Effect of heat load, Solar cookers, Solar desalination, Solar dryers, Passive solar house heating and cooling, Solar refrigeration and air conditioning, Solar thermal energy storage, Central receiver power plant, Dish stirling systems, Solar ponds.

DET 6204: Solar PV System and Net Metering

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Solar PV System Components: Solar charge controllers and solar inverters-types and characteristics, Solar cables, Solar mounting system, Solar PV system types -off grid, hybrid and on grid systems, Solar photovoltaic applications, Solar system performance measurement and monitoring, Solar system operation and maintenance. PV system installation considerations, Metering of PV system output, Technical considerations for connecting to the grid, IEEE standard issues, National electrical code considerations and other issues.

Introduction to Net Energy Meter: Benefits & Drawbacks of net energy meter. Post Net Metering successor tariffs, time of use metering, Market rate net metering, Excess generation, Energy storage, Net purchase and sale, Virtual net metering.

Net Metering Guidelines: Eligibility criteria, Consumer categories, capacity and energy export limits, Energy accounting and settlement, Tariff structure, Metering arrangement, Application procedure, approved equipment.

Interconnection Requirements: Description of the indirect renewable energy system, Feeding method, Equipment standards, Connection types.

General Interconnection Requirements: Normal voltage operating range, Voltage fluctuation, RE generation power factor, Reactive power compensation, Injection of direct current, Harmonic, Voltage unbalance, Short circuit level.

Protection Guidelines: Smart inverter, Frequency, Synchronization, Inverter fault current contribution, Failure of system protection or control equipment, Utility interface disconnect switch. Safety Requirement: Operation & Labeling.

DET 6205: Hydro Power Engineering

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Introduction: Hydropower, Water turbines, Gradient, Flow, Force, Power, Energy and Flow equations.

Hydro Power Plant: Fundamentals and classification of hydro power plants, Status and prospect of hydropower, Advantages and disadvantages of hydropower, Site selection of hydroelectric plant, hydrological cycle, Essential elements of a hydroelectric power plant.

Hydro Power Plant Development: Run of the river and Storage schemes, Diversion structures, Power channels, Desilting arrangements, Forebay tank and balancing reservoir, Penstock and power house, **V**arious types of turbines, Suction tube, Cavitation, Characteristics of Francis, Kaplan, Pelton and Bankiho turbines, Transmission and Distribution system.

Environmental and Economical Aspect of Hydro Power: Environmental benefits and problems, Cost structure analysis.

DET 6206: Geothermal and Ocean Energy

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Geology of Geothermal Regions: Fundamentals and strategical techniques of exploration, Heat source systems for ambient air utilization and Shallow geothermal utilization.

Geothermal Well Drilling: Design of up and down hole part system, District heating system, Environmental analysis of geothermal energy, Case study.

Geothermal Power Plants: Single and double flash steam power plants, Binary cycle power plants, Advanced geothermal energy conversion systems, Exergy analysis applied to geothermal power systems.

Ocean Energy: Fundamentals and principals of tidal and wave energy conversion, Operation principal of ocean thermal energy conversion, Future of ocean energy conversion.

DET 6207: Waste to Energy Conversion

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Solid Waste: Sources, Types, Compositions, Properties of solid waste, Collection, Transfer stations, waste minimization and recycling of municipal waste. Landfill method of solid waste disposal, Landfill classification, Methods & siting consideration. Waste treatment & disposal size reduction: Incineration; furnace type, Types of incinerators, fuel economy, Medical / pharmaceutical waste / Hazardous waste / Nuclear waste incineration, Environmental impacts, Measures of mitigate environmental effects due to incineration.

Biochemical Conversion: Sources of energy generation, Industrial waste, Agro residues.

Anaerobic Digestion: Biogas production, Determination of BOD, DO, COD, TOC, & Organic loading, Aerobic & Anaerobic treatments, Types of digesters, Factors affecting bio-digestion, Activated sludge process. Methods of treatment and recovery from the industrial waste water, Case studies in sugar, distillery, Dairy, pulp and Paper mill, fertilizer, Tanning, steel industry, Textile, petroleum refining, Chemical and Power plant.

Rural Applications of Biomass: Combustion, Chulhas, Improved chulhas, Biomass- physical and chemical composition, Properties of biomass, TGA, DSC characterization, ash characterization.
Preparation of Biomass: Size reduction, Briquetting of loose biomass, Briquetting machine.

Thermochemical Conversion: Basic aspects of biomass combustion, Heat of combustion, Different types of grates, Co-combustion of biomass, Gasification – fixed and fluidized bed gasifier, Gasification technologies for the selected waste like rice husk, Coir pith, bagasse, Poultry litter etc. Pyrolysis.

DET 6208: Fuel Cells

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Fuel Cell: Review of fuel cell, Thermodynamics and kinetics of fuel cell process, Eat released, Reasons for losses in voltage, Electrode kinetics, Porous electrodes, Characteristics, Fabrication of electrodes, Assembly of fuel cells, Testing, Classification of fuel cells based on nature of electrolyte, operating temperature, Performance evaluation of fuel cell, Comparison on battery Vs fuel cell.

Characteristics and Status of Various Types of Fuel Cells: Alkaline Fuel Cells (AFC), Phosphoric Acid Fuel Cells (PAFC), Polymer Electrolyte Membrane Fuel Cells (PEMFC), Direct Methanol Fuel Cells (DMFC), Molten Carbonate Fuel Cells (MCFC), Solid Oxide Fuel Cells (SOFC), Regenerative Fuel Cells (RFC), use of alternative fuel in fuel cells, Specific characteristics, Advantages and applications.

Fuel Cell Power Plants and Applications: Fuel cell plants and sub systems, Efficiency of systems, Performance, Emissions, Heat balance, Environmental benefits, Heat rate of various fuel cell plants, Natural gas and coal-based fuel cell power plant concepts, Cogeneration and CHP, Fuel cell hybrids, Fuel cell systems for portable, Automotive, Stationary applications, Future challenges.

DET 6209: Heating Ventilation and Air Conditioning Systems

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Introduction to Automotive Heating, Air Conditioning, and Ventilation (A/C Components and HVAC Operation) Concept of HVAC systems, comfort data, cooling and heating load calculation of various applications, Air distribution system and duct design, Air conditioning equipment, Air purification, Installation of units, Charging, Leak detection, wiring diagram and service; Troubleshooting.
Introduction to Refrigeration system, Analysis of vapor-compression refrigeration system and its modifications.

DET 6210: Energy Management in Smart Building

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Processes in Building: Indoor Activities and Environmental Control, Internal and External Factors on Energy Use and the Attributes of the Factors, Characteristics of Energy Use and Its Management.

Indoor Environmental Requirement and Management: Thermal Comfort, Ventilation and Air Quality, Air-conditioning Requirement, Visual Perception, Illumination Requirement, Auditory Requirement
Climate, Solar Radiation and Their Influences: The Sun-Earth Relationship and the Energy Balance of the Earth's Surface, Climate, Wind, Solar Radiation, and Temperature, Sun Shading and Solar Radiation on Surfaces, Energy Impact on the Shape and Orientation of Buildings.

End-use Energy Utilization and Requirements: Lighting and Daylighting, End-use Energy Requirements, Status of Energy use in Buildings, Estimation of Energy Use in a Building Heat Gain and Thermal Performance of Building Envelope Steady and No steady Heat Transfer Through the Glazed Window and the Wall. Solar-Generated Desiccant Dehumidification for Ventilation, Radiant Panel Cooling, Daylighting Application.

Heat Gain Through Window: Solar Radiation Transmission through Complex Fenestration System, Thermal Gain and Net Heat Gain, Methods of Control. Dynamic Air-Conditioning Load; Dynamic and Latent Heat Gain from External and Internal Source by Air, Cooling Coil Load and Air-Conditioning Load.

DET 6211: Instrumentation in Energy Systems

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Introduction: Methods of measurements, Measurement Errors - Materials, radiant storage- Transducer classification- Static and dynamic characteristics of transducers, Transient analysis of a control system.

Measuring instruments: Classification of measuring instruments. Ammeter, Voltmeter, Wattmeter, AVO meter, Energy meter, Maximum demand meter for measuring AC and DC quantities. Power factor meter-Analog signal conditioning, Amplifiers, Instrumentation amplifier, A/D and D/A converters, Digital data processing and Data acquisition system.

Instrumentation: Extension of instrument range. Use of C.T ant P.T and calculation of their burden, Instrumentation of the substation.

Temperature Measurement - Pressure thermometers, Thermocouples, RTD, Thermistors, and Pyrometry.

DET 6212: Numerical Computation and Analysis

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Solution of Non- Linear Equations: iterative process, localization of the roots, initial approximation and convergence criteria, relaxation and conjugate gradient method for system equation, Newton's method.

Partial Differential Equation: stability and convergence of numerical methods, finite difference and finite element method for solving partial differential equations.

DET 6213: Energy Storage Technologies

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Introduction to Energy Storage for Power Systems**:** Role of energy storage systems, Applications.

Overview of Energy Storage Technologies: Thermal, Mechanical, Chemical, Electrochemical, Electrical, Efficiency of energy storage systems.

Electrical Energy Storage: Batteries, Super capacitors, Superconducting Magnetic Energy Storage (SMES), Charging methodologies, SoC, SoH estimation techniques. Hydrogen production and storage, fuel cells.

Hybrid Energy Storage Systems: Configurations and applications.

Storage for Renewable Energy Systems: Solar energy, Wind energy, pumped hydro energy, Fuel cells. Energy storage in Micro-grid and Smart grid. Energy Management with storage systems, Battery SCADA, Increase of energy conversion efficiencies by introducing energy storage.

DET 6214: Power Plant Engineering

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Introduction: Types of power plants and its modern trend, Field survey of power plants in Bangladesh, gas plant.

Diesel Electric Power Plant: Scope, Arrangements, Air fuel system, Cooling system and lubrication system, Starting methods.

Steam Power Plant: Introduction, Principle of operation, Steam turbine and its performance, Stage efficiency, Installation of steam power plant, Fuel handling and burning system.

Hydroelectric Power Plant: Types of operation, Site selection, Turbine selection, Seasonal and intermittent plants, Components of the plant, Efficiency.

Gas Turbine Power Plant: Scope, Installation, Governing and maintenance.

Nuclear Power Plant: Scope, Plant layout, Types of reactors, Fuels, Waste disposal and safety.

Hybrid Power Plant: Concept, Solar/wind hybrid system, Diesel/wind hybrid system, Solar/biomass hybrid system.

Power Plant Accessories: Draft systems and chimney design, Water-cooling systems, Water conditioning and Industrial water treatment.

Electrical Transmission and Distribution: Basic concept, Types of transmission and distribution system, Major electrical equipment in power plants, Smart grid.

DET 6215: Power System Planning and Operation

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Generation System Capacity Adequacy Planning: Probabilistic models of generating unit outage performance and system load-evaluation of loss of load and loss of energy indices, Probabilistic production costing, Inclusion of power generation from renewable energy sources in the reliability analysis.

Interconnected Systems: Multi-area reliability analysis, Power pool operation and power/energy exchange contracts, Quantification of economic and reliability benefits by pool operation, Demand / energy forecasting: Sector-wise peak demand and energy forecasting by trend and econometric projection methods, Optimal power system expansion planning: Formulation of least cost optimization problem incorporating the capital, Operating and maintenance costs of candidate plants of different types (thermal, hydro, nuclear, non-conventional etc.) and minimum assured reliability constraint-optimization techniques for solution by linear and dynamic programming approaches-case studies.

DET 6216: Pollution Control in Power Plants

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Coal and Nuclear based Power Plants – Fly Ash generation and environment impact, Fly ash utilization and disposal, Nuclear fuel cycle, Radioactive wastes – treatment and disposal, Pollution control methods (i) Pre-combustion controls, (ii) Combustion controls Low NOx burners, fluidized bed boilers, (iii) Post Combustion Controls, Particulate controls, Cyclone, Wet scrubbers, ESP and fabric filters, Gaseous pollutants controls flue gas desulfurization (FGD) systems, CSR reduction applications of electron beam and non-thermal plasmas for SOx and NOx treatments, Thermal pollution and its impact on aquatic life.

DET 6217: Solar Refrigeration and Air Conditioning

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Potential and Scope of Solar Cooling, Types of solar cooling systems, Solar collectors and storage systems for solar refrigeration and air-conditioning, Solar operation of vapour absorption and vapour compression refrigeration cycles and their thermodynamic assessment, Rankine cycle, Sterling cycle based solar cooling systems, Jet ejector solar cooling systems, Fuel assisted solar cooling systems, Solar desiccant cooling systems, Open cycle absorption / Desorption solar cooling alternatives, Advanced solar cooling systems, Thermal modeling and Computer simulation for continuous and Intermittent solar refrigeration and Air-conditioning systems, Refrigerant storage for solar absorption cooling systems, Solar thermoelectric refrigeration and Air-conditioning, Solar thermo acoustic cooling and Hybrid air conditioning, Solar economics of cooling systems.

Summary of the Courses for PGD in Env.E:

First Semester

Sl. No.	Course Code	Course Title	Credit	Hours/ Week Lecture+Lab
1	DENV 6000	Project	5.00	0+5
2	DENV 6101	Introduction to Environmental Engineering	3.00	2+2
3	DENV 6102	Energy, Ecology and Environment	3.00	2+2
4	DENV 6103	Environmental Accounting and Auditing	3.00	2+2
5	DENV 61**	Optional I	3.00	2+2
6	DENV 61**	Optional II	3.00	2+2
		Total	20.00	10+15

Second Semester

Sl. No.	Course Code	Course Title	Credit	Hours/ Week Lecture+Lab
1	DENV 6000	Project	5.00	0+5
2	DENV 6201	Global Environmental Issues and Policies	3.00	2+2
3	DENV 6202	Project Planning and Management	3.00	2+2
4	DENV 62**	Optional I	3.00	2+2
5	DENV 62**	Optional II	3.00	2+2
6	DENV 62**	Optional III	3.00	2+2
		Total	20.00	10+15

Optional Courses:

Sl. No.	Course Code	Course Title	Credit	Hours/ Week Lecture+Lab
1	DENV 6104	Geo-environment	3.00	2+2
2	DENV 6105	Climate Change and Human Adaptability	3.00	2+2
3	DENV 6106	GIS and Remote Sensing	3.00	2+2
4	DENV 6107	Environmental Laws and Ethics	3.00	2+2
5	DENV 6108	Aerosol Technology	3.00	2+2
6	DENV 6109	Industrial Energy and Environmental Analysis	3.00	2+2
7	DENV 6110	Climate Change, Impacts, Adaptation and Mitigation measures	3.00	2+2
8	DENV 6111	Environmental Hazards of Trace and Radioactive Elements	3.00	2+2
9	DENV 6203	Water Resources: Planning and Management	3.00	2+2
10	DENV 6204	Environmental Impact Assessment	3.00	2+2
11	DENV 6205	Society and Environment	3.00	2+2
12	DENV 6206	Environmental Health and Sanitation	3.00	2+2
13	DENV 6207	Environmental Planning and Sustainable Development	3.00	2+2
14	DENV 6208	Disaster and Environmental Management	3.00	2+2
15	DENV 6209	Environmental Engineering and Risk Assessments	3.00	2+2
16	DENV 6210	Carbon Capture and Storage	3.00	2+2
17	DENV 6211	Environment and Governance	3.00	2+2
18	DENV 6212	Environment, Mass Media and Awareness	3.00	2+2
19	DENV 6213	Automotive Air Pollution Control	3.00	2+2
20	DENV 6214	Environmental Pollution and Waste Management	3.00	2+2
21	DENV 6215	Green Technologies for Clean Environment	3.00	2+2
22	DENV 6216	Zero Emission Vehicles	3.00	2+2

Core Courses for First Semester

DENV 6000: Project

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 5.0)

The project work as guided by the supervisor.

DENV 6101: Introduction to Environmental Engineering

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Definition, history and development of environmental science. Biotic and abiotic factors and their interactions with environment. Human influences on ecosystem. Scope and significance of environmental science study.

Environmental problems and issues: Groundwater arsenic contamination, Stratospheric ozone layer depletion, Elnino, La-Nina, Tsunami, Acid rain, Greenhouse effect, Global warming and climate change. Surface water pollution, Air pollution in major cities, Brick-fields, Industrial waste, deforestation and desertification in the Barind region, Hill cutting and shifting cultivation, Salinity intrusion in southern Bangladesh, Top-dying symptom of Sundarban, Agro-chemical pollution, Wetland and fisheries resources depletion, Bhopal gas leak, Chernobyl disaster, etc.

Renewable and non-renewable energy, Environmental health and toxicology. Concepts of sustainable development. Environmental laws and ethics, Environmental awareness and global environmental politics. Concepts of EPA, UNEP, CITES, WWF, IUCN, Green Peace, etc.

DENV 6102: Energy, Ecology and Environment

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Interrelationship between energy and environment, Biological processes, Photosynthesis, Autecology and Synecology, Population, Community Ecosystem (wetland, terrestrial, marine) Food chains, Ecosystem theories. Sources of energy, Classification of energy sources, Environmental issues related to harnessing to fossil fuels (coal, oil, natural gas), Geothermal, Tidal, Nuclear energy, Solar, Wind, Hydropower, Biomass, Energy flow and nutrient cycling in ecosystems, Environmental degradation, primary and secondary pollutants. Thermal/ radioactive pollution, Air and water pollution, Micro climatic effects of pollution, Pollution from stationary and mobile sources, Biological effects of radiation, Heat and radioactivity disposal, Acid rain, Global warming and greenhouse gases, Ozone layer depletion.

DENV 6103: Environmental Accounting and Auditing

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Origin, significance and importance of environmental accounting. Is this type accounting possible in Bangladesh? The role of environmental accounting, improved environmental management.

Nature of environmental auditing – definition, characteristics, types. Environmental audit methodology, Audit preparation, Objectives and scope, Audit team and familiarization, Pre-audit planning. Environmental audit methodology – on-site audit activities, inspection techniques, document review, interviews and meeting, post-audit activities, audit report, corrective action, program and follow-up activities.

Environmental auditing for government and non-governmental organizations; Types of environmental administration, Natural resource management, Energy consumption, Water consumption, Firms,

various environmental research organizations. Audit case study – site visit, report writing and presentation.

Optional Courses for First Semester

DENV 6104: Geo-environment

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Geology and Environment, Importance of Geology in environmental science; Solar system; Earth history and Geological time scale.

Major Earth components: Atmosphere: Birth and history of the atmosphere, Structure and significance of the atmosphere, Atmospheric compositions and their sources, Principal uses of the atmosphere, Solar radiation, Green-house effect and Global warming.

Lithosphere: Description of the lithosphere, Continental drift and Plate tectonic theory, Structure of the earth interior, Composition of crust, Mantle and core, Rock- classification, Composition, Rock cycle; Soil-soil formation, Classification, Soil profile, Composition and management.

Hydrosphere: Water classification and its distribution, Hydrologic cycle, Surface water, Ground Water-Vertical distribution, Groundwater compositions and their sources, Concentration and effect on usability, Aquifer and its types, Sea water- composition of sea water, Sources of sea salt, Salinity, Sea water intrusion and its environmental impact in coastal area of Bangladesh.

Biosphere: Definition, Extent of the Biosphere etc.

Biogenic deposits: Origin of petroleum; Sources of petroleum; Natural gas, Crude oil and coal-their classification and composition, Petroleum deposits and their reserve in Bangladesh, Impact of mining development environment.

Geo-environment of Bangladesh: Geological characteristics of Bangladesh, Tectonic framework of Bangladesh, Hydrogeology, Climate and vegetation, Indian, Mountains and River basins- Ganges, Brahmaputra, Meghna and Industry.

DENV 6105: Climate Change and Human Adaptability

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Overview of Climate System. Climate variation during the postglacial period and to assess prospects for future decades and second current understanding of key climate issues such as the working of the climate system, Impacts on humanity, The natural causes of climate change and anthropogenic effects on climate.

Basic Science: Covers the fundamental science underlying the problem of global climate change induced by greenhouse and gas emissions, Including greenhouse gas sources, Gas cycles, Modeling effects on global temperature, Sea level and regional climate, Detection of the global warming signal and climate impacts.

Policy Responses: Adaptation and emission control, the two possible societal responses to the threat of global climate change, and it involves the study of the practical application of policy-orientated models dealing with, for example, the imposition of emission targets, energy taxes and land management options as well as study of the framework convention on climate change.

DENV 6106: GIS and Remote Sensing

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Geography and GIS: basic concepts its origin GIS, CAC and CAD, map as model, paradigm shift in cartography. Spatial location and reference, Spatial patterns, Geographic data collection and sources, Concept of DBMS data tables. GIS data structures, Database structure for managing data, GIS data models, Vector versus raster. Introduction to Cartalinx and Arc view data input. Storage and editing input devices digitization different types of errors. Introduction to GPS and its integration into GIS. The concept of remote sensing, its use in mapping and geographic analysis, history and development of remote sensing Energy used in feature photography/imaging – its properties, Radiation principles, energy interaction in the atmosphere, Energy interaction with earth surface features. Elements of photographic system conventional camera, film – aerial film camera panoramic camera stereoscopic viewing digital camera system. Preparing maps from aerial photographs rule of thumbs, of photo/image interpretation feature grouping, Classification image interpretation equipment. Earth observing satellites, different types, Satellite orbits, Sensing coverage, Data sources. Satellite sensor systems, MSS, Thermal, Hyperspectral, Digital image processing, Data restoration, Rectification. Image enhancement and image contrast manipulation, Multi-image manipulation. Image classification, Unsupervised, Supervised, Hybrid application of remote sensing different fields, land use, forestry, agriculture, environment and coastal ecosystem urban etc.

DENV 6107: Environmental Laws and Ethics

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Environmental laws and ethics, Environmental awareness and global environmental politics. History and relevance of environmental law, Legal aspects of environmental resource management, Origin of environmental law in Bangladesh and other countries: major environmental laws, policies and regulations such as Environment Conservation Act (ECA, 1995), Environment Conservation Rules (ECR, 1997), Green Court (2000), Forest Ac (2000), Wildlife Preservation Act, Fish Ac etc.

Environmental dispute and resolution over common resource sharing: River water sharing (Ganga, Nile, Indus, etc.), Trans-boundary air pollution, biological diversity & intellectual etc., International environmental conventions, Protocols and treaties and their implementation in Bangladesh, International organizations involved in environmental law, Protocols, Conventions and Treaties (UNEP, UNDP, Green Peace, CBD, WWF, CITES, IUCN etc.).

DENV 6108: Aerosol Technology

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Aerosol physics, Aerosol chemistry, Sources and sinks of aerosols in indoor and outdoor environments, Lung deposition, Particle size distribution, Sampling and measurement techniques. Aerosol properties and typical particle pollution in indoor and working environments as well as in ambient air. Particles' effects on human health and environment. Application of aerosol technology in clean room technology, Electronics and pharmaceutical industry.

DENV 6109: Industrial Energy and Environmental Analysis

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Industrial energy use and its disaggregation (in terms of production dependent, weather dependent and independent etc. components), Energy intensity, Pinch analysis, Lean energy analysis,

Thermodynamics and energy analysis, Life cycle energy analysis, Energy analysis and energy management, Energy audits, Managing energy efficiency in the industry. Basic approaches and tools for environment analysis, Life cycle analysis and environmental impact assessment of industrial products and processes, Inventory of materials and energy inputs and environmental emissions, Emission factors, Relevant ISO standards (such as ISO 14040 and ISO 14044), Potential of energy and materials recovery, Case studies.

DENV 6110: Climate Change, Impacts, Adaptation and Mitigation measures

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Current knowledge about observed and future impacts of climate change on the natural and human environment: Freshwater resources and their management, Ecosystems, their properties, Goods and services, Food, Fibre and forest products, Coastal systems and low-lying areas, Industry, settlement and society, Human health. Future impacts of climate change in Africa, Asia, Australia and New Zealand, Europe, Latin America, North America, Polar Regions (Arctic and Antarctic) and Small islands.

Impact on Public Health: Quantitative health impact assessment, Disasters: Floods and windstorms, vector borne diseases, Waterborne and flood borne diarrheal diseases, Food security, Vulnerable populations.

Assessment of Adaptation Practices, options, constraints and capacity. Inter-relationships between adaptation and mitigation. Assessing key vulnerabilities and the risk from climate change. Perspectives on climate change and sustainability. Issues related to mitigation in the long-term context: Energy supply, Transport and its infrastructure, Residential and commercial buildings, Industry, Agriculture, Forestry, Waste management. Mitigation from a cross sectoral perspective.

Sustainable Development and mitigation. Policies, instruments and co-operative agreements and Case studies.

DENV 6111: Environmental hazards of trace and radioactive elements

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Problems related to excessive trace and radioactive element contents of soils, Trace and radioactive elements in Soils, Excess of Trace and radioactive elements in soils, Availability of trace Metals to Plants, Permissible trace metal levels and loads in soils.

Speciation of Heavy Metals in Soils and Groundwater: Introduction, Processes, and General Trends, Reactions Decreasing Solubility, Reactions Enhancing Solubility: Dissolved Inorganic and Organic Complexation, Ternary Species (Co-Adsorption – Co-Precipitation), Kinetics and Reversibility of the Geochemical Reactions Involved in Speciation, Methods for determining the speciation, Predictive Trends (Natural and Provoked Mobility).

Environmental Radiation Monitoring and Detection: Radiation detectors, Different methods of detection, Gamma Spectroscopy system, Calibration, Efficiency and Minimum detection limit of gamma spectroscopy system, Environmental sample counting and analysis, Counting statistics, Dose measuring instruments, Survey meter, Pocket Dosimeters. TLD, etc. Dose assessment of environmental radioactivity, Radioactivity levels in the environment of Bangladesh.

Core Courses for Second Semester

DENV 6201: Global Environmental Issues and Policies

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Characterization of global environmental issues and overview of global sustainability around the world. Key environmental issues for global sustainability: Population and demographic transition, Food production, urbanization, Oil production, Electricity generation, Greenhouse gas production, Climate change, Sea level rise and the renewable transition. Global sustainability for Ecological health, Grass-roots development, Gender equity and appropriate technology, Global sustainability for Green politics and economics, Civil society, Ethics and spirituality. Basic principles for institutional, legal, and regulatory framework for environmental policies, Strategies, Regulations and governance. State of the environment and policy retrospective of 1972–2008: Our common future, Earth Summit, Kyoto protocol, and Johannesburg Earth Summit; Innovation and networking for environmental policy for sustainable environmental management since Rio (Earth Summit): Guidelines for environmental policies of World Bank, UNEP, WHO, OECD, and other international and UN organizations.

Market-based environmental policies and actions for achieving the Millennium Development goals and related outcomes; Analysis of environmental policies developed and developing countries. Case study of environmental policies and natural resource management in South-East Asia.

DENV 6202: Project Planning and Management

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Introduction to projects: Features of projects, Project cycle and Context of environmental projects.

Project Preparation and Development: Project Identification, Project proposal preparation, Pre-feasibility and Feasibility studies, Budgeting and Project approval and implementation.

Cost Concepts and Financial Calculations: Cost concepts, Time value of money, Interest formulas and equivalence, Inflation and Depreciation.

Economic Evaluation of Projects: Alternative methods of project evaluation, Economic vs. financial evaluation, Valuation of costs and benefits, Sensitivity analysis and break-even analysis.

Environmental Issues in Energy Projects: Evaluation of environmental impacts, Methods of economic evaluation of environmental impacts and effects of environmental regulations in project evaluation.

Financing of Energy Projects: Sources of funds and the cost of capital, Project financing and Raising funds in the international market.

Risk Analysis in Project Development: Origins of project risk, Methods of describing project risk, Measurement of investment worth under risk.

Life Cycle Analysis (LCA) of Energy Projects: Life cycle cost analysis, other aspects of life cycle analysis, LCA applications in energy projects.

Optional Courses for Second Semester

DENV 6203: Water Resources Planning and Management

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Principles of water quality control, monitoring and sampling methods, Groundwater aquifer system in the Bengal Delta in Bangladesh, Groundwater contamination, Groundwater-surface water interaction, aquifer protection and rehabilitation. Basic concepts in water resource planning and management: Precipitation, Evaporation, Transpiration, Infiltration, Water resource development, and conservation in dry periods and in arid regions, Rainwater harvesting, Wetlands and water resources, Soil-water relationship, Human impacts on water resources: Irrigation and flood control system, Case studies of Farakka Barrage, Flood Action Plan and National Water Management Plan of Bangladesh.

DENV 6204: Environmental Impact Assessment (EIA)

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Introductory Background: Nexus between development and environment. Origin and development of EIA in USA and Bangladesh. The role of USEPA in developing the EIA in developing countries. Relation of EIA to sustainable development. EIA costing. EIA in project planning and implementation.

Introduction of EIA, Environment and Sustainable Development, Objectives of an EIA, Impact Identification, Prediction and Evaluation, Environmental Issues related to Infrastructural Development, Screening, Initial Environmental Examination (IEE) and detailed EIA, Structure and format of an IEE report. Categorization of projects and major criteria for project site location. EIA methodology: Baseline information collection, scooping, Impact assessment methods (checklist and matrix), Mitigation measures, Environmental management plan (EMP) and environmental monitoring. Application procedure for environmental clearance, Case Study.

Risk assessment and risk management. Mitigation measures: Green bills. Review of EIA procedures in some developing countries: India, Srilanka, Thailand, Malaysia and Philippines.

DENV 6205: Environment, Development and Society

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Connection between environment, development, and society, Industrialization and risk society, Challenge of sustainable development, Perception of the environment, Dependence for livelihood, Identity, and Power of natural resources, Social ecology, Role of religion in determining our world view and relation with the environment, Recognition of indigenous knowledge, rise of environmental movements, Development projects and recent conflict over natural resources, Understanding major environmental disasters and industrial accidents, Global climate change negotiations, gender and environment.

DENV 6206: Environmental Health and Sanitation

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Environment and diseases. Transmission of disease. Classification of transmission mechanisms (waterborne, water-washed, water based and insect vector). Classification of infections (excreta-related: fecal-oral by bacteria and non-bacteria, Soil transmitted helminths, Beef and pork tapeworms,

water-based helminths, excreta related insect vectors). Vectors, Parasites and their control. Principles of toxicology. Epidemiological studies. Development of health criteria. Application to home, Work and community environment. Comprehensive planning. Health administration. Environmental factors and quality of human health. Types of toxic substances affecting human health. Adverse effects of air pollution, Water pollution and land degradation. Village, Urban, Industrial and institutional sanitation. Introduction to hygienic sanitation system. Water pollutant removal and purification techniques, Water supply and different types sanitary toilets and waste management. Environmentally sound settlement planning.

DENV 6207: Environmental Planning and Sustainable Development

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Significance of environmental planning and design in sustainable development. Planning processes and methodologies – content and function, the plan as a process, social and historical considerations, Elements of planning and team work. The concept of planning in the developed and developing countries. Protection and restoration of natural system. Design plan – implementation process, comprehensive plan, zoning plan, industrial performance, history, preservation, flexible zoning, specific plan.

Concepts of sustainable development, Dynamic relationship of population, environment and sustainable development, Methods of integrating population variables into development planning and institutional framework for formulating population and development planning.

Ecological and other perspectives on the interrelationship of population and environment, Consequences of environment degradation, Carrying capacity, Utilization of resources, Population-resource ratio, Population and land utilization, Population growth and increasing pressure on food and other resources, Factors affecting supply and demand of natural resources, and environmental impact of development programs.

DENV 6208: Disaster and Environmental Management

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Disasters, Environmental Emergency Vulnerability, Hazards, Risks, Natural disasters and man-made disasters. Land movement disasters- landslides, Slope stability, Causes of landslides, Human use and landslides, River erosion, Avalanches, Lahars and Volcanic eruptions. Earthquake, Intensity and frequency of earthquakes, Earthquake hazard reduction, Prediction and control. Floods-types, magnitude and frequency of floods, Nature and extends of flood hazards, Urbanization and flooding; Limnic eruptions and Tsunamis etc. Blizzards, Storms, Hailstorms, Cyclones, Tornadoes, Drought, Heat waves. Fire disasters, Health and Diseases- Epidemic and Famine.

Disaster Management: Risk assessment, Extreme event analysis, Risk perception, Adjustment to hazards and loss sharing, Hazard resistance, Preparedness, Forecasting, and Warning, Environmental hazards and disasters management system in Bangladesh.

DENV 6209: Environmental Engineering and Risk Assessments

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Soil Mechanics and Engineering: Basic behavior and site characterization, Introduction on Geotechnical and Geo-environmental engineering, Basic soil mechanics: Soil type, geologic formation and classification, basic elements, Soil forming minerals and types of rocks, Soil forming

processes, Soil fabric and structures, Definitions, and relationships between basic soil properties, Seepage through saturated soil, Basic mechanics, Compressibility and Consolidation.

Engineering Properties of Geologic Materials: Engineering properties of soils typical correlation, Particle shape, Void ratio, Density index, Atterberg Limits, Expansion index, Sensitivity, Hydraulic conductivity, Elastic properties, Swelling and shrinkage. Strengths of geologic materials, Shear strength, Factors affecting soil shear strength, Strength of intact rock and rock masses, Stability analysis, Site planning and preparations.

Risk Assessment: Definition of risk, Hazard and disaster, Factors of risk, Types of risk, Point of risk analysis, Risk management goals, Strategies, Principles of risk management framework, Risk management methods, Principles of decision making, and public perception of risk. Geo-environmental problem identification and risk management, Framework for risk-based site management, Defining goals, Regulatory and Societal issues, Site assessment for risk-based site management.

DENV 6210: Carbon Capture and Storage

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Introduction to source of CO_2 (Greenhouse gas) from thermal energy systems and their Global warming potential (GWP), Carbon and CO_2 cycle, Scenario of CO_2 concentration in atmosphere, Relationship between radiative forcing and greenhouse gas concentration, Estimation of the equilibrium surface temper change, and global warming and climate change. Mechanism of CO_2 emission formation during combustion in power plants (steam turbine, gas turbine and internal combustion engines), CO_2 emission reduction by use of alternative fuels and energy efficiency improvement in thermal energy system, Measurement and analysis of CO_2 emission in heat engines / power plants / thermal energy system. Carbon capture: different methods (physical / chemical / biological) of Carbon capture from power plants, CO_2 capture through pre-combustion methods, oxygen-combustion method, Post combustion methods (physical solvents/sorbents, membranes, cryogenic fractionation), Chemical-looping combustion and algae species. Carbon storage under empty oil well, Ocean storage, etc. Carbon sequestration: mineral carbonation, Photosynthesis of plants, Fuel production, Refrigerant, Dry ice, Fertilizer, Working fluid for power plants, Industrial applications (textile, paint, mining, oil etc.) and Case studies / numerical calculations for energy input requirement for CCS system.

DENV 6211: Environment and Governance

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Fundamentals of interrelation between environment policy-management issues and politico-administrative settings, Socio-politico dynamics in the developing nations with special reference to Bangladesh. Environmental issues in the perception and papers of different stakeholders of the governance. Environmental politics-actors, Interests and policy formulation. Institutions, organizations and strategic actions for environment policy management. Resource allocation for environmental management-review of different Five-year plans. People's participation in governance of environmental issues-experience of northern and southern countries. Go-NGO partnership in environmental management. Gender environment and governance. Tools and techniques of monitoring, evaluation of environmental projects, Environmental challenges and governmental responses.

DENV 6212: Environment, Mass Media and Awareness

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Revisiting the concepts of Communication, Media, Environment and Awareness. Functions of communication, and communication media. Importance of communication media in meeting environmental problems. Media theories and its critiques. Environmental psychology and the role of mass media in raising human awareness about the environment. Researches on the role of communication media in raising people's awareness and relevant learning.

Environmental politics and international media, The role of the print, Electronic, and Folk media in Bangladesh to overcome environmental enigma, and evaluation of the concerned media policies and related studies. Investigating the body of environmental related indigenous knowledge in Bangladesh and the harms caused by mass media particularly in the sector of agriculture. Planning for communication campaign and advocacy for creating mass awareness for the environment.

DENV 6213: Air Pollution Control Engineering

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Overview of air pollution from mobile and stationary sources. Pollutants from diesel and gasoline engine: causes of formation of UHC, NOx, CO, PM and odor from diesel and gasoline engine, comparison of diesel and gasoline emissions. Models of controlling diesel and gasoline engine emissions. Effects of different engine parameters on emission and their optimization.

Fuel modification: Alternative fuel and additive for diesel and gasoline engine.

Exhaust after treatment: Particulate trap, Three-way catalyst, oxidation catalyst, EGR, Reduction catalyst, Thermal reactor. Emission of modern engines: Hybrid vehicles, Electric vehicles, Fuel cell vehicles, Solar energy for vehicle propulsion.

Stationary sources of air pollutants, Household pollutants and control of indoor air quality, Control of pollutants from power plants.

DENV 6214: Environmental Pollution and Waste Management

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Water Pollution: Definition, Classification of water pollutants, Sources and consequences of water pollution and Wastewater treatment techniques.

Air Pollution: Definition, Sources and types of air pollutants, Effects and control of air pollution.

Noise Pollution: Definition, Sources, Effects and Control of noise pollution.

Radiation Pollution: Definition, Radiation sources in the environment, Biological effects of radiation, dose limits, Control for radioactive sources and Radiation apparatus.

Soil Pollution: Definition, Causes of soil pollution, Effects and control of soil poll Solid Waste: Sources and types of solid waste, Physical and chemical properties of solid waste, Domestic waste, domestic solid waste, Disposal of municipal and Industrial waste-different methods: Sludge treatment and disposal facilities, Recovery of resources.

Hazardous waste: Identification and characteristics of hazardous waste, Processing and treatment of hazardous waste-physical processes, Chemical processes, Thermal processes, Biological processes, natural systems for hazardous waste treatment, Waste stabilization pond, Aquatic weeds and constructed wetland system, Hazardous waste disposal, Biological detoxification and Application of biotechnology.

DENV 6215: Green Technologies for Clean Environment

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Green technology: Global perspectives, Selectivity of green technology, Solvent free micro-wave assisted technique, Microwave activation, Non-purely thermal techniques, Hyphenated techniques, use of hyphenated tools, Species derivatization, Opportunity and challenges. Non-traditional green alternatives: Oxidative technology mechanism, Mechanism of oxidation of pollutants, Cavitation, application of cavitation to wastewater treatment, the use of Fenton chemicals, Sun photocatalytic oxidation, Hybrid and photo-Fenton process. Cleaner technology: the transition to cleaner technology, factors promoting cleaner technology, Regulatory frameworks, Need for state intervention, Impacts of regulation on innovation and competitiveness, Policy instruments, Cleaner technology versus competitiveness, Cost minimization, Public information, Cleaner technology promotion, Radical changes in process technology. Preventing Industrial Waste and Pollution through Cleaner Production: Cleaner industrial production without use of toxic chemicals, Cleaner agricultural production, Cleaner renewable energy sources, Clean coal technology, Change in production processes for cleaner production, Material substitution for cleaner production, Equipment modification for cleaner production.

DENV 6216: Zero Emission Vehicles

(Theory: 2 Hours/Week, Lab: 2 Hours/Week, Credit: 3.0)

Introduction to various zero emission vehicles, Fundamentals of Internal combustion (IC) engines (Spark ignition and Compression ignition engines), Emission and its formation mechanism (HC, CO, NO_x, N_2O, PM etc.), Emission control strategies including EGR; Exhaust gas after treatment devices (TWC, SCR, LNT, DoC, DPF), Lean burn combustion (PCCI and HCCI), Controlled auto ignition, Homogeneous charge preparation strategies, Hydrogen fueled vehicle: Back firing, Power drop, Fuel induction techniques; Battery operated vehicles: Introduction, Types, Batteries, Accessories, Hybrid vehicles: Introduction, Classification, Advantages and disadvantages.

Fuel cell vehicles: Introduction, Fuel cell system, Classification, Speed Torque and Speed-power characteristics, operational issues, Well to wheel analysis of zero emission vehicles, Net impact (including embodied energy) of zero emission vehicles on Environment for assessment of CO_2 emission.