SYLLABUS OF
M.Phil./Ph.D. COURSES

A booklet of the courses offered for advanced research degrees (M.Phil. or Ph.D.) in energy or relevant arenas

Institute of Energy
Faculty of Engineering and Technology
University of Dhaka

Introduction

A registered M.Phil. or Ph.D. student should complete two (each 100 marks, 48 classes) or four (each 50 marks, 24 classes) and one viva voce exam (of 100 marks) in first year as per the university ordinances and regulations stated in Dhaka University Calendar-III. For the Ph.D. candidates who have M.Phil. or honours degree of four years and master degree of one year from the University of Dhaka need not to take the theoretical course as per the syndicate meeting held on 10 June 2015.

Institute of Energy offers the following optional courses (3.0 credit hours (100 marks) for each course) for M.Phil. or Ph.D. students. Every M.Phil. or Ph.D. student would be required to select two theoretical courses, suggested by his/her supervisor. He will also have to face one viva-voce exam of 3.0 credit (100 marks) at the end of the theoretical exams. These courses are passed by the meeting of Academic Council that was held on 25 April, 2019 (decision no. 53).

The supervisor (with due acknowledgement of the Academic Committee of the Institute) of M.Phil. or Ph.D. student may suggest one or more relevant courses for his student, which are offered at any level of the Institute of Energy or other departments. These courses would not be considered as the two theoretical courses, but would be considered in the viva-voce examination.

List of theoretical courses

Course code	**Course title**	**Credit**
IE 6001	Research Methodology	3
IE 6002	Energy Economics	3
IE 6003	Energy Audit, Management and Conservation	3
IE 6004	Bioenergy and Systems	3
IE 6005	Energy from Water Resources	3
IE 6006	Solar Photovoltaic Energy and Systems	3
IE 6007	Solar Thermal Energy and Systems	3
IE 6008	Wind Energy and Conversion Systems	3
IE 6009	Climate Modeling and Carbon Management	3
IE 6010	Fossil Fuel Based Power Plant	3

IE 6001 Research Methodology 03Credits

Fundamentals:	Meaning, Objectives, Motivation, General characteristics, Criteria of good research, Types of research based on area and purpose, Understanding of research procedure, Landmark researches on Energy, Global and regional trends of energy research, Essence of reviewing literature, Sources and types of research literature – journal paper and patent, Introduction of major research data bases.
Plan of research work:	Optimizing level of expectation on the basis of resources availability, Preparation of the research plan, Selection of research topics, Avoiding reinventing wheel, Expectation and research ethics.
Research Methodology:	Experiments, Quantitative and Qualitative Methods, Computer Applications, Methods for collection of data, Major considerations for data collection, Questionnaire preparation, Data analysis and its interpretation, Use of statistics of energy research, Use of models for energy research.
Reporting research outcomes:	Preparation and presentation of Figures, Graphs and Tables, Technical writing, Process of manuscript preparation, Dissertation preparation, References and Bibliography, Plagiarism detection.

Texts/References

- Kothari C R (2004). Research Methodology: Methods and Techniques. New Age International Private Limited Publishers, New Delhi
- Drake P (2010). Practitioner Research at Doctoral Level: Developing Coherent Research Methodologies. Routledge Publisher
- Bly R W and Blake G (2002). Elements of Technical Writing, Pearson

IE 6002 Energy Economics 03Credits

Energy Demand Analysis:	Energy Basics, Energy Statistics, Energy Balances, Energy supply chain, Energy accounting framework, Energy demand models and analysis, Energy demand forecasting, Energy demand management, Demand side management (DSM), Load management, Energy efficiency, Rebound effect, Energy saving opportunities.
Supply Economics:	Economic and Financial Energy Investment Analysis, Fossil fuel production and supply economics, Economics of Electricity Supply, Cost effectiveness of energy saving opportunities, Economics of Renewable Energy
Economics of climate change:	Economic approach to valuing climate change, Social value of climate change, Economics of greenhouse gas emissions control, Emissions trading, economics of climate change mitigation.
Energy Markets:	Energy Pricing, Energy Taxation, Electricity Markets, Renewable Energy markets.
Project feasibility analysis:	Time Value of Money, Simple Payback Period, IRR, NPV, Life cycle analysis, Cost of saved energy, Cost of generated energy, Social cost and benefit analysis, Concept of externality of environmental impacts, uncertainty analysis, sensitivity analysis, sustainability of project.

Texts/References

- Bhattacharyya S.C (2011). Energy Economics Concepts, Issues, Markets and Governance, Springer-Verlag
- Biggar, D.R and Hesamzadeh, M.R. (2014), The Economics of Electricity Markets, Wiley
- Perman, R., Ma, Y., Common, M, Maddison, D. and McGilvray, J. (2011), Natural Resources and Environmental Economics, Addison Wesley
- Roger Fouquet (2013). Handbook on Energy and Climate Change. Edward Elgar Publishing, Cheltenham
- Goulder, Lawrence and William Pizer (2005). The Economics of Climate Change. The New Palgrave Dictionary of Economics, Second Edition.

IE 6003 Energy Audit, Management and Conservation 03Credits

Introduction:	Definition, Objectives and principles of Energy Management, Energy Management Skills, Energy Management Strategy. Methodology and Approach of energy management, Bench marking, Energy performance, Matching energy usage to requirements, Maximizing system efficiency, Optimizing the input energy requirements, Energy management concept in building. Natural Resources and Renewable Energy integration.
Procedure and techniques:	Data gathering, Special tests, Questionnaire, Analytical Techniques, Incremental cost concept, mass and energy balancing techniques, inventory of Energy inputs and rejections, Heat transfer calculations, Evaluation of electric load characteristics, process and energy system simulation, Evaluation of saving opportunities in money and noneconomic factors, Conservation opportunities, Estimating cost of implementation, Energy audit reporting, Carbon emission and CDM in Building, Insulation, Automation, Sensors.
Thermal Energy Auditing:	Design of heat exchangers, Heat pumps, HVAC systems, Waste heat recovery and co-generation schemes, Pinch analysis, Energy efficient motors.
Electrical energy conservation:	Load management, Conservation methods, Energy management opportunities in electrical heating, lighting and other systems, Cable selection, Efficiency of electrical equipment, Harmonics; Requirements for Energy Action Planning, fuel shifting, fuel mix.
Load management:	Demand control techniques, Utility monitoring and control system, HVAC and energy management, Economic justification, Boiler, Elevator, Power Factor correction.
Energy Management in Buildings:	Thermal properties and energy content of building materials, Energy conservation and efficiency techniques, Passive and active methods of heating, cooling and lighting, Green building, pollution consequence of building material, Net metering Feed-in Tariff, Building code.

Texts/References

- Barney L. Capehart, Wayne C. Turner, and William J. Kennedy (2006). Guide to Energy Management, Fifth Edition, The Fairmont Press, Inc.
- Amit K. Tyagi (2003). Handbook on Energy Audits and Management, TERI
- Kennedy, Turner and Capehart (2011). Guide to Energy Management, The Fairmount Press
- Smith C.B. (2015). Energy Management Principles, Pergamon Press, 2nd edition

IE 6004 Bioenergy and Systems 03Credits

Biomass resources:	Classification and characteristics, Techniques for biomass assessment, Application of remote sensing in forest assessment
Different processes:	Direct combustion, incineration, pyrolysis, gasification and liquefaction, Economics of thermochemical conversion, hydrolysis and hydrogenation, Solvent extraction of hydrocarbons, Solvolysis of wood, Chemical kinetics and mathematical modeling of biomethanation process.
Biogas digester types:	Fixed dome and floating drum biogas plants, Design considerations, Factors affecting generation of biogas, Maintenance, Utilization of biogas, Economics of biogas plant with their environmental and social impacts.
Solid waste:	Definitions, Sources, types, compositions; Physical, chemical and biological properties of municipal solid waste, Its collection, transfer stations, Waste minimization and recycling of municipal waste.
Waste Treatment & Disposal:	Size reduction, Aerobic composting, incineration, Furnace type & Design, Medical/Pharmaceutical waste incineration, Environmental impacts, Measures of mitigate environmental effects due to incineration, Land Fill method of solid waste disposal, Land fill classification, Types, methods & siting consideration, Design of landfills, Environmental monitoring system for land fill gases.

Electricity generation:	Utilization of gasifier for electricity generation, Operation of spark ignition and compression ignition engine with wood gas, methanol, ethanol & biogas, Biomass integrated gasification/combined cycles system, Sustainable co-firing of biomass with coal, Utilization and advantages of briquetting; Environment benefits of biochemical and thermochemical conversion.

Texts/References

- Shah, Kanti L. (2000). Basics of Solid & Hazardous Waste Management Technology, Prentice Hall
- D.O. hall and R.P. Overeed (1987). Biomass Renegerable Energy, John Wiley and Sons, New York
- L.P. White (1981). Biomass as Fuel, Academic press

IE 6005 Energy from Water Resources and Other Sources 03Credits

Water resource:	Water resources and their global distribution, surface and ground water resources, Remote Sensing in water resources management.
Hydrology and hydrological modelling:	Hydrological cycle, the water balance (continuity equation), Method of discharge measurement, Calculation of river discharge, Velocity area method, Salt dilution method, Float method, Construction of hydrograph, Concept of flow-duration curve.
Hydrological model:	Criteria and protocols for a hydrological model, Models for evapotranspiration, plant interception and infiltration, nivo-glacial dissolution, Flood wave models, Continuous hydrological models, Calibration and validation of models.
Hydro Power Plant:	Function, Classification of the typologies of HPPs and main components, Overview of micro, mini and small hydro systems, Hydroelectric plants with reservoir and run of the river plants, Operations management, Selection of site and design criteria of pumps and turbines, Fuel cell.
Tidal Energy:	Tides and tidal currents, Tidal dynamics, Tidal power, Tidal energy generation, impact of tides on climate.
Wave Energy:	Wave energy resources, Classification of wave energy converters, Wave energy harnessing systems, Oscillating Water Columns, Tapchans, Pendulor Devices, Ocean Thermal Energy Conversion (OTEC).
Hydrogen Energy:	Merit as a fuel, Production, Storage, Fuel Cell, Eelectrochemical principles, Fuel cell electrodes and carbon nano tubes.
Other Energy	Lightening energy, Magnetic energy, Energy storage, New energy resources and Energy conversion system.

Texts/References

- P.A. Lynn (2014). Electricity from Wave and Tide An Introduction to Marine Energy, Wiley
- Multon, B. (2012). Marine Renewable Energy Handbook. ISTE Ltd John Wiley & Sons
- Sabins F.F. (1997)., "Remote Sensing – Principles and Interpretations", W.H. Freeman & Co.
- Mays L.W. (2004), "Water Resources Engineering", John Wiley and Sons Publications

IE 6006 Solar Photovoltaic Energy and Systems 03Credits

Introduction:	Energy levels of semiconductors, Probability of occupation of allowed states, Density of electrons and holes, Continuity equations, Homo and Hetero junctions, Metal-semiconductor interface, Efficiency limits, spectrum splitting and cell stacking, Multi-junction and Tandem structure.
Inorganic Solar cell:	Silicon, GaAs, InP solar cell; High efficiency III-V, II-VI multi-junction solar cell; a-Si:H based solar cells, buffer layers, band alignment engineering.
Organic solar cell:	DSSC, Quantum dots and its applications, Perovskites and its application, Hybrid solar cells.
Efficiency improvement techniques:	Anti-reflection coating, texturing, Multiple career generation, Light down conversion and up conversion mechanisms, Back surface fields.

PV systems:	Shadow analysis, PV system design, Storage autonomy, Voltage regulation, Maximum tracking, Centralized and decentralized SPV systems; Stand alone, hybrid and, grid connected system, Requirements for renewable energy systems for grid integration, benefits and problems in grid integration.
Electrochemical energy storage:	Electrochemical Energy Storage Systems, Superconducting Magnet Energy Storage (SMES) systems, Electrochemical Double Layer Capacitor (EDLC), Role of activated carbon and carbon nanotube.
Power Conditioning:	Charge Controllers and Monitoring Systems for Batteries in PV Power Systems, Maximum power point trackers, Inverters, Inverters for Grid-connected Systems, Inverters for Stand-alone operation, Power quality of Inverters, Active Quality Control in the Grid, Safety Aspects with Grid-connected Inverters.

Texts/References

- J A Duffie and W A Backman (1980). Solar Engineering of Thermal Processes, Wiley N Y
- Narayan R and B Viswanathan (1998). Chemical and Electrochemical Energy Systems, University Press (India) Ltd.
- Sarangpani, S. J. A. Kosek and A. B. LaConti (1995). Handbook of Solid State Batteries and Capacitors, World Scientific Publications, NJ, USA.
- Wolf, Edmond L. (2004). Nanoparticles and nanotechnology: An introduction to modern concepts of nanoscience, John Wiley and sons, Canada
- Larry D Partain (1995). Solar Cells and their Applications, John Wiley and Sons, Inc, NY
- F Lasnier and T G Ang, Adam Hilger (1990). Photovoltaic Engineering Handbook

IE 6007 Solar Thermal Energy and Systems 03Credits

Introduction:	Solar radiation, Solar angles, day length, angle of incidence on tilted surface; Sunpath diagrams, Extraterrestrial characteristics, Measurement & estimation on horizontal and tilted surface radiations.
Flat plate collectors:	Theory, Description, Flat-plate energy balance equation, temperature distributions in flat-plate solar collectors, collector heat removal factor and flow factor, collector overall heat transfer coefficient, mean fluid and plate temperatures, selective coating, effective transmittance-absorbance product, heat capacity effects in flat plate collectors.
Solar water heating:	Built in storage solar water heaters, separate collector and storage type water heater, Natural and forced circulation or pumped system; performance prediction of solar water heaters, Tubular type SWHS and concentrating SWHS.
Solar cookers:	Types of solar cookers, performance of box type solar cooker, testing of a solar cooker.
Solar desalination:	Simple solar still, basics of solar still, material problems in solar stills, performance prediction of basin-type still.
Solar dryers:	Basics, Types, Natural convection or direct type solar dryers, Mixed mode type solar dryer, Forced circulation type dryers-hybrid dryer, bin-type grain dryers, solar timber drying.
Passive solar house heating and cooling:	Direct gain, thermal storage wall, attached greenhouse (sunspace), thermal storage roof, convective loop; passive cooling of building-shading, ventilation, evaporation, radiation cooling, ground coupling, dehumidification.
Solar refrigeration and air conditioning:	Carnot refrigeration cycle, absorption cooling, Lithium Bromide-Water absorption refrigeration system, Aqua-ammonia absorption refrigeration system, Intermittent absorption refrigeration system, Vapor compression refrigeration, desiccant cooling.
Solar thermal energy storage:	Necessity, size and duration of storage, Sensible heat storage, Storage in phase change materials, Storage in reversible chemical reactions.

Texts/References:

- J. A. Duffie and W. A. Beckman (1991). Solar Engineering of Thermal Processes, second edition, John Wiley, New York

- D. Y. Goswami, F. Kreith and J. F. Kreider (2000). Principles of Solar Engineering, Taylor and Francis, Philadelphia
- M. S. Sodha, N. K. Bansal, P. K. Bansal, A. Kumar and M. A. S. Malik (1986). Solar Passive Building: science and design, Pergamon Press, New York
- Tiwari G.N., Suneja S. (1997). Solar Thermal Engineering System, Narosa Publishing House, New Delhi, 1997

IE 6008 Wind energy and conversion systems 03Credits

Introduction:	Wind speed, wind direction, roughness, terrain, Obstacles, Mean power density, Weibull parameters.
Power production:	Wind energy conversion principles, Types and classification of WECS, Power, torque and speed characteristics, Aerodynamic design principles, Axial momentum, blade element, Rotor characteristics, Maximum power coefficient, Tip speed ratio, Prandlt's tip loss correction, airfoils, wake analysis.
Wind turbine types:	Vertical Axis Type, Horizontal Axis, Constant Speed Constant Frequency, Variable speed Variable Frequency, Up Wind, Down Wind, Stall Control , Pitch Control, Gear Coupled Generator type, Direct Generator Drive /PMG/Rotor Excited Sync Generator.
Wind turbine design considerations:	Theoretical simulation of wind turbine characteristics, Test methods, Stand alone, grid connected and hybrid applications of WECS; Economics of wind energy utilization.
Control and monitoring:	Details of Pitch System & Control Algorithms, Protections used & Safety consideration in Wind turbines, Wind Turbine Monitoring with Error codes, SCADA & Databases, Remote Monitoring and Generation Reports, Operation & Maintenance for Product Life Cycle, Balancing technique (Rotor & Blade), FACTS control & LVRT & New trends for new Grid Codes.

Texts/References:

- Erich Hau (2000). Wind Turbines: Fundamentals, Technologies, Application and Economics, Springer Verlag
- J. F. Manwell, J. G. McGowan, A. L. Rogers (2002). Wind Energy Explained, John Wiley & Sons; 1st edition
- Tony Burton, David Sharpe, Nick Jenkins, Ervin Bossanyi (2001) Wind Energy Handbook, John Wiley & Sons; 1st edition
- H-J Wagner and J. Mathur (2013). Introduction to Wind Energy Systems : Basics, Technology and Operation Second Edition, Springer

IE 6009 Climate modeling and Carbon Management 03Credits

Energy Balance:	Solar constant, Energy emission from the sun, Solar spectrum, Heat transfer laws, Sun-earth energy balance.
Climate models:	Climate data and simulation of earth's changing climate, Uncertainty and climate modeling, Prediction for future climate change.
Greenhouse gases:	Green House Gases GHGs) and their Emission Sources, Greenhouse Effect, Quantification of CO_2 Emission, Global Warming Potential (GWP), Impacts of climate change, Carbon footprint, LCA method, Regulations, Policy, and Market Opportunities.
Carbon management:	Kyoto Protocol, Carbon trading mechanisms, Cleaner Development Mechanisms, Low carbon energy technologies, Non-fossil energy systems, Innovation and Carbon di Oxide management, International and national policies in mitigation of GHG emission, Carbon neutrality model.
Carbon Capture	Introduction, Absorption process, Selection of absorbent, Adsorption process, Selection of adsorbent, Membrane process, Selection of membrane materials.
Carbon Sequestration:	Geologcal sequestration, Geologic Carbon Sequestration, Continuum Scale, Geologic Carbon Sequestration, Pore-Scale Phenomena, Biological sequestration, Geoengineering.

Texts/ References:

- Drake, John (2014). Climate Modeling for Scientists & Engineers. SIAM
- Rasch, Philip (Ed.) (2015). Climate Change Modeling Methodology. Larkspur, CA: Springer
- Emmanuel, Rohinton and Baker, Keith (2012). Carbon Management in the Built Environment. New York: Routledge
- Ian S.F. Jones (2011). Engineering Strategies for Greenhouse Gas Mitigation, Cambridge University Press
- Steffen D. Saldana (2010), Sources and Reduction of Greenhouse Gas Emissions, New York : Nova Science Publishers
- Global Warming: The Science and Climate Change, Francis D., (2000), Oxford University Press

IE 6010 Fossil fuel based power plant 03Credits

Types of Power Generation:	Types of thermal power plants, Steam power plant based on fossil fuels, Thermal power plant equipment, Instrumentation and control, Heat balance, Plant layout, Selection of site, Different systems such as coal handling system, pulverizes and coal burners, combustion system, draft, ash handling system, Dust collection system.
Gas Turbine Power plant:	Open and close cycles, Regeneration, Inter-cooling and reheating, Steam-gas power plant, Combined cycle power plant, Power plant boilers including critical and super critical boilers.
Hydropower Plant:	Mass curve and storage capacity, Classification, Components, Turbines, Plant layout and design, Underground, automatic, remote controlled, and pumped storage plants.
Nuclear Power Plant:	Basic components of nuclear reactions, Nuclear reactors and fuels, Important types of reactors, Radioactivity, Mass defect and binding energy, Chain reaction, Nuclear power station, Materials used in nuclear plants, Nuclear waste disposal, Site selection of nuclear power plants.
Diesel-electric Power Plant:	Use, Sub-systems, Starting and stopping, Heat balance, Plant layout, operation and maintenance.
Management and Economics:	Choice of power plant, Load & Load duration curves, Load factor, Diversity factor, Load deviation curve, Load management, Number and size of generating unit, Cost of electrical energy, Tariff, GHG emissions and mitigation.

Texts/ References:

- Gupta, B.R (2001). Generation of Electrical Energy ; Eurasia Publishing House
- Black and Veatch (1998). Power Plant Engineering, CBS Pub and Distributors, New Delhi
- Nag P K (1998). Power Plant Engineering; Steam & Nuclear, Tata McGraw Hill, New Delhi
- A J Wood and B F Wallenberg (1986). Power Generation, Operation and Control, 2nd Ed. John Wiley and Sons, New York, 1986.