Energy and Environment

MINOR Courses

[with effect from 2024 – 2025 onwards]

DEPARTMENT OF ENERGY AND ENVIRONMENT
NATIONAL INSTITUTE OF TECHNOLOGY, TIRUCHIRAPPALLI.

LIST OF MINOR COURSES

Students who have registered for **Minor in Energy and Environment** can opt to study any 5 of the courses listed below.

Sl. No.	Course Code	Course Title	Credits
1.	ENMI10	Energy Intensive Unit Operations	3
2.	ENMI11	Power Plant Engineering	3
3.	ENMI12	Energy Efficient Buildings	3
4.	ENMI13	Energy Audit and Management	3
5.	ENMI14	Solar Thermal Technology	3
6.	ENMI15	Solar Photo Voltaic Technology	3
7.	ENMI16	Bio - Energy Conversion	3
8.	ENMI17	Wind Energy - Fundamentals	3
9.	ENMI18	Energy Storage Materials	3
10.	ENMI19	Combined Heat and Power	3
11.	ENMI20	Hydrogen and Fuel Cell Technology	3
12.	ENMI21	Green cooling technologies	3

Course Code	ENMI 10
Course Title	Energy Intensive Unit Operations
Number of Credits	3
Course Type	Minor

Course Learning Objectives (CLOs)

CLO1	To understand the fundamental principles and equipment involved in size reduction, separation, and conveying of bulk solids.
CLO2	To explain mixing and filtration processes used in liquid, gas, and solid systems in industrial applications.
CLO3	To analyse heat and mass transfer operations such as evaporation and drying, including their performance parameters.
CLO4	To develop knowledge of separation techniques like distillation and their operational and design considerations.

Course Content

Crushing, Grinding Size Separation & Conveying Of Bulk Solids Various Laws of Crushing - Classification of Crushing and Grinding Machineries -

Mixing of Liquids / Liquids, Liquids / Gases, Liquids / Solids - Types of Mixers - Industrial Filtration

Evaporator- Duhrings Chart - Boiling Point Elevation - Capacity and Economy of Evaporators - Evaporators Classification – Economy and capacity

Humidity Chart - Wet bulb Temperature and Measurement of Humidity Equilibrium Moisture Content - Bound, Unbound, Free Moisture - Drying Rate Curves Classification of Dryers

Distillation Methods - Minimum Reflux Ratio - Total Reflux - Optimum Reflux Ratio - Steam Distillation Calculations Concepts of Azeotropic and Extractive Distillation –

Reference Books

1. *P Chattopadhyay, "Unit operations of Chemical Engineering", 2nd edition, Khanna Publishers, 1996.*
2. *W. L. McCabe and J.C. Smith and P. Harriot, "Unit operations of Chemical Engineering", 6th edition, McGraw Hill International editions, 2001.*
3. *Alan S Foust, "Principles of Unit Operations", Second Edition, Wiley International Edition, 1960.*
4. *J.M. Coulson & Richardson, Chemical Engineering,, 5th edition, ButterworthHeinemann,1996.*

Course Outcomes (COs)

CO1	Explain the working principles and classification of equipment used in crushing, grinding, and solid handling operations.
CO2	Apply concepts of mixing and filtration to evaluate industrial process performance.
CO3	Analyze evaporation and drying processes using key parameters such as capacity, economy, and drying characteristics.
CO4	Evaluate distillation processes and determine key operating parameters such as reflux ratio and separation efficiency.

Course Code	ENMI 11
Course Title	Power Plant Engineering
Number of Credits	3
Course Type	Minor

Course Learning Objectives (CLOs)

CLO1	To understand thermodynamic principles and global energy scenarios relevant to power plant systems.
CLO2	To explain the working, components, and performance of conventional power plants including coal, diesel, and gas turbine systems.
CLO3	To analyze renewable and nuclear power generation technologies along with their environmental impacts.
CLO4	To develop knowledge of economic evaluation methods and emission considerations in power generation

Course Content

INTRODUCTION AND REVIEW OF THERMODYNAMICS RELEVANT TO POWER PLANTS: Introduction to power plant engineering; Global and Indian Power Scenario; Review of thermodynamics concepts relevant to the subject of power plant engineering

COAL, OIL AND GAS TURBINE POWER PLANTS: Cycle analysis-Layout of modern coal-based power plant; Performance parameters; Super Critical Boilers -FBC Boilers. Subsystems –Water and Steam, Fuel and ash handling, Air and Gas, Draught system. Diesel and Gas Turbine power plants - Layout and Functioning. Environmental impact and Control.

RENEWABLE ENERGY POWER PLANTS: Solar power plants –Photovoltaic and Thermal; Wind power plants –Vertical and Horizontal axes Wind Turbines; Biomass power plants –Gasification and combustion; Tidal and Ocean Thermal Energy plants; Geothermal plants. Hydro power plants; Fuel cell
–Types; Hybrid power plants.

NUCLEAR POWER PLANTS: Layout and subsystems. Fuels and Nuclear reactions. Boiling Water Reactor, Pressurized Water Reactor, Fast Breeder Reactor, Gas Cooled and Liquid Metal Cooled Reactors –working and Comparison. Safety measures. Environmental aspects.

ECONOMICS OF POWER GENERATION: Load and load duration curves. Electricity billing – costing of electrical energy –Tariff structures. Economics of power plant –Fixed and variable cost. Payback period. Net Present Value, Internal Rate of Return. Emission calculation and carbon credit.

References

1. *Nag P.K , Power plant Engineering, Tata McGraw - Hill, 4th edition, 2014.*
2. *G.D. Rai, "Non-conventional energy sources', Khanna Publishers, New Delhi, 2006*
3. *Arora, S.C. and Domkundwar, S. , A course in Power plant Engineering, Dhanpat Rai and Sons, 2016.*

Course Outcomes (COs)

CO1	Explain thermodynamic concepts and their application in power plant operations.
CO2	Analyze the performance and subsystems of conventional power plants.
CO3	Evaluate different renewable and nuclear power technologies based on efficiency, safety, and environmental impact.
CO4	Apply economic and emission analysis methods for power generation systems.

Course Code	ENMI12
Course Title	Energy Efficient Buildings
Number of Credits	3
Course Type	Minor

Course Learning Objectives (CLOs)

CLO1	To understand principles of thermal comfort, climate classification, and traditional building practices.
CLO2	To analyze heat transfer mechanisms and cooling load calculations in buildings.
CLO3	To explain passive and low-energy building design concepts for different climatic conditions.
CLO4	To develop knowledge of building simulation tools, HVAC systems, and green building rating frameworks.

Course Content

Introduction
Review of topics on thermal comfort, Classification of climate zones, Review of traditional architecture
Heat flow calculations in building
Unsteady heat flows through walls, roof, windows etc. Direct heat gains through windows
Convective gains/losses, air exchange rates, Gains from people, appliances etc., Air conditioning load calculations
Passive and low energy concepts and applications
Passive cooling/heating concepts, Building form and orientation, Internal and external shading devices, Ventilation, passive concepts for composite climates, evaporative and nocturnal cooling Earth–air tunnel, sky-therm system, Solar chimney-based hybrid system
Building simulation
Introduction and use of different building simulation software for modelling of non-air conditioned spaces such as TRNSYS, ECOTECT etc.
HVAC systems.
Description of different components of HVAC systems, Rating systems in different countries. Green building rating systems such as LEED and GRIHA. BEE and ECBC

References

1. *Minke, G., 2006. Building with Earth: design & technology of a sustainable architecture, SpringerLink*
2. *Givoni, B., 1969. Man, Climate and Architecture. Elsevier Publishing Company Ltd.*
3. *Givoni, B., 1998. Climatic Considerations in Buildings and Urban Design, John Wiley & Sons, Canada*
4. *N. K. Bansal, Gerd Hauser, Gernot Minke, 1994. Passive building design: a handbook of natural climatic control, Elsevier Science B.V.*
5. *Krishnan, A., Baker, N., Yannas, S., Szokolay, S., (Eds) 2001. Climate Responsive Architecture- A*
6. *Design Handbook for Energy Efficient Buildings, Tata McGraw-Hill, New Delhi*
7. *Givoni, B., 1994. Passive and Low Energy Cooling of Buildings, John Wiley &Sons Inc., New York*
8. *Santamouris, M., 1996. Passive Cooling of Buildings, James & James (Science Publishers) Ltd., London*
9. *Karlen, M and Benya, J., 2004. Lighting Design Basics, John Wiley &Sons Inc., New York*

10. *American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE): Fundamentals, Equipment*
11. *Indian Society of Heating, Refrigerating and Air-Conditioning Engineers (ISHRAE) Standards*
12. *Richard R Janis and William K Y Tao, 2008. Mechanical and Electrical Systems in Buildings, Prentice Hall*
13. *Vedavarz, A., Kumar, S. and Hussain, Md., 2007. HVAC: Heating, Ventilation and Air-Conditioning Handbook for design & Implementation, Industrial Press, New York*
14. *Jan F. Kreider, Peter S. Curtiss and Ari Rabl, 2010. Heating and Cooling of Buildings- Design for efficiency, revised second edition, CRC Press, USA*

Course Outcomes (COs)

CO1	Explain thermal comfort parameters and climate-responsive building design principles.
CO2	Analyze heat flow and cooling load requirements in buildings using standard methods.
CO3	Evaluate passive design strategies for energy-efficient buildings in various climates.
CO4	Apply building simulation tools and assess HVAC systems and green building rating standards.

Course Code	ENMI13
Course Title	ENERGY AUDIT AND MANAGEMENT
Number of Credits	3
Course Type	Minor

Course Learning Objectives (CLOs)

CLO1	To understand the role of energy management in industries, including energy monitoring, auditing, and targeting practices.
CLO2	To analyze economic evaluation methods for energy conservation and generation systems.
CLO3	To explain energy efficiency concepts in thermal and electrical systems such as boilers, steam systems, pumps, compressors, and HVAC.
CLO4	To develop knowledge of performance assessment tools, organizational strategies, and case-based approaches for energy management.

Course Content

Energy Scenario - Role of Energy Managers in Industries – Energy monitoring, auditing & targeting – Economics of various Energy Conservation schemes. Total Energy Systems Energy

Economics - Simple Payback Period, Time Value of Money, IRR, NPV, Life Cycle Costing, Cost of Saved Energy, Cost of Energy generated, Examples from energy generation and conservation

Steam engineering, steam traps and various Energy Conservation Measures in Steam; Boilers - types, losses and efficiency calculation methods. Boiler controls.

Energy conservation in Centrifugal pumps, Fans & Blowers, Air compressor – energy consumption & energy saving potentials – Design consideration. Power factor improvement methods.

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; Specific energy consumption and energy cost calculation methodologies - CUSUM, balanced ratio etc. Case studies across industries. Visit to energy generation / consumption facility.

References

1. *Eastop T.D & Croft D.R, Energy Efficiency for Engineers and Technologists,.Logman Scientific & Technical, ISBN-0-582-03184, 1990.*
2. *Reay D.A, Industrial Energy Conservation, 1stedition, Pergamon Press, 1977.*
3. *Bureau of Energy Efficiency - Energy Management Series*
4. *Larry C Whitetal, Industrial Energy Management & Utilization*

Course Outcomes (COs)

CO1	Explain principles of energy management and auditing in industrial systems.
CO2	Apply economic analysis methods such as payback period, NPV, and IRR for energy projects.
CO3	Analyze energy consumption and conservation opportunities in thermal and electrical utilities.
CO4	Evaluate energy performance using tools such as specific energy consumption, CUSUM, and case study analysis.

Course Code	ENMI 14
Course Title	Solar thermal technology
Number of Credits	3
Course Type	Minor

Course Learning Objectives (CLOs)

CLO1	To understand the design, construction, and performance of various solar collectors and associated components.
CLO2	To explain different solar water heating and space conditioning systems and their operational principles.
CLO3	To analyze diverse solar energy applications including thermal, passive, and utility-scale systems.
CLO4	To develop knowledge of economic evaluation methods for assessing feasibility of solar energy systems.

Course Content

UNIT I SOLAR COLLECTORS

Flat plate - Evaculated tube – Concentrated - Pool and Air collectors Construction – Function - Suitability – Comparison - Storage Tank - Solar Fluids.

UNIT II SOLAR WATER HEATING SYSTEMS

Integral Collector Storage System - Thermosyphon System - Open Loop, Drain Down, Drain Back, Antifreeze Systems - Refrigerant Solar Water Heaters - Solar Heated Pools - Solar Heated Hot Tubs and Spas.

UNIT III SOLAR SPACE CONDITIONING SYSTEMS

Liquid Type Solar Heating System With / Without Storage - Heat Storage Configurations - Heat Delivery Methods - Air-Type Solar Heating Systems - Solar Refrigeration and Air Conditioning.

UNIT IV OTHER SOLAR APPLICATIONS

Solar Cooking – Distillation - Desalination - Solar Ponds – Solar Passive Architecture – Solar Drying
– Solar Chimney.

UNIT V SOLAR ECONOMICS

Application of economic methods to analyze the feasibility of solar systems to decide project / policy alternatives - Net energy analysis - and cost requirements for active and passive heating and cooling - for electric power generation - and for industrial process-heating.

References

1. *H P Garg, M Dayal, G Furlan, Physics and Technology of Solar Energy- Volume I: Solar Thermal Applications, Springer, 2007.*
2. *Sukhatme and Nayak, Solar Energy: Principles Of Thermal Collection And Storage, Tata McGraw.Hill, 2008.*
3. *Bob Ramlow & Benjamin Nusz, Solar Water Heating, New Society Publishing, 2006.*
4. *John Canivan, Solar Thermal Energy, Sunny Future Press - 2003.*

5. *Charles Christopher Newton - Concentrated Solar Thermal Energy- Published by VDM Verlag, 2008.*
6. *H.P.Garg, S.C.Mullick, A.K.Bhargava, D.Reidal, Solar Thermal Energy Storage Springer, 2005.*
7. *Anne Grete Hestnes, Robert Hastings, Bjarne Saxhof, Solar Energy Houses: Strategies, Technologies Examples, Earthscan Publications, 2003.*

Course Outcomes (COs)

CO1	Explain the working principles and selection criteria of different solar collectors and storage systems.
CO2	Analyze the performance of solar water heating and space conditioning systems under varying conditions.
CO3	Evaluate different solar energy applications based on technical feasibility and efficiency.
CO4	Apply economic analysis methods to assess the viability of solar energy projects.

Course Code	ENMI 15
Course Title	Solar Photo Voltaic Technology
Number of Credits	3
Course Type	Minor

Course Learning Objectives (CLOs)

CLO1	To understand the fundamentals, design, and electrical characteristics of solar photovoltaic cells and modules.
CLO2	To explain the configuration and operation of stand-alone and grid-connected PV systems.
CLO3	To analyze hybrid energy systems integrating PV with other energy sources for different applications.
CLO4	To develop knowledge of design, sizing, modelling, and simulation of PV systems for practical deployment.

Course Content

UNIT – I INTRODUCTION TO SOLAR PHOTOVOLTAICS

Solar cell Fundamental – Semiconductor- Design of Solar cell- Types, Electrical properties and behaviour of Solar Cells- PV Cell Interconnection and Module Fabrication – Electrical characteristics of the solar cell - equivalent circuit - Effects of temperature, irradiation and series/shunt resistances on the open-circuit voltage and short-circuit current - PV generators, shadow effects – Blocking and bypass diodes - hot spot problem in a PV module – Emerging solar cell technologies

UNIT – II STAND ALONE PV SYSTEMS

Schematics and Components - Balance of system components for DC and/or AC Applications - Maximum power point tracking (MPPT) algorithms - Interfacing PV modules to loads – Direct connection of loads to PV modules - Connection of PV modules to a battery and load together - Typical applications for lighting, water pumping etc- Concentrating PV technologies.

UNIT – III GRID CONNECTED PV SYSTEMS

Schematics and Components - Balance of system Components - Interface Components – Net
metering - Feasible operating region of inverter at different power factor - Active power filtering with real power injection.

UNIT – IV HYBRID SYSTEMS

Need for Hybrid Systems - Range and type of Hybrid systems - Case studies of Diesel-PV,Wind-PV, Micro hydel-PV, Biomass-Diesel systems, Electric and hybrid electric vehicles -Comparison and selection criteria for a given application.

UNIT – V DESIGN OF PV SYSTEMS

Design of System Components for different PV Applications - Sizing and Reliability – Modelling and simulation (PV-Syst & Sketup tool) of stand-alone and grid-connected PV systems – Case Studies.

References

1. *A. Goetzberger, V. U. Hoffmann, Volker Uwe, Photovoltaic Solar Energy Generation (2005), Springer-Verlag Berlin Heidelberg, ISBN: 978-3-540-23676-4, pp.234.*
2. *Jenny Nelson, The Physics of Solar Cells. Imperial College Press, 2003*
3. *Chetan Singh Solanki, Solar Photovoltaics: Fundamentals, Technologies and Applications (2011), 2nd edition, PHI PHI Learning Pvt. Ltd, pp. 512.*
4. *T. Markvart, Solar Electricity (2000), John Wiley & Sons, ISBN: 978-0-471-98852-6, pp.298.*
5. *R. A. Messenger and Amir Abtahi, Photovoltaic Systems Engineering (2017), 4th Edition, CRC Press, Boca Raton, ISBN: 9781498772778, pp. 504*

Course Outcomes (COs)

CO1	Explain the working principles and characteristics of solar PV cells, modules, and associated components.
CO2	Analyze the performance and operation of stand-alone and grid-connected PV systems.
CO3	Evaluate hybrid PV systems for different applications based on technical and operational criteria.
CO4	Apply design, sizing, and simulation tools for PV system development and reliability assessment

Course Code	ENMI 16
Course Title	Bio-energy Conversion
Number of Credits	3
Course Type	Minor

Course Learning Objectives (CLOs)

CLO1	To understand the chemistry and biochemistry of biomass, including composition and degradation of lignocellulosic materials.
CLO2	To explain chemical and biochemical conversion processes for producing biofuels such as biodiesel and biogas.
CLO3	To analyze thermochemical conversion technologies for biomass-to-energy and biofuel production.
CLO4	To develop knowledge of integrated biorefinery concepts, process systems, and sustainability aspects of biomass utilization.

Course Content

Chemistry and biochemistry of biomass

Course content includes studies and types of biomass. Long-term sustainability and reliability of feedstock supply; feedstock quality, minimizing feedstock cost and regional/climatic considerations of the process chain. Composition of lignocellulose; energy crops; chemical pretreatment; enzymatic pretreatment; degradation of lignocellulose by fungi and bacteria; degradation of lignin; the role of peroxidases; degradation of cellulose; bacterial cellulases.

Chemical conversion technologies

Course content includes sources and processing of biodiesel; nature of lipids, especially fatty acids and triglycerides. Sources and characteristics of lipids for use as biodiesel feedstock; and conversion of feedstock into biodiesel. Use of vegetable oil and waste vegetable oil. Engineering, processing system; standards for biodiesel quality; and major policies and regulations pertaining to the production, distribution, and use of biodiesel.

Biochemical conversion technologies

Course content includes studies related to the formation of biomethane or biogas, and manure. Hydrolysis; anaerobic digestion; methanogenesis, rate of methane formation; and one and two stage fermentation. Thermal depolymerization. Use of exhaust gases from geothermal power plants and industrial operations as an energy source and harvesting into biomass technologies with fuel cells.

Thermochemical conversion technologies

Course content includes studies of advanced fractionation and conversion systems for the combined production of biofuels/bioenergy and bio products. Gasification processes and the main types of gasifier designs; production of electricity by combining a gasifier with a gas turbine or fuel cell. Combined- cycle electricity generation with gas and steam turbines, and generation of heat and steam for distant heating systems or CHP, including Kalina cycle. Production of synthesis gas for subsequent conversion to hydrogen and transport fuels; advanced gas cleaning technologies for biomass. Biological conversion of syngas into liquid biofuels. Fast pyrolysis technology to produce liquid bio-oil pyrolysis oil from biomass, refined to produce a range of fuels, chemicals, and fertilizers; bio refineries, and new uses for glycerine in bio refineries. Fisher-tropsch synthesis of methanol, acetic acid, olefins, etc.; combustion for heat.

References

1. *Vaughn C. Nelson, Kenneth L. Starcher, 'Introduction to Bioenergy', CRC press, 2016.*
2. *'Bioenergy: Biomass to Biofuels' edited by Anju Dahiya, Acedemic press, 2015.*
3. *Nelson David L., Albert L. Lehninger, Michael M.. Cox, 'Lehninger, Principles of Biochemistry, 7th Edition.*

Course Outcomes (COs)

CO1	Explain the composition and conversion mechanisms of biomass at chemical and biological levels.
CO2	Analyze biodiesel and biogas production processes based on feedstock and operational parameters.
CO3	Evaluate thermochemical conversion pathways such as gasification and pyrolysis for energy generation.
CO4	Apply concepts of biorefinery and integrated biomass utilization for sustainable energy production.

Course Code	ENMI 17
Course Title	Wind Energy Fundamentals
Number of Credits	3
Course Type	Minor

Course Learning Objectives (CLOs)

CLO1	To understand the fundamentals of wind energy, resource assessment, and theoretical limits of energy conversion.
CLO2	To explain different types of wind energy conversion systems and aerodynamic principles of wind rotors.
CLO3	To analyze design aspects and performance characteristics of wind turbines and their control systems.
CLO4	To develop knowledge of wind resource assessment, site selection, and hybrid wind energy systems.

Course Content

India's wind resource and potential, Power available in wind; Thermodynamics of wind energy; efficiency limit for wind energy conversion

Types of wind energy conversion devices; HAWT; VAWT; Variables in wind energy conversion systems – wind power density; power law index -Betz constant -Terrain value Aerodynamics of wind rotors

Design of wind turbine rotor; tower design Power-speed characteristics; Torque-speed characteristics Wind turbine control systems: Pitch angle control; stall control; power electronics control, yaw control

Wind site analysis and selection: Wind measurement, Controls and instrumentation; wind speed statistics; wind rose diagrams; Beau fort number; site and turbine selection Hybrid energy systems: Wind-Diesel hybrid systems; Systems with battery back-up

Reference

1. *S.Rao & B.B Parulekar, Energy Technology" 4th edition, Khanna publishers, 2005.*
2. *Wind energy Handbook, Edited by T. Burton, D. Sharpe, N. Jenkins and E. Bossanyi, John Wiley & Sons, 2001*
3. *Wind and Solar Power Systems, Mukund. R. Patel, 2nd Edition, Taylor & Francis,2001*
4. *L .L. Freris, Wind Energy Conversion Systems, Prentice Hall, 1990.*
5. *D. A. Spera, Wind Turbine Technology: Fundamental concepts of Wind Turbine Engineering, ASME Press 1983.*
6. *Anna Mani & Nooley, " Wind Energy Data for India", 1983.*
7. *IS 875 Part IV and IS 1893 semics D+STDS mareials STDS IS 226 (IS 2862, ASTMS 36, BS 4360 GR 43D and A).*
8. *Logan (EARL), "Turbo Machinery Basic Theory and Application", 1981*

Course Outcomes (COs)

CO1	Explain wind energy potential, power extraction, and efficiency limits of wind energy systems.
CO2	Analyze the performance of different wind energy conversion devices based on aerodynamic principles.
CO3	Evaluate wind turbine design, operational characteristics, and control strategies.
CO4	Apply wind resource assessment techniques and design considerations for site selection and hybrid systems.

Course Code	ENMI 18
Course Title	Energy Storage Systems
Number of Credits	3
Course Type	Minor

Course Learning Objectives (CLOs)

CLO1	To understand global and national energy demand patterns and the role of conventional and renewable energy sources.
CLO2	To explain the need for energy storage and various modes of energy storage
CLO3	To analyze thermal and electrochemical energy storage technologies and their performance characteristics.
CLO4	To develop knowledge of advanced electrical and magnetic energy storage systems and their applications.

Course Content

ENERGY DEMANDS AND ENERGY SOURCES

World energy consumption. Energy in developing countries. Firewood crises. Indian energy sources. Non-conventional renewable energy sources. Potential of renewable energy sources. Solar energy types. Wind energy. Wave, tidal and OTEC. Super-conductors in power system.

NEED OF ENERGY STORAGE; DIFFERENT MODES OF ENERGY

Need for Energy storage. Potential energy: Pumped hydro storage; KE and Compressed gas system: Flywheel storage, compressed air energy storage; Electrical and magnetic energy storage: Capacitors, electromagnets; Chemical Energy storage: Thermo-chemical, photo-chemical, bio-chemical, electro- chemical, fossil fuels and synthetic fuels. Hydrogen for energy storage. Solar Ponds for energy storage.

THERMAL ENERGY STORAGE SYSTEMS

Thermal energy storage- sensible and latent heat storage systems. Phase change materials-properties- types. Solid-Liquid and Solid – Solid PCM; characterization, selection criterion and design of TES systems. Solar energy and TES. Energy savings with TES. Case studies.

ELECTROCHEMICAL ENERGY STORAGE SYSTEMS

Batteries: Primary, Secondary batteries; difference between primary and secondary batteries, chemistries of primary batteries such as Zinc-Carbon, Alkaline and secondary batteries such as Lead acid, Nickel Cadmium, Metal hydrides, lithium ion, lithium phosphate and high temperature batteries- sodium-sulphur. Advantages, disadvantages, limitations and application each above mentioned batteries

MAGNETIC AND ELECTRIC ENERGY STORAGE SYSTEMS

Superconducting Magnet Energy Storage (SMES) systems; Capacitor and Batteries: Comparison and application; Super capacitor: Electrochemical Double Layer Capacitor (EDLC), principle of working, structure, performance and application, role of activated carbon and carbon nano-tube.

References

1. *Johannes Jensen Bent Squrensen, "Fundamentals of Energy Storage", John Wiley, NY , 1984.*
2. *IEE Energy Series' "Electro-chemical Power Sources".*
3. *Ibrahim Dincer, Marc A. Rosen, Second Edition, "Thermal Energy Storage: Systems and Applications", Wiley 2010.*
4. *P.D.Dunn, "Renewable Energies". First Edition, Peter Peregrinus Ltd, London, United Kingdom , 1986*
5. *S Srinivasan, "Fuel Cells: From Fundamentals to Applications", Springer 2006*
6. *O'Hayre, SW Cha, W Colella and FB Prinz, "Fuel Cell Fundamentals", Wiley, 2005*
7. *Xianguo Li, "Principles of Fuel Cells", Taylor and Francis, 2005*
8. *J Larminie and A Dicks, "Fuel Cell Systems Explained", 2nd Edition, Wiley,2003*

Course Outcomes (COs)

CO1	Explain energy demand scenarios and the role of different energy sources in meeting energy needs.
CO2	Analyze various energy storage methods based on physical, chemical, and operational principles.
CO3	Evaluate thermal and electrochemical storage systems for different energy applications.
CO4	Apply concepts of advanced storage technologies such as supercapacitors and SMES for energy systems.

Course Code	ENMI 19
Course Title	Combined Heat and Power
Number of Credits	3
Course Type	Minor

Course Learning Objectives (CLOs)

CLO1	To understand economic evaluation methods for energy systems and conservation measures.
CLO2	To explain the principles, performance, and applications of cogeneration and combined heat and power systems.
CLO3	To analyze process integration techniques such as pinch technology for energy optimization.
CLO4	To develop knowledge of waste heat recovery methods and advanced thermal energy systems.

Course Content

Energy Economics - Simple Payback Period, Time Value of Money, IRR, NPV, Life Cycle Costing, Cost of Saved Energy, Cost of Energy generated, Examples from energy generation and conservation

Basic concepts of CHP- The benefits and problems with CHP –Balance of energy demand– Types of prime movers - Economics– CHP in various sectors. Application & techno economics of Cogeneration- Cogeneration -Performance calculations, Part load characteristics- financial considerations - Operating and Investments

Pinch Technology–significance– Selection of pinch temperature difference – Stream splitting – Process retrofit – Installation of heat pumps, heat engines - Grand composite curve.

Insulation – Recuperative heat exchanger – Run –around coil systems – Regenerative heat exchangers
– Heat pumps – Heat pipes –. Waste Heat Recovery -Cogeneration Technology

Sources of waste heat, Cogeneration - Principles of Thermodynamics - Combined Cycles- Topping - Bottoming - Organic Rankine Cycles- Advantages Of Cogeneration Technology

Reference

1. *Eastop, T.D. & Croft D.R, "Energy efficiency for engineers and Technologists", 2nd edition, Longman Harlow, 1990.*
2. *O"Callaghan, Paul W, "Design and Management for energy conservation", Pergamon,1993.*
3. *Osborn, peter D, "Handbook of energy data and calculations including directory of products and services", Butterworths, 1980.*
4. *Charles H.Butler, Cogeneration, McGraw Hill Book Co., 1984.*
5. *Horlock JH, Cogeneration - Heat and Power, Thermodynamics and Economics, Oxford,1987*

Course Outcomes (COs)

CO1	Apply economic analysis methods such as payback period, NPV, and IRR to energy systems.
CO2	Analyze the performance and feasibility of cogeneration and CHP systems in various sectors.
CO3	Evaluate process integration techniques like pinch analysis for improving energy efficiency.
CO4	Apply waste heat recovery and advanced thermal system concepts for energy conservation

Course Code	ENMI 20
Course Title	Hydrogen and Fuel cell technology
Number of Credits	3
Course Type	Minor

Course Learning Objectives (CLOs)

CLO1	To understand hydrogen as an energy carrier, its properties, applications, and production methods.
CLO2	To explain various hydrogen storage techniques and their material and performance characteristics.
CLO3	To analyze the fundamentals, electrochemistry, and performance of fuel cells.
CLO4	To develop knowledge of different fuel cell types, design considerations, and operational challenges.

Course Content

Unit 1: Hydrogen energy – Hydrogen as a fuel, application. Hydrogen production methods – production of hydrogen from fossil fuels, electrolysis, thermal decompositions, photochemical and photocatalytic methods

Unit-2: Hydrogen storage methods – metal hydrides, metallic alloy hydrides, carbon nano-tubes, sea as source of deuterium.

Unit-3: Fuel cells – Basics: Fuel cell definition, difference between batteries and fuel cells, fuel cell history, components of fuel cells, principles of working and performance characteristics of fuel cells, efficiency of fuel cells, fuel cell electrochemistry – nearsnt equation, electrochemical kinetics, butler- volmer equation

Unit-4: Overview of fuel cells: Fuel cell types – classification by operating temperature/electrolyte type, fuel cell performance, activation, ohmic and concentration over potential fuel cell design and components – cell components, stack components, system components.

Unit-5: Types of fuel cells: Overview of intermediate/high temperature fuel cells –sloid oxide fuel cells, molten carbonate fuel cells, phosphoric acid fuel cells, polymer electrolyte membrane fuel cells – heat and mass transfer, water management, current issues, direct methanol fuel cells – electrochemical kinetics methanol oxidation, current issues, fuel crossover, water management, high methanol concentration operation, limiting current density.

References

1. *'Principles of Fuel Cells', by Xianguo Li, Taylor & Francis, 2006*
2. *'Fuel Cells, Principles and Applications', Viswanathan, B. and Scibioh, Aulice M, Universities Press, 2006*
3. *'Hydrogen and Fuel Cells: Emerging Technologies and Applications', Bent Sørensen, Academic press, 2012.*

Course Outcomes (COs)

CO1	Explain hydrogen production methods and its role as a clean energy fuel.
CO2	Analyze hydrogen storage systems based on material properties and efficiency.
CO3	Evaluate fuel cell performance using electrochemical principles and
CO4	Apply concepts of different fuel cell technologies for design and application in energy systems.

Course Code	ENMI 21
Course Title	Green cooling technologies
Number of Credits	3
Course Type	Minor

Course Learning Objectives (CLOs)

CLO1	To understand cooling energy demand, climatic considerations, and HVAC standards and policies.
CLO2	To explain cyclic and non-cyclic refrigeration systems and their thermodynamic principles.
CLO3	To analyze advanced and alternative cooling technologies and refrigerants.
CLO4	To develop knowledge of cooling load estimation, passive cooling strategies, and energy-efficient system design.

Course Content

Introduction: Cooling energy demand – Global and national, Global climatic zones, comfort conditions, HVAC standards and definitions, HVAC policies and strategies.

Cyclic and non-cyclic refrigeration techniques: thermodynamic analysis of vapor compression refrigeration, heat pumps, air conditioning and psychrometry, chiller types and design, cooling tower design, controls and instrumentation of cooling systems emissions and mitigation.

Vapor absorption refrigeration system, thermodynamics, merits and demerits of VARS, green refrigerants, properties and usage of green refrigerants, design of VARS system, Trigeneration systems, waste heat recovery and utilization. Gas cycle refrigeration.

CO2 refrigeration, Thermo-electric, thermo-acoustic, magnetic refrigeration, Solar, Solar-hybrid cooling systems, Jet ejector solar cooling, Types of air-conditioning units and its analysis.

Heat load estimation, passive cooling techniques, evaporative cooling, radiative cooling, Nano-photonics, chilled beam, thermal energy storage in cooling systems, Energy efficiency enhancement in cooling systems. Case studies.

References

1. *Kaushik S. C., Solar Refrigeration and space conditioning, Divyajyoti Publications, 1989.*
2. *Stocker, W. F. and Jones, J. W., "Refrigeration and Air Conditioning" , McGraw Hill, N. Y. 1986.*
3. *Dossat, R. J., "Principles of Refrigeration", John Wiley and Sons, 1988.*
4. *3. Threlked, J.L., "Thermal Environmental Engineering", Prentice Hall, N. Y. , 1970.*
5. *4. Baron, R. F., "Cryogenics Systems", Oxford Press, USA, 1985.*
6. *5. ASHRAE Fundamentals, Applications, Systems and Equipment, 1999 .*
7. *Process Heat Transfer; D. Q. Kern; Tata McGraw Hill*

Course Outcomes (COs)

CO1	Explain cooling demand patterns and HVAC fundamentals in different climatic conditions.
CO2	Analyze the performance of refrigeration and air conditioning systems using thermodynamic principles.
CO3	Evaluate advanced cooling technologies and refrigerants for sustainable applications.
CO4	Apply heat load estimation and energy efficiency techniques in cooling system design.