

ANNA UNIVERSITY, CHENNAI
NON- AUTONOMOUS COLLEGES
AFFILIATED TO ANNA UNIVERSITY
M.E. ENERGY ENGINEERING
REGULATIONS 2025

PROGRAMME OUTCOMES (POs):

PO	Programme Outcomes
PO1	An ability to independently carry out research /investigation and development work to solve practical problems
PO2	An ability to write and present a substantial technical report/document.
PO3	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

PROGRAMME SPECIFIC OUTCOMES (PSOS)

PSO	Programme Specific Outcomes
PSO1	Demonstrate versatility in using modern tools, software, and techniques for improving the efficiency of energy systems, and managing projects effectively from both technical and financial perspectives.
PSO2	Design and develop energy products and processes with environmental consciousness and sustainability, while working independently or in teams, fostering lifelong learning, industry collaboration, and professional ethics.



ANNA UNIVERSITY, CHENNAI

POSTGRADUATE CURRICULUM (NON-AUTONOMOUS AFFILIATED INSTITUTIONS)

Programme: M.E., Energy Engineering

Regulations: 2025

Abbreviations:

BS– Basic Science (Mathematics)

ES – Engineering Science (General (**G**), Programme Core (**PC**), Programme Elective (**PE**) & Emerging Technology (**ET**))

SD – Skill Development

TCP –Total Contact Period(s)

L–Laboratory Course

T– Theory

LIT –Laboratory Integrated Theory

PW – Project Work

Semester I

S. No.	Course Code	Course Title	Type	Periods Per Week			TCP	Credits	Category
				L	T	P			
1.	MA25C06	Applied Mathematical and Statistical Modelling	T	3	1	0	4	4	BS
2.	TE25C01	Advanced Thermodynamics	LIT	3	0	2	5	4	ES (PC)
3.	TE25C02	Advanced Fluid Mechanics and Heat Transfer	LIT	3	0	2	5	4	ES (PC)
4.	TE25C03	Instrumentation and Control for Thermal Systems	T	3	0	0	3	3	ES (PC)
5.	EY25101	Sustainable Energy Systems	LIT	3	0	2	5	4	ES (PC)
6.	EY25C01	Energy Storage Technologies	T	3	0	0	3	3	ES (PC)
7.	EY25102	Technical Seminar	-	0	0	2	2	1	SD
Total Credits							27	23	

Semester II

S. No.	Course Code	Course Title	Type	Periods Per Week			TCP	Credits	Category
				L	T	P			
1.	EY25201	Energy Conservation and Management	LIT	3	0	2	5	4	ES (PC)
2.	TE25C06	Computational Fluid Dynamics	LIT	3	0	2	5	4	ES (PC)
3.	TE25C04	Fuels and Combustion	LIT	3	0	2	5	4	ES (PC)
4.		Programme Elective I	T	3	0	0	3	3	ES (PE)
5.		Programme Elective II	T	3	0	0	3	3	ES (PE)
6.		Industry Oriented Course I	---	1	0	0	1	1	SD
7.		Self-Learning Course	---	-	-	-	-	1	-
Total Credits							22	20	

Semester III

S. No.	Course Code	Course Title	Type	Periods Per Week			TCP	Credits	Category
				L	T	P			
1.	EY25C02	Artificial Intelligence and Machine Learning in Energy Systems	T	3	0	0	3	3	ES (PC)
2.		Programme Elective III	T	3	0	0	3	3	ES (PE)
3.		Programme Elective IV	T	3	0	0	3	3	ES (PE)
4.		Programme Elective V	T	3	0	0	3	3	ES (PE)
5.	EY25301	Industrial Training	-	-	-	-	-	2	SD
6.		Industry Oriented Course II	-	1	0	0	1	1	SD
7.	EY25302	Project Work I		0	0	12	12	6	SD
Total Credits							25	21	

Semester IV

S. No.	Course Code	Course Title	Type	Periods Per Week			TCP	Credits	Category
				L	T	P			
1.	EY25401	Project Work II	---	0	0	24	24	12	SD
Total Credits							24	12	

PROGRAMME ELECTIVE COURSES (PE)

S. No.	Course Code	Course Title	Periods Per Week			Total Contact Periods	Credits
			L	T	P		
1.	EY25001	Bio Energy Technologies	3	0	0	3	3
2.	EY25002	Wind Energy Systems	3	0	0	3	3
3.	EY25003	Solar Energy Systems	3	0	0	3	3
4.	EY25C05	Polygeneration Systems	3	0	0	3	3
5.	EY25C04	Waste to Energy	3	0	0	3	3
6.	EY25C07	Sustainability in Buildings	3	0	0	3	3
7.	EY25C03	Modern Power Plants	3	0	0	3	3
8.	EY25006	Energy Modelling and Project Management	3	0	0	3	3
9.	EY25007	Energy Policy, Economics, and Regulatory Frameworks	3	0	0	3	3
10.	TE25C07	Modelling and Analysis of Thermal Systems	3	0	0	3	3
11.	TE25C09	Carbon Sequestration and Utilisation	3	0	0	3	3
12.	EY25C06	Hydrogen Energy and Fuel Cell Technology	3	0	0	3	3
13.	EY25008	Smart Grid Technology and Energy Informatics	3	0	0	3	3
14.	EY25009	Nanomaterial for Energy Systems and Environmental Applications	3	0	0	3	3
15.	EY25010	Nuclear Power Engineering	3	0	0	3	3
16.	TE25C08	Thermal Management in Electronics and Batteries	3	0	0	3	3

Semester I

MA25C06	Applied Mathematical and Statistical Modelling	L	T	P	C
		3	1	0	4
<p>Course Objectives:</p> <ul style="list-style-type: none"> To equip students with advanced mathematical techniques, specifically Fourier Transforms, for formulating and solving partial differential equations that model fundamental mechanical engineering phenomena such as heat transfer, vibrations, and fluid flow. To provide a strong foundation in statistical inference, enabling students to estimate population parameters (like material properties and process capabilities) from experimental data and assess the quality and reliability of these estimators. To enable students to design efficient, structured experiments and apply appropriate statistical tests to make valid, data-driven decisions for comparing processes, optimizing designs, and solving complex engineering problems. 					
<p>Fourier Transform: Definitions, Properties, Transform of elementary functions, Dirac delta function, Convolution theorem, Parseval's identity, Solutions to partial differential equations: Heat equation, Wave equation, Laplace and Poisson's equations.</p> <p>Estimation Theory: Unbiasedness, Consistency, Efficiency and sufficiency, Maximum likelihood estimation, Method of moments.</p> <p>Testing of Hypothesis: Sampling distributions, Small and large samples, Tests based on Normal, t, Chi square, and F distributions for testing of means, variance and proportions, Analysis of r x c tables, Goodness of fit, independent of attributes.</p> <p>Design of Experiments: Analysis of variance, One way and two-way classifications, Completely randomized design, Randomized block design, Latin square design, 2² Factorial design.</p>					
<p>Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%.</p>					
<p>References:</p> <ol style="list-style-type: none"> Andrews, L. C., & Shivamoggi, B. K. (2003). Integral transforms for engineers. Prentice Hall of India. Devore, J. L. (2014). Probability and statistics for engineering and the sciences, Cengage Learning. Johnson, R. A., Miller, I., & Freund, J. (2015). Miller and Freund's probability and statistics for engineers, Pearson Education Asia. 					
<p>E-resources:</p> <ol style="list-style-type: none"> https://www.edx.org/learn/probability-and-statistics/massachusetts-institute-of-technology-probability-the-science-of-uncertainty-and-data https://www.itl.nist.gov/div898/handbook/ https://ocw.mit.edu/courses/2-830j-control-of-manufacturing-processes-sma-6303-spring-2008 					

TE25C01	Advanced Thermodynamics	L	T	P	C
		3	0	2	4
<p>Course Objectives:</p> <p>To develop the ability to apply thermodynamic principles for analyzing energy systems and cycles using theoretical, experimental, and simulation approaches.</p>					
<p>Thermodynamic Laws and Systems: Thermodynamics Laws and processes, Closed & Open Systems, Steady-state operations, Second Law efficiency.</p> <p>Practical: Verification of First Law using Calorimeter, Experiment on Heat Work Interaction in Closed System (P-V diagram plotting)</p>					
<p>Availability: Available Work: Non-flow and steady flow processes, Entropy Generation Mechanisms, Entropy Minimization Techniques, Exergy of fuels, Combustion Process and Exergy, Exergy Analysis in Heat exchangers, Boilers, Heat pumps, Turbomachines, Internal combustion Engines.</p> <p>Practical: Entropy Generation in Flow through Pipe (Friction Loss Measurement), Entropy Change during Heat Transfer using Heat Exchanger Setup, Exergy Analysis of a Heat Exchanger (Shell & Tube setup), Fuel Combustion Calorific Value Analysis using Bomb Calorimeter, Software Simulation: Exergy analysis using Software.</p>					
<p>Ideal & Real Gas Mixtures: Van der Waals Equation of state, Virial Equations, Maxwell Relations, Joule–Thomson Coefficient, Thermodynamic Relations, Real gas mixtures</p> <p>Practical: Joule-Thomson Expansion Experiment (Throttle Valve Setup, P-V-T Data Analysis using Real Gas Equations (Van der Waals/Virial),</p>					
<p>Thermodynamic Cycles: Rankine, Kalina, Supercritical and Gas Cycles, Refrigeration & Heat Pump Cycles, Combined Cycle and Cogeneration Systems.</p> <p>Practical: Performance Test on a Vapour Compression Refrigeration Unit, Analysis of Rankine Cycle using a Mini Steam Power Plant Setup, Gas Power Cycle Demonstration using Internal Combustion Engine Setup, Simulation: Rankine/Kalina Cycle analysis using Software.</p>					
<p>Weightage: Continuous Assessment: 50%, End Semester Examinations: 50%</p>					
<p>Assessment Methodology: Quiz (5%), Project (10%), Assignment (10%), Practical (25%), Review of Question papers (IES, SSC, GATE) (20%), Internal Examinations (30%)</p>					
<p>References:</p> <ol style="list-style-type: none"> 1. Bejan, A. (2016). Advanced engineering thermodynamics. John Wiley & Sons. 2. Annamalai, K., Puri, I. K., & Jog, M. A. (2011). Advanced thermodynamics engineering. CRC Press. 3. Kuo, K. K. (2005). Principles of combustion. John Wiley & Sons. 					

4. Wark, K., Jr. (1995). Advanced thermodynamics for engineers. McGraw-Hill.
5. Borel, L., & Favrat, D. (2010). Thermodynamics and energy systems analysis: From energy to exergy. CRC Press.

E-Resources:

<https://ocw.mit.edu/courses/mechanical-engineering/2-05-thermodynamics-fall-2003/>
<https://www.youtube.com/@LearnEngineering>
<https://nptel.ac.in/courses/112/105/112105275>
<https://ocw.tudelft.nl/courses/thermodynamics/>
<https://nptel.ac.in/courses/112/103/112103231>
<https://www.coursera.org/learn/energy-systems>
<https://dwsim.org/>

Other Resources:

Interactive simulation platforms:

<https://direns.mines-paristech.fr/Sites/ThermoptimEN>

<https://www.tlk-thermo.com/>

<https://www.grc.nasa.gov/www/k-12/airplane/>

Interactive learning:

https://www.energyquest.ca.gov/games/energy_island/index.html

<https://phet.colorado.edu/en/simulation/energy-skate-park>

	Description of CO	Mapped POs	PSO1	PSO2
CO1	Apply the fundamental laws of thermodynamics to analyze energy interactions in closed and open systems.	PO3 (3)	3	–
CO2	Evaluate entropy generation, exergy, and availability in energy systems and combustion processes.	PO1 (3), PO3 (3)	3	3
CO3	Analyze real gas behavior, thermodynamic relations, and validate concepts through experimental studies.	PO1 (2), PO2 (3), PO3 (3)	3	–
CO4	Simulate and assess the performance of advanced thermodynamic cycles and energy conversion systems using theoretical, practical, and software-based approaches.	PO1 (3), PO2 (3), PO3 (3)	3	3

TE25C02	Advanced Fluid Mechanics Heat Transfer	L	T	P	C
		3	0	2	4
<p>Course Objectives: To provide knowledge and skills to analyze and apply principles of fluid mechanics and heat transfer, including conduction, convection, phase change, and advanced applications, through theoretical study, experimental investigation, and computational techniques.</p>					
<p>Fluid Kinematics and Boundary Layer Theory: 3D Governing Equations: Mass, momentum and applications, Rotational & irrotational flows, stream & potential functions, Vorticity, flow visualization concepts, Velocity Boundary layer theory: displacement, momentum & energy thickness, Laminar and turbulent boundary layers (flat plate & circular pipe)</p> <p>Practical: Measurement of boundary layer thickness over a flat plate in a wind tunnel, Determination of velocity profile for laminar/turbulent flow using Pitot tube.</p>					
<p>Fluid Flow Analysis: Laminar flow: parallel plates and circular pipes, Friction factor, smooth vs rough pipes, Moody diagram, Minor and major losses, pipes in series/parallel, Power transmission through pipes, 1D compressible flow in variable area ducts, Nozzles and diffusers, choking and flow regimes</p> <p>Practical: Flow rate measurement in pipes using venturi/mass flow meters, Determination of friction factor using Moody's chart, Losses in pipe systems (major & minor losses), experimental setup</p>					
<p>Conduction: Boundary Conditions, Thermal Conductivity, Conduction equation, Fin Design, analytical solutions, Multi-dimensional steady state heat conduction, Transient Heat conduction, Lumped Capacitance Method, Semi-Infinite Media Method</p> <p>Practical: Thermal conductivity of solids & liquids and effect of temperature, Thermal analysis of fins, Lumped heat method for analysis of different geometries</p>					
<p>Convection: Energy & Momentum equations, Laminar & Turbulent Boundary Layers, Entry length, Reynolds-Colburn Analogy, Heat transfer coefficient for flow over a flat surface, circular & non-circular ducts</p> <p>Practical: Thermal & hydraulic boundary layer development through fluid, Free & Forced convective heat transfer coefficient studies.</p>					
<p>Two-Phase Heat Transfer: Pool & Convective boiling, critical heat flux, Dropwise & filmwise condensation, Melting & Solidification, Heat transfer enhancement methods.</p> <p>Practical: Plotting of boiling & condensation curves, T-t plots during melting & solidification</p>					
<p>Thrust Areas: Thermoregulation, Laser Generated Heat Transfer, Tissue Thermal Properties and Perfusion, Thermal Damage and Rate Processes in Biologic Tissues, Thermal Injury, Mathematical models of bio-heat transfer</p>					

Machine Learning in Heat Transfer, Linear regression and Neural networks, Practical considerations & Applications.

Practical: Irradiation studies & heat generation from lasers

Weightage: Continuous Assessment: 50%, End Semester Examinations: 50%

Assessment Methodology: Quiz (5%), Project (10%), Assignment (10%), Practical (25%), Review of Question papers (IES, SSC, GATE) (20%), Internal Examinations (30%)

References:

1. Çengel, Y. A., & Cimbala, J. M. (2018). Fluid mechanics: Fundamentals and applications. McGraw-Hill.
2. White, F. M. (2016). Fluid mechanics. McGraw-Hill Education.
3. Lienhard, J. H., IV, & Lienhard, J. H., V. (2020). A heat transfer textbook. Phlogiston Press.
4. Bejan, A. (2013). Convection heat transfer. Wiley.
5. Holman, J. P. (2002). Heat transfer. Tata McGraw-Hill.
6. Çengel, Y. A. (2020). Heat and mass transfer: Fundamentals and applications. McGraw-Hill.
7. Brennen, C. E. (2005). Fundamentals of multiphase flow. Cambridge University Press.
8. Collier, J. G., & Thome, J. R. (n.d.). Convective boiling and condensation. Oxford University Press.
9. Incropera, F. P., & DeWitt, D. P. (2002). Fundamentals of heat and mass transfer. John Wiley & Sons.
10. Welch, A. J., & van Gemert, M. J. C. (2011). Optical-thermal response of laser-irradiated tissue. Springer Dordrecht.
11. Prakash, P., & Srimathveeravalli, G. (2021). Principles and technologies for electromagnetic energy-based therapies. Academic Press.

E-Resources:

https://nptel.ac.in/courses/112105269?utm_
<https://www.youtube.com/playlist?list=PLbMVogVj5nJTZJHsH6uLCO00I-ffGyBEm&utm>
https://onlinecourses.nptel.ac.in/noc25_me171/preview?utm
https://onlinecourses.nptel.ac.in/noc23_ch32/preview?utm

Other Resources:

Interactive simulation platforms:
Interactive learning:

	Description of CO	Mapped POs	PSO1	PSO2
CO1	Apply principles of fluid mechanics to analyze flow behavior, boundary layers, and pressure/velocity variations in internal and external flows.	PO3 (3)	3	–
CO2	Evaluate fluid flow parameters, frictional losses, and compressible flow behavior in ducts, nozzles, and diffusers through theoretical and experimental studies.	PO1 (2), PO3 (3)	3	–
CO3	Analyze heat transfer by conduction, convection, and phase change, and validate models using experimental investigations.	PO1 (3), PO2 (2), PO3 (3)	3	3
CO4	Utilize computational and modern techniques, including machine learning, to simulate advanced heat transfer and bio-heat transfer processes for sustainable applications.	PO1 (3), PO2 (3), PO3 (3)	3	3

TE25C03	Instrumentation and Control for Thermal Systems	L	T	P	C
		3	0	0	3
<p>Course Objectives: To provide knowledge and skills in experimental methods, measurement systems, and industrial automation for accurate data acquisition, analysis, and process control.</p>					
<p>Experimental Methods: Statistical and regression analysis, uncertainty and data reduction, experimental design, basics of data analytics and machine learning. Activities: Mini-project on regression and uncertainty analysis using software, Design of Experiments (DoE) simulation using Taguchi method, Introduction to Python/R for basic data analytics.</p>					
<p>Sensors, Transducers and Calibration: LVDT, strain gauge, capacitive, piezoelectric, optical and magnetic transducers; thermocouple, RTD, thermistor; calibration of sensors; electronic, fibre-optic and pneumatic transmitters; telemetry. Activities: Lab experiments using LVDT, strain gauge, and thermocouples, Sensor signal acquisition and visualization via DAQ systems, Calibration experiments with standard temperature and pressure instruments</p>					
<p>Measurements in Thermal Systems: Temperature, pressure, and flow measurements, Measurement of: Thermal conductivity, Specific heat, Viscosity, Rheological analysis of Newtonian and non-Newtonian fluids, Humidity, Solar irradiation, Differential Scanning Calorimetry, Calorific values of fuels (solid, liquid, gas) Activities: Measurement of temperature, pressure, flow using industrial instruments, Determination of thermal conductivity and specific heat in the lab, Analysis using Differential Scanning Calorimetry (DSC)</p>					
<p>Control Systems and Industrial Automation: Open/closed loop systems, transfer functions, feedback, signal conditioning, DAQ, PID and PLC controllers, regulators, thermostats, drives, SCADA, DCS, IIoT, and system optimisation. Activities: Simulation of PID control using software, PLC programming using ladder logic (e.g., Siemens, Allen-Bradley), Hands-on with SCADA/DCS platforms (demo setups or software simulators), Virtual labs on IIoT and remote monitoring systems</p>					
<p>Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%</p>					
<p>Assessment Methodology: Quiz (5%), Project (10%), Assignment (10%), Practical (25%), Review of Question papers (IES, SSC, GATE) (20%), Internal Examinations (30%)</p>					
<p>References:</p> <ol style="list-style-type: none"> Holman, J. P. (2011). Experimental methods for engineers. Tata McGraw-Hill. Doebelin, E. O. (2004). Measurement systems: Application and design. McGraw-Hill. Kirkup, L. (2019). Experimental methods for science and engineering students. Cambridge University Press. Morris, A. S., &Langari, R. (2015). Measurement and instrumentation: Theory and application. Elsevier. 					

5. Anderson, N. A. (2017). Instrumentation for process measurement and control. CRC Press.
6. Datta, A., & Goel, P. (2023). Practical guide to instrumentation, automation and robotics. Elsevier.
7. Lipták, B. G. (Ed.). (2018). Instrument engineers' handbook: Process measurement and analysis. CRC Press.

E-resources and Other Resources:

<https://nptel.ac.in/courses/106/106/106106179/>
<https://nptel.ac.in/courses/108/105/108105062/>
<https://nptel.ac.in/courses/112/104/112104906/>
<https://nptel.ac.in/courses/108/101/108101037/>
<https://nptel.ac.in/courses/108/105/108105062/>

Other Resources:

Interactive simulation platforms:

Interactive learning:

	Description of CO	Mapped POs	PSO1	PSO2
CO1	Apply experimental methods, statistical analysis, and data analytics for accurate investigation of thermal systems.	PO1 (3), PO2 (2)	3	–
CO2	Demonstrate the use of sensors, transducers, and advanced measurement systems for thermal parameters.	PO3 (3)	3	–
CO3	Design and implement control and automation strategies (PID, PLC, SCADA, IIoT) for efficient and sustainable thermal system operations.	PO1 (3), PO2 (3), PO3 (3)	3	3

EY25101	Sustainable Energy Systems	L	T	P	C
		3	0	2	4
<p>Course Objectives:</p> <p>To provide foundational knowledge and technical understanding of sustainable energy sources like solar, wind, biomass, hydro, and geothermal and to emphasize their practical applications and evaluates their design, performance, and sustainability in real-world contexts.</p>					
<p>Energy Scenario: Indian and global energy scenario, renewable vs. non-renewable energy sources, renewable energy integration and smart grid, energy demand and supply trends, energy pricing and energy substitution</p> <p>Practical: Study of India's energy mix using data sets (MNRE, IEA), analysis of energy consumption trends and fuel substitution, study of energy policy framing</p>					
<p>Environmental Impact & Policy: Greenhouse gases and global warming, Ozone depletion and climate change, UNFCCC, Kyoto protocol, Paris agreement, environmental sustainability in energy, environmental impact assessment, role of energy in achieving SDGs.</p> <p>Practical: Carbon footprint calculator, Case study: UNFCCC, Kyoto protocol, India's INDC, Environmental impact analysis using LCA software or spreadsheet.</p>					
<p>Solar Energy Systems: Solar radiation and measurement, solar thermal collectors: flat plate, concentrating, solar thermal applications and storage, solar PV system design, PV/T, CPV, BIPV and its applications.</p> <p>Practical: Measurement of solar radiation, testing of flat plate and concentrating solar collectors, I-V characteristics of solar PV panels under varying intensity</p>					
<p>Wind Energy Technology: Wind characteristics and site selection, wind energy estimation and Betz limit, wind turbines, materials and components, wind farm layout and performance, hybrid systems, wind turbine recycling, environmental impact and applications.</p> <p>Practical: Wind speed measurement, Estimation of power from a wind turbine</p>					
<p>Bio-Energy Conversion Technologies: Biomass resources and classification, Thermochemical conversion: gasification, pyrolysis, combustion, Biochemical conversion: fermentation, biomethanation, Physicochemical: biodiesel production, briquetting, bioenergy applications, hybrid systems.</p> <p>Practical: Study of a biomass gasifier/biogas plant (demo or visit), Transesterification process for biodiesel production, Solid fuel briquette manufacturing (demo or visit).</p>					
<p>Weightage: Continuous Assessment: 50%, End Semester Examinations: 50%</p>					

Assessment Methodology: Quiz (5%), Project (10%), Assignment (10%), Practical (25%), Review of Question papers (IES, SSC, GATE) (20%), Internal Examinations (30%)

References:

1. Boyle, G. (2017). Renewable energy: Power for a sustainable future. Oxford University Press.
2. Khan, B. H. (2016). Non-conventional resources. McGraw Hill.
3. Nayak, J. K., & Sukhatme, S. P. (2017). Solar energy. McGraw Hill.
4. Rai, G. D. (2014). Non-conventional energy sources. Khanna Publishers.
5. Twidell, J. (2022). Renewable energy resources. Routledge.

E-Resources:

<https://mnre.gov.in>
<https://unfccc.int>
<https://www.solarenergy.org>
<https://nptel.ac.in/courses/112105051>
<https://nptel.ac.in/courses/121106014>
<https://www.fao.org/bioenergy>
<https://www.hydropworld.com>

Other Resources:

Interactive simulation platforms:
<https://pvlib-python.readthedocs.io>
<https://www.mathworks.com/matlabcentral/fileexchange/128213-hybrid-renewable-energy-system>
<https://www.renewables.ninja>
<https://qblade.org>
<https://www.renewables.ninja>

	Description of CO	Mapped POs	PSO1	PSO2
CO1	Analyze the global and Indian energy scenario, energy mix, demand–supply trends, and role of renewable integration in sustainable development.	PO1 (3), PO2 (2)	3	2
CO2	Evaluate the environmental impacts of energy systems and interpret policies, protocols, and sustainability frameworks (UNFCCC, Kyoto, Paris, SDGs).	PO6 (3), PO7 (3)	–	3
CO3	Apply theoretical and practical knowledge of solar, wind, biomass, and other renewable systems to design and assess performance of sustainable energy technologies.	PO1 (3), PO2 (3), PO3 (2)	3	–
CO4	Demonstrate hands-on skills in measurement, testing, and analysis of renewable energy systems and technologies through laboratory/practical activities.	PO4 (3), PO5 (2)	2	–
CO5	Develop competence to analyze hybrid energy systems and propose sustainable energy solutions with technical, environmental, and policy considerations.	PO2 (3), PO3 (3), PO7 (2)	3	3

EY25C01	Energy Storage Technologies	L	T	P	C
		3	0	0	3
<p>Course Objectives:</p> <p>To provide foundational knowledge of various energy storage methods thermal, electrical, chemical, and mechanical and analyse the performance of modern systems like batteries and hydrogen storage, explores emerging technologies, safety challenges</p>					
<p>Overview of Energy Storage Systems: Classification, key performance parameters, comparison of technologies, energy storage prediction and system optimization using software.</p> <p>Activities: Comparison of at least 6 energy storage technologies on key performance parameter, Case Study – Analyze a real-world energy storage project and present its technology, performance, and challenges, Debate - which energy storage technology will dominate in the next decade and justify your reasoning.</p>					
<p>Thermal Energy Storage: Sensible heat storage systems, latent heat storage systems, Phase Change Materials (PCMs) and packed bed units, thermochemical storage systems, modern developments: solid-solid PCM and compact thermal storage systems.</p> <p>Activities: Identify suitable PCMs for a solar water heating system based on melting point and thermal properties, Design a packed bed storage unit for a small-scale industrial heat recovery application.</p>					
<p>Electrochemical and Electrical Storage: Lead-acid, NiCd, NiMH, Li-ion, zinc-air batteries, battery performance and safety, supercapacitors, ultracapacitors, SMES, emerging technologies: solid-state batteries, fast charging systems, Vehicle to Grid(V2G) technology, AI applications in battery health monitoring and predictive diagnostics.</p> <p>Activities: Create a performance matrix for lead-acid, NiCd, NiMH, Li-ion, and zinc-air batteries, Analyze a vehicle-to-grid implementation and its impact on grid stability, Model charge–discharge cycles of different battery chemistries using softwares.</p>					
<p>Hydrogen Energy Storage: Challenges in hydrogen storage, storage methods, storage protocols, hybrid storage systems.</p> <p>Activities: Identify and explain key technical challenges in large-scale hydrogen storage, Summarize international standards and safety protocols for hydrogen storage and handling, Analyze a real-world hydrogen storage project and its operational performance.</p>					
<p>Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%</p>					

Assessment Methodology: Quiz (5%), Project (10%), Assignment (10%), Practical (25%), Review of Question papers (IES, SSC, GATE) (20%), Internal Examinations (30%)

References:

1. Dincer, I., & Rosen, M. A. (2002). Thermal energy storage systems and applications. John Wiley & Sons.
2. Larminie, J., & Dicks, A. (2003). Fuel cell systems explained. Wiley Publications.
3. Cabeza, L. F. (Ed.). (2015). Advances in thermal energy storage systems: Methods and applications. Elsevier Woodhead Publishing.
4. Huggins, R. (2015). Energy storage: Fundamentals, materials and applications. Springer.
5. Liu, R., Zhang, L., & Sun, X. (2012). Electrochemical technologies for energy storage and conversion. Wiley Publications.

E-Resources:

<https://doi.org/10.21105/joss.06411>
<https://energyplus.net/MathWorks+2>
<https://globalwindatlas.info>
<https://nptel.ac.in/courses/112107291>
<https://www.edx.org/course/energy-storage>
<https://www.coursera.org/learn/batteries>
<https://www.homerenergy.com>

Other Resources:

Interactive simulation platforms:

<https://www.calmac.com/energy-storage-video-energy-storage-simulator> ASME Digital Collection+3
<https://www.mathworks.com/matlabcentral/fileexchange/176408-thermal-energy-storage-design-with-simscape>
<https://pvlib-python.readthedocs.io/en/stable/>

	Description of CO	Mapped POs	PSO1	PSO2
CO1	Classify and compare different energy storage systems (thermal, electrochemical, electrical, hydrogen) on technical and economic bases.	PO1 (3), PO2 (2)	3	2
CO2	Analyze thermal energy storage methods (sensible, latent, thermochemical, PCM, packed bed) and assess their sustainable applications.	PO1 (3), PO2 (3), PO3 (2)	3	–
CO3	Evaluate electrochemical/electrical storage systems (batteries, capacitors, SMES) and hydrogen storage technologies with respect to safety, standards, and emerging developments.	PO1 (3), PO2 (3), PO3 (2)	3	3
CO4	Apply software tools, case studies, and system-level performance analysis to optimize and manage real-world energy storage projects.	PO2 (3), PO3 (3)	3	2

Semester II

EY25201	Energy Conservation and Management	L	T	P	C
		3	0	2	4

Course Objectives:

To offer a strong basis in energy management and auditing to increase the efficiency of HVAC, electrical, and thermal systems; to give exposure in financial analysis, policy frameworks, and performance evaluation methods; and to apply new technologies such as artificial intelligence, the Internet of Things, and smart energy systems for sustainable energy optimization.

Introduction to Energy Management and Auditing

Need for energy management and energy audit, Types and methodology of audits, Energy costing, benchmarking, TANGEDCO billing parameters, Demand Side Management (DSM). Energy audit data analytics and consumption pattern prediction.

Practicals: Load profile analysis and energy audit report preparation, Study of TANGEDCO billing and tariff structures, Use of digital energy meters and clamp meters

Applications: Identifying high-energy consuming equipment in factories, Verifying utility bills and optimizing demand charges, Energy benchmarking in manufacturing units

Boilers, Furnaces, and Thermic Fluid Heaters

Types of boilers, furnaces, thermic fluid heaters, Performance evaluation (direct and indirect method), Energy conservation opportunities, Steam distribution: assessment of losses, steam trapping, recovery systems. Smart sensors and AI-based monitoring for combustion efficiency.

Practicals: Efficiency analysis of boilers (direct & indirect method), Steam trap inspection and testing, Flue gas analysis using combustion analyzer

Applications: Boiler efficiency improvement in food, textile, and pharma industries, Waste heat recovery system assessment, Preventive maintenance of steam distribution networks

HVAC and Waste Heat Recovery (WHR) Systems

Vapour Compression Refrigeration System (VCRS): performance, energy saving, Vapour Absorption Machines (VAM): types, advantages, comparison with VCRS, Cooling towers: operation, losses, optimization, Waste heat recovery systems: types, benefits.

Practicals: Performance testing of vapour compression refrigeration system (VCRS), Study of vapour absorption machine (VAM) operation, Heat exchanger effectiveness testing, Cooling tower approach and effectiveness analysis

Applications: HVAC energy audits in commercial buildings, WHR systems in cement, steel, and chemical industries, Cooling optimization in data centers and hotels

Electrical Systems and Energy Efficiency

Transformers: energy conservation, Cables: loss analysis, Power factor correction, Harmonics measurement, causes, mitigation, Motors, fans, blowers, pumps, compressors: performance and efficiency, Illumination systems: lux level, LED retrofits, IoT-enabled electrical load monitoring, AI for load forecasting

Practicals: Motor efficiency measurement using load test, Measurement of transformer losses and cable resistance, Harmonics analysis using power quality analyzers, Lux level measurement and lighting system audit

Applications: Power factor improvement in industrial electrical panels, Retrofitting lighting systems in office buildings, Energy saving in fans, pumps, and compressors

Energy Monitoring, Targeting and Financial Analysis

Energy Monitoring and Targeting (M&T), energy performance indicators, PAT scheme, and carbon credits, CUSUM analysis for trend detection, Financial analysis: IRR, NPV, payback period, Depreciation and sensitivity analysis,

Practicals: Calculation of simple payback, NPV, IRR for retrofit projects, Use of CUSUM charts for energy monitoring, Case study on ESCO project evaluation

Applications: Justification of energy-saving investments in industries, Tracking savings from conservation measures, Preparing DPRs for green building certifications

Emerging Trends, Digital Tools & Smart Energy Management

Digital energy platforms and dashboards, Smart meters and real-time energy analytics,

AI/ML in energy demand forecasting and anomaly detection, Energy management in smart buildings and smart factories, Integration with Industry 5.0 and IoT, Case studies from modern industries and green buildings

Practicals: Real-time monitoring with IoT-based energy meters, Data logging and trend analysis using cloud dashboards, AI-based load forecasting using sample data, Simulation of smart energy management systems

Applications: Smart factory energy dashboards, Predictive maintenance of rotating equipment, AI-integrated Building Management Systems (BMS)

Weightage: Continuous Assessment: 50%, End Semester Examinations: 50%

Assessment Methodology and weightage:

Assessment Exams (50%), Assignments/Case Study (10%), Quiz/Problem (10%),

Virtual demonstration/Software Analysis (10%), Flipped Classroom (10%), Review of GATE & IES questions(10%)

References:

1. Energy Manager Training Manual (4 Volumes) available at <https://aipnpc.org/Guidebooks.aspx> Guidebooks for National Certification Examination, Bureau of Energy Efficiency (BEE), Government of India
2. L.C. Witte, P.S. Schmidt, D.R. Brown, "Industrial Energy Management and Utilisation" Hemisphere Publication, Washington, 1988.
3. Stephen A. Roosa, Steve Doty, Wayne.C.Turner, "Energy Management Handbook", River Publishers, 2018
4. W.R. Murphy and G. McKay "Energy Management", Elsevier, 2007
5. Eastop.T.D & Croft D.R, "Energy Efficiency for Engineers and Technologists", Longman Scientific & Technical, 1990.
6. Albert Thumann, Terry Niehus, William J.Younger, "Handbook of Energy Audits", River Publishers, Ninth Edition, 2012

E-Resources:

<https://nptel.ac.in/courses/112106210>

<https://www.unep.org/explore-topics/energy>

<https://www.se.com/in/en/work/services/training/energy-university.jsp>

CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Identify and apply energy audit methods and instruments to assess and benchmark energy consumption in industrial and commercial systems	PO1 (3), PO2 (2)	3	2
CO2	Analyze the performance of thermal systems such as boilers, furnaces, and steam networks, and suggest energy-saving measures	PO1 (3), PO3 (2)	3	2
CO3	Evaluate HVAC systems and waste heat recovery options, including their operational efficiency and integration with polygeneration systems	PO1 (3), PO3 (3)	3	3
CO4	Assess electrical systems and utilities like motors, transformers, and lighting for energy efficiency improvements using modern tools	PO1 (3), PO3 (3)	3	3

TE25C06	Computational Fluid Dynamics	L	T	P	C
		3	0	2	4

Course Objectives:

To impart the fundamentals of computational fluid dynamics and provide hands-on training, while introducing advanced CFD tools for analyzing complex systems.

Governing Differential Equations

Finite Volume approach – Scalar, Vector, Tensor, Governing equations for conservation of mass, momentum and energy – Classification of partial differential equations – Types of Boundary Conditions, Initial and Boundary value problems, Taylor’s Series, Stoke’s law, Vorticity, Diffusion, Divergence theorem, Types of Errors

Practicals:

Determination of approximate solutions for Navier-Stokes equation using computer software

Grid Generation

Types of Meshes – Structured, Body-Fitted & Unstructured Mesh, Coordinate Transformations, Topology, Refinement, Overlapping, Adaptive Mesh, Moving Mesh, Mesh Quality & Mesh Design, Coarse & Fine Mesh, Grid Independence Test.

Practicals:

Mesh Generation for various geometries

Diffusion

Multidimensional diffusion problems, Discretisation of steady & unsteady diffusion equations – Explicit, Implicit and Crank-Nicholson’s schemes, Stability of schemes, Numerical Solutions.

Practicals:

Simulation of steady & transient diffusion problem using CFD Tool with results and reports.

Convection-Diffusion

1D convection – diffusion problem, Discretisation using Central difference scheme, upwind scheme, QUICK scheme.

Phase Change – Mathematical Formulation, Discretisation, Enthalpy method, Problems

Practicals:

Discretisation of governing equation using software, Simulation of phase-change problems using CFD Tool.

Flow Modelling

Pressure-velocity coupling algorithms – SIMPLE, SIMPLEC, PISO, Turbulence Models – Governing equation for turbulent kinetic energy & dissipation (k-ε model), Large Eddy Simulation

Practicals:

Simulation of internal and external flows and execution of CFD Project with results and reports.

Weightage: Continuous Assessment: 50%, End Semester Examinations: 50%

Assessment Methodology and weightage:

Assessment Exams (50%), Assignment/Case Study (10%), Quiz/Problem (10%), Virtual demonstration/Software Analysis (10%), Flipped Classroom (10%), Review of GATE & IES questions (10%)

References:

1. Versteeg and Malalasekera, N, "An Introduction to computational Fluid Dynamics, Finite Volume Method," Pearson Education, Ltd., Second Edition, 2014.
2. Subas and V. Patankar "Numerical heat transfer fluid flow", CRC Press, 2018.
3. Jiyuan Tu, Gaun-Heng Yeoh, Chaoqun Liu, Computational Fluid Dynamics: A practical approach, Elsevier, 2018.
4. Chung T.J, Computational Fluid Dynamics, Cambridge University Press, 2014.
5. Randall J. LeVeque, Finite Volume Methods for Hyperbolic Problems, Cambridge University Press, 2004.
6. Vladimir D. Liseikin, Grid Generation Methods, Springer, 2017.
7. Moukalled F, Mangani L, Darwish M, The Finite Volume Method in Computational Fluid Dynamics, Springer, 2016.
8. Hirsch Ch, Numerical Computation of Internal and External Flows: The Fundamentals of Computational Fluid Dynamics, Elsevier, 2007.
Oleg Zikanov, Essential Computational Fluid Dynamics, Wiley, 2019.

E-resources:

<https://nptel.ac.in/courses/112/105/112105045/>

<https://ocw.mit.edu/courses/mechanical-engineering/2-29-numerical-fluid-mechanics-spring-2015/>

<https://www.grc.nasa.gov/www/cfd/>

<https://www.ansys.com/training-center>

<https://www.journals.elsevier.com/journal-of-computational-physics>

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain governing equations, boundary conditions, discretization methods, and numerical errors in CFD	PO1 (3), PO3 (2)	3	2
CO2	Apply finite volume methods, mesh generation, and numerical schemes to solve fluid flow and heat transfer problems	PO1 (3), PO2 (3)	3	3
CO3	Estimate stability, convergence, and accuracy of CFD solutions and grid independence	PO1 (3), PO3 (3)	3	3
CO4	Analyze CFD results, turbulence models, and flow simulations for problem-solving and optimization	PO3 (3)	3	3

TE25C04	Fuels and Combustion	L	T	P	C
		3	0	2	4
<p>Course Objective To introduce the principles of combustion, stoichiometry, flame behavior, and thermodynamics across solid, liquid, and gaseous fuels and to emphasize the analysis of combustion systems, emissions, and safety, with a focus on modern fuel technologies and sustainable energy application</p>					
<p>Combustion Fundamentals and Stoichiometry: Combustion types and mechanisms, stoichiometry and flame characteristics, ignition, flame stabilization and combustion kinetics, flue gas analysis</p> <p>Practical: Estimation of calorific value using bomb calorimeter, orsat gas analysis for flue gases, determination of air-fuel ratio for a given fuel.</p>					
<p>Solid Fuels: Solid fuel types, properties and analysis, carbonization, gasification, and liquefaction, advanced biomass processing and hybrid fuels</p> <p>Practical: Proximate and ultimate analysis of coal/biomass, study of fixed bed gasifier setup, fuel handling and briquetting of biomass</p>					
<p>Liquid and Gaseous Fuels: Refining and testing of liquid fuels, synthetic fuels, bio, and alternative fuels, gaseous fuels: properties, production, and applications</p> <p>Practical: Flash point and fire point testing (Pensky-Martens apparatus), Kinematic viscosity testing using redwood viscometer, measurement of octane and cetane numbers (engine method/demo)</p>					
<p>Combustion Devices: Burners for fuels, pulverized fuel, furnaces and fluidized beds, low-NOx and smart burner technologies.</p> <p>Practical: Performance testing of bunsen/industrial burner, design of a simple liquid/gas fuel burner, combustion efficiency measurement, flame visualization using high-speed camera/schlieren methods (demo or project)</p>					
<p>Emissions and Combustion Safety: Emission sources, measurements and control, sensors, safety in fuel storage and combustion systems.</p> <p>Practical: Measurement of NOx, SOx, CO, and particulate matter, study of fire extinguishing systems and combustion safety protocols</p>					
<p>Combustion Sustainability: Green Fuels: hydrogen, ammonia, bio-fuels, and carbon-neutral fuels, AI/IoT in combustion optimization, emission reduction strategies, carbon capture in combustion systems, lean premixed combustion.</p> <p>Practical: Performance evaluation of engine on biodiesel, Combustion of hydrogen or ammonia (simulation or demo setup), IoT-enabled emission monitoring, life cycle assessment (LCA) of biofuels, simulation of oxy-fuel combustion in software.</p>					
<p>Weightage: Continuous Assessment: 50%, End Semester Examinations: 50%</p>					
<p>Assessment Methodology: Quiz (5%), Project (10%), Assignment (10%), Practical (25%), Review of Question papers (IES, SSC, GATE) (20%), Internal Examinations (30%)</p>					

References:

1. Sarkar, S. (2009). Fuels and combustion. Orient Longman Pvt. Ltd.
2. Philips, H. J. (2008). Fuels – solids, liquids, and gases: Their analysis and valuation. Bioblolife Publisher.
3. Turns, S. R. (2012). An introduction to combustion: Concepts and applications . Tata McGraw-Hill.
4. Mishra, D. P. (2010). Fundamentals of combustion. University Press.
5. Sharma, S. P., & Mohan, C. (1984). Fuels and combustion. Tata McGraw-Hill.
6. Mukhopadhyay, R., & Datta, S. (2007). Engineering chemistry. New Age International Pvt. Ltd.

E-Resources:

<https://nptel.ac.in/courses/112106184>

<https://ocw.mit.edu/courses/2-61-internal-combustion-engines-spring-2017/>

<https://www.coursera.org/learn/energy-production>

<https://www3.nd.edu/~powers/ame.60636/notes.pdf>

<https://www.ieabioenergy.com/>

Other Resources:

Interactive simulation platforms:

<https://vlabs.iitkgp.ac.in/heat/>

<https://learncheme.com/simulations/thermodynamics/adiabatic-flame-temperature/>

<https://learncheme.com/quiz-yourself/interactive-self-study-modules/combustion-reactions/>

<https://www.nist.gov/services-resources/software/fire-dynamics-simulator-fds>

	Description of CO	Mapped POs	PSO1	PSO2
CO1	Describe the combustion fundamentals, stoichiometry, and flame behavior concepts to analyze different fuel types.	PO1 (3), PO3 (2)	3	–
CO2	Evaluate properties, testing methods, and performance of solid, liquid, and gaseous fuels including biofuels.	PO1 (3), PO2 (2), PO3(2)	3	–
CO3	Design and analyze combustion devices, emission control techniques, and safety protocols for fuel systems.	PO1 (3), PO2 (3)	3	2
CO4	Assess sustainable and advanced combustion practices for clean energy applications.	PO1 (3), PO3 (3)	–	3

Semester III

EY25C02	Artificial Intelligence and Machine Learning in Energy Systems	L	T	P	C
		3	0	0	3
Course Objectives:					
To introduce AI and Machine Learning techniques for modern energy systems with a focus on data-driven modeling, optimization, and their applications in renewable energy forecasting, smart grids, energy management, and predictive maintenance.					
AI in Energy Systems					
Basics of Artificial Intelligence (AI), Machine Learning, Role of AI in modern energy systems, data acquisition from energy devices and sensors (IoT), case studies.					
Activities					
Simulate a simple AI-based decision system for energy efficiency using software, Collect sample IoT sensor data (temperature, voltage, current) and visualize trends.					
Forecasting and Optimization in Energy Systems					
Time-series forecasting of solar irradiance, wind speed, and load demand, ML models: linear regression, decision trees, random forest, SVM, optimization techniques: genetic algorithms, particle swarm optimization, ant colony optimization, energy demand prediction and scheduling, battery storage and microgrid optimization using AI.					
Activities					
Build a solar irradiance forecasting model using time-series data, Compare ML models (Linear Regression vs. Random Forest vs. SVM) for load prediction, Implement a simple Genetic Algorithm or Particle Swarm Optimization for battery scheduling.					
Intelligent Control and Fault Detection					
AI in HVAC systems and building energy management, smart controllers using ANN and fuzzy logic, fault detection and diagnostics in PV, turbines, and motors, predictive maintenance using ML and DL, classification techniques: KNN, naïve bayes, CNN for anomaly detection					
Activities					
Design a fuzzy logic controller for HVAC temperature control, Implement ANN-based predictive maintenance model for motor vibration data, Train a CNN to detect anomalies in PV panel output patterns.					
Smart Grids and Energy Analytics					
AI in smart grid management and demand-side response, load disaggregation and consumption pattern analysis, AI in grid stability, outage detection, and cyber-physical systems, big data and cloud platforms (e.g., TensorFlow, AWS IoT) for energy analytics, case studies on AI-powered utilities and smart meters.					

Activities

Apply AI algorithms for outage detection from grid event logs, perform load disaggregation using machine learning on household energy data, deploy a simple AI-based demand response simulation using AWS IoT or Google Cloud AI tools.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology and weightage:

Assessment Exams (50%), Assignments/Case Study (10%), Quiz/Problem (10%), Virtual demonstration/Software Analysis (10%), Flipped Classroom (10%), Review of GATE & IES questions(10%)

References:

1. Siano, Pierluigi, Artificial Intelligence Techniques for Renewable Energy Systems, Springer, 2021
2. James Smith, AI and Machine Learning for Energy Engineers, Wiley, 2022.
3. Mohamed E. El-Hawary, Artificial Intelligence Applications in Power Systems, IEEE Press, 2020.
4. Sebastian Raschka, Python Machine Learning, Packt Publishing, 2020
5. Research articles from IEEE Xplore, ScienceDirect, and SpringerLink

E-Resources:

<https://nptel.ac.in/courses/106102220>

<https://nptel.ac.in/courses/112106298>

<https://www.coursera.org/learn/ai-for-everyone>

<https://www.coursera.org/specializations/data-science-python>

<https://www.edx.org/course/artificial-intelligence-ai>

<https://www.udemy.com/course/ai-for-renewable-energy/>

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain AI and ML concepts, data acquisition from energy devices, and applications in modern energy systems.	PO1 (3), PO3 (2)	3	2
CO2	Apply ML models and optimization techniques (linear regression, decision trees, random forest, SVM, GA, PSO) for energy forecasting, scheduling, and battery/microgrid optimization.	PO1 (3), PO2 (3)	3	3
CO3	Estimate performance of intelligent control systems, predictive maintenance models, and fault detection in PV panels, turbines, and motors.	PO1 (3), PO3 (3)	3	3
CO4	Analyze AI-enabled smart grid operations, load disaggregation, demand-side management, and energy analytics for optimized energy management.	PO3 (3)	3	3

EY25301	Industrial Training	L	T	P	C
		0	0	0	2
Course Objectives:					
To understand, learn and apply the principles and practices of Energy Conservation in Industrial Utilities through hands on training.					
GUIDELINES:					
<ul style="list-style-type: none"> • Each student has to undergo Industrial training for a minimum period of four weeks during the upcoming summer vacation (i.e., between II and III Semester). • The Internship has to be undergone continuously for the entire period. • The Internship must be carried out in an energy intensive industry (HT Consumer) • The End Semester Examination must be conducted at the start of III Semester. The mark will be based on the project report (Introduction; Project or Training details; Techno Economics; Discussion; and Conclusion) and their presentation followed by oral examination on the same by internal examiner. 					
Weightage:					
Assessment: 100%					

EY25302	Project Work I	L	T	P	C
		0	0	12	6

Course Objectives:

- The main learning objective of this course is to prepare the students for identifying a specific problem for the current need of the society and or industry, through detailed review of relevant literature, developing an efficient methodology to solve the identified specific problem.

GUIDELINES:

- Each PG student shall work individually on a selected specific topic. Which shall be approved by the Head of the Division under the supervision of a Faculty Member (Guide / Supervisor) who is familiar in the selected specific topic. The selected specific topic maybe theoretical and or experimental and or simulation and or case study. The students' Project Work – Phase I shall be evaluated through Internal Examination and End Semester Examination.
- The Internal Examination must be conducted periodically (Zeroth, First, Second and Third) through Project Work Review Presentation Meetings followed by questions from the panel of Review Committee Members comprising of two expert faculty members and a project coordinator.
- At the end of the semester, a detailed report on the work done by the PG student must be submitted with the approval from the Guide/Supervisor and the Review Committee Members. The Project Work – Phase I Report must contain the Introduction with clear definition along with detailed review of relevant literature on the selected specific problem; an efficient methodology to solve the selected specific problem along with necessary hypothesis and or experimental setup and or simulation and or case study for carrying out the research project work along with preliminary results; discussions, relevant conclusions and future direction along with specified references.
- The End Semester Examination must be conducted through Project Work Presentation followed by questions from the panel of Examiners comprising an External Examiner and Project Coordinator as Internal Examiner.

Semester IV

EY25401	Project Work II	L	T	P	C
		0	0	24	12
Course Objectives:					
<p>The main learning objective of this course is to prepare the students for solving the specific problem for the current need of the society and or industry, through the formulated efficient methodology, and to develop necessary skills to critically analyse and discuss in detail regarding the project results and making relevant conclusions.</p>					
GUIDELINES:					
<ul style="list-style-type: none"> • The student may continue to work on the Project Work – I's selected topic as per the formulated efficient methodology under the same Faculty Member (Guide/Supervisor). • The students' Project Work – II shall be evaluated through Internal Examination and End Semester Examination. • The Internal Examination must be conducted periodically (First, Second and Third) through Project Work Review Presentation Meetings followed by questions from the panel of Review Committee Members comprising of two expert faculty members and a project coordinator. • At the end of the semester, a detailed report on the work done by the PG student must be submitted with the approval from the Guide/Supervisor and the Review Committee Members. The Thesis (Project Work – II Report) must contain the Introduction with clear definition along with detailed review of relevant literature on the selected specific problem; an efficient methodology to solve the selected specific problem along with necessary theoretical hypothesis and or experimentation and or simulation and or case study for carrying out the research project work along with complete results with critical analysis and detail discussions, followed by relevant conclusions, along with specified references. • The End Semester Examination must be conducted through Project Work Presentation followed by questions from the panel of Examiners comprising an External Examiner and Project Coordinator as Internal Examiner 					
Weightage: Assessment: 100%					

PROGRAMME ELECTIVE COURSES

EY25001	Bio Energy Technologies	L	T	P	C
		3	0	0	3
Course Objectives:					
To provide comprehensive knowledge on various biomass conversion technologies, including combustion, thermochemical, biochemical, and mechanical processes and introduce advanced tools, sustainability practices, and Optimization for efficient and eco-friendly energy production from biomass.					
Biomass Resources, Characterization, and Assessment					
Types of biomass, Advantages, drawbacks, and carbon neutrality of biomass, Indian biomass availability and potential, Biomass vs. coal: proximate and ultimate analysis, Thermo-Gravimetric Analysis (TGA), Differential Thermal Analysis (DTA), Differential Scanning Calorimetry (DSC)					
Applications: Fuel quality control in biomass power plants and pellet factories, Supply chain optimization for agro-waste collection and storage, Carbon credit generation based on carbon neutrality studies, Feedstock suitability assessment for biorefineries and cogeneration units					
Biomass Combustion and Co-Generation Technologies					
Types of combustion, Stoichiometric air calculation and ER, combustion efficiency, Fixed bed and FBC technologies for biomass, Steam generation and cost comparison with coal, Combined Heat and Power (CHP) systems with real-time optimization, Biomass cofiring systems, Emission monitoring and compliance using AI-driven combustion control					
Applications: Biomass power plants using fixed and fluidized bed combustion, Cogeneration (CHP) in sugar mills, paper, textile, and food industries, Co-firing in thermal power stations to reduce coal usage and emissions, Steam generation for process heating in small and medium industries, Emission monitoring and compliance using AI-driven combustion control					
Thermochemical Conversion Technologies					
Gasification: chemistry, types (fixed, fluidized, entrained), syngas applications, Pyrolysis: slow, fast, flash – bio-oil and char yield, governing parameters, Carbonization: charcoal production methods, Comparison of thermochemical routes and economic viability, Plasma gasification, torrefaction, and integrated gasifier–fuel cell systems					
Applications: Biomass gasifiers for rural electrification and industrial gas engines, Pyrolysis systems for bio-oil production and carbon black in chemical industries, Charcoal and activated carbon production for metallurgy and water treatment, Fuel cells powered by syngas in pilot-scale applications, Waste-to-energy plants using torrefaction or advanced gasification					
Biochemical and Mechanical Conversion Pathways					
Biochemical: Biomethanation: Anaerobic digestion kinetics and microbial action, Alcoholic fermentation: methanol & ethanol from biomass, Biogas plant layout,					

efficiency, and applications, Mechanical: Transesterification: chemistry and production of biodiesel from vegetable oils & algae, Briquetting and palletisation: types, process parameters, and economics

Applications: Biogas plants for waste-to-energy in municipalities, dairies, and food industries, Alcohol fuel production (bioethanol/methanol) for blending in transport fuels, Biodiesel production from vegetable oils and algae for commercial transport fleets, Biomass briquettes and pellets for boiler fuel in various industries, IoT-enabled smart biogas units for continuous monitoring in smart farming setups

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Poster presentation (10%), Quiz (10%), Assignment (20%), Field visit/Case study report (20%), Internal Examinations (40%)

References:

1. Sjaak van Loo, Jaap Koppejan, "The Handbook of Biomass Combustion and co-firing", Routledge, First Edition, 2008.
2. David C. Dayton, Thomas D. Foust, "Analytical Methods for Biomass Characterization and Conversion", Elsevier, 2019 (ebook).
3. D.D. Hall and R.P. Grover, "Biomass Regenerable Energy", John Wiley, First Edition, 1987.
4. Chakraverthy A, "Biotechnology and Alternative Technologies for Utilization of Biomass or Agricultural Wastes", Oxford & IBG publishing Co. Ltd., First Edition, 1989.
5. Samir K. Khanal, "Bioenergy and Biofuel from Biowastes and Biomass", ASCE, 2010.

E-Resources:

- <https://nptel.ac.in/courses/121106014>
- <https://www.fao.org/energy/bioenergy/en/>
- <https://www.irena.org/bioenergy>
- <http://www.biomassenergycentre.org.uk>

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain various biomass resources and evaluate their properties using advanced characterization techniques	PO1 (2), PO3 (2)	2	2
CO2	Apply combustion and cogeneration systems using biomass, including efficiency and environmental performance	PO1 (3), PO2 (3), PO3 (3)	3	3
CO3	Estimate thermochemical conversion process parameters such as gasification, pyrolysis, and carbonization for energy production	PO1 (3), PO3 (2)	3	2
CO4	Analyze biochemical and mechanical conversion technologies such as biomethanation, fermentation, and biodiesel production	PO1 (3), PO3 (3)	3	3

EY25002	Wind Energy Systems	L	T	P	C
		3	0	0	3

Course Objectives:

To provide comprehensive understanding of wind energy systems, including resource assessment, turbine design, and power generation with exposure to modern control, AI, and IoT-based monitoring technologies for efficient and sustainable wind power integration.

Wind Resource Assessment & Energy Fundamentals

Basics of wind energy, Power content in wind; Betz’s limit, Wind classes, types of turbines (overview), Instrumentation, Wind data logging, resource estimation and turbulence analysis, AI/ML-based wind forecasting models, LIDAR-based remote sensing of wind profiles, GIS tools for wind potential mapping

Applications: Wind farm feasibility studies and site selection, Wind speed and turbulence profiling for turbine placement, Power potential estimation for small and large-scale installations

Wind Turbine Aerodynamics & Structural Classification

Airfoil aerodynamics, rotor performance, and blade dynamics, Types of wind turbines, stall and pitch control, Blade balancing techniques and load types, Materials for blades and turbine structures, Types of generators, FD simulations for rotor design, Bio-inspired blade designs, Digital twin for blade performance monitoring

Applications: Design and testing of blades and turbine structures, Optimization of airfoil shapes for high-efficiency turbines, Structural health monitoring of rotor and blade systems.

Gear Coupled and Direct Drive Wind Power Systems

Gear-coupled system components, Safety systems: yaw & pitch control, UPS, lightning arrestors, Direct drive systems: power management, and grid integration, Monitoring units and protection systems, I-driven predictive maintenance for gearboxes and generators, Use of supercapacitors for pitch systems, Cybersecurity for grid-tied wind systems

Applications: Wind turbine drivetrain and control systems, Integration with grid and energy storage systems, Real-time condition monitoring and diagnostics

Smart Monitoring, Grid Compliance & Control Systems

SCADA systems for real-time monitoring, Pitch control systems and protection logic, Operation & maintenance strategies for lifecycle optimization, remote diagnostics, and failure analysis, Grid code compliance, FACTS, LVRT integration, Blade reengineering and retrofitting for life extension, IoT-based turbine health monitoring.

Applications: SCADA systems for wind turbine monitoring, Remote diagnostics and performance tracking, Grid code compliance and power quality control.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Poster presentation (10%), Quiz (10%), Assignment (20%), Field visit/Case study report (20%), Internal Examinations (40%)

References:

1. J. F. Maxwell, J. G. McGowan, and A. L. Rogers, "Wind Energy Explained – Theory, Design, and Applications", John Wiley & Sons, 2010
2. M. Hansen, Aerodynamics of Wind Turbines, Routledge, 2015
3. T. Burton, D. Sharpe, N. Jenkins and E. Bossanyi, "Wind energy Handbook", John Wiley & Sons, 2001
4. S. Heier, "Grid Integration of Wind Energy Conversion Systems", Wiley, 2014.
5. F. M. Vanek and L. D. Albright, "Energy Systems Engineering – Evaluation & Implementation", McGraw Hill Professional, 2016.
6. John D Sorensen & Jens N Sorensen," Wind Energy Systems", Woodhead Publishing Ltd, 2011,
7. NIWE: Wind Energy Resources Survey in India.
8. David A. Spera, "Wind Turbine Technology: Fundamental Concepts in Wind Turbine Engineering", ASMS Press, Second Edition, 2009

E-Resources:

<https://nptel.ac.in/courses/121105004>

<https://niwe.res.in>

<https://www.irena.org/wind>

<https://windeurope.org>

<https://globalwindatlas.info>

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain the fundamental principles of wind energy, atmospheric science, and resource assessment techniques	PO1 (2), PO3 (2)	2	2
CO2	Apply aerodynamic analysis and mechanical design concepts to various types of wind turbines	PO1 (3), PO2 (3), PO3 (3)	3	3
CO3	Estimate the performance of electrical and electronic systems used in gear-coupled and direct-drive wind power generation	PO1 (3), PO3 (2)	3	2
CO4	Analyze monitoring, control systems, and safety protocols for wind turbine operation and grid integration	PO1 (3), PO3 (3)	3	3

EY25003	Solar Energy Systems	L	T	P	C
		3	0	0	3
Course Objectives:					
To provide knowledge of solar radiation, thermal and photovoltaic systems, energy storage, and solar applications with integration of advanced technologies like AI, IoT, and smart control for designing efficient solar energy solutions.					
Fundamentals of Solar Radiation and Measurement					
Solar spectrum and extraterrestrial characteristics, Solar constant, solar angles, sun path diagrams, Air mass, Rayleigh and Mie scattering, Solar radiation measurement, Concepts of irradiation, insolation, peak sunshine hours, Satellite and drone-based solar mapping, Smart solar tracking prediction algorithms.					
Applications: Solar Power Project Planning: Used by renewable energy companies and utility firms for assessing solar potential using satellite/drone-based solar mapping, Smart Solar Farms: AI-based solar tracking algorithms and sun path prediction are used for efficiency optimization in large-scale solar PV or CSP plants.					
Solar Thermal Technologies and Thermal Energy Storage					
Thermodynamic and optical analysis of collectors, Types of collectors: flat plate, evacuated tube, parabolic trough, LFR, Scheffler, heliostats, Solar concentrators and tracking systems, Thermal energy storage: sensible heat, latent heat, phase change materials, AI-based sun-tracking and heat flux optimization, Integration of CSP with thermal energy storage for dispatchable power					
Applications: Concentrated Solar Power (CSP) Plants: Parabolic troughs, LFR, heliostats used in large-scale thermal power generation (e.g., in Rajasthan, Spain, California), Industrial Process Heat: Flat plate and evacuated tube collectors provide hot water and steam for textile, food processing, chemical, and dairy industries, Thermal Energy Storage (TES): Phase change materials and AI-based heat tracking are used in dispatchable power plants to supply energy after sunset.					
Solar Photovoltaic Systems and Energy Storage					
PV conversion fundamentals and IV characteristics, Types of solar cells (mono/poly-crystalline, thin film, PERC, bifacial, perovskite), PV module and array design, Standalone, grid-connected, and hybrid PV systems, MPPT algorithms and power electronics, Digital twin models for PV performance prediction, BESS (Battery Energy Storage Systems) and PV-hydrogen hybrid plants					
Applications: Solar Farms and Rooftop Systems: Widely used in grid-connected utility-scale PV systems and residential/commercial rooftop systems, BESS & Microgrids: Battery Energy Storage Systems are used in rural microgrids, EV charging stations, and peak load shaving in urban centers, Hydrogen-PV Hybrid Plants: Emerging in green hydrogen production hubs for decarbonization in steel and chemical industries.					
Solar Applications and Passive Architecture					
Applications: solar cookers, dryers, desalination, water pumps, vehicles, furnaces, cooling, Solar thermal power plants, BIPV, adaptive solar buildings, Solar passive architecture, Thermal comfort, evaporative and radiative cooling, earth air tunnels,					

Smart solar buildings with IoT and automation, AI-driven thermal comfort management, BIPV integration with smart grids

Applications: Green Building Industry: BIPV (Building Integrated Photovoltaics), earth air tunnels, and adaptive facades are used in LEED-rated buildings and smart cities, Desalination & Drying: Used in fisheries, salt industries, and herbal product drying for reducing fossil fuel use, Solar Thermal Furnaces & Vehicles: Experimental and niche applications in material testing, solar mobility, and off-grid refrigeration, AI & IoT-based Smart Architecture: Used in smart building control systems for thermal comfort, automated shading, and HVAC control.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Poster presentation (10%), Quiz (10%), Assignment (20%), Field visit/Case study report (20%), Internal Examinations (40%)

References:

1. S. P. Sukhatme, J K. Nayak, "Solar Energy", McGraw Hill, New Delhi, Fourth Edition, 2017.
2. John A. Duffie, William A. Beckman, "Solar Engineering of Thermal Processes", John Wiley & Sons, 2013
3. Chetan Singh Solanki, "Solar Photovoltaics – Fundamentals, Technologies and Applications", PHI Learning Private limited, 2011
4. HP Garg and J Prakash, "Solar Energy: Fundamentals and Applications", Tata McGraw Hill, 2010.
5. Robert Huggins, "Energy Storage: Fundamentals, Materials and Applications", 2nd edition, Springer, 2015
6. David A. Bainbridge, Ken Haggard, Kenneth L. Haggard, "Passive Solar Architecture: Heating, Cooling, Ventilation, Daylighting, and More Using Natural Flows", Chelsea Green Publishing, 2011.

E-Resources:

<https://nptel.ac.in/courses/117105122>

<https://mnre.gov.in>

<https://www.pveducation.org>

<https://www.irena.org/solar>

<https://niwe.res.in>

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Analyze solar radiation characteristics, measurement techniques, and their applications in energy system design	PO1 (3), PO3 (2)	3	2
CO2	Evaluate the design, performance, and efficiency of various solar thermal collectors and energy storage systems	PO1 (3), PO3 (2)	3	2
CO3	Design and assess standalone, grid-connected, and	PO1 (3),	3	3

	hybrid solar photovoltaic systems with suitable storage and power electronics	PO2 (3), PO3 (3)		
CO4	Apply solar energy for industrial, residential, and commercial applications using advanced technologies like BIPV, solar cooling, and transport	PO1 (3), PO2 (3), PO3 (3)	3	3

EY25C05	Polygeneration Systems	L	T	P	C
		3	0	0	3
Course Objectives:					
To provide knowledge of design, integration, and operation of polygeneration systems for producing multiple energy outputs efficiently with application of advanced technologies like AI, digital twins, and smart control for sustainable energy management.					
Fundamentals of Polygeneration and Energy System Integration					
Overview of polygeneration systems and their multi-output capabilities (power, heat, cooling, fuels), Classification based on fuel type (fossil, renewable, hybrid) and application (CHP, CCHP, etc.), Concepts of energy system integration and coupling of thermal, electrical, and chemical streams.					
Applications: Integrated Energy Parks combining solar, wind, and biomass for rural electrification, Industrial energy hubs that supply power, steam, and heating to industrial clusters. Urban energy systems providing electricity, hot water, and space cooling, Community-based polygeneration for remote/off-grid villages using hybrid energy sources					
Components and Conversion Processes in Polygeneration					
Processes: Internal combustion engines, steam cycles, gas turbines, Organic Rankine Cycles (ORC), combined cycles, fuel cells, Refrigeration: Electric and thermally-driven systems, Solar, wind, and biomass-based conversion systems, Energy storage: Batteries, hydrogen storage, thermal storage					
Applications: CHP systems in textile, paper, and chemical industries, Use of Organic Rankine Cycle (ORC) in waste heat recovery of cement and steel plants, Microgrid systems using gas turbines and fuel cells in commercial buildings, Solar-biomass hybrid plants in agro-processing and dairy farms					
Performance and Thermo-economic Evaluation of Polygeneration					
Evaluation of natural gas, solar, and biomass-based systems, First law and exergy-based performance metrics, Environmental and emission benefits of integrated systems, Optimal design strategies for maximum resource utilization, Thermo-economic analysis and multi-objective optimization					
Applications: Exergy and cost optimization in refineries and petrochemical plants, Energy-efficiency audits and thermo-economic modeling in integrated power plants, Life cycle cost analysis of solar + diesel + battery hybrid systems, AI-driven operational optimization in smart cities and net-zero campuses					
Applications in Buildings and Industries					
Building energy systems :heating, cooling, and electrical loads, Solar and IC engine-based polygeneration for net-zero buildings, Case studies on building-scale polygeneration (BIPV + heat pumps + hydrogen), Industrial applications: low-grade heat recovery, coal-renewable hybrids, Polygeneration in process industries and					

agro-processing units, Demand-side forecasting and load prediction using neural networks, Integration with smart grids and demand response systems

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Poster presentation (10%), Quiz (10%), Assignment (20%), Field visit/Case study report (20%), Internal Examinations (40%)

References:

1. Ibrahim Dincer and Yusulf bicer, "Integrated Energy Systems for multigeneration", Elsevier Ltd, 2020
2. Franceso Calise, Maasimo Daccadia, Laura Vanoli and Maria Vicidomini, "Polygeneration systems – Deign, Process and echnlogies", Academic Press, 2022.
3. Majid Amidpour, Mohammad Hasan Khoshgoftar Manesh, "Cogeneration and Polygeneration Systems", Elesevier Science, 2020
4. Yang Chen, "Optimal Design and Operation of Energy Polygeneration Systems", MIT Press, 2013
5. Cristina Gil de Moya, Carl-Johan Fogelholm, "Technoeconomic Assessment of Polygeneration Systems", Universitat Politècnica de Catalunya. Escola Tècnica Superior d' Enginyeria Industrial de Barcelona, 2008

E-Resources:

- <https://nptel.ac.in/courses/112101015>
- <https://nptel.ac.in/courses/112105231>
- <https://ocw.mit.edu/courses/energy-systems/>
- <https://www.iea.org/topics/renewables/cogeneration>
- <https://www.irena.org>

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain fundamentals of polygeneration systems, classifications, energy integration concepts, and multi-output capabilities	PO1 (3), PO3 (2)	3	2
CO2	Apply knowledge of components and conversion processes, including engines, turbines, fuel cells, ORC, storage, and renewable integration in polygeneration systems	PO1 (3), PO2 (3)	3	3
CO3	Estimate performance metrics, exergy efficiency, environmental impact, and cost-effectiveness of polygeneration systems using thermoeconomic analysis	PO1 (3), PO3 (3)	3	3
CO4	Analyze polygeneration applications in buildings and industries, including smart-grid integration, AI-driven optimization, and net-zero energy solutions	PO3 (3)	3	3

EY25C04	Waste to Energy	L	T	P	C
		3	0	0	3
<p>Course Objectives:</p> <p>To provide knowledge of technologies that convert waste into usable energy forms like heat, electricity, biofuels and provides application of advanced tools for optimizing and evaluating waste-to-energy systems.</p>					
<p>Energy from Waste & Waste Characterization</p> <p>Introduction to energy from waste: Definition, scope, and need, Classification and characterization of waste, Waste as fuel, Overview of conversion technologies, Circular economy and zero-waste concepts in energy systems, Introduction to Life Cycle Assessment (LCA) of waste-to-energy systems</p> <p>Applications: Applied in urban waste management systems (e.g., Chennai, Pune, Indore) to classify organic, plastic, and inert waste for energy use, Used in converting agro-industrial residues like bagasse and rice husk into bioenergy in sugar mills and food processing units.</p> <p>Combustion & Thermal Conversion Technologies</p> <p>Combustion processes: Theory and principles, Densification of biomass and waste solids, Biomass stoves and Fixed bed combustors, Inclined grate combustors and fluidized bed combustors ,Energy and efficiency analysis of combustion systems, Waste-to-energy from plastics and refuse-derived fuel (RDF), Emission control and pollutant capture in combustion-based WTE</p> <p>Applications: Applied in pyrolysis and RDF-based cement kilns to reduce landfill burden and recover heat, Community heating using biomass stoves and fixed-bed combustors in rural Himalayan areas.</p> <p>Gasification and Pyrolysis Technologies</p> <p>Gasification systems: Fixed bed, fluidized bed, Syngas generation and thermal applications, Engine-generator integration and electrical power generation from syngas, Pyrolysis: Types, process parameters, charcoal production, Pyrolytic oils and gases: Yield optimization, applications, Co-gasification of biomass and plastic waste</p> <p>Applications: Decentralized Biomass Gasifiers are used in off-grid rural electrification projects (e.g., Husk Power Systems in Bihar) to supply power from rice husk, Syngas Production is applied in small-scale industries for thermal applications or as a fuel in IC engines, Biochar and Pyrolysis Oil Production is used in agriculture for soil amendment and in research on alternative fuels.</p> <p>Biological & Emerging Waste-to-Energy Technologies</p> <p>Anaerobic digestion: Process fundamentals, biogas production, Fermentation processes: Ethanol, butanol, hydrogen production, Transesterification of waste oils to biodiesel, Microbial Fuel Cells (MFCs): Principles and design, Algal biomass</p>					

cultivation from wastewater, energy extraction from algae, Integration of biorefineries and carbon capture.

Applications: Cow dung, kitchen, and food waste are used in community biogas plants (e.g., Pune, Bengaluru) for cooking gas and electricity, Microbial Fuel Cells (MFCs) in emerging application in wastewater treatment plants to simultaneously treat water and generate electricity. Algae-Based Wastewater Treatment and Biofuel Production is applied in experimental setups in urban STPs to convert nutrient-rich waste into algal biomass for bioenergy.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Poster presentation (10%), Quiz (10%), Assignment (20%), Field visit/Case study report (20%), Internal Examinations (40%)

References:

1. Sjaak van Loo, Jaap Koppejan, "The Handbook of Biomass Combustion and co-firing", Routledge, First Edition, 2008.
2. David C. Dayton, Thomas D. Foust, "Analytical Methods for Biomass characterization and Conversion", Elsevier, 2019 (ebook).
3. D.D. Hall and R.P. Grover, "Biomass Regenerable Energy", John Wiley, First Edition, 1987.
4. Chakraverthy A, "Biotechnology and Alternative Technologies for Utilization of Biomass or Agricultural Wastes", Oxford & IBG publishing Co. Ltd., First Edition, 1989.
5. Samir K. Khanal, "Bioenergy and Biofuel from Biowastes and Biomass", ASCE, 2010

E-Resources:

<https://nptel.ac.in/courses/103106214>

<https://www.coursera.org/learn/renewable-energy-entrepreneurship>

<https://www.edx.org/course/energy-principles>

<https://cpcb.nic.in/municipal-solid-waste/>

<https://mnre.gov.in/biomass-powercogen>

<https://www.eia.gov/energyexplained/biomass/>

<https://www.irena.org/>

<https://www.journals.elsevier.com/waste-management>

<https://www.tatapower.com/businesses/waste-to-energy.aspx>

<https://www.unep.org/resources/report/state-waste-energy-sector>

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain waste-to-energy concepts, waste characterization, and LCA	PO1 (3), PO3 (2)	3	2
CO2	Apply thermal, biological, and emerging WTE technologies for energy generation	PO1 (3), PO2 (3)	3	3
CO3	Estimate energy output, efficiency, and emissions from different WTE systems	PO1 (3), PO3 (3)	3	3
CO4	Analyze performance, optimization, and integration of WTE processes and biorefineries	PO3 (3)	3	3

EY25C07	Sustainability in Buildings	L	T	P	C
		3	0	0	3
<p>Course Objectives:</p> <p>To provide a comprehensive understanding of sustainable building design principles and climate-responsive architecture and exposure to passive design strategies, energy-efficient materials, and integration of renewable energy systems in buildings. To apply simulation tools for optimizing building performance and achieving environmental certification standards.</p>					
<p>Foundations of Sustainable Building Design</p> <p>Relationship between climate and building design: thermal zones, climatic data analysis, Historical evolution of green building concepts, Key aspects of sustainable buildings, Indoor environmental quality (IEQ), Building performance standards: ECBC, GRIHA, LEED, WELL and IGBC, Sustainable building life cycle and carbon footprint basics., Integration of sustainability goals in building codes and smart cities</p> <p>Applications: LEED, GRIHA, WELL standards in real estate and institutional buildings, Selection of sustainable sites based on orientation, terrain, and microclimate, Use of low-embodied energy and recycled materials in construction, Integration of sustainable design principles in urban master plans</p> <p>Sustainable Landscaping and Building Envelopes</p> <p>Energy-efficient landscaping: microclimate modification, xeriscaping, shading devices, arbors, green roofs, Role of vegetation in passive design, Building envelope design: thermal comfort, psychrometry, comfort indices, Thermal properties of materials, insulation strategies, reflective materials, Use of Energy Plus or Design Builder in façade retrofits and new construction</p> <p>Applications: Use of xeriscaping, green roofs, and shade trees in housing societies, IT parks, Passive insulation and thermal lag management in schools, hospitals, and government offices, Applied in urban heat island mitigation projects</p> <p>Passive Strategies and Climate-Responsive Architecture</p> <p>Introduction to HVAC and limitations in sustainable design, Passive heating techniques: sun path diagrams, direct gain, indirect gain, isolated systems, Passive cooling techniques: natural ventilation, evaporative cooling, radiative cooling, earth-air tunnels, Daylighting design: principles, visual comfort, shading strategies, Bioclimatic building design and thermal zoning, AI and parametric tools for daylight and thermal optimization</p> <p>Applications: Maximizing daylight while minimizing glare and heat gain, Stack effect and cross ventilation used in hostels, community centers, and dormitories, Earth-Air Tunnels and Radiative Cooling Implemented in resorts, eco-homes, and public pavilions in hot regions, Bioclimatic Architecture in Remote or Rural Housing</p> <p>Building Performance, Renewable Integration & Simulation</p> <p>Heat gain/loss through fenestration, infiltration, Overall Thermal Transmittance (U-</p>					

value) calculations, Building thermal load estimation, Thermal storage systems in buildings, Integration of renewable energy, Simulation tools for sustainable building design: eQuest, Energy Plus, IES-VE, Techno-economic analysis of renewable integration and Net Zero Energy Buildings (NZEBs)

Applications: Rooftop Solar PV and BIPV Systems Used in smart homes, airports, railway stations, and SEZs, Thermal Load Calculations for HVAC Optimization are critical in malls, data centers, and hospitals, Tools like IES-VE, eQuest used for green building compliance.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Poster presentation (10%), Quiz (10%), Assignment (20%), Field visit/Case study report (20%), Internal Examinations (40%)

References:

1. Baruch Givoni: "Climate considerations in building and Urban Design", John Wiley & Sons, 1996.
2. Jakhar O P, "Energy Conservation in Buildings", Khanna Publishers, 1st Edition, 2020.
3. Jan F. Kreider, Peter S. Curtiss, Ari Rabl, "Heating and Cooling of buildings: Design for Efficiency", CRC Press, Second Edition, 2010.
4. Ana-Maria Dahija, "Energy Efficient Buildings Design", Springer, 2020
5. J.L. Threlkeld, "Thermal Environmental Engineering", Prentice Hall, 1970

E-Resources:

- <https://nptel.ac.in/courses/105107213>
- <https://onlinecourses.nptel.ac.in/noc22-ar06/preview>
- <https://www.usgbc.org/leed>
- <https://www.grihaindia.org/>
- <https://energyplus.net/>

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain climate-responsive building design, sustainable materials, green certification systems (LEED, GRIHA, ECBC, WELL, IGBC), and life-cycle sustainability concepts.	PO1 (3)	3	2
CO2	Apply sustainable landscaping, passive design strategies, thermal comfort analysis, and building envelope optimization using simulation tools.	PO1 (3), PO3 (3)	3	3
CO3	Estimate building thermal loads, U-values, energy consumption, daylight performance, and renewable energy generation potential.	PO2 (3), PO4 (3)	3	3
CO4	Analyze building performance, HVAC efficiency, renewable integration, and techno-economic feasibility toward Net Zero Energy Buildings (NZEBs).	PO3 (3), PO4 (3)	3	3

EY25C03	Modern Power Plants	L	T	P	C
		3	0	0	3
<p>Course Objectives: To understand and analyze conventional and advanced power generation systems including coal-based, diesel, gas turbine, cogeneration, combined, hydro, and nuclear plants with focusing on efficiency, components, safety, load parameters, cost, and environmental impact.</p>					
<p>Coal-Based: Supercritical, Pulverized fuel, AFBC/PFBC boilers, Superheat, Reheat, Regenerative Rankine Cycles, Turbines, Condensers and Cooling Towers.</p> <p>Activities: Rankine Cycle simulation using software, Case study on supercritical and PF boilers in Indian power stations</p> <p>Diesel and Gas Turbine: Diesel Engine, cycle, plant layout, performance, cooling and lubrication systems, Gas turbines, Brayton cycle, advantages, limitations with intercooling, reheating, regeneration – analysis and improvement.</p> <p>Activities: Layout drawing of a diesel power plant with cooling/lubrication systems, Performance evaluation of turbocharged vs non-turbocharged engines, Lab demo or video on gas turbine start-up and operation</p> <p>Cogeneration and MHD Systems: Cogeneration types, heat-to-power ratio, performance, Combined Heat and Power, Binary and Polygeneration cycles, MHD: Open/Closed cycles, Hybrid MHD-steam systems.</p> <p>Activities: Comparison chart of different cogeneration systems (steam, gas, IC engine-based), Simulation or animation-based learning of MHD generation principles, Mini-project: Analyze a real-world CHP system (e.g., sugar or cement plant)</p> <p>Hydroelectric and Nuclear Power Plants: Hydro: types, components, pumped storage, micro/mini plants, Nuclear fuels, fertile fuels, moderators, coolants, reactor types, safety measures and environmental concerns.</p> <p>Activities: Create a scaled diagram of a hydroelectric system including pumped storage, Poster presentation on nuclear reactor types with pros and cons, Safety and environmental review of historical nuclear incidents</p> <p>Economics and Environmental Issues: Load parameters and load curve analysis, site selection, capital and operating cost, power tariffs, pollution control, and waste disposal from power plant.</p> <p>Activities: Plot load curves using real or simulated daily power demand data, Cost comparison assignment for different power plant types (CAPEX/OPEX)</p>					
<p>Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%</p>					
<p>Assessment Methodology and weightage: Assessment Exams (50%), Assignment/Case Study (10%), Quiz/Problem (10%), Virtual demonstration/Software Analysis (10%), Flipped Classroom (10%), Review of GATE & IES questions (10%)</p>					

References:

1. Nag, P.K., "Power Plant Engineering", Tata McGraw Hill Publishing Co Ltd, New Delhi, 2002.
2. Haywood, R.W., "Analysis of Engineering Cycles", Pergamon Press Oxford, 4th Edition, 2012
3. Wood, A.J., Wollenberg, B.F., "Power Generation, operation and control", John Wiley, New York, 1991
4. Gill, A.B., "Power Plant Performance", Butterworths, 1984.
5. Lamarsh, J.R., "Introduction to Nuclear Engineering", Addison-Wesley, 2nd edition, 1983.
6. Arora and S. Domkundwar, "A Course in Power Plant Engineering", Dhanpat Rai Publications, 6th edition, 2016

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain principles, components, and cycles of conventional and advanced power plants	PO1 (3), PO3 (2)	3	2
CO2	Apply simulation and analysis techniques to evaluate power plant performance	PO1 (3), PO2 (3)	3	3
CO3	Estimate efficiency, cost, and environmental impact of different power generation systems	PO1 (3), PO3 (3)	3	3
CO4	Analyze operational performance, optimization, and integration of power plant systems	PO3 (3)	3	3

EY25006	Energy Modelling and Project Management	L	T	P	C
		3	0	0	3

Course Objectives:

To equip students with modern tools and techniques for energy forecasting, system modelling, and project management, integrating AI and data-driven methods. The course emphasizes sustainable planning, policy awareness, and decision-making for energy projects, with a focus on renewable integration, smart grids, optimization, and techno-economic risk evaluation.

Energy Systems & Socioeconomic Linkages

Role of energy in economic and social development: GDP, GNP, HDI, Energy demand and supply trends – sectoral consumption (residential, commercial, industrial), State and national level energy statistics and challenges, Global and Indian status of renewable energy – trends and projections, Decarbonization pathways and energy transition strategies, Introduction to AI in energy data analytics

Applications: Governments use energy statistics and demand trends for national energy planning and budget allocation, Identifying high-consumption sectors for implementing ENCON (Energy Conservation) programs, nergy flow modeling for sustainable urban infrastructure, integrating renewable energy sources, Using AI models to assist national utilities (e.g., POSOCO, CEA) in forecasting peak demand and improving grid reliability.

Energy Forecasting Techniques

Forecasting types: Qualitative vs Quantitative, Regression, Moving Averages, Exponential Smoothing, ARIMA, Time Series Decomposition, Machine Learning models: Linear Regression, Decision Trees, Support Vector Regression, Deep Learning for solar and wind forecasting: LSTM, GRU models, Application in smart grids, demand-side management, energy trading, AI/ML-based forecasting tools (TensorFlow, Python scikit-learn), Hybrid ML-ARIMA approaches for accuracy improvement

Applications: Utilities use ML and ARIMA models to predict renewable generation for day-ahead scheduling and balancing reserves, AI-based tools used by DISCOMs (Distribution Companies) to forecast hourly loads and optimize distribution, Forecasting helps market participants (like IEX) optimize bidding in day-ahead, real-time, and renewable energy markets, Predictive models enable time-of-use pricing and demand-side management strategies.

Optimization and System Modelling

Basics of optimization in energy systems, Multi-objective optimization using metaheuristics: GA, PSO, ACO, Formulating energy problems with constraints and objective functions, Satellite-based irradiance and renewable forecasting, Fuzzy logic and neural networks in energy modelling, Integration of AI in energy dispatch

and storage optimization, AI-assisted microgrid optimization, Digital twins for energy systems modelling

Applications: AI algorithms optimize battery charge-discharge cycles for microgrids and solar + storage systems, Multi-objective optimization used in dispatch scheduling to balance cost, emissions, and reliability, Genetic Algorithm (GA) and PSO applied to design off-grid solar-wind-diesel-battery systems in rural areas, Applied in intelligent controllers for air-conditioning, lighting, and smart appliances in buildings.

Sustainable Project Management for Energy Systems

Project lifecycle: concept to commissioning, Feasibility studies and detailed project reports (DPR), Social cost–benefit analysis (SCBA), Techno-economic risk analysis in renewable energy projects, Solar, wind, and hybrid project planning, Financial models: CAPEX, OPEX, IRR, NPV, AI in project feasibility and risk estimation, Smart project dashboards and digital monitoring platforms

Applications: Techno-economic feasibility, resource risk analysis, and social impact assessments using AI-driven platforms, Tools like PVsyst, RET Screen, and SAM use AI inputs for project design and sensitivity analysis, Lenders and investors use ML models to evaluate payback periods and IRR under uncertain tariff policies, Real-time monitoring of project milestones, budget tracking, and automated reporting.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Poster presentation (10%), Quiz (10%), Assignment (20%), Field visit/Case study report (20%), Internal Examinations (40%)

References:

1. George Kariniotakis, “Renewable energy forecasting – From models to applications”, A volume in woodhead publishing series in energy, 2017.
2. William Holderbaum, “Energy Forecasting and Control Methods for Energy Storage Systems in Distribution Networks: Predictive Modelling and Control Techniques”, Springer, 1st Edition, 2023.
3. Jan Kleissl, “Solar Energy Forecasting and Resource Assessment”, Elsevier, 1st Edition, 2013
4. Dhandapani Alagiri, “Energy Security in India Current Scenario”, The ICFAI University Press, 2006.
5. Spyros G. Makridakis, Steven C. Wheelwright, Rob J. Hyndman, “Forecasting: Methods and Applications, John Wiley & Sons, 4th Edition, 2003.
6. Yang X.S., “Introduction to mathematical optimization: From linear programming to Metaheuristics”, Cambridge, Int. Science Publishing, 2008.
7. Armstrong J.Scott (ed.), “Principles of forecasting: a hand book for researchers and practitioners”, Norwell, Massachusetts: Kluwer Academic Publishers, 1st Edition, 2001.

E-Resources:

<https://nptel.ac.in/courses/121106014>

<https://nptel.ac.in/courses/121106108>

<https://nptel.ac.in/courses/110107081>

<https://www.udemy.com/course/ai-for-renewable-energy/>

<https://www.edx.org/course/energy-principles>

<https://www.coursera.org/learn/renewable-energy-entrepreneurship>

<https://www.coursera.org/learn/ai-for-everyone>

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain energy consumption patterns and trends at state and national levels to support strategic energy planning	PO1 (2), PO3 (2)	2	2
CO2	Apply statistical and AI-based forecasting techniques to predict renewable and conventional energy demands	PO1 (3), PO2 (3), PO3 (3)	3	3
CO3	Estimate and optimize energy systems using advanced computational models and decision-making tools	PO1 (3), PO3 (2)	3	2
CO4	Analyze feasibility reports, risk assessments, and financial models for sustainable energy projects	PO1 (3), PO3 (3)	3	3

EY25007	Energy Policy, Economics, and Regulatory Frameworks	L	T	P	C
		3	0	0	3

Course Objectives:

To provide in-depth understanding of energy policies, economic analysis, and regulatory mechanisms in the context of India’s evolving energy sector, enabling students to critically assess and contribute to sustainable energy transitions.

Energy Policy Landscape – Global and Indian Context

Energy policy: Need, scope, and evolution, Indian energy policy timeline: Five-year plans, National Energy Policy (NEP), Integrated Energy Policy (IEP), Institutions: MNRE, CEA, MoP, NITI Aayog, BEE, SECI, Energy security, energy access, and sustainability, International energy policies (EU, USA, China) – comparative review

Energy Economics and Pricing Mechanisms

Micro and macroeconomics in energy, Demand-supply forecasting and elasticity, Cost-benefit analysis, LCOE (Levelized Cost of Electricity), IRR, NPV, Tariff setting: Electricity Act 2003, cross-subsidies, open access, Fossil fuel and renewable energy subsidies – economic impact

Regulatory Frameworks and Institutional Mechanisms in India

Role of CERC, SERCs, APTEL – powers and limitations, Electricity Act, 2003 – reforms, unbundling, RPOs, Renewable Energy Certificates (REC), DSM regulations, Green Energy Open Access Rules 2022, Regulatory challenges in transmission/distribution and tariff policy, Case studies: Tamil Nadu Electricity Regulatory Commission (TNERC), UDAY scheme

Climate Policy, Energy Transition and Emerging Trends

National Action Plan on Climate Change (NAPCC) – 8 missions, State Action Plans (SAPCC), INDCs, COP commitments, ESG, carbon trading, green bonds, CDM, PAT scheme, Just energy transition, energy justice and social equity, Hydrogen economy, EV policies, Smart grid policies, Green hydrogen and BESS policies.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Poster presentation (10%), Quiz (10%), Assignment (20%), Field visit/Case study report (20%), Internal Examinations (40%)

References:

1. Bhattacharyya, Subhes C., Energy Economics: Concepts, Issues, Markets and Governance, 2011, Springer, 1st Edition.
2. Reddy, B. Sudhakara and Balachandra, P., Energy for Sustainable Development: The Case of India, 2006, Tata McGraw-Hill Education, 1st Edition
3. Mukhopadhyay, Kanchan, Energy Policy and Planning, 2015, The Energy and Resources Institute (TERI Press), 1st Edition
4. Srinivasan, T.N. (Ed.), The Future of India's Energy Security: Trends and Policy Options, 2012, Oxford University Press, 1st Edition
5. Prayas Energy Group (Editors), Regulatory and Policy Framework for Electricity in India, 2018, Prayas Publications, Pune, 1st Edition
6. Kumar, Satish and Aggarwal, Shalini, Electricity Sector in India: Policy and Regulation, 2020, Academic Foundation, New Delhi, 1st Edition

E-Resources:

<https://nptel.ac.in>

<https://www.coursera.org>

<https://www.edx.org/course/energy-within-environmental-constraints>

<https://niti.gov.in>

<https://mnre.gov.in>

<https://cercind.gov.in>

<https://beeindia.gov.in>

<https://www.iea.org>

<https://www.irena.org>

<https://prayaspune.org/peg>

<https://cstep.in>

<https://www.teriin.org>

<https://www.downtoearth.org.in>

<https://data.worldbank.org/topic/energy>

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain the historical evolution and current framework of energy policies in India and globally	PO1 (2), PO3 (2)	2	2
CO2	Apply economic tools to analyze energy supply-demand scenarios and assess project feasibility	PO1 (3), PO2 (3), PO3 (3)	3	3
CO3	Estimate and interpret regulatory structures and reforms in India's energy sector	PO1 (3), PO3 (2)	3	2
CO4	Analyze the role of international energy treaties and India's climate commitments	PO1 (3), PO3 (3)	3	3

TE25C07	Modelling and Analysis of Thermal Systems	L	T	P	C
		3	0	0	3
Course Objectives:					
To understand energy conversion principles, develop and model thermal systems using numerical and flow analysis techniques, apply optimization and AI-based methods to solve energy-related problems, and integrate economic models for effective energy system analysis.					
Energy Systems: Energy conversion methods and system development, Characteristics of workable and optimum systems, Concept selection and creativity, Energy balance for closed and control volume systems, Solving Governing equations: parabolic, elliptic, hyperbolic, Finite element and finite volume methods.					
Activities: Perform lab experiments (e.g., on a heat exchanger or boiler setup) on energy balance, develop simple system models using MATLAB/Excel, Apply least squares method for curve fitting.					
Modeling and Simulation: Modelling: steps and levels, Basics of mathematical modelling, Exponential forms and least squares method, Modeling of heat exchangers, Effectiveness-NTU method, pressure drop, pumping power, Simulation types: sequential/simultaneous, Flow diagrams, Newton-Raphson method, Optimization basics and problem formulation					
Activities: Simulate heat exchangers using Effectiveness-NTU method, calculate pressure drop and pumping power in a piping system using experimental or simulated data, solve nonlinear equations using Newton-Raphson.					
Optimization Techniques: Dynamic and geometric programming, Lagrange multipliers and constrained optimization, Linear regression, thermodynamic property relations, Advanced techniques: genetic algorithms, simulated annealing.					
Activities: Solve optimization problems using Excel/MATLAB, conduct linear regression on thermodynamic data, implement genetic algorithms in Python/MATLAB, Apply simulated annealing to design problems.					
Energy-Economy Analysis: Energy-economy modeling: multiplier analysis, Energy and environmental input/output analysis, Econometric energy demand models, Search techniques, univariate/multivariate analysis.					
Activities: Build econometric energy demand models, Solve PDEs (e.g., heat conduction) using MATLAB/Python, Run FEM/FVM simulations with COMSOL/ANSYS/Open FOAM to solve thermal or fluid problems.					
Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%					
Assessment Methodology and weightage:					
Assessment Exams (50%), Assignment/Case Study (10%), Quiz/Problem (10%), Virtual demonstration/Software Analysis (10%), Flipped Classroom (10%), Review of GATE & IES questions (10%)					

References:

1. B.K.Hodge: "Analysis and Design of Thermal Systems", Prentice Hall Inc., 1990.
2. Bejan, A, Tsatsaronis, G and Moran, M., "Thermal Design and Optimization", John Wiley & Sons, 1996
3. J. Nagrath & M.Gopal: "Systems Modelling and Analysis", Tata McGraw Hill, 2007
4. D.J. Wide: "Globally Optimal Design", Wiley- Interscience, 1978.
5. Mark E. Davis, "Numerical Methods and Modelling for Chemical Engineers", John Wiley & Sons, 1984.
6. Stoecker W.F., "Design of Thermal Systems", McGraw Hill, 2011
7. Yogesh Jaluria, "Design and Optimization of Thermal Systems", CRC Press INC, 2008

E-Resources:

<https://nptel.ac.in/courses/112/101/112101097/>

<https://nptel.ac.in/courses/112/106/112106133/>

<https://nptel.ac.in/courses/112/105/112105182/>

<https://nptel.ac.in/courses/112/101/112101097/>

<https://ocw.mit.edu/courses/mechanical-engineering/2-14-analysis-and-design-of-feedback-control-systems-spring-2014/>

CO	CO Description	PO	PSO1	PSO2
CO1	Explain the fundamentals of energy conversion, thermal system development, and governing equations	PO1 (3), PO3 (2)	3	2
CO2	Apply numerical methods, modeling, and simulation techniques (MATLAB, Excel, COMSOL/ANSYS) to thermal systems	PO2 (3), PO3 (2)	3	2
CO3	Estimate system performance, pressure drop, pumping power, and effectiveness of thermal devices	PO2 (3), PO3 (2)	3	2
CO4	Analyze and optimize thermal systems using AI techniques, optimization methods, and energy-economy models	PO3 (3), PO5 (2)	3	3

TE25C09	Carbon Sequestration and Utilisation	L	T	P	C
		3	0	0	3
Course Objectives:					
To provide students with a thorough understanding of the science, engineering, policy, and economics of carbon capture, utilization, and storage technologies in the context of climate mitigation, with emphasis on Indian and global perspectives.					
Introduction to CCUS and Climate Context					
Climate change science and GHG emissions, Role of carbon capture, utilization, and storage (CCUS) in carbon neutrality and net-zero goals, Sources of CO ₂ emissions: Power, industry, transportation, Types of CCUS: Post-combustion, pre-combustion, oxyfuel combustion, Global CCUS status and initiatives (IEA, IPCC, UNFCCC), Indian initiatives: NCAP, NDCs, National Hydrogen Mission, Long-term Low Emissions Development Strategy					
CO₂ Capture and Compression Technologies					
CO ₂ capture principles – absorption, adsorption, membranes, cryogenic, Solvent-based (amine), solid sorbents, advanced materials (MOFs, zeolites), CO ₂ compression and dehydration systems, Energy penalty, efficiency losses, and cost implications, Case studies: NTPC CCUS pilot plant, Indian coal-based capture trials					
CO₂ Transport, Utilization, and Geological Storage					
Transport modes: Pipelines, ships, road, CO ₂ utilization: Enhanced Oil Recovery (EOR), urea manufacturing, mineralization, algae cultivation, concrete curing, Geological storage: Saline aquifers, depleted oil and gas fields, Site selection, reservoir modeling, monitoring, and verification (MMV), Environmental and safety risks – leakage, induced seismicity.					
Economics, Policies, and Regulatory Frameworks					
CCUS project cost components and economic modelling, Carbon pricing, carbon credits, ETS, and carbon trading mechanisms, CCUS in India: Policy status, draft roadmaps, stakeholder roles, International frameworks: EU Green Deal, U.S. Inflation Reduction Act (IRA), Article 6 of the Paris Agreement, Social acceptance, legal liability, financing mechanisms (Green Climate Fund, MDBs).					
Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%					
Assessment Methodology: Poster presentation (10%), Quiz (10%), Assignment (20%), Field visit/Case study report (20%), Internal Examinations (40%)					
References:					
<ol style="list-style-type: none"> 1. M. M. Maroto-Valer, Carbon Capture and Storage, Elsevier, 2010, 1st Edition. 2. Ian Havercroft, Richard Macrory, Stefan Schwarze, Carbon Capture and Storage: Emerging Legal and Regulatory Issues, Hart Publishing, 2018, 2nd Edition. 3. B. Sudhakara Reddy, Energy and Climate Change: India's Clean Energy Pathways, Routledge, 2022, 1st Edition. 					

4. S. M. Aithal Carbon Capture, Utilization and Storage: Technologies and Indian, Initiatives, TERI Press, 2021, 1st Edition.
5. IPCC Special Report Carbon Dioxide Capture and Storage, Cambridge University Press, (for IPCC), 2005, 1st Edition.

E-Resources:

<https://www.iea.org/topics/carbon-capture-utilisation-and-storage>

<https://www.globalccsinstitute.com>

<https://niti.gov.in>

<https://moef.gov.in>

<https://www.teriin.org>

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain climate change, CCUS technologies, and regulatory frameworks	PO1 (3), PO3 (2)	3	2
CO2	Apply CO ₂ capture, transport, utilization, and storage methods	PO1 (3), PO2 (3)	3	3
CO3	Estimate economic, energy, and environmental parameters of CCUS projects	PO1 (3), PO3 (3)	3	3
CO4	Analyze CCUS performance, monitoring, and optimization strategies	PO3 (3)	3	3

EY25C06	Hydrogen Energy and Fuel Cell Technology	L	T	P	C
		3	0	0	3
<p>Course Objectives: To provide an integrated understanding of hydrogen as a clean energy carrier, its generation, storage, and utilization, along with the design, working, and application of fuel cell technologies for sustainable energy systems.</p>					
<p>Hydrogen Energy – Fundamentals, Properties, and Policies Salient characteristics of hydrogen as an energy carrier, Global and Indian hydrogen policy landscape, Hydrogen economy and net-zero commitments, Hydrogen colour codes: Grey, Blue, Green, Pink, etc., Physical and chemical properties of hydrogen, Hazards, types, safety codes, regulations, and standards</p> <p>Applications: National Green Hydrogen Mission (India) – driving hydrogen demand in steel, refining, and fertilizer sectors., Hydrogen Handling and Safety Codes: Used by industries such as Linde, Air Liquide, BOC India, which deal with compressed hydrogen and cryogenic systems, Oil & Gas Industry (e.g., Reliance, IOCL) requiring compliance with global hydrogen safety standards (ISO, NFPA).</p> <p>Hydrogen Generation and Storage Technologies Hydrogen production methods: Steam reforming, partial oxidation, Coal gasification and biomass conversion, Electrolysis (Alkaline, PEM, SOE), Photocatalytic and biological methods, Hydrogen storage techniques: Physical: Compressed gas, liquefied hydrogen, Chemical: Metal hydrides, chemical carriers, novel adsorbents, Safety and management of hydrogen storage, Comparison of methods and challenges in scale-up</p> <p>Application: Steam methane reforming in large-scale industries like BPCL, HPCL, Green hydrogen production via electrolysis – pilot projects by NTPC, Adani, Indian Oil-L&T ReNew Power JV, Used in waste-to-hydrogen projects by Indian Oil R&D Centre, Thermax, and CSIR labs, Cryogenic storage systems in industrial gas suppliers (e.g., INOX Air Products),</p> <p>Fuel Cell Technology – Fundamentals, Classification, and Performance Basics of fuel cell operation and components, Fuel cells vs. batteries: comparative overview, Classification based on temperature/electrolyte: Working principles, materials, and fabrication methods, Thermodynamic and electrochemical theory, Fuel cell losses: Polarization and power density curves, Efficiency and performance improvement techniques</p> <p>Application: PEMFC in backup power for telecom towers (e.g., by Ballard Power Systems, H2e Power Systems), SOFC and MCFC in industrial CHP and microgrids, Labs at ARCI Hyderabad, IISc Bangalore, BHEL R&D, and DRDO, Pilot fuel cell buses: Tata Motors in collaboration with IOCL and NTPC,</p> <p>Applications, Integration, and Future Directions Applications of hydrogen and fuel cells in: Domestic, industrial, commercial, transportation, and grid-scale sectors, Use of hydrogen in ICEs, sensors, and hydrogen refueling infrastructure, Environmental and economic aspects: Cost,</p>					

LCA, emissions, Fuel cell-powered vehicles and infrastructure (Indian pilot projects: NTPC, IOCL, TATA), Future trends: Hydrogen corridors, green hydrogen hubs, ammonia economy, Policy, funding mechanisms (e.g., India's National Green Hydrogen Mission)

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Poster presentation (10%), Quiz (10%), Assignment (20%), Field visit/Case study report (20%), Internal Examinations (40%)

References:

1. Gupta, R. B., "Hydrogen Fuel: Production, Transport and Storage", Taylor and Francis, 2009.
2. Agata Godula Jopek, "Hydrogen Production by Electrolysis", Wiley-VCH, 2015
3. Michael Hirscher, "Handbook of Hydrogen Storage", Wiley-VCH, 2010.
4. James Larminie and Andrew Dicks, "Fuel cell systems Explained", Wiley publications, 2003.
5. Ryan O. H., Suk Won C. and Whiteny C., "Fuel Cell Fundamentals", John Wiley & Sons, 2016
6. Christopher M A Brett, "Electrochemistry – Principles, Methods and Applications", Oxford University, 2004

E-Resources:

- <https://mnre.gov.in>
- <https://niti.gov.in>
- <https://www.fccea.org>
- <https://www.iea.org>
- <https://nptel.ac.in/courses/103106116>
- <https://www.indiah2alliance.com>

CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain hydrogen fundamentals, properties, policies, and safety standards	PO1 (3), PO3 (2)	3	2
CO2	Apply hydrogen generation, storage, and handling methods in practical scenarios	PO1 (3), PO2 (3)	3	3
CO3	Estimate performance, efficiency, and losses in fuel cells and hydrogen systems	PO1 (3), PO3 (3)	3	3
CO4	Analyze applications, integration, and future trends of hydrogen energy and fuel cells	PO3 (3)	3	3

EY25008	Smart Grid Technology and Energy Informatics	L	T	P	C
		3	0	0	3
<p>Course Objectives:</p> <p>To provide an in-depth understanding of smart grid systems and energy informatics, including advanced communication, control, data analytics, and decision-support tools that enable efficient, reliable, and sustainable energy management in the context of evolving Indian and global power sectors.</p>					
<p>Fundamentals of Smart Grids</p> <p>Evolution and concept of smart grids, Characteristics of traditional grid vs. smart grid, Smart grid architecture and layered structure, Components: Smart meters, sensors, PMUs, smart appliances, EV chargers, Microgrids and virtual power plants (VPPs), Benefits and challenges of smart grid deployment</p> <p>Applications: Power utilities are transitioning from centralized generation to intelligent, decentralized grids. They use digital communication and automation for real-time</p> <p>Smart Grid Communication and Control Technologies</p> <p>Communication requirements and standards: SCADA, IEC 61850, IEEE 2030, Technologies: RF, Zigbee, Wi-Fi, LTE, Optical fiber, 5G, Intelligent Electronic Devices (IEDs) and RTUs, Wide Area Monitoring Systems (WAMS), PMUs, and synchrophasors, Cybersecurity and resilience in smart grids, Demand response (DR) and home energy management systems (HEMS)</p> <p>Application: Used by power utilities and substations for real-time monitoring, remote control, and data logging of transmission and distribution systems, Enables interoperability between IEDs in substations and facilitates automation, event reporting, and fault diagnostics, Provides guidelines for integrating renewable energy sources and electric vehicles into the smart grid, Used for protection, automation, and remote operation in smart substations, Protects energy infrastructure from cyber threats like malware or hacking of control systems.</p> <p>Energy Informatics and Data Analytics</p> <p>Introduction to energy informatics and big data in power systems, Energy data acquisition, cleaning, storage, and visualization, AI/ML applications: Load forecasting, fault detection, theft detection, OpenADR, smart home informatics, edge computing, Energy dashboards and customer portals, Use of cloud platforms (AWS, Azure) for grid analytics</p> <p>Application: Energy informatics helps utilities and grid operators manage massive volumes of data from smart meters, sensors, and substations for grid optimization and predictive maintenance, Smart meters and IoT devices collect real-time consumption and voltage data, AI models like LSTM, XGBoost forecast hourly and daily loads for energy scheduling and tariff planning, Open ADR (Open Automated Demand Response) allows utilities to remotely reduce or shift loads by sending</p>					

real-time signals to smart appliances and HVAC systems.

Renewable Integration, Policy, and Smart Grid Deployment in India

Grid integration of solar, wind, and hybrid systems, Role of energy storage: BESS, flywheels, pumped hydrogen, Vehicle-to-grid (V2G), EV charging integration, National Smart Grid Mission (NSGM) – objectives, funding, projects, Smart grid regulatory framework in India: CERC, SERCs, BIS, Case studies: Puducherry Smart Grid, TPDDL Smart Grid, Kerala's KSEB smart initiatives

Application: Large-scale solar parks (e.g., Pavagada in Karnataka, Rewa in Madhya Pradesh) and wind farms are integrated into regional grids using smart inverters and flexible AC transmission systems (FACTS), **Battery Energy Storage Systems (BESS):** Used for frequency regulation and peak load shaving in RE-rich grids, □ V2G enables bidirectional power flow, allowing parked EVs to supply energy to the grid during peak demand, Smart EV chargers are integrated with the grid for demand response and time-of-use pricing.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Poster presentation (10%), Quiz (10%), Assignment (20%), Field visit/Case study report (20%), Internal Examinations (40%)

References:

1. *Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Smart Grid: Technology and Applications, 2nd Ed., 2018, Wiley*
2. *James Momoh, Smart Grid: Fundamentals of Design and Analysis, 2012, Wiley-IEEE Press*
3. *S. Chakrabarti, M. Bhattacharya, S. Sengupta, S. Pal, Smart Grid: Technology and Applications, 2018, CRC Press*
4. *Stephen F. Bush, Smart Grid: Communication-Enabled Intelligence for the Electric Power Grid, 2014, Wiley*
5. *Abraham Reibman, Energy Informatics: Data-Driven Innovation for the Electricity Sector, 2021, Springer*
6. *Stuart Borlase, Smart Grids: Infrastructure, Technology, and Solutions, 2013, CRC Press.*

E-Resources:

<https://nptel.ac.in/courses/108105159>

<https://nptel.ac.in/courses/108107112>

<https://www.coursera.org/learn/smart-grids>

<https://www.edx.org/course/data-analytics-for-smart-grids>

<https://www.futurelearn.com/courses/smart-grid>

CO	CO Description	PO	PSO1	PSO2
CO1	Explain the architecture, functions, and components of smart grids and energy systems	PO1 (3), PO3 (2)	3	2
CO2	Apply integration of renewable energy systems, storage, and energy informatics tools	PO2 (3), PO4 (2)	3	2
CO3	Estimate performance, energy balance, and demand-side impacts of smart grid systems	PO2 (3), PO3 (2)	3	2
CO4	Analyze communication technologies, cybersecurity, and policies for optimization of smart grids	PO3 (3), PO5 (2)	3	3

EY25009	Nanomaterials for Energy Systems and Environmental Applications	L	T	P	C
		3	0	0	3
<p>Course Objectives: To Provide fundamentals of nanomaterials, emphasizing their unique properties and synthesis methods. It explores their applications in energy systems such as solar cells, fuel cells, and hydrogen storage. The course also covers environmental solutions like carbon capture using advanced nanomaterials.</p>					
<p>Fundamentals and Properties of Nanomaterials</p> <p>Introduction to Nanotechnology, Classification of Nanomaterials, Differences Between Nanoscale and Bulk Materials, Mechanical, Optical, Electrical, Magnetic, Physical, and Chemical Properties of Nanomaterials</p> <p>Applications: Nanomaterials like graphene, carbon nanotubes (CNTs), and quantum dots are used in transistors, displays, and sensors due to their electrical and optical properties, Used in tire materials, engine components, and fuel efficiency improvements via nanostructured coatings,</p> <p>Synthesis and Characterization Techniques</p> <p>Top-Down and Bottom-Up Approaches, Synthesis Methods: Colloidal, Sol-Gel, Electrodeposition, Aerosol Synthesis, Spray Pyrolysis, Electrospinning, Core/Shell Structures, Carbon-based Nanomaterials, Characterization Techniques: X-ray Diffraction (XRD), Scanning and Transmission Electron Microscopy (SEM, TEM), Atomic Force Microscopy (AFM), Fourier-Transform Infrared Spectroscopy (FTIR), X-ray Photoelectron Spectroscopy (XPS)</p> <p>Application: Controlled synthesis methods like sol-gel and colloidal synthesis are used for drug delivery systems, nanoformulations, and imaging agents, Characterization tools like XRD, SEM, and AFM are vital in semiconductor, battery, and material research labs for quality assessment and product development.</p> <p>Nanomaterials for Energy Generation</p> <p>Nanomaterials in Solar Cells: Nano, Micro, Polycrystalline, and Amorphous Silicon, Organic Solar Cells and Dye-Sensitized Solar Cells (DSSCs), Organic-Inorganic Hybrid Solar Cells</p> <p>Fuel Cells: Carbon Electrodes, Graphene-based Materials, Polymer Membranes for Fuel Cells</p> <p>Application: Quantum dots and perovskite materials improve light absorption and efficiency in solar panels, Used in thin-film solar cells and Dye-Sensitized Solar Cells (DSSCs), Nanostructured carbon (graphene, CNTs) and metal catalysts are used in proton exchange membranes and electrodes to improve fuel cell durability and output.</p> <p>Nanomaterials for Energy Storage and Environmental Applications</p> <p>Hydrogen Energy and Storage: Merits of Hydrogen as Fuel, Storage Techniques: Metal Hydrides, Physisorption, Nanostructures (3D Supports, CNTs), Carbon Capture and Sequestration: Greenhouse Gas Emissions, CO₂ Capture Methods. Adsorption and Absorption Materials</p>					

Application: Battery Manufacturing: Nanomaterials like silicon nanoparticles and graphene are used in Li-ion and solid-state batteries to improve energy density and charging speed, Used in **metal hydride storage systems, CNT-based adsorption tanks, and fuel cell hydrogen tanks**, Nanoadsorbents and catalysts used in CO₂ capture, air filtration, and wastewater treatment

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Poster presentation (10%), Quiz (10%), Assignment (20%), Field visit/Case study report (20%), Internal Examinations (40%)

References:

1. Vollath D, "Nanomaterials - An introduction to Synthesis, Properties and Applications", Wiley-VCH, 2013.
2. Cao G, "Nanostructures and Nanomaterials - Synthesis, Properties and Applications", Imperial College Press, 2006.
3. Michael Hirscher, "Handbook of Hydrogen Storage", Wiley, 2010.
4. Robert Huggins, "Energy Storage: Fundamentals, Materials and Applications", 2nd edition, Springer, 2015
5. Robert A Varin, "Nanomaterials for Solid State Hydrogen Storage", Springer, 2007.
6. Berendsmit, "Introduction to Carbon Capture and Sequestration", Imperial College Press, 2014.

E-Resources:

https://onlinecourses.nptel.ac.in/noc24_mm38/preview

<https://nptel.ac.in/courses/118102003>

<https://archive.nptel.ac.in/courses/117/108/117108047>

<https://www.edx.org/course/nanotechnology-fundamentals-purdue-nano530x>

<https://elearn.nptel.ac.in/shop/nptel/selection-of-nanomaterials-for-energy-harvesting-and-storage-application>

<https://www.coursera.org/learn/duke-nanotechnology>

CO	CO Description	PO	PSO1	PSO2
CO1	Explain the classification, structure, and unique properties of nanomaterials compared to bulk materials	PO1 (3), PO3 (2)	3	2
CO2	Describe and differentiate various top-down and bottom-up synthesis methods and characterization techniques	PO2 (3), PO3 (2)	3	2
CO3	Analyze the role of nanomaterials in enhancing the performance and efficiency of solar cells and fuel cells	PO3 (3), PO4 (2)	3	3
CO4	Evaluate nanotechnology-based approaches for energy storage including hydrogen storage and environmental remediation	PO3 (3), PO5 (2)	3	3
CO5	Apply interdisciplinary knowledge of nanomaterials to design sustainable energy and environmental solutions	PO2 (3), PO4 (2), PO3 (2)	3	3

EY25010	Nuclear Power Engineering	L	T	P	C
		3	0	0	3
Course Objectives:					
<p>To impart comprehensive knowledge of nuclear energy systems, including reactor physics, nuclear fuel cycles, material processing, and reprocessing technologies and give exposure in waste management, radiation protection, and international safety standards, enabling students to critically assess and apply nuclear technologies for sustainable energy production and safe operational practices in real-world scenarios.</p>					
Nuclear Reactions and Reactor Fundamentals					
<p>Basics of nuclear fission and fusion, radioactivity, and decay chains, Neutron interactions and the fission process, Nuclear reactors: types, principles, and components, Fast breeder reactors and other reactor designs, Reactor construction and shielding techniques, Heat transfer methods in nuclear reactors</p>					
<p>Applications: Used in large-scale electricity production in nuclear power plants like Kudankulam (India) and Tarapur using Pressurized Water Reactors (PWRs) and Boiling Water Reactors (BWRs), Research in materials testing, neutron activation analysis, advanced cooling methods (liquid metal, gas-cooled reactors) applied in Generation IV reactor designs for improved efficiency and safety.</p>					
Reactor Materials and Fuel Cycles					
<p>Overview of nuclear fuel cycles (open and closed), Properties and selection of nuclear fuels: Uranium, Thorium, Zirconium, Beryllium, Uranium mining, production, purification, Conversion of Uranium to UF_4 and UF_6, Introduction to reactor-grade fuel processing</p>					
<p>Applications: Thorium-based Advanced Heavy Water Reactor (AHWR) being developed for sustainable nuclear energy using India's rich thorium reserves, Use of Uranium Hexafluoride (UF_6) in enrichment facilities globally (e.g., USEC in the USA, URENCO in Europe), Development of high-temperature materials, zirconium cladding, and corrosion-resistant alloys in nuclear-grade metallurgy.</p>					
Reprocessing and Product Separation					
<p>Spent fuel characteristics and reprocessing objectives, Solvent extraction in nuclear reprocessing, Solvent extraction equipment and flow diagrams, Fuel element dissolution, Separation techniques, Electro-refining, oxidative slagging, Isotope separation principles and applications</p>					
<p>Applications: India's Kalpakkam Reprocessing Plant and Tarapur Facility reprocess spent fuel using PUREX method for plutonium recovery, Stable isotopes (e.g., Cobalt-60, Iodine-131, Technetium-99m) are separated for use in cancer therapy, diagnostic imaging, and industrial radiography, Recovered plutonium and uranium reused in MOX fuel for Fast Breeder Reactors, reducing fresh fuel demand, Advanced partitioning techniques being developed to separate high-level radioactive elements and reduce long-term storage needs.</p>					
Waste Disposal and Radiation Safety					
<p>Types and classification of nuclear wastes, Waste handling and long-term disposal strategies, Safety protocols for nuclear operations, Radiation protection and</p>					

shielding, Pollution control and abatement measures, National and international standards and conventions on nuclear safety (e.g., IAEA), Radiation hazard prevention in nuclear facilities

Applications: Vitrification of high-level liquid waste at Tarapur and Kalpakkam; solid waste stored in shielded containers., Long-term disposal of radioactive waste being explored (e.g., Onkalo Repository in Finland)., IAEA and AERB regulations enforced in Indian nuclear facilities to ensure operational safety and radiation control, Use of dosimeters, ALARA principle, and controlled access systems to protect workers in nuclear industries.

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Poster presentation (10%), Quiz (10%), Assignment (20%), Field visit/Case study report (20%), Internal Examinations (40%)

References:

1. Cacuci, Dan Gabriel, "Nuclear Engineering Fundamentals", Springer, 2010
2. Kenneth Shultis J., Richard E. Faw, "Fundamentals of Nuclear Science and Engineering", CRC Press; 3rd Edition, 2016
3. Kenneth D. Kok, "Nuclear Engineering", CRC Press, 2009
4. Lamarsh, J.R., "Introduction to Nuclear Reactor Theory", Wesley, 2002
5. Tatjana Tevremovic, "Nuclear Principles in Engineering", Springer, 2008

E-Resources:

- <https://nptel.ac.in/courses/115104043>
<https://nptel.ac.in/courses/112101088>
<https://nptel.ac.in/courses/121106014>
<https://www.nrc.gov/>
<https://www.barc.gov.in/>
<https://world-nuclear.org/>

CO	Description of CO	Mapped POs	PSO1	PSO2
CO1	Explain nuclear fission, radioactivity, and neutron reactions in reactor operations	PO1 (3), PO3 (2)	3	2
CO2	Apply knowledge of nuclear fuel properties, fuel cycles, and material selection	PO2 (3), PO3 (2)	3	2
CO3	Estimate reprocessing methods, reactor product separation, and waste handling	PO3 (3), PO4 (2)	3	3
CO4	Analyze nuclear safety protocols, waste classification, and international radiation standards	PO3 (3), PO5 (2)	3	3

TE25C08	Thermal Management in Electronics and Batteries	L	T	P	C
		3	0	0	3

Course Objectives:

To Understand chilled water systems, chiller types, and selection criteria. To Explore advanced cooling methods and assess their effectiveness in electronics. To Analyse thermal management in real-world electronic systems across industries. To Learn battery thermal behavior and design effective thermal management systems.

Thermal Fundamentals in Electronics

Heat transfer modes, electronics packaging, material properties, contact/spreading resistance, heat sinks, thermal interface materials, JEDEC standards.

Activities: Simulate heat sink design (ANSYS/SolidWorks), Analyze material thermal properties, Case study using JEDEC standards

Applications: Design of efficient electronic packaging, Optimizing heat sinks and thermal interfaces in processors, Ensuring device reliability via proper thermal resistance control, Standard-compliant electronics cooling (JEDEC).

Cooling Technologies

Microchannels, fluid selection, jet impingement, immersion cooling, heat pipes, vapor chambers, thermoelectric coolers, MEMS/NEMS cooling, recent trends.

Activities: CFD simulation of microchannel/jet cooling, Prototype immersion or heat pipe system, Use thermoelectric cooler in experiment

Applications: High-performance cooling in CPUs/GPUs and power electronics, Thermal control in compact devices (e.g., smartphones, VR headsets), Emerging tech: MEMS/NEMS cooling in miniaturized systems

Applications

Thermal management in automobiles, trains, ships, avionics, data centers, laptops, Mobile phones, IoT devices, TVs, RADAR, satellites, LEDs, and LASERs.

Activities: Case study: automotive or avionics cooling, Thermal profiling of laptops/smartphones, LED/LASER cooling analysis

Applications: Thermal solutions in transport systems (cars, trains, aircraft), Mobile/IoT device heat management, Thermal design in consumer electronics (LEDs, TVs, RADAR, LASERs)

Battery Systems and Thermal Management

Battery types, energy balance, electrochemical modeling, duty cycle, thermal behavior, runaway, BTMS design (air, liquid, PCM), and recent advances.

Activities: Battery thermal modeling (MATLAB), Heat generation and energy balance study, Design air/liquid/PCM BTMS, Review on latest BTMS advancements

Applications: Battery pack design for EVs and hybrid vehicles, Thermal safety in energy storage systems, Preventing battery aging and thermal runaway, Efficient BTMS in drones, power tools, and portable devices

Weightage: Continuous Assessment: 40%, End Semester Examinations: 60%

Assessment Methodology: Poster presentation (10%), Quiz (10%), Assignment (20%), Field visit/Case study report (20%), Internal Examinations (40%)

References:

1. Younes Shabany, Heat Transfer: Thermal Management of Electronics, CRC Press Inc, 2010.
2. L.T. Yeh, Thermal Management of Microelectronic Equipment, ASME, 2016.
3. Arman Vassighi, Manoj Sachdev, Thermal and power management of integrated circuits, Springer, 2006.
4. Marc A Rosen, Aida Farsi, Battery Technology: From Fundamentals to Thermal Behaviour and Management, Elsevier, 2023.
5. Shriram Santhanagopalan, Kandler Smith, Gi-Heon Kim, Jeremy Neubauer, Ahmad A. Pesaran, Matthew Keyers, Design and Analysis of Large Lithium-Ion Battery Systems, Artech House Publishers, 2014.
6. Jerry E. Sargent, Al Krum, Thermal Management Handbook: For Electronic Assemblies, McGraw-Hill, 1998.
7. Shichun Yang, Xinhua Liu, Shen Li, Cheng Zhang, Advanced Battery Management System for Electric Vehicles, Springer, 2022.

E-Resources:

- <https://nptel.ac.in/courses/112101097>
<https://www.jedec.org/>
<https://nptel.ac.in/courses/112106282>
<https://nptel.ac.in/courses/112105129>
<https://nptel.ac.in/courses/108106170>

CO	Course Outcome (CO)	POs	PSO1	PSO2
CO1	Explain heat transfer fundamentals, electronics packaging, cooling technologies, application domains, and battery thermal behavior including BTMS concepts	PO1 (3), PO2 (2)	3	2
CO2	Apply thermal principles, CFD/simulation tools, and cooling techniques to design thermal management systems for electronics and batteries	PO1 (3), PO3 (3)	3	3
CO3	Estimate heat generation, thermal resistance, cooling performance, and battery thermal characteristics under varying operating conditions	PO1 (3), PO2 (3)	3	3
CO4	Analyze thermal performance, reliability, safety issues, and effectiveness of cooling systems and BTMS in real-world applications	PO3 (3)	3	3