MAULANA AZAD NATIONAL INSTITUTE OF TECHNOLOGY, BHOPAL–462003
Department of Energy Science and Engineering

Master of Science (M. Sc.) in Energy Economics and Management
Scheme and Syllabus

FIRST SEMESTER:

Course Code	Title of the Course	L	T	P	Credit
MC EM 1101	Statistical Analysis	3	0	-	3
EN EM 1102	Sustainable Energy Systems	3	0	-	3
HS EM 1103	Managerial Economics	3	0	-	3
EN EM 1104	Energy Audit and Management	3	0	-	3
	Department Elective-1	3	0	-	3
EN EM 1105	Energy Lab-1	-	-	2	1
HS EM 1106	Economics Lab	-	-	2	1
EN EM 1107	Seminar-1	-	-	2	1
EN EM 1108	Minor Project-1 (Self Learning)	-	-	-	2
HS 1101	Communication Skills	-	-	2	0
				Total No. of Credits:	**20**

- Communication Skill will be Audit Course of 2 credits which will not be counted in SGPA/CGPA calculation

SECOND SEMESTER:

Course Code	Title of the Course	L	T	P	Credit
HS EM 1201	Econometrics	3	-	-	3
EN EM 1202	Waste & Pollution Management	3	-	-	3
EN EM 1203	Energy Policies and Planning	3	-	-	3
EN EM 1204	Green Buildings Economics	3	-	-	3
	Department Elective II	3	-	-	3
EN EM 1205	Energy Lab 2	-	-	2	1
HS EM 1206	Econometrics Lab-1	-	-	2	1
EN EM 1207	Seminar-2	-	-	2	1
EN EM 1208	Minor Project-2 (Self Learning)	-	-	-	2
				Total No. of Credits:	20

THIRD SEMESTER:

Course Code	Title of the Course	L	T	P	Credit
MG EM 2101	Project and Financial Management of Energy Systems	3	-	-	3
HS EM 2102	Energy and Environmental Economics	3	-	-	3
EN EM 2103	Energy Storage Management	3	-	-	3
EN EM 2104	Smart Energy Systems Management	3	-	-	3
	Departmental Elective III	3	-	-	3
EN EM 2105	Energy Lab 3	-	-	2	1
HS EM 2106	Econometrics Lab-2	-	-	2	1
EN EM 2107	Seminar-3	-	-	2	1
EN EM 2108	Minor Project-3 (Self Learning)	-	-	-	2
				Total No. of Credits:	**20**

FOURTH SEMESTER:

Course Code	Title of the Course	L	T	P	Credi
EN EM 2201	Major Project Dissertation	-	-	40	20
				Total No. of Credits:	**20**

Grand Total of Course Credits = 20 + 20 + 20 + 20 = 80

List of Electives I, II & III

List of Department Electives I	
EN EM 1151	Power Plant Economics
EN EM 1152	Operation Research & Management
EN EM 1153	Energy Efficiency in Electrical Utilities
EN EM 1154	Alternative Fuels
List of Department Electives II	
EN EM 1251	Energy Efficiency in Thermal Utilities
EN EM 1252	Life Cycle Analysis of Energy Systems
HS EM 1253	International Trade & Business in Energy
EN EM 1254	Hybrid Renewable Energy Management
EN EM 1255	Research Methodology
List of Department Electives III	
EN EM 2151	Climate Change & Carbon Sequestration
EN EM 2152	Modelling & Simulation of Energy Systems
MG EM 2153	Green Finance & Fintech for Energy Systems
EN EM 2154	Design & Optimization Software for Energy System

Detailed Syllabus

Name of Program: M.Sc. in Energy Economics and Management Semester: I
Name of Course: **Statistical Analysis** Course Code: **MC EM 1101**
Core/ Elective/other: Core subject L: T: P: Cr 3:0:0:3
Prerequisite:

Course Assessment Methods:

Component	Maximum Marks	Remarks
Teacher's Assessment	40	[30 marks for quizzes/assignments/presentations/surprise tests + 10 marks for attendance]
Mid Semester Examination	20	The Mid Semester marks shall be awarded on the basis of the performance in Mid semester examination in offline mode.
End Semester Examination	40	On campus 2 hour written examination

Course Objectives:

1. Understand and apply descriptive statistics to summarize data using measures of central tendency, dispersion, skewness, and kurtosis.
2. Gain foundational knowledge of probability theory, including Bayes' Theorem, and apply it to real-world uncertainty and decision-making problems.
3. Analyze relationships between variables using correlation, regression, and curve fitting techniques.
4. Interpret and apply theoretical probability distributions such as Binomial, Poisson, and Normal in data modeling.

Course Outcomes:

S.NO.	Course Outcomes
CO1:	Understand and compute measures of central tendency, dispersion, skewness, moments, and kurtosis to analyze and summarize datasets effectively.
CO2:	Apply probability theory, including Bayes' Theorem, and analyze random variables using theoretical distributions like Binomial, Poisson, and Normal.
CO3:	Perform correlation and regression analysis, including curve fitting techniques, to model relationships and trends in data.
CO4:	Formulate hypotheses and apply statistical tests (z, t, F, Chi-square) and ANOVA techniques to draw valid conclusions and support decision-making.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	3	3	3
CO2	3	3	3	2	3
CO3	3	3	2	2	3
CO4	3	3	2	2	2

Course Outcomes (CO), Program Outcomes (POs) & Program Specific Outcomes (PSOs)
Enter correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High), ***If there is no correlation, "-".***

Course Content :

Module	Content	Lectures
1	Fundamental concepts of data description through descriptive statistics.	**8**
2	Central Tendencies: mean, median partition values (Measures of Dispersion: range, mean deviation, standard deviation, coefficient of variation) skewness, Moments and kurtosis	**8**
3	Theory of Probability, Baye's Theorem. Correlation and Regression. Curve Fitting Theoretical Distributions: Binomial, Poisson Normal Distributions etc.	**8**
4	Hypothesis Testing-Testing of Statistical Hypothesis, Null Hypothesis, Tests of Hypothesis and Significance, Chi-Square, t, z and F Tests	**8**
5	ANOVA	**8**

Textbooks/ References:	
1.	**Mathematical Statistics** – *M. Ray* Comprehensive coverage of probability theory, statistical distributions, and hypothesis testing.
2.	**Fundamentals of Mathematical Statistics** – *S.C. Gupta & V.K. Kapoor*
3.	**Probability and Statistics** – *Miller & Freund*

Name of Program: M.Sc. in Energy Economics and Management Semester I
Name of Course: **Sustainable Energy Systems** Course Code: **EN EM 1102**
Core/ Elective/other: Core subject L: T: P: Cr
3:0:0:3 Prerequisite:

Course Assessment Methods:

Component	Maximum Marks	Remarks
Teacher's Assessment	40	[30 marks for quizzes/assignments/presentations/surprise tests + 10 marks for attendance]
Mid Semester Examination	20	The Mid Semester marks shall be awarded on the basis of the performance in Mid semester examination in offline mode.
End Semester Examination	40	On campus 2 hour written examination

Course objective:

1. Understanding Energy Fundamentals, Study Renewable Energy Sources.
2. Analyze Energy Systems and Technologies, understand the environmental impacts of various energy systems, including greenhouse gas emissions and pollution.
3. Explore Policy and Economics, Promote Energy Efficiency.

Course Outcome:

S.NO.	Course Outcomes
CO1:	To understand the fundamentals of Energy and sustainability, Renewable Energy Proficiency
CO2:	To comprehend the Technical aspects of various Energy Systems.
CO3:	To analyze the environmental footprints of various energy systems.
CO4:	To evaluate the sustainable energy systems and develop sustainable solutions to various energy challenges.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5
CO1	3	1	1	2	2
CO2	3	2	3	2	3
CO3	3	3	3	2	3
CO4	3	3	1	2	2

Course Outcomes (CO), Program Outcomes (POs) & Program Specific Outcomes (PSOs)
Enter correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High), ***If there is no correlation, "-".***

Course content:

Module	Content	Lectures
1	Introduction to energy fundamentals and overview of various kinds of energy sources. Concept of sustainable development, Analysis of the Indian energy scenario and challenges. Introduction to sustainability and sustainable development.	**8**
2	Solar Energy fundamentals (Photosynthetic, Thermal, and Photovoltaic energy systems. Solar energy applications and solar power plants.	**8**
3	Biomass energy source and conversion processes, and Introduction to waste to energy and environmental implications.	**8**
4	Wind energy basics, calculation, and design of a wind turbine. Hydro energy principle, technologies, and environmental implications.	**8**
5	Emerging Technologies, Ocean, Geothermal, hydrogen, fuel cell and Electric vehicles and their Environmental implications.	**8**

Textbooks/ References:	
1.	Renewable Energy: Power for a Sustainable Future" by Godfrey Boyle .
2.	Sustainable Energy: Choosing Among Options" by Jefferson W. Tester, Elisabeth M. Drake, Michael J. Driscoll, Michael W. Golay, and William A. Peters .
3.	Energy Systems Engineering: Evaluation and Implementation" by Francis Vanek, Louis Albright, and Largus Angenent .
4.	Principles of Sustainable Energy Systems, Second Edition" by Frank Kreith and D. Yogi Goswami .
5.	Fundamentals of Renewable Energy Processes" by Aldo V. da Rosa .

Name of Program: M.Sc. in Energy Economics and Management Semester I
Name of Course: **Managerial Economics** Course Code: **HS EM 1103**
Core/ Elective/other: Core subject L: T: P: Cr 3:0:0:3
Prerequisite:

Course Assessment Methods:

Component	Maximum Marks	Remarks
Teacher's Assessment	40	[30 marks for quizzes/assignments/presentations/surprise tests + 10 marks for attendance]
Mid Semester Examination	20	The Mid Semester marks shall be awarded on the basis of the performance in Mid semester examination in offline mode.
End Semester Examination	40	On campus 2 hour written examination

Course Objective:

1. Grasp fundamental economic concepts such as supply and demand, elasticity, production and cost functions, and market structures.
2. Develop frameworks for analyzing business decisions using economic theory.
3. Analyze different market structures, including perfect competition, monopoly, monopolistic competition, and oligopoly.
4. Learn techniques for estimating and forecasting demand for products and services, Production and Cost Analysis, Pricing Strategies.

Course Outcomes:

S.NO.	Course Outcomes
CO1:	Demonstrate a thorough understanding of core economic concepts such as supply and demand, elasticity, and market structures.
CO2:	Utilize economic theories and models to make informed managerial decisions.
CO3:	Market Structure Analysis , Demand and Supply Analysis
CO4:	Analyze production processes and understand the relationship between production and costs.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	2	2
CO2	3	3	3	2	3
CO3	3	3	3	2	3
CO4	3	3	3	2	3

Course Outcomes (CO), Program Outcomes (POs) & Program Specific Outcomes (PSOs)
Enter correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High), ***If there is no correlation, "-".***

Course Content:

Module	Content	Lectures
1	Managerial Economics - Introduction, Meaning, nature and scope. Fundamental Economics Concepts: Opportunity Cost, Discounting principle, Time perspective, Incremental reasoning, Equi-Marginal concept, Marginal concept in economics. Economies of information: Risk, uncertainty, Theory of firm.	**8**
2	Demand and Supply - Introduction, Market demand and supply functions and curves. Market equilibrium. Consumer behavior and rational choice: cardinal and ordinal approaches of consumer utility-Maximization of consumer utility by the technique of indifference curves and budget lines. Demand Forecasting and its methods and uses.	**8**
3	Laws of diminishing returns to a factor. Returns to scale, Economies & Diseconomies of scale. Production function- Estimation of production function: Cobb Douglas and CES Production functions. Concepts of cost - Cost analysis, economic &accounting cost, Role of time in cost analysis. Cost Volume profit Analysis.	**8**
4	Price determination under perfect competition. Monopoly, Oligopoly, Duopoly & Monopolistic competition. Game theory & competitive strategy - Dominant strategy, Nash equilibrium, prisoner's dilemma. Types of pricing practice- Competitive pricing & Non pricing strategies.	**8**
5	Definition, Measuring the National Income in India, Importance of National Income in India, Importance of National Income Analysis. Business cycles – Meaning, Types of Business cycles, Characteristics of Business Cycles, Causes of Business Cycles and Phases of Business Cycles	**8**

Textbooks/ References:	
1.	Dominik Salvatore, "Managerial Economics", 2008, 6th Ed. Oxford University Press.
2.	Hal Varian, "Intermediate Microeconomics. 8th.Edition", 2009, 8th Ed. W W Norton & Co Inc

Name of Program: M.Sc. in Energy Economics and Management — Semester I
Name of Course: **Energy Audit and Management** — Course code: **EN EM 1104**
Core/ Elective/other: Core Subject — L: T: P: Cr 3:0:0:3
Prerequisite: Basic Electrical Engineering, Basic Mechanical Engineering

Course Assessment Methods:

Component	Maximum Marks	Remarks
Teacher's Assessment	40	[30 marks for quizzes/assignments/presentations/surprise tests + 10 marks for attendance]
Mid Semester Examination	20	The Mid Semester marks shall be awarded on the basis of the performance in Mid semester examination in offline mode.
End Semester Examination	40	On campus 2 hour written examination

Course Objective:

1. Learn the importance of energy management in the context of environmental sustainability and economic efficiency.
2. Energy Audit Methodologies, Energy Management Principles.
3. Tools and Techniques for Energy Auditing, Identifying Energy Saving Opportunities.
4. Financial and Economic Analysis, Renewable Energy Integration.

Course Outcomes:

S.NO.	Course Outcomes
CO1:	Demonstrate the ability to conduct comprehensive energy audits in various types of facilities, including residential, commercial, and industrial settings.
CO2:	Analyze energy data to identify patterns, inefficiencies, and opportunities for energy savings.
CO3:	Develop and implement effective energy management strategies to optimize energy use.
CO4:	Conduct financial analysis of energy efficiency projects, including cost-benefit analysis, payback period, and return on investment (ROI).

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	2	2
CO2	3	3	3	2	3
CO3	3	3	3	2	3
CO4	3	3	3	2	3

Course Outcomes (CO), Program Outcomes (POs) & Program Specific Outcomes (PSOs)
Enter correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High), ***If there is no correlation, "-".***

Course content:

Module	Content	Lectures
1	Energy Audit, types of energy audit; Energy Audit approach: optimizing the input energy requirement; Energy audit instruments.	**8**
2	Energy Management: Concept of energy management, energy demand and supply, economic analysis; Duties and responsibilities of energy managers, Financial Management: Investment-need, Appraisal and criteria, financial analysis techniques-Tutorial Questions	**8**
3	Energy Conservation: Basic concept, energy conservation in the Household, Transportation, Agricultural, service, and Industrial sectors, Lighting, Heating, Ventilation & Air Conditioning.	**8**
4	Energy Action Planning, Monitoring, and Targeting. Energy Conservation Act. Energy Management in Electrical Systems: Electricity billing, Tariff, Power factor, Electric Motors	**8**
5	Demand Side management concept, Energy Efficient Practices and Technologies.	**8**

Textbooks/ References	
1.	Guide Book 2.General Aspects of Energy Management & Energy Audit Bureau of Energy Efficiency(BEE) Learning materials
2.	Handbook of Energy Audits by Albert Thuman, Ninth Edition, CRC Press
3.	Energy Management and Conservation Handbook by Kreith & Goswami, Routledge – Taylor and Francis group

Name of Program: M.Sc. in Energy Economics and Management
Semester I
Name of Course: **Communication skills**
Course Code: **HS 1101**
Core/ Elective/other: Core subject
L: T: P: Cr 3:0:0:3
Prerequisite:

Course Assessment Methods:

Component	Maximum Marks	Remarks
Teacher's Assessment	25	[20 marks for quizzes/seminar presentations (5 marks per quiz x 4 quizzes) + 5 marks for attendance]
Mid Semester Examination	25	The Mid Semester marks shall be awarded on the basis of the performance in Mid semester examination in offline mode.
End Semester Examination	50	On campus 2 hour written examination

Course objective:

1. Develop clear and structured technical communication skills aligned with the scientific method, including hypothesis formulation and logical argumentation.
2. Enhance listening and reading abilities for academic purposes through effective note-taking, literature review, and strategic reading.
3. Build strong writing and presentation skills, including reports, abstracts, visual data presentation, and oral communication.
4. Promote ethical and responsible communication practices, addressing plagiarism, authorship, diversity, and digital etiquette.

Course Outcome:

S.NO.	Course Outcomes
CO1:	Students will be able to apply the scientific method to structure technical documents with logical coherence and evidence-based arguments.
CO2:	Students will demonstrate effective listening and reading strategies for academic and research purposes, including note-taking and literature analysis.
CO3:	Students will produce well-organized written reports, abstracts, and visual data presentations, and communicate ideas effectively in oral formats.
CO4:	Students will exhibit ethical awareness in communication, adhering to standards of academic integrity, authorship, and respectful digital interaction.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5
CO1	3	1	1	2	2
CO2	3	2	3	2	3
CO3	3	3	3	2	3
CO4	3	3	1	2	2

Course Outcomes (CO), Program Outcomes (POs) & Program Specific Outcomes (PSOs)
Enter correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High), ***If there is no correlation, "-".***

Course content:

Module	Content	Lectures
1.	**Scientific Method and its Relationship to Technical Communication** Basics of technical communication, Formulation of hypothesis, Paragraph organisation, Argument development, Evidence and elaboration	**8**
2.	**Listening and Reading Skills** Note taking, Survey of literature, Different reading strategies	**8**
3.	**Writing Skills** Report writing, Peer review skills, Summary and abstract writing, Bibliography and references, Data Analysis and Presentation, Visual communication	**8**
4.	**Speaking Skills** Elevator pitch, Oral presentation, Slides for presentation, Group discussions, Interview skills	**8**
5.	**Ethics in Communication** Ethics in education and research, Copyrights and plagiarism, Authorship, Gender and diversity, Net etiquettes and workplace communication	**8**

Textbooks/ References:	
1.	Arora, V.N., and Lakshmi Chandra. Improve your Writing. 1981. New Delhi: Oxford UP, 2001.
2.	Graff Gerald, and Birkenstein Cathy. "They Say I Say"-The Moves That Matter in Academic Writing. W.W.Norton and Company. Fourth edition. 2018
3.	Lesikar, Raymond V and Marie E. Flatley. Basic Business Communication: Skills for Empowering the Internet Generation: Ninth Edition. New Delhi: Tata McGraw-Hill Publishing Company Ltd., 2002.
4.	Graff Gerald, and Birkenstein Cathy. "They Say I Say"-The Moves That Matter in Academic Writing. W.W.Norton and Company. Fourth edition. 2018
5.	Kumar Sanjay, and Lata Pushp. Communication Skills. 2011. Oxford University Press, 2015
6.	Raman Meenakshi, and Sharma Sangeeta. Technical Communication: Principles and Practice. 2015. Oxford University Press, 2015

Name of Program: M.Sc. in Energy Economics and Management Semester II
Name of Course: **Econometrics** Course Code: **HS EM 1201**
Core/ Elective/other: Core subject L: T: P: Cr 3:0:0:3
Prerequisite:

Course Assessment Methods:

Component	Maximum Marks	Remarks
Teacher's Assessment	40	[30 marks for quizzes/assignments/presentations/surprise tests + 10 marks for attendance]
Mid Semester Examination	20	The Mid Semester marks shall be awarded on the basis of the performance in Mid semester examination in offline mode.
End Semester Examination	40	On campus 2 hour written examination

Course objective:

1. Grasp fundamental econometric concepts, including the purpose and scope of econometrics.
2. Develop a strong foundation in statistical theories and methods, including probability distributions, hypothesis testing, and estimation techniques.
3. Learning Regression Analysis, Identify and solve common econometric problems such as multicollinearity, heteroscedasticity, and autocorrelation.
4. Explore advanced econometric methods, including time series analysis, panel data models, and instrumental variable techniques, empirical Research Skills.

Course Outcomes:

S.NO.	Course Outcomes
CO1:	Proficiency in Econometric Methods, Conduct simple and multiple linear regression analyses to explore relationships between economic variables
CO2:	Addressing Econometric Challenges, Utilize advanced econometric methods, including time series analysis, panel data models, and instrumental variable techniques, for complex data analysis
CO3:	Empirical Research Competence, Formulate and test hypotheses based on economic theory using econometric methods
CO4:	Gain proficiency in using econometric software packages such as Stata, R, EViews, or SAS for data analysis.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	2	2
CO2	3	3	3	2	3
CO3	3	3	3	2	3
CO4	3	3	3	2	3

Course Outcomes (CO), Program Outcomes (POs) & Program Specific Outcomes (PSOs)
Enter correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High), ***If there is no correlation, "-".***

Course Content:

Module	Content	Lectures
1	Econometrics and its nature and scope; The nature, sources and types of data; The classical linear regression model (CLRM) assumptions; Best Linear Unbiased Estimator; R^2: a measure of goodness of fit of the estimated regression	**8**
2	Perfect vs Imperfect Collinearity; Multicollinearity- Meaning, causes, consequences, detection and remedial measures- Heteroscedasticity- Meaning, causes, consequences, detection and remedial measures.	**8**
3	Autocorrelation- Meaning, causes, consequences, detection and remedial measures-Model Specification Errors- Meaning, causes, consequences, detection and remedial Measures.	**8**
4	Endogeneity- Meaning, causes, consequences, detection and remedial measures- Time Series Econometrics: The importance of stationary time series; Tests of stationarity; The unit root test of stationarity; Trend stationary vs. difference stationary time series; The random walk model (RWM).	**8**
5	Dummy variables and its use; The linear probability model (LPM); The logit model; The probit model.	**8**

Textbooks/ References:	
1.	Woolridge, J.M., 2003. Introductory econometrics: A modern approach. *South-Western College Pub.*
2.	Gujarati, D (1998): Basic Econometrics, 4th Edition, New York: McGraw Hill
3.	Johnston, J (1995): Econometric Methods, 3rd edition, New York: McGraw Hill.
4.	Pindyck, Robert S. and Daniel L. Rubinfeld (1995): Econometric Models and Economic Forecasts, 4th Edition, Irwin McGraw-Hill, New York
5.	Ramanathan, Ramu (2000): Introductory Econometrics with Applications, 5th Edition, Cengage Learning India Pvt. Ltd., New Delhi

Name of Program: M.Sc. in Energy Economics and Management Semester II
Name of Course: **Waste and Pollution Management** Course Code: **EN EM 1202**

Core/ Elective/other: Core L: T: P: Cr 3:0:0:3

Prerequisite:

Course Assessment Methods:

Component	Maximum Marks	Remarks
Teacher's Assessment	40	[30 marks for quizzes/assignments/presentations/surprise tests + 10 marks for attendance]
Mid Semester Examination	20	The Mid Semester marks shall be awarded on the basis of the performance in Mid semester examination in offline mode.
End Semester Examination	40	On campus 2 hour written examination

Course Objective:

1. Understanding of Waste Types: To introduce students to various types of waste, including solid, liquid, and gaseous waste, and their sources, characteristics, and impacts on the environment and human health.
2. Regulatory Framework: To familiarize students with national and international regulations, policies, and frameworks governing waste management and pollution control.
3. Waste Management Techniques: To explore different waste management techniques such as reduction, reuse, recycling, composting, and disposal methods like landfills, incineration, and waste-to-energy conversion.
4. Pollution Control Measures: To examine strategies and technologies for preventing, controlling, and mitigating pollution in air, water, and soil environments

Course Outcomes:

S.NO.	Course Outcomes
CO1:	To acquire comprehensive knowledge of various types of waste, including their characteristics, sources, and associated environmental and health impacts.
CO2:	To ensure regulatory compliance by interpreting and applying relevant waste management regulations and standards across diverse contexts.
CO3:	To develop technological proficiency in waste management by understanding the principles, applications, advantages, and limitations of various technologies and techniques.
CO4:	To strengthen problem-solving abilities for analyzing complex waste management and pollution control challenges, identifying effective solutions, and critically evaluating their feasibility.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	2	2
CO2	3	3	3	2	3
CO3	3	3	3	2	3
CO4	3	3	3	2	3

Course Outcomes (CO), Program Outcomes (POs) & Program Specific Outcomes (PSOs)
Enter correlation levels 1, 2 or 3 as defined below: 1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High), ***If there is no correlation, "-".***

Course Content:

Module	Content	Lectures
1	Introduction to Waste Management, waste Sources and categories, Principles and process. Waste Hierarchy: Waste Collection, Segregation, and Transportation,	8
2	Hazardous Waste Management: Classification and Characteristics of Hazardous Waste, Hazardous Waste Treatment and Disposal Methods Storage, Transport, and Handling of Hazardous Waste, Risk Assessment and Safety Measures.	8
3	Treatment Methods: Physical, Chemical, Biological Landfills and Incineration, Composting and Anaerobic Digestion	8
4	Pollution Control Technologies, Air Pollution Control Technologies Water Pollution Control and Land Pollution control technologies	8
5	Sustainable and integrated Waste Management, Concepts of Sustainability and Circular Economy, and Innovations, Community Participation and Public Awareness, Case Studies on Sustainable Practices	8

S.No.	Textbooks/ References:
1.	"Solid Waste Management: Principles and Practice" by Ramesha Chandrappa and Diganta Bhusan Das.
2.	"Environmental Pollution Control Engineering" by C. S. Rao
3.	"Waste Management Practices: Municipal, Hazardous, and Industrial" by John Pichtel
4.	"Pollution: Causes, Effects and Control" edited by Roy Harrison
5.	ENVIRONMENTAL ENGINEERING Vol. 2 by S.K. Garg.

6.	"World Health Organization (WHO) Guidelines" WHO offers guidelines and standards on environmental health issues, including waste management and pollution control, focusing on health impacts and safety standards.
7.	UNEP publishes reports and guidelines on environmental management, including waste management and pollution control, with a focus on sustainable practices.

Name of Program: M.Sc. in Energy Economics and Management Semester II
Name of Course: **Energy Policies and Planning** Course Code: **EN EM 1203**
Core/ Elective/other: Core Subject L: T: P: Cr 3:0:0:3
Prerequisite: Renewable Energy Systems, Ecology and Environment

Course Assessment Methods:

Component	Maximum Marks	Remarks
Teacher's Assessment	40	[30 marks for quizzes/assignments/presentations/surprise tests + 10 marks for attendance]
Mid Semester Examination	20	The Mid Semester marks shall be awarded on the basis of the performance in Mid semester examination in offline mode.
End Semester Examination	40	On campus 2 hour written examination

Course Objective:

1. Introduce students to the fundamental concepts and principles of energy systems, including generation, distribution, and consumption patterns.
2. Examine various energy sources such as fossil fuels, renewable energy, and nuclear energy, along with their technological, economic, and environmental aspects.
3. Study the economic principles underlying energy markets, including supply and demand dynamics, pricing mechanisms, and market structures. Analyze the economic impacts of energy policies and regulations.
4. Explore strategies for accelerating the transition to renewable energy sources, including incentives, subsidies, and regulatory mandates. Analyze the economic, social, and environmental benefits of renewable energy deployment.

Course Outcome:

S.NO.	Course Outcomes
CO1:	To educate students about the EEE, Energy -Economy & Environment, Linkages of a nation, Environment Impact, Assessment EIA, Environmental Acts and Policy Integration EPI
CO2:	To impart enough knowledge about Global Climate Change issues and initiatives behind the Energy Policy purpose and action for energy intense industries
CO3:	To sensitize students to the core competencies and skills required for formulating Strategies of various Energy utilization portfolios and its Implementation agencies of India
CO4:	To train students to interpret different policies, Policy Assessment and Policy Relevance, Policies & Planning from Urban and Rural perspectives

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	2	2
CO2	3	3	3	2	3
CO3	3	3	3	2	3
CO4	3	3	3	2	3

Course Outcomes (CO), Program Outcomes (POs) & Program Specific Outcomes (PSOs)
Enter correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High), ***If there is no correlation, "-".***

Course Content:

Module	Content	Lectures
1	Energy and Environment Basic Issues, Environmental degradation Global Climate Change issues and initiatives Kyoto Protocol, Emissions Inventories, Carbon Trading, Clean development mechanism, Relevant Case Studies.	8
2	Criteria for Economic Growth, Energy-Economy-Environment Linkages, Environment Impact Assessment EIA, Indian environmental degradation, Effluent sewage, noise pollution standards and ambient air, water quality standards, The environmental protection act 1986 - Environmental laws prevention & control of pollution act 1974, Wild life protection act, Forest Conservation Acts, Environmental Acts and Treaties, , Environmental Policy Integration EPI.	8
3	Energy policy purpose, perspective, Contents, Formulation, Ratification, Energy Policy basic Features and Typical Format, Energy Policy Statements of energy intense industries, Energy Management Principles, responsibilities of energy manager, Energy Action Planning Key elements and Force Field Analysis Tool.	8
4	Functions of various ministries and organizations regarding Energy Policy and Planning, drivers and strategies of Energy policy of India, National Energy Policy features, Other Indian national Energy Acts and Treaties, Implementation agencies like IREDA, BEE, MPUVN, SECI etc. and organizations like CEA, NHPC, PNGRB, CERC etc.	8
5	Policy Analysis Concept and various approaches, Dimensions or factors for analyzing various policies, Policy Assessment and Policy Relevance, Planning Issues for Developing Countries, Policies & Planning from Urban and Rural perspectives Energy Planning Decision support systems, and energy policy simulation and analysis methodologies.	8

Textbooks/ References/URLs:	
1	Energy Sources & Policies in India by Rishi Muni Dwivedi
2	Energy Planning Reports of CMIE, State Governments & Govt. of India
3	International Energy Agency, India 2020, Energy policy review report
4	The Handbook of Global Energy Policy by Andreas Goldthau © 2013 John Wiley & Sons, Ltd
5	NEP, NITI Aayog Reports

Name of Program: M.Sc. in Energy Economics and Management Semester II
Name of Course: **Green Buildings Economics** Course Code: **EN EM 1204**
Core/ Elective/other: Core L: T: P: Cr 3:0:0:3
Prerequisite:

Course Assessment Methods:

Component	Maximum Marks	Remarks
Teacher's Assessment	40	[30 marks for quizzes/assignments/presentations/surprise tests + 10 marks for attendance]
Mid Semester Examination	20	The Mid Semester marks shall be awarded on the basis of the performance in Mid semester examination in offline mode.
End Semester Examination	40	On campus 2 hour written examination

Course Objective:

1. To introduce the key components and features of green buildings, including energy efficiency, water conservation, and sustainable materials.
2. To understand the cost-benefit analysis of green building projects, including initial investment, operational savings, and long-term financial benefits.
3. To evaluate the economic impact of green building certifications, such as LEED (Leadership in Energy and Environmental Design) and BREEAM (Building Research Establishment Environmental Assessment Method).
4. To develop skills in using tools such as life-cycle costing, net present value (NPV), and return on investment (ROI) to evaluate the financial viability of green buildings.

Course Outcomes:

S.NO.	Course Outcomes
CO1:	Students will be able to conduct economic analyses of green building projects, including cost-benefit analysis, life-cycle costing, and return on investment calculations.
CO2:	Students will understand the economic implications of selecting sustainable materials and technologies for green buildings, including their cost, performance, and environmental impact.
CO3:	Students will be familiar with green building certification systems such as LEED, BREEAM, and Green Globes, and understand their economic impacts on building projects.
CO4:	Students will be able to evaluate the economic benefits of energy efficiency measures in green buildings, including reduced operational costs and improved occupant comfort.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	2	2
CO2	3	3	3	2	3
CO3	3	3	3	2	3
CO4	3	3	3	2	3

Course Outcomes (CO), Program Outcomes (POs) & Program Specific Outcomes (PSOs)
Enter correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High), ***If there is no correlation, "-".***

Course content:

Module	Content	Lectures
1	**Introduction to Green Building and Sustainable Development:** Concept of Green Building: Definition, historical perspective, and the role of green buildings in sustainable development. Principles of Green Building Design: Environmental, economic, and social benefits; integrating design with sustainability. The Green Economy: Understanding the relationship between green building and the broader green economy concept	**8**
2	**Economics of Green Building:** Life Cycle Cost Analysis: Evaluating the costs and benefits of green building materials and technologies over the building's lifespan. Economic Benefits of Green Buildings: Reduced operating costs (energy, water), increased property value, and enhanced occupant productivity. Financing Sustainable Real Estate: Exploring different funding models for green building projects at the asset and portfolio levels.Cost Considerations in Green Building: Addressing upfront costs and long-term savings associated with sustainable construction.	**8**
3	**Green Building Technologies and Practices:** Energy Efficiency: Passive and active solar design, energy simulation tools, and lighting system design. Water Conservation: Waste water treatment, water reuse strategies, and water-efficient fixtures. Sustainable Materials: Selection of low-emitting, regionally sourced, and recycled materials. Indoor Environmental Quality: Strategies for ventilation, filtration, and minimizing harmful emissions from building materials	**8**
4	**Green Building and the Built Environment:** Impact of Climate Change: Understanding the role of buildings in climate change mitigation and adaptation. Green Cities: Integrating green buildings into urban planning and development. Policy and Regulation: Exploring the impact of government policies and incentives on green building adoption. Economic Analysis Tools, Cost-benefit analysis, Return on investment (ROI).Net present value (NPV) analysis.	**8**
5	**Green Building in the Indian Context:** Indian Building Codes: Understanding the role of Energy Conservation Building Code (ECBC) and National Building Code (NBC). Green Building Rating Systems in India: Focus on GRIHA and IGBC standards. Green building certification systems such as LEED, BREEAM, and Green Globes, and understand their economic impacts on building projects.	**8**

S.No.	Textbooks/ References/URLs:
1.	"Green Building Economics: Value, Costs, and Benefits" by Lisa M. Tucker and Joel D. Gehman
2.	"Green Building: Project Planning and Cost Estimating" by RS Means Engineering Department:
3.	"Economics of Green Building" by M. Ragheb
4.	"Green Building Economics: A Guide to Making Smart Investments" by John A. Kilpatrick and R. Randall Curlee.

Name of Program: M.Sc. in Energy Economics and Management Semester III
Name of Course: **Project and Financial Management of Energy Systems** Course Code: **MG EM 2101**
Core/ Elective/other: Core L: T: P: Cr 3:0:0:3
Prerequisite: Renewable Energy Sources, Operation Research

Course Assessment Methods:

Component	Maximum Marks	Remarks
Teacher's Assessment	40	[30 marks for quizzes/assignments/presentations/surprise tests + 10 marks for attendance]
Mid Semester Examination	20	The Mid Semester marks shall be awarded on the basis of the performance in Mid semester examination in offline mode.
End Semester Examination	40	On campus 2 hour written examination

Course Objective:

1. To introduce students to the fundamental concepts, principles, and practices of project management in the context of energy systems.
2. To explore techniques such as Gantt charts, Critical Path Method (CPM), and Program Evaluation and Review Technique (PERT).
3. To understand the types of risks associated with energy projects, including technical, financial, regulatory, and environmental risks.
4. To introduce the basic principles of financial management, including budgeting, financial analysis, and cost control.

Course Outcomes:

S.NO.	Course Outcomes
CO1:	Students will understand the principles and practices of project management specific to energy systems, including project lifecycle phases, from initiation to closure.
CO2:	Students will be familiar with financial management principles, including budgeting, cost estimation, financial analysis, and risk management as they apply to energy projects.
CO3:	Students will be able to develop comprehensive project plans, including defining scope, setting objectives, creating work breakdown structures, and scheduling using tools like Gantt charts and Critical Path Method (CPM).
CO4:	Students will conduct financial analysis and investment appraisal using techniques such as net present value (NPV), internal rate of return (IRR), payback period, and cost-benefit analysis to evaluate the financial viability of energy projects

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	2	2
CO2	3	3	3	2	3
CO3	3	3	3	2	3
CO4	3	3	3	2	3

Course Outcomes (CO), Program Outcomes (POs) & Program Specific Outcomes (PSOs)
Enter correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High), ***If there is no correlation, "-".***

Course Content:

Module	Content	Lectures
1	Project Finance: Methods of investment appraisal- Rate of return method, Payback period method, Net present value method (NPV)- Internal Rate of Return method (IRR)- Adoption of the methods in energy conservation campaign- Types of projects- Purpose of project management - Classification – Role and qualities of project manager - Types of budgets - Budget committee – budgeting.	**8**
2	Overview of Indian Energy Challenges, Cost and energy technologies, cost Volume Profit analysis and BEP Analysis in Energy Sector, Case studies on techno-economics of energy conservation and renewable energy technologies.	**8**
3	Overview of Global Energy Challenges, Dividend theory and capital structure theory role in the Energy Sector, Regulation of Energy Industries.	**8**
4	Introduction to energy trading, Financial Statement Analysis of Natural Gas, Electricity, oil, coal, Emission markets, financial options and statistics. Option pricing, spread option, spatial load forecasting, tolling agreements, Wheeling power – trading mechanism, solar power- Investment Perspective.	**8**
5	Wind power- Financial modeling, nuclear power- trading issues, Electricity storage, Natural gas transportation, Natural gas storage and liquefied natural gas.	**8**

Textbooks/ References:	
1.	Energy Efficiency: The Definitive Guide to the Cheapest, Cleanest, Fastest Source of Energy 1st Edition by Steven Fawkes.
2.	Energy Finance and Economics: Source by Editors Betty J. Simkins Russell E. Simkins, Published by John Wiley & Sons, Inc., Hoboken, New Jersey.
3.	Global Energy Transformation: Four Necessary Steps to Make Clean Energy the Next Success Story (English Edition) M. Larsson.

Name of Program: M.Sc. in Energy Economics and Management Semester III
Name of Course: **Energy and Environmental Economics** Course Code: **HS EM 2102**
Core/ Elective/other: Core subject L: T: P: Cr 3:0:0:3
Prerequisite:

Course Assessment Methods:

Component	Maximum Marks	Remarks
Teacher's Assessment	40	[30 marks for quizzes/assignments/presentations/surprise tests + 10 marks for attendance]
Mid Semester Examination	20	The Mid Semester marks shall be awarded on the basis of the performance in Mid semester examination in offline mode.
End Semester Examination	40	On campus 2 hour written examination

Course Objective:

1. Understanding Economic Principles in Energy and Environment.
2. Study the structure and functioning of energy markets, including electricity, oil, natural gas, and renewable energy markets.
3. Learn the key principles of environmental economics, including externalities, public goods, and the economics of pollution control.
4. Evaluate different energy technologies and their economic viability.

Course Outcomes:

S.NO.	Course Outcomes
CO1:	Demonstrate a solid grasp of economic concepts related to energy supply, demand, and pricing.
CO2:	Analyze the structure and functioning of various energy markets, including oil, natural gas, coal, and electricity.
CO3:	Apply principles of environmental economics to analyze externalities, public goods, and pollution control.
CO4:	Assess the economic implications of climate change and the role of energy consumption in greenhouse gas emissions.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	2	2
CO2	3	3	3	2	3
CO3	3	3	3	2	3
CO4	3	3	3	2	3

Course Outcomes (CO), Program Outcomes (POs) & Program Specific Outcomes (PSOs)
Enter correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High), ***If there is no correlation, "-".***

Course Content:

Module	Content	Lectures
1	Introduction to Energy and Environmental Economics and Multidimensional Interactions, Basics of Environmental Sciences, Energy Basics, How Energy Is Defined, Alternative Classification of Energy, Renewable vs. Non-renewable sources, Economic theory of depletable resources, Resource curse, Introduction to Energy System, Energy Information, Energy Accounting Framework: Components of Energy Account, Commodity Accounts and Overall Energy Balance, Units, Conversion Factors and Aggregation of Energy Flow. Energy Resources and Energy Commodities; Properties of Energy Resources and Energy Commodities; Law of Thermodynamics; Energy, economy and environment interactions, role of energy in development and growth.	**8**
2	Cost versus Return of Investment; Basic pricing model, Pricing Structure of different Energy sources such as short run and long run, peak and off peak, single part and two-part tariffs, Regulated vs market price, Average and Marginal cost pricing, ToD pricing, seasonal, and block pricing.	**8**
3	Energy taxes and subsidies: principles of optimal indirect taxation, equity considerations, and issues related to numerical determination of a burden, Tax and subsidy structure in Indian Context, Energy pricing in Indian Context (Coal, Gas and Electricity), and Different Energy Markets.	**8**
4	Economy and Environment, Environment economy relationship- Laws of Thermodynamics and Material Balance Model, Environmental Kuznets Curve (EKC): Concepts and Genesis. Explanations of inverted-U shaped EKC- empirical evidence- N-shaped EKC. Environmental Pollution as Economic Problem- Environmental Pollution as a Negative Externality (Pigou), the issue of Property Rights (Coase), Optimal Pollution.	**8**
5	Pollution Control: Command and Control and Alternative Market Based Instruments- Command and Control measures; Pigouvian taxes and subsides, marketable pollution permits and mixed instruments (the charges and fees), Tradable pollution permits and international carbon tax, Coase' s bargaining solution and collective action; Hybrid Instruments- two-part tariff, double dividend hypothesis, illicit dumping. Environmental Valuation- Basic issues of environmental valuation, Revealed Preference Approach- household production function, travel cost, Hedonic price; Stated Preference Approach- contingent valuation method.	**8**

Textbooks/ References:	
1.	Charles Kolstad (2010), Environmental Economics, Oxford University Press.
2.	Hanley, Nick, Shogren, Jason, White, Ben (2007): Environmental Economics in Theory & Practice, Pearson.
3.	M. Karpagam (1993), Environmental Economics, Sterling Publishers, New Delhi.
4.	Charles Kolstad (2015), Environmental Economics, Oxford University Press.
5.	Hanley, Nick, Shogren, Jason, White, Ben (2012): Environmental Economics in Theory & Practice, Pearson.

Name of Program: M.Sc. in Energy Economics and Management Semester III
Name of Course: **Energy Storage Management** Course Code: **EN EM 2103**
Core/ Elective/other: Core L: T: P: Cr 3:0:0:3
Prerequisite: Basic Electrical and Electronics Engineering, Basic Thermodynamics and mechanical engineering

Course Assessment Methods:

Component	Maximum Marks	Remarks
Teacher's Assessment	40	[30 marks for quizzes/assignments/presentations/surprise tests + 10 marks for attendance]
Mid Semester Examination	20	The Mid Semester marks shall be awarded on the basis of the performance in Mid semester examination in offline mode.
End Semester Examination	40	On campus 2 hour written examination

Course Objective:

1. To explore various energy storage technologies, including batteries, supercapacitors, flywheels, compressed air energy storage (CAES), pumped hydro storage, and thermal storage.
2. To study the materials and components used in different energy storage technologies, including electrode materials, electrolytes, and containment systems.
3. To analyze the performance characteristics of energy storage systems, such as energy density, power density, efficiency, lifespan, and response time.
4. To study the integration of energy storage systems with renewable energy sources, such as solar and wind, and their impact on grid management.

Course Outcomes:

S.NO.	Course Outcomes
CO1:	Students will gain an in-depth understanding of different energy storage technologies, such as batteries, supercapacitors, flywheels, compressed air energy storage (CAES), and pumped hydro storage.
CO2:	Students will be able to evaluate the performance characteristics of various energy storage systems, including energy density, power density, efficiency, lifecycle, and cost.
CO3:	Students will develop skills to design, size, and optimize energy storage systems for specific applications, considering factors such as load requirements, available space, and economic constraints.
CO4:	Students will be able to analyze the role of energy storage in enhancing the reliability and efficiency of renewable.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	2	2
CO2	3	3	3	2	3
CO3	3	3	3	2	3
CO4	3	3	3	2	3

Course Outcomes (CO), Program Outcomes (POs) & Program Specific Outcomes (PSOs)
Enter correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High), ***If there is no correlation, "-".***

Course Content:

Module	Content	Lectures
1	**Unit 1: Introduction to Energy Storage** • Fundamentals of energy systems and need for storage • Classification of energy storage systems o Mechanical, Thermal, Electrical, Electrochemical, Chemical, and Hybrid systems • Characteristics of energy storage systems: energy density, power density, efficiency, life cycle, cost • Applications in grid, transportation, and renewable energy integration Overview of recent advancements and trends	**8**
2	**Unit 2: Mechanical and Thermal Energy Storage** • **Mechanical Systems:** o Pumped Hydro Storage (PHS) o Compressed Air Energy Storage (CAES) o Flywheel Energy Storage (FES) • **Thermal Systems:** o Sensible heat storage (e.g., water, rock beds) o Latent heat storage (phase change materials) o Thermochemical storage (chemical reactions) • Design considerations, efficiencies, and operational aspects	**8**
3	**Unit 3: Electrochemical Energy Storage (Batteries)** • Fundamentals of electrochemical storage • Battery types: o Lead-Acid o Nickel-Cadmium (Ni-Cd) o Nickel-Metal Hydride (NiMH) o Lithium-ion (Li-ion) o Sodium-Sulfur (NaS), Redox Flow batteries • Battery performance parameters • Battery management systems (BMS) • Safety, degradation, recycling, and environmental impact	**8**
4	**Unit 4: Electrical and Chemical Energy Storage** • **Electrical Storage:** o Supercapacitors (Ultracapacitors) o Superconducting Magnetic Energy Storage (SMES) • **Chemical Storage:** o Hydrogen production, storage and fuel cells o Power-to-Gas technologies o Ammonia and other synthetic fuels • Integration with renewable sources and smart grids	**8**

5	**Unit 5: Integration, Economics, and Emerging Trends** • Integration of storage systems with: o Solar PV, Wind turbines, Hybrid Energy Systems, Microgrids • Control strategies and sizing of energy storage • Economics of energy storage: o Levelized Cost of Storage (LCOS), ROI, cost drivers • Policy, regulatory frameworks, incentives • Emerging technologies: Metal-air batteries, solid-state batteries, gravity-based storage.	**8**

Textbooks/ References	
1.	Energy Storage by Mullick and Garg
2.	Advanced Energy Storage Technologies and Their Applications (AESA), Energies 2018
3.	Energy Storage Science & Technology by Pendse
4.	Energy Storage: Fundamentals, Materials and Applications by Huggins, Robert

Name of Program: M.Sc. in Energy Economics and Management Semester III
Name of Course: **Smart Energy Systems Management** Course code: **EN EM 2104**
Core/ Elective/other: Core L: T: P: Cr 3:0:0:3
Prerequisite: Renewable Energy Sources, Power controllers

Course Assessment Methods:

Component	Maximum Marks	Remarks
Teacher's Assessment	40	[30 marks for quizzes/assignments/presentations/surprise tests + 10 marks for attendance]
Mid Semester Examination	20	The Mid Semester marks shall be awarded on the basis of the performance in Mid semester examination in offline mode.
End Semester Examination	40	On campus 2 hour written examination

Course Objective:

1. To introduce the configurations and classifications of IES and HES in stand-alone and grid-connected systems.
2. To develop knowledge of energy management systems, including cost analysis, benchmarking, and optimization strategies.
3. To explore smart grid architecture, operational models, and control strategies for advanced energy systems.
4. To examine smart building and smart city technologies with IoT, BEMS, and AI-based energy solutions.

Course Outcome:

S.NO.	Course Outcomes
CO1:	Demonstrate knowledge of IES and HES configurations and evaluate their applicability in different energy system scenarios.
CO2:	Apply energy management principles to analyze energy performance, cost optimization, and system efficiency.
CO3:	Analyze the structure and operational models of Smart Grids, including their integration with emerging digital technologies.
CO4:	Assess smart building and smart city solutions using IoT, AI, and BEMS to enhance energy efficiency and automation.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5
CO1	**3**	**2**	**2**	**2**	**2**
CO2	**3**	**3**	**3**	**2**	**3**
CO3	**3**	**3**	**3**	**2**	**3**
CO4	**3**	**3**	**3**	**2**	**3**

Course Outcomes (CO), Program Outcomes (POs) & Program Specific Outcomes (PSOs)

Enter correlation levels 1, 2 or 3 as defined below:

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High), ***If there is no correlation, "-".***

Course Content:

Module	Content	Lectures
1	**Introduction:** Demand-side management, stand-alone and grid connected energy systems: Integrated Energy system: IES, HES, components, classifications, configurations.	**8**
2	**Energy management system**: Definition and objective of energy management and its importance. Need of energy management, general principles of energy management, energy management skills, and energy management strategy. Energy management approach, understanding energy costs, benchmarking, energy performance, maximizing system efficiency, roles, responsibilities and accountability of Energy Management	**8**
3	**Smart Grid:** Concept and evolution of smart grid, architecture and functional components. Smart grid and emerging technologies: Operating principles and models of smart gird components, scheduling, management and control of next generation smart grid.	**8**
4	**Smart buildings & Offices:** Introduction to smart buildings, Concept of smart buildings and offices, Building Energy Management Systems (BEMS), smart sensors and automation, energy efficiency strategies, IoT and AI in building management, case studies of smart offices and campuses, challenges and cybersecurity issues, emerging trends like digital twins and zero-energy buildings.	**8**
5	**Smart cities:** Components of Smart Cities, integrated approaches to smart city modelling, challenges, Smart Parking, Smart Roads, Smart Payments, Smart Vending Machines. Smart Home Systems: Home automation systems, smart appliances, Smart lighting.	**8**

Textbooks/ References:	
1.	Smart Grid: Integrating Renewable, Distributed and Efficient Energy by Fereidoon P. Shoshanis, Academic Press, Elsevier
2.	Smart Grid – Fundamentals of Analysis & Design by James Momoh, IEEE Press

Name of Program: M.Sc. in Energy Economics and Management Semester I
Name of Course: **Power Plants Economics** Course Code: **EN EM 1151**
Core/ Elective/other: Elective I L: T: P: Cr 3:0:0:3
Prerequisite: Basics of Thermal Engineering, Basics of Electrical Engineering

Course Assessment Methods:

Component	Maximum Marks	Remarks
Teacher's Assessment	40	[30 marks for quizzes/assignments/presentations/surprise tests + 10 marks for attendance]
Mid Semester Examination	20	The Mid Semester marks shall be awarded on the basis of the performance in Mid semester examination in offline mode.
End Semester Examination	40	On campus 2 hour written examination

Course Objective:

1. Understanding Power Generation Economics: To familiarize students with the economic principles governing the operation, maintenance, and profitability of power plants.
2. Analyzing Cost Structures: To enable students to analyze the cost structures associated with different types of power plants including coal, gas, nuclear, hydroelectric, wind, and solar.
3. Evaluating Investment Decisions: To equip students with the skills to evaluate investment decisions related to the construction, expansion, or decommissioning of power plants considering factors like capital costs, operating costs, and revenue projections.
4. Exploring Regulatory Frameworks: To provide an overview of the regulatory frameworks and policies governing the power generation sector, including incentives, subsidies, and environmental regulation.

Course Outcomes:

S.NO.	Course Outcomes
CO1:	Ability to Perform Economic Analysis: Students should be able to conduct economic analyses of power generation projects, including calculating metrics such as levelized cost of electricity (LCOE), net present value (NPV), and internal rate of return (IRR).
CO2:	Skill in Decision Making: Students should develop the skills necessary to make informed decisions regarding the selection, financing, and operation of power plants, considering both financial and non-financial factors.
CO3:	Understanding of Market Dynamics: Students should gain an understanding of the dynamics of energy markets, including supply and demand fundamentals, price formation mechanisms, and the role of regulation and policy.
CO4:	Competence in Risk Management: Students should be able to identify, assess, and mitigate risks associated with power plant investments, using techniques such as sensitivity analysis, scenario analysis, and risk hedging strategies.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	2	2
CO2	3	3	3	2	3
CO3	3	3	3	2	3
CO4	3	3	3	2	3

Course Outcomes (CO), Program Outcomes (POs) & Program Specific Outcomes (PSOs)
Enter correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High), ***If there is no correlation, "-".***

Course Content:

Module	Content	Lectures
1	Introduction and Power Generation Planning: Energy sources, their availability, recent trends in power generation, layouts of steam. Comparison and selection, Load forecasting, load curves, load duration curve, Baseload, and Peak load Power Plants, connected Load, maximum demand, demand factor, Group diversity factor, load factor, significance of load factor, plant factor, capacity factor, selection of unit size, No. of Units, cost of power generation, Depreciation, and tariff.	8
2	Conventional Energy Sources: coal-based power plants: Selection of site, capacity calculations, classification, Schematic diagram and working of Thermal Power Stations, Rankine cycle, Comparison of Rankine and Carnot vapor cycles, Regenerative cycles, Ideal working fluid for vapor power cycles, Binary vapor cycle, Thermodynamics of coupled cycles, Process heat and by-product power. Steam Generators: Classification of boilers, Description of Cochran, hydel, diesel, nuclear gas turbine power plants, and interconnected generation of power plants. Lancashire, and Babcock-Wilcox boilers, Boiler mounting and accessories, High-pressure boilers, Lamont, Benson, and Velox boilers.	8

3	Non-Conventional Energy Sources: Hydroelectric power plants – classification, Typical Layout, and associated components, including Turbines. Principle, construction, and working of wind, tide, solar photovoltaic (SPV), solar thermal, geothermal, biogas, and fuel cell power systems.	**8**
4	Relevance of financial and economic feasibility evaluation of energy technologies and systems, Basics of engineering economics, financial evaluation of energy technologies, social cost benefit analysis, Case studies on techno-economics of energy conservation and renewable energy technologies.	**8**
5	Energy demand analysis and forecasting, Energy supply assessment and evaluation, Energy demand – supply balancing, Energy models. Energy – economy interaction, Energy investment planning and project formulation. Energy pricing. Policy and planning implications of energy – environment interaction, clean development mechanism. Financing of energy systems. Energy policy related acts and regulations. Carbon credit calculations.Software for energy planning.	**8**

Textbooks/ References:	
1.	P.K.Nag, Power Plant Engineering, TMH Publication
2.	M. Kleinpeter, Energy Planning and Policy, John Wiley & sons, 1995
3.	M. S. Kumar, Energy Pricing Policies in Developing Countries: Theory and Empirical Evidence, International Labor Organization, 1987.
4.	R. Codoni, H. Park and K.V. Ramani, Integrated Energy Planning: A Manual, Vols. I, II & III. Asian and Pacific Development Centre, Kuala Lumpur, 1985.
5.	El-Wakil, Power Plant Technology, McGraw Hill Publication
6.	Loftness, Nuclear Power Plants', D. Van Nostrand Company Inc, Princeton

Name of Program: M.Sc. in Energy Economics and Management Semester I
Name of Course: **Operation Research and Management** Course code: **EN EM 1152**
Core/ Elective/other: Elective I L: T: P: Cr 3:0:0:3
Prerequisite: Advanced Mathematics, Operation Research

Course Assessment Methods:

Component	Maximum Marks	Remarks
Teacher's Assessment	40	[30 marks for quizzes/assignments/presentations/surprise tests + 10 marks for attendance]
Mid Semester Examination	20	The Mid Semester marks shall be awarded on the basis of the performance in Mid semester examination in offline mode.
End Semester Examination	40	On campus 2 hour written examination

Course Objective:

1. To introduce students to the fundamental concepts, techniques, and methodologies of operations research.
2. To teach students how to formulate real-world problems as mathematical models. To develop skills in constructing and analyzing various types of OR models, such as linear programming, integer programming, and nonlinear programming.
3. To introduce students to probabilistic models and their applications in operations research.
4. To explore various optimization techniques used in operations research, including simplex method, duality theory, sensitivity analysis, and network optimization.

Course Outcomes:

S.NO.	Course Outcomes
CO1:	Students will demonstrate a deep understanding of the fundamental concepts, principles, and methodologies of operations research.
CO2:	Students will be able to formulate real-world problems as mathematical models, selecting appropriate optimization techniques for solving them.
CO3:	Students will demonstrate proficiency in applying various optimization techniques, such as linear programming, integer programming, and network optimization, to solve complex problems in management.
CO4:	Students will be able to develop and analyze probabilistic models and use simulation techniques to model and analyze complex systems under uncertainty.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5
CO1	**3**	**2**	**2**	**2**	**2**
CO2	**3**	**3**	**3**	**2**	**3**
CO3	**3**	**3**	**3**	**2**	**3**
CO4	**3**	**3**	**3**	**2**	**3**

Course Outcomes (CO), Program Outcomes (POs) & Program Specific Outcomes (PSOs)
Enter correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High), ***If there is no correlation, "-".***

Course Content:

Module	Content	Lectures
1	Introduction to Operations Research, Introduction, Historical Background, Scope of Operations Research, Features of Operations Research, Phases of Operations Research, Types of Operations Research Models, Operations Research Methodology, Operations Research Techniques and Tools	**8**
2	Linear Programming: Introduction, Linear Programming Problem, Requirements of LPP, Mathematical Formulation of LPP, Case Studies of LPP, Applications, Advantages, Limitations	**8**
3	Graphical Analysis of Linear Programming Problems: Introduction, Graphical Analysis, Graphical Methods to Solve LPP, Some Exceptional Cases, Important Geometric Properties of LPP	**8**
4	Transportation Problem: Introduction, Formulation of Transportation Problem (TP), Transportation Algorithm (MODI Method), the Initial Basic Feasible Solution, Moving Towards Optimality Finite Queuing Models: Introduction, Finite Queuing Models, Degeneracy.	**8**
5	Assignment Problem: Introduction, Mathematical Formulation of the Problem, Hungarian Method Algorithm, Routing Problem, Travelling Salesman Problem Project Scheduling Network Analysis, PERT-CPM: Introduction, Basic Difference between PERT and CPM, PERT/CPM Network Components and Precedence Relationship, Project Management – PERT.	**8**

Textbooks/ References:	
1.	Operation Research by Sharma, Gupta Chawla
2.	Operation Research by H.A Taha

Name of Program: M.Sc. in Energy Economics and Management Semester I
Name of Course: **Energy Efficiency in Electrical Utilities** Course Code: **EN EM 1153**
Core/ Elective/other: Elective I L: T: P: Cr 3:0:0:3
Prerequisite: Basic Electrical Engineering, Basic Mechanical Engineering

Course Assessment Methods:

Component	Maximum Marks	Remarks
Teacher's Assessment	40	[30 marks for quizzes/assignments/presentations/surprise tests + 10 marks for attendance]
Mid Semester Examination	20	The Mid Semester marks shall be awarded on the basis of the performance in Mid semester examination in offline mode.
End Semester Examination	40	On campus 2 hour written examination

Course Objective:

1. To explore the economic and environmental benefits of energy efficiency measures.
2. To develop skills in analyzing energy consumption patterns in various electrical utilities.
3. To train students in conducting energy audits and assessments in electrical utilities.
4. To understand the implementation of energy efficiency measures in different types of electrical systems and components.

Course Outcomes:

S.NO.	Course Outcomes
CO1:	Perform energy audits to evaluate the energy performance of electrical systems.
CO2:	Apply various tools and techniques to enhance energy efficiency in electrical utilities.
CO3:	Analyze energy consumption data and recommend appropriate energy efficiency solutions.
CO4:	Describe the key regulations, standards, and policies related to energy efficiency

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5
CO1	**3**	**2**	**2**	**2**	**2**
CO2	**3**	**3**	**3**	**2**	**3**
CO3	**3**	**3**	**3**	**2**	**3**
CO4	**3**	**3**	**3**	**2**	**3**

Course Outcomes (CO), Program Outcomes (POs) & Program Specific Outcomes (PSOs)
Enter correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High), ***If there is no correlation, "-".***

Course Content:

Module	Content	Lectures
1	Introduction to Electrical system Electricity billing, Electrical load management andmaximum demand control, Power factor improvement and its benefit.	**8**
2	Electric motors: Types, Losses in induction motors, Motor efficiency, Factors affecting motor performance, Energy saving opportunities with energy efficientmotors.	**8**
3	HVAC and Refrigeration System, Fans and blowers, Pumps and Pumping System.	**8**
4	Lighting System: Light source, Choice of lighting, Luminance requirements, andEnergy conservation avenues.	**8**
5	Diesel Generating system: Factors affecting selection, Energy performance assessment of diesel conservation avenues.	**8**

Textbooks/ References/URLs:	
1.	Guide Book 3.Energy Efficiency in Electrical Utilities, Fourth Edition, by Bureau of Energy Efficiency(BEE) Learning materials
2.	Energy Efficiency, 1st Edition by **F Sioshansi**

Name of Program: M.Sc. in Energy Economics and Management | Semester I
Name of Course: **Alternative Fuels** | Course Code: **EN EM 1154**
Core/ Elective/other: Elective I | L: T: P: Cr 3:0:0:3

Course Assessment Methods:

Component	Maximum Marks	Remarks
Teacher's Assessment	40	[30 marks for quizzes/assignments/presentations/surprise tests + 10 marks for attendance]
Mid Semester Examination	20	The Mid Semester marks shall be awarded on the basis of the performance in Mid semester examination in offline mode.
End Semester Examination	40	On campus 2 hour written examination

Course Objective:

1. Understanding Alternative Fuels: Provide students with a comprehensive understanding of various alternative fuels used in transportation and energy sectors.
2. Analyzing Environmental Impact: Analyze the environmental impact of alternative fuels compared to conventional fossil fuels, including greenhouse gas emissions, air quality, and sustainability.
3. Exploring Production Technologies: Explore the technologies and processes involved in the production, refinement, and distribution of alternative fuels such as biodiesel, ethanol, hydrogen, and others.
4. Evaluating Economic Viability: Evaluate the economic viability and market potential of alternative fuels, considering factors such as production costs, infrastructure requirements, and government policies.

Course Outcomes:

S.NO.	Course Outcomes
CO1:	Identify Various Alternative Fuels: Students will be able to identify and describe various alternative fuels such as biodiesel, ethanol, natural gas, hydrogen, and electricity, along with their sources and production methods.
CO2:	Analyze Environmental Impacts: Students will be able to analyze and compare the environmental impacts of alternative fuels, including their potential to mitigate climate change, reduce air pollution, and conserve natural resources.
CO3:	Evaluate Technological Advancements: Students will be able to evaluate recent technological advancements and innovations in the production, storage, and utilization of alternative fuels and energy systems.
CO4:	Develop Sustainability Strategies: Students will be able to develop strategies for promoting the sustainable use of alternative fuels, including the integration of renewable energy sources and the development of efficient transportation systems.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	2	2
CO2	3	3	3	2	3
CO3	3	3	3	2	3
CO4	3	3	3	2	3

Course Outcomes (CO), Program Outcomes (POs) & Program Specific Outcomes (PSOs)
Enter correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High), ***If there is no correlation, "-".***

Course Content:

Module	Content	Lectures
1	Need for Alternative Fuels: Energy security, Climate change and greenhouse gas emissions, Sustainable development.	**8**
2	Biofuels: Biofuels Overview, Types of biofuels: first, second, and third generation. Feedstocks for biofuel production. Biodiesel: Production processes (transesterification). Properties and Standards. Applications and benefits. Bioethanol: Fermentation process. Properties and standards. Applications and benefits. Biogas: Anaerobic digestion process. Properties and standards. Applications and benefits.	**8**
3	Hydrogen as a Fuel, Hydrogen Production, Methods: electrolysis, steam methane reforming, and biomass gasification. Renewable vs. non-renewable hydrogen. Hydrogen Storage and Distribution: Storage technologies: compressed gas, liquid hydrogen, and metal hydrides. Transportation and infrastructure challenges. Applications of Hydrogen: Hydrogen fuel cells. Hydrogen in internal combustion engines, Industrial applications.	**8**
4	Natural Gas and Synthetic Fuels, Compressed Natural Gas (CNG) and Liquefied Natural Gas (LNG), Production and distribution. Properties and standards. Applications in transportation and industry. Synthetic Fuels (Synfuels), Fischer-Tropsch synthesis. Coal-to-liquid (CTL) and gas-to-liquid (GTL) technologies. Properties and applications. Other Alternative Fuels, Algae-based Fuels, Production and potential. Challenges and future prospects. Other Emerging Fuels Methanol, butanol, and dimethyl ether (DME). Production processes and applications.	**8**
5	Technical Challenges and Future Trends, Technical Challenges Integration with existing infrastructure. Technological barriers and solutions. Future Trends, Innovations and research in alternative fuels. Future outlook and potential advancements.	**8**

Textbooks/ References:	
1.	"Alternative Fuels: The Future of Hydrogen" by Michael Frank Hordeski
2.	"Alternative Fuels and Advanced Vehicle Technologies for Improved Environmental Performance" edited by Richard Folkson
3.	"Biofuels Engineering Process Technology" by Caye M. Drapcho, Nghiem Phu Nhuan, and Terry H. Walker

Name of Program: M.Sc. in Energy Economics and Management Semester II
Name of Course: **Energy Efficiency in Thermal Utilities** Course Code: **EN EM 1251**
Core/ Elective/other: Elective II L: T: P: Cr 3:0:0:3
Prerequisite: Renewable Energy Sources, Thermal Engineering

Course Assessment Methods:

Component	Maximum Marks	Remarks
Teacher's Assessment	40	[30 marks for quizzes/assignments/presentations/surprise tests + 10 marks for attendance]
Mid Semester Examination	20	The Mid Semester marks shall be awarded on the basis of the performance in Mid semester examination in offline mode.
End Semester Examination	40	On campus 2 hour written examination

Course objective:

1. Develop a thorough understanding of basic energy concepts, including energy forms, energy conversion, and the importance of energy efficiency.
2. Gain knowledge on energy auditing techniques, procedures, and the role of energy management in enhancing energy efficiency in thermal utilities.
3. Learn about the different types of thermal energy systems, their operation, and how they can be optimized for better energy performa.
4. Study various techniques and technologies available for improving the efficiency of thermal utilities, including heat recovery systems, insulation, and advanced control strategies.

Course Outcomes:

S.NO.	Course Outcomes
CO1:	Effectively conduct energy audits in thermal systems, identifying key areas where energy savings can be realized, and suggesting appropriate measures to improve efficiency.
CO2:	Demonstrate the ability to optimize thermal energy systems, implementing best practices and utilizing advanced technologies to enhance energy performance.
CO3:	Apply the fundamental principles of energy efficiency in the context of thermal utilities, demonstrating a clear understanding of energy forms, conversion processes, and efficiency metrics.
CO4:	Perform economic evaluations of energy efficiency projects, calculating potential savings, payback periods, and justifying investments based on financial analysis

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	2	2
CO2	3	3	3	2	3
CO3	3	3	3	2	3
CO4	3	3	3	2	3

Course Outcomes (CO), Program Outcomes (POs) & Program Specific Outcomes (PSOs)
Enter correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High), ***If there is no correlation, "-".***

Course Content:

Module	Content	Lectures
1	Introduction to Fuels, Properties of Fuel oil, Coal and Gas, Storage, handling and preparation of fuels.	8
2	Principles of Combustion, Combustion of Oil, Coal, and Gas; Boilers: Types, Combustion in boilers, Performances evaluation of thermal devices.	8
3	Analysis of losses, Feed water treatment, Blow down, Energy conservation opportunities. Steam System; Furnaces: Classification.	8
4	General fuel economy, Safety measures in furnaces, Excess air, Heat distribution, Temperature control, Draft control.	8
5	Waste heat recovery. Insulation and Refractories; Mechanism of fluidized bed combustion boilers.	8

Textbooks/ References:	
1.	Energy Efficiency in Thermal Utilities by Bureau of Energy Efficiency India
2.	Energy Performance Assessment for Equipment and Utility Systems By Bureau of Energy Efficiency India

Name of Program: M.Sc. in Energy Economics and Management Semester II
Name of Course: **Life Cycle Analysis of Energy Systems** Course Code: **EN EM 1252**
Core/ Elective/other: Elective II L: T: P: Cr 3:0:0:3
Prerequisite:

Course Assessment Methods:

Component	Maximum Marks	Remarks
Teacher's Assessment	40	[30 marks for quizzes/assignments/presentations/surprise tests + 10 marks for attendance]
Mid Semester Examination	20	The Mid Semester marks shall be awarded on the basis of the performance in Mid semester examination in offline mode.
End Semester Examination	40	On campus 2 hour written examination

Course Objective:

1. To provide a comprehensive overview of different energy systems, including fossil fuels, renewable energy sources, nuclear energy, and emerging technologies.
2. To teach students the methodology of conducting life cycle analysis, including goal and scope definition, inventory analysis, impact assessment, and interpretation.
3. To develop skills in collecting and analyzing data for LCA, including the identification and quantification of inputs and outputs across the life cycle stages of energy systems
4. To explore various impact assessment methods used in LCA, such as global warming potential, acidification potential, eutrophication potential, and human toxicity.
5. To familiarize students with LCA software tools and databases, such as GaBi, SimaPro, and Eco invent, and develop practical skills in using these tools for LCA studies.

Course Outcome:

S.NO.	Course Outcomes
CO1:	Students will demonstrate a thorough understanding of the fundamental principles, methodologies, and frameworks of life cycle analysis (LCA) and its application to energy systems.
CO2:	Students will be proficient in applying various LCA methodologies, including inventory analysis, impact assessment, and interpretation, to evaluate the environmental impacts of different energy systems.
CO3:	Students will develop skills in collecting, managing, and analyzing data required for conducting LCA studies, including the use of databases and software tools specific to LCA.
CO4:	Students will be able to conduct comprehensive life cycle inventories for energy systems, identifying and quantifying all relevant inputs and outputs across different stages of the life cycle.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	2	2
CO2	3	3	3	2	3
CO3	3	3	3	2	3
CO4	3	3	3	2	3

Course Outcomes (CO), Program Outcomes (POs) & Program Specific Outcomes (PSOs)
Enter correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High), ***If there is no correlation, "-".***

Course Content:

Module	Content	Lectures
1	Overview of LCA: Definition and purpose, History and development of LCA , Key principles and concepts in LCA, ISO standards for LCA (ISO 14040 and ISO 14044), Goal and scope definition, Functional unit and system boundaries.	**8**
2	Data collection and quality assessment, Inventory data for energy systems , Energy and material flow analysis,	**8**
3	Life Cycle Impact Assessment (LCIA), Impact categories and indicators , Classification, characterization, normalization, and weighting, Interpretation of LCIA results.	**8**
4	LCA of Fossil Fuel Energy Systems: Cradle-to-grave analysis of coal, oil, and natural gas, Environmental impacts of extraction, processing, and combustion Case studies and examples LCA of Renewable Energy Systems: LCA of solar energy: Photovoltaic and thermal LCA of wind energy, CA of biomass and bioenergy systems.	**8**
5	LCA of Nuclear Energy: Environmental impacts of uranium mining, fuel production, and waste disposal, Comparative LCA of nuclear and other energy systems Case studies and examples LCA of Emerging Energy Technologies: Life cycle assessment of hydrogen energy systems LCA of energy storage technologies (batteries, pumped hydro) Case studies of innovative energy solutions.	**8**

S.No.	Textbooks/ References:
1.	"Life Cycle Assessment Handbook: A Guide for Environmentally Sustainable Products" by Mary Ann Curran.
2.	"Life Cycle Assessment: Theory and Practice" by Michael Z. Hauschild, Ralph K. Rosenbaum, and Stig Irving Olsen.
3.	"Life Cycle Assessment of Energy Systems: From Methodology to Applications" by Nicholas Sakellariou.

Name of Program: M.Sc. in Energy Economics and Management Semester II
Name of Course: **International Trade and Business in Energy** Course Code: **HS EM 1253**
Core/ Elective/other: Elective II L: T: P: Cr 3:0:0:3
Prerequisite:

Course Assessment Methods:

Component	Maximum Marks	Remarks
Teacher's Assessment	40	[30 marks for quizzes/assignments/presentations/surprise tests + 10 marks for attendance]
Mid Semester Examination	20	The Mid Semester marks shall be awarded on the basis of the performance in Mid semester examination in offline mode.
End Semester Examination	40	On campus 2 hour written examination

Course Objective:

1. To introduce students to the structure and dynamics of global energy markets.
2. To explain the principles and practices of international trade as they apply to the energy sector.
3. To explore the economic theories and principles related to energy production, consumption, and trade.
4. Regulatory and Policy Environments, to assess the geopolitical factors influencing global energy markets and trade.

Course Outcomes:

S.NO.	Course Outcomes
CO1:	Comprehensive Understanding of Global Energy Markets, Knowledge of International Trade Principles.
CO2:	Economic Analysis of Energy Markets, Awareness of Regulatory and Policy Frameworks.
CO3:	Geopolitical Insight, Strategic Business Acumen in Energy.
CO4:	Sustainability and Environmental Awareness , Understanding of Global Energy Security

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	2	2
CO2	3	3	3	2	3
CO3	3	3	3	2	3
CO4	3	3	3	2	3

Course Outcomes (CO), Program Outcomes (POs) & Program Specific Outcomes (PSOs)
Enter correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High), ***If there is no correlation, "-".***

Course Content:

Module	Content	Lectures
1.	Global Scenario of Energy: Energy consumption in various sectors and its changing patterns. The future energy security and market behavior, Global demand and supply outlook, Energy needs and demand of developing countries. Energy and climate nexus, Climate commitments and energy implications.	**8**
2.	Challenges for International Trade in Energy: Unequal distribution of energy resources, Issues related to restrictive practices of energy exporting countries; Energy dual pricing policies, Period of high oil prices; 1973-85 and post COVID, Increasing Global Competition, Import Dependence.	**8**
3.	Models of the Oil Market: Competitive Models: Property Rights Model (Nationalization), Supply Shocks Model, Target Revenue Model. Non-Competitive Models: OPEC Cartel, Oligopoly Model. Market for coal and issues around coal important export. International trading and market around gas. Energy security related challenges around gas.	**8**
4.	International Business Environment- Global Trade; Foreign Direct Investment; National and Regional Competitiveness; Regional Economic Integration; Global Growth Generators (Emerging economies); Intellectual property rights.	**8**
5.	Trade in oil, gas and electricity; Challenges in Trade in oil, gas and electricity: Infrastructure and construction of transportation pipe lines, Transmission grid. Global initiatives taken around renewable energy such as OSOG, ISA and other initiatives, WTO and energy and climate change related issues. Climate change commitments and energy issues in global declarations such as carbon trading (voluntary and mandatory),energy, climate change and SDGs etc.	**8**

Textbooks/ References:	
1.	Andre Mornier (2008):"Setting the Rules of Energy Trade" In Fundamentals of the Global Oil and Gas Industry. London: Petroleum Economists.
2.	Adelman, M. A. (1982) "OPEC as a Cartel." in J. M. Griffin and D.J. Teece, OPEC Behavior and World Oil Prices, London: George Allen & Unwin.
3.	Adelman, M. A. (1986) "Scarcity and World Oil Prices." Review of Economics and Statistics.
4.	Baldwin N.and Prosser R. (1988): "World Oil MarketSimulation." InSterner T., International Energy Economics. Chapman & Hall.

Name of Program: M.Sc. in Energy Economics and Management | Semester II
Name of Course: **Hybrid Renewable Energy Management** | Course Code: **EN EM 1254**
Core/ Elective/other: Elective II | L: T: P: Cr 3:0:0:3

Course Assessment Methods:

Component	Maximum Marks	Remarks
Teacher's Assessment	40	[30 marks for quizzes/assignments/presentations/surprise tests + 10 marks for attendance]
Mid Semester Examination	20	The Mid Semester marks shall be awarded on the basis of the performance in Mid semester examination in offline mode.
End Semester Examination	40	On campus 2 hour written examination

Course Objectives:

1. Introduce the principles, components, and configurations of hybrid renewable energy systems and assess their role in sustainable energy development.
2. Analyse the performance and integration of solar PV and wind systems, including MPPT techniques, policy frameworks, and economic drivers.
3. Evaluate various energy storage technologies and battery management systems in hybrid configurations with a focus on lifecycle and reliability.
4. To develop skills in techno-economic analysis, system optimization, and software-based modelling of hybrid energy systems through real-world case studies.

Course Outcomes:

S.NO.	Course Outcomes
CO1:	Understand the configurations, components, and operational principles of hybrid renewable energy systems and evaluate their technical and economic feasibility.
CO2:	Analyze the performance of solar PV and wind energy systems, including MPPT techniques and government policies, to assess their integration in hybrid setups.
CO3:	Evaluate the role and selection of various energy storage technologies in hybrid systems with an emphasis on battery management and lifecycle analysis.
CO4:	Perform techno-economic analysis and system optimization of hybrid energy systems using software tools and real-world case studies.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	2	2
CO2	3	3	3	2	3
CO3	3	3	3	2	3
CO4	3	3	3	2	3

Course Outcomes (CO), Program Outcomes (POs) & Program Specific Outcomes (PSOs)
Enter correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High), ***If there is no correlation, "-".***

Course Content:

Module	Content	Lectures
1	Introduction to Hybrid Renewable Energy Systems: Definition and significance of Integrated renewable energy systems, Components and configurations of hybrid systems, Advantages and challenges of hybrid systems.	**8**
2	Solar PV systems: configurations, components, and performance analysis. Case studies: utility-scale and rooftop solar economics. Wind energy conversion systems (WECS): types, characteristics, and power extraction, Maximum power point tracking (MPPT) techniques for solar and wind, Government incentives, tariff structures, and subsidy mechanisms.	**8**
3	Role of energy storage in hybrid systems, types of storage: battery, flywheel, supercapacitor, hydrogen, thermal, and pumped hydro. Battery management systems and lifecycle analysis.	**8**
4	Hybrid system topologies: Solar-Wind, Solar-Diesel, PV-Battery. System sizing, component selection, and techno-economic analysis, Case studies on hybrid systems in rural and urban applications.	**8**
5	Economic analysis of hybrid energy systems, including design concept optimization, software tools overview, and case study evaluation.	**8**

Textbooks/ References:	
1.	"Hybrid Renewable Energy Systems: Modeling, Simulation, and Optimization" by Umakanta Sahoo.
2.	"Handbook of Renewable Energy Technology" by Ahmed F. Zobaa and Ramesh C. Bansal.
3.	"Renewable Energy Systems: Integration and Optimization" by Henrik Lund

Name of Program: M.Sc. in Energy Economics and Management Semester II
Name of Course: **Research Methodology** Course Code: **EN EM 1255** Core/ Elective/other: Elective II
L: T: P: Cr 3:0:0:3

Course Assessment Methods:

Component	Maximum Marks	Remarks
Teacher's Assessment	40	[30 marks for quizzes/assignments/presentations/surprise tests + 10 marks for attendance]
Mid Semester Examination	20	The Mid Semester marks shall be awarded on the basis of the performance in Mid semester examination in offline mode.
End Semester Examination	40	On campus 2 hour written examination

Course Objective:

1. To introduce students to the fundamental concepts and principles of research.
2. To guide students in designing a research study, including selecting appropriate research methods and tools.
3. To provide knowledge on various data collection methods (surveys, interviews, experiments, observations).
4. To introduce students to statistical and non-statistical methods of data analysis.

Course Outcomes:

S.NO.	Course Outcomes
CO1:	Comprehensive Understanding of Research Principles
CO2:	Ability to Design Research Studies, Proficiency in Literature Review.
CO3:	Mastery of Data Collection Techniques, Data Analysis Skills.
CO4:	Ethical Research Conduct, Application of Research to Real-World Problems.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	2	2
CO2	3	3	3	2	3
CO3	3	3	3	2	3
CO4	3	3	3	2	3

Course Outcomes (CO), Program Outcomes (POs) & Program Specific Outcomes (PSOs)
Enter correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High), ***If there is no correlation, "-"***

Course content:

Module	Content	Lectures
1	Meaning of Research; Objectives, Motivation and Types of Research; Research Approaches; Significance of Research; Research Methods versus Methodology; Research Process; Criteria of Good Research	**8**
2	Meaning of Research Design; Need for Research Design; Features of a Good Design; Important Concepts Relating to Research Design; Different types of Research Designs**.**	**8**
3	Measurement in Research; Measurement Scales; Sources of Error in Measurement; scaling and types- Collection of Primary Data; Observation Method; Interview Method; Collection of Data through Questionnaires; Collection of Data through Schedules; Difference between Questionnaires and Schedules; Some Other Methods of Data Collection	**8**
4	Research Writing Methods and Processes – This module introduces key academic writing formats such as research papers, review papers, book chapters, conference papers, and presentations. It focuses on their structure, purpose, and writing process, including planning, referencing, and peer review.	**8**
5	Population and sample; Objects of Sampling; Methods of Sampling-Random and Non-Random; Techniques of sampling under each method ; Sampling error and non-sampling error; Sampling distribution of a Statistic.	**8**

Textbooks/ References:	
1.	Kothri, C.R., and Garg, Gaurav (2020): Research methodology, New Age international Publishers .
2.	Welman, Chris and Kruger, Fanie (2002): Research Methodology for the Business and Administrative Sciences, Oxford Publishers .

Name of Program: M.Sc. in Energy Economics and Management — Semester III
Name of Course: **Climate Change and Carbon Sequestration** — Course Code: **EN EM 2151**
Core/ Elective/other: Elective III — L: T: P: Cr 3:0:0:3
Prerequisite:

Course Assessment Methods:

Component	Maximum Marks	Remarks
Teacher's Assessment	40	[30 marks for quizzes/assignments/presentations/surprise tests + 10 marks for attendance]
Mid Semester Examination	20	The Mid Semester marks shall be awarded on the basis of the performance in Mid semester examination in offline mode.
End Semester Examination	40	On campus 2 hour written examination

Course Objectives:

1. Develop a foundational understanding of the causes and effects of climate change.
2. Educate students on the mechanisms and techniques of carbon sequestration.
3. Explore the policies and technologies aimed at reducing greenhouse gas emissions.
4. Equip students with the knowledge to assess and implement climate mitigation strategies.

Course Outcomes:

S.NO.	Course Outcomes
CO1:	Understand Climate Science: Explain the scientific basis of climate change, including the greenhouse effect, carbon cycle, and climate modeling.
CO2:	Identify Impacts: Describe the environmental, social, and economic impacts of climate change at global, regional, and local levels.
CO3:	Analyze Mitigation Strategies: Evaluate various climate change mitigation strategies, including renewable energy, energy efficiency, and carbon sequestration.
CO4:	Implement Carbon Sequestration Techniques: Apply knowledge of biological, geological, and technological carbon sequestration methods.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	2	2
CO2	3	3	3	2	3
CO3	3	3	3	2	3
CO4	3	3	3	2	3

Course Outcomes (CO), Program Outcomes (POs) & Program Specific Outcomes (PSOs)
Enter correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High), ***If there is no correlation, "-".***

Course Content :

Module	Content	Lectures
1	Climate Science and Modeling, The carbon cycle, Climate feedback mechanisms, Climate models and projections, Uncertainty in climate predictions. Impacts of Climate Change: Physical impacts: sea-level rise, extreme weather events, and temperature changes, Ecological impacts: biodiversity loss, ecosystem changes, Socio-economic impacts: agriculture, health, migration, and economic costs.	**8**
2	Climate Change Mitigation: Overview of mitigation strategies, Renewable energy technologies (solar, wind, hydro, geothermal), Energy efficiency and conservation, Role of policy and international agreements (Paris Agreement, Kyoto Protocol, COP[1—26]).	**8**
3	Carbon Sequestration Techniques: Definition and importance of carbon sequestration, Biological methods: afforestation, reforestation, soil carbon sequestration, Geological methods: carbon capture and storage (CCS), enhanced oil recovery (EOR), Technological methods: direct air capture, bioenergy with carbon capture and storage (BECCS).	**8**
4	Biological Carbon Sequestration, Forest carbon sequestration, Soil carbon management, Ocean fertilization, Blue carbon (coastal ecosystems).	**8**
5	Introduction to air quality management • Introduction to Air Pollution: • Meteorology and Air Pollution: • Air Quality Assessment and Monitoring: • Control of Air Pollution: • Indoor Air Quality Management:	**8**

Textbooks/ References:	
1.	"Carbon Sequestration in Forest Ecosystems" by Klaus Lorenz and Rattan Lal
2.	"Introduction to Modern Climate Change" by Andrew E. Dessler
3.	"Climate Change: A Very Short Introduction" by Mark Maslin
4.	Vashi, D., Vashi, P. D., Shah, D. V., & Kurmi, K. B. Air pollution and its control measures. 2. Textbook. de Nevers, N., “Air Pollution Control Engineering,” McGraw-Hill, Inc., 2000.

Name of Program: M.Sc. in Energy Economics and Management Semester III
Name of Course: **Modelling & Simulation of Energy Systems** Course Code: **EN EM 2152**
Core/ Elective/other: Elective III L: T: P: Cr 3:0:0:3
Prerequisite: Industrial Engineering, Knowledge of Matlab and basic softwares.

Course Assessment Methods:

Component	Maximum Marks	Remarks
Teacher's Assessment	40	[30 marks for quizzes/assignments/presentations/surprise tests + 10 marks for attendance]
Mid Semester Examination	20	The Mid Semester marks shall be awarded on the basis of the performance in Mid semester examination in offline mode.
End Semester Examination	40	On campus 2 hour written examination

Course Objective:

1. Understanding Energy Systems: Gain a comprehensive understanding of various energy systems, including fossil fuel-based, renewable, and hybrid systems.
2. Modelling Principles: Learn the fundamental principles of mathematical modelling as applied to energy systems, including system dynamics, thermodynamics, and fluid mechanics.
3. Simulation Techniques: Acquire skills in simulating energy systems using appropriate software tools and techniques, including discrete event simulation, agent-based modelling, and system dynamics simulation.
4. Optimization Techniques: Explore optimization techniques applicable to energy systems, including linear programming, genetic algorithms, and stochastic optimization.

Course Outcomes:

S.NO.	Course Outcomes
CO1:	Students will be able to develop mathematical models of energy systems, considering various components such as energy sources, converters, storage systems, and consumers.
CO2:	Students will gain proficiency in simulating energy systems using appropriate software tools, accurately representing system behavior and dynamics.
CO3:	Students will be able to analyze energy data to identify patterns, trends, and anomalies, supporting the modelling and simulation process.
CO4:	Students will understand and apply optimization techniques to improve the performance and efficiency of energy systems, considering factors such as cost, emissions, and reliability.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	2	2
CO2	3	3	3	2	3
CO3	3	3	3	2	3
CO4	3	3	3	2	3

Course Outcomes (CO), Program Outcomes (POs) & Program Specific Outcomes (PSOs)
Enter correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High), ***If there is no correlation, "-".***

Course Content

Module	Content	Lectures
1	Energy Models. Surveys, Steady-State Computer Models Dynamic Models: advantages and disadvantages.	8
2	Interdependence of energy-economy-environment; Modeling concept, and application.	8
3	Network analysis: PERT, CPM, Gannt Chart. Quantitative methods.	8
4	Basic concept of econometrics and statistical analysis, Two variable regression model, The multiple regression model, Tests of regression coefficients and regression equation, Forecasting Techniques: Moving Average, Method of Least Squares, Parabolic trend, Exponential trend, Seasonal Index Analysis of Variance: ANOVA (one way & two way). usage of MATLAB.	8
5	Econometric techniques used for energy analysis with case studies. Input-output analysis, Energy multiplier and implication of energy multiplier for analysis of regional and national energy policy.	8

Textbooks/ References:	
1.	Energy Planning and Economics by A.V. Desai.
2.	Energy Policy Analysis and Modeling by Munasinghe M. and P. Meier.

Name of Program: M.Sc. in Energy Economics and Management Semester III
Name of Course: **Green Finance and Fintech for Energy Systems** Course Code: **MG EM 2153**
Core/ Elective/other: Elective III L: T: P: Cr 3:0:0:3

Course Assessment Methods:

Component	Maximum Marks	Remarks
Teacher's Assessment	40	[30 marks for quizzes/assignments/presentations/surprise tests + 10 marks for attendance]
Mid Semester Examination	20	The Mid Semester marks shall be awarded on the basis of the performance in Mid semester examination in offline mode.
End Semester Examination	40	On campus 2 hour written examination

Course Objective:

1. To understand the structure and evolution of environmental finance. Equip students with knowledge of traditional vs. alternative investments and the environmental finance value chain, including ESG factors and climate-related financial risks.
2. Explore financial instruments used in climate risk mitigation, provide insight into green bonds, their issuers and investors, performance tracking, and hedging mechanisms like insurance, weather derivatives, and catastrophe bonds.
3. To examine sustainable finance practices and green investment models. Introduce sustainable project financing, microfinance institutions, carbon markets, and the role of SMEs in sustainable investing.
4. Analyze the impact of FinTech on the financial and energy sectors.

Course Outcomes:

S.NO.	Course Outcomes
CO1:	Understand Environmental Finance and Investment Frameworks. Explain traditional and alternative investments in environmental finance, including the value chain and ESG issues impacting financial decisions.
CO2:	Analyze Climate Finance Instruments and Risk Mitigation Tools. Evaluate green bonds, their issuance, standardization, and climate risk hedging mechanisms like insurance, weather derivatives, and catastrophe bonds.
CO3:	Apply Sustainable Finance Principles and Investment Strategies. Assess sustainable investment approaches, including microfinance, carbon markets, green project financing, and the role of SMEs in sustainability.
CO4:	Evaluate the Role of FinTech in Transforming Energy Finance. Examine FinTech developments such as BankTech, InsureTech, crowdfunding, cryptocurrencies, and peer-to-peer lending, focusing on their impact on energy markets and environmental sustainability.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5
CO1	3	3	2	3	2
CO2	3	3	3	2	3
CO3	3	3	3	3	3
CO4	3	2	3	2	3

Course Outcomes (CO), Program Outcomes (POs) & Program Specific Outcomes (PSOs)
Enter correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High), ***If there is no correlation, "-".***

Course Content:

Module	Content	Lectures
1	Traditional vs. Alternative Investments in Environmental Finance. The environmental finance & investment value chain – system components. Mainstreaming environmental finance. An investors perspective on the ESG issues impacting financial value. Climate change – the ultimate environmental finance issue	8
2	Green Bonds: Tracking Green Performance. Corporate green bonds – who is issuing?. Green bonds – who is buying?. Standardization of green bonds. Green bond underwriting and auditing. Hedging climate change risk: insurance, weather derivatives, catastrophe bonds	8
3	Sustainable Finance: Introduction to Sustainable Finance . Sustainable Investment in Equities. Microfinance Institutions, Green Project Financing, Sustainable Project Financing, Investment in Carbon Market, Sustainable Investment by SMEs	8
4	FinTech Development in energy sector: Technological Revolution in Finance industry, Introduction to BankTech and InsureTech, Use cases of FinTech in banks, Main characteristics and developments in FinTech, Crowdfunding and alternative sources of financing, The influence of FinTech on financial institutions, Regulatory and corporate governance issues	8
5	Fintech role in Energy Market: Cryptocurrency markets of energy sector, Peer-to-peer lending and financial inclusivity, FinTech and environmental sustainability, Future directions of Fintech development, Fintech unicorns and business models in Energy companies	8

S.No.	Textbooks/ References:
1	Carbon Finance, Chapter 8: Adapting to Adverse and Severe Weather (Canvas)
2.	The Price on Nature (Richard Sandor): https://www.youtube.com/watch?v=rW-ovT6z5e8
3.	The Finance of Climate Change, Chapter 14: Weather Derivatives and Carbon
4.	Meyer et al., 2016. Designing A Great Lakes Shipping Derivative (Canvas)
5	Municipal bond: DC Water Authority Green Performance Bond
6	Fintech Innovation: From Robo-Advisors to Goal-Based Investing and Gamification" by Paolo Sironi

Name of Program: M.Sc. in Energy Economics and Management Semester III
Name of Course: **Design and Optimization software for Energy Systems** Course Code: **EN EM 2154**
Core/ Elective/other: Elective III L: T: P: Cr 3:0:0:3

Prerequisite:

Course Assessment Methods:

Component	Maximum Marks	Remarks
Teacher's Assessment	40	[30 marks for quizzes/assignments/presentations/surprise tests + 10 marks for attendance]
Mid Semester Examination	20	The Mid Semester marks shall be awarded on the basis of the performance in Mid semester examination in offline mode.
End Semester Examination	40	On campus 2 hour written examination

Course Objective:

1. Understanding Energy Systems: Gain a comprehensive understanding of various energy systems, including renewable and non-renewable sources, and their integration into modern energy grids.
2. Software Proficiency: Develop proficiency in using specialized software tools for designing and optimizing energy systems, including but not limited to simulation software, optimization algorithms, and data analysis tools.
3. Problem-Solving Skills: Enhance problem-solving skills by applying software tools to real-world energy system design challenges, considering factors such as efficiency, cost-effectiveness, and environmental impact.
4. Integration of Renewable Energy: Learn techniques for integrating renewable energy sources such as solar, wind, and hydroelectric power into existing energy systems, with a focus on optimization and sustainability.

Course Outcomes:

S.NO.	Course Outcomes
CO1:	Simulate and optimize Solar PV systems using PVsyst and MATLAB-based modeling.
CO2:	Perform techno-economic analysis and hybrid system optimization using HOMER.
CO3:	Design and analyze wind energy projects using WAsP and WindFarmer software.
CO4:	Develop dynamic energy models for buildings using EnergyPlus, DesignBuilder, and Climate Consultant.

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	2	2
CO2	3	3	3	2	3
CO3	3	3	3	2	3
CO4	3	3	3	2	3

Course Outcomes (CO), Program Outcomes (POs) & Program Specific Outcomes (PSOs)
Enter correlation levels 1, 2 or 3 as defined below:
1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High), ***If there is no correlation, "-".***

Course Content:

Module	Content	Lectures
1	**Solar Photovoltaic System Design Software:** PVsyst, MATLAB.Photovoltaic module characteristics, system sizing, and yield analysis, Database management, shading analysis, and inverter selection in PVsyst, Performance modelling of PV systems and I–V curve generation in MATLAB, Simulation of Maximum Power Point Tracking (MPPT) algorithms, Sensitivity analysis for orientation, tilt angle, and system losses.	8
2	**Hybrid System Optimization and Energy Planning Software:** HOMER(HOMER Pro / HOMER Grid)Principles of hybrid energy systems incorporating PV, wind, diesel, and battery storage, Input of resource data and selection of optimization variables, Cost modelling, sensitivity analysis, and interpretation of optimization outputs, Design considerations for off-grid and grid-connected systems, Economic feasibility evaluation using NPC, COE, IRR, and payback metrics	8
3	**Wind Resource Assessment and Farm Design Software:** WAsP, WindFarmer Wind data analysis and Weibull distribution, WAsP for micro-siting, roughness mapping, and wake effect analysis, WindFarmer for large-scale wind farm design and optimization, Layout optimization for minimum wake losses and maximum energy yield, Case Study: 50 MW wind farm design.	8
4	**Building Energy Simulation and Management Software:** Energy Plus, Design Builder, Climate Consultant. Fundamentals of building energy simulation, Interpretation of weather data (EPW files), Modeling of HVAC systems, lighting, and occupancy schedules, Simulation workflows in Energy Plus and interpretation of outputs, Thermal load calculations through Design Builder interface, Application of Climate Consultant for passive design and climate-responsive strategies, **Case Study:** Optimization of annual energy consumption in a commercial building	8
5	**Advanced Simulation and Structural Analysis Software:** ANSYS, TRNSYS, MATLAB (Optimization & CFD) Computational Fluid Dynamics (CFD) analysis in ANSYS, Thermal simulation of photovoltaic modules and storage systems in TRNSYS, Application of optimization techniques (e.g., PSO, GA) in MATLAB for design refinement, Integration of simulation outputs for enhanced decision-making	8

S.No.	Textbooks/ References:
1.	"Energy Systems Engineering: Evaluation and Implementation" by Francis Vanek, Louis Albright, and Largus T. Angenent .
2.	"Renewable and Efficient Electric Power Systems" by Gilbert M. Masters.
3.	"Optimization of Energy Systems" by Ibrahim Dincer and Marc A. Rosen
4.	TRNSYS 18: A Transient System Simulation Program" by Thermal Energy System Specialists (TESS)
5.	"EnergyPlus Engineering Reference: The Reference to EnergyPlus Calculations" by the U.S. Department of Energy

THE END