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COURSE CODE	CATEGORY	COURSE NAME	TEACHING &EVALUATION SCHEME								
			THEORY			PRACTICAL		L	T	P	CREDITS
			END SEM University Exam	Two Term Exam	Teachers Assessment*	END SEM University Exam	Teachers Assessment*				
MTRE121	**DSE**	**Optimization Techniques**	60	20	20	0	0	3	0	0	3

Legends: **L** - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; **C** - Credit;
***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

Course Educational Objectives (CEOs):
To prepare the students to have knowledge of different types of optimization techniques and to identify tools of optimization in engineering applications.

Course Outcomes (COs):
Upon completion of this course students will be able to:

1. Demonstrate constraint and unconstraint optimization.
2. Identify various optimization problems.
3. Solve various optimization problems.
4. Apply optimization in operation research.

Syllabus

UNIT I **6 Hrs.**
Unconstrained Optimization: Introduction, Optimizing Single-Variable Functions, conditions for Local Minimum and Maximum, Optimizing Multi-Variable Functions

UNIT II **8 Hrs.**
Constrained Optimization: Optimizing Multivariable Functions with Equality Constraint: Direct Search Method, Lagrange Multipliers Method, Constrained Multivariable Optimization with inequality constrained: Kuhn-Tucker Necessary conditions, Kuhn –Tucker Sufficient Conditions.

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MTRE121	**DSE**	**Optimization Techniques**	60	20	20	0	0	3	0	0	3

Legends: **L** - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; **C** - Credit;
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UNIT III **9 Hrs.**

Optimization: Quasi-Newton Methods and line search, least squares optimization, Gauss-Newton, Levenberg- Marquartd, Extensions of LP to Mixed Integer Linear Programming (MILP), Non-Liner Programming, The Newton Algorithm, Non-Linear Least Squares, Sequential Quadratics Programming (SQP), Constrained Optimization, SQP Implementation, Multi-Objective Optimization, Branch and Bound Approaches, Genetic Algorithms and Genetic Programming, Singular Based Optimization, On-Line Real-Time Optimization.

UNIT IV **9 Hrs.**

Optimization and Functions of a Complex Variable and Numerical Analysis: The Finite Difference Method for Poisson's Equation in two Dimensions and for the Transient Heat Equation, Eulers Method, The Modified Euler Method and the Runga-Kutta Method for Ordinary Differential Equations, Gaussian QuardativeTranzoidal Rule and Simpson"s 1/3 and 3/8 Rules, the Newton Raphson in one and two Dimensions, Jacobi"s Iteration Method.

UNIT V **8 Hrs.**

Optimization in Operation Research: Dynamic Programming, Transportation – Linear Optimization Simplex and Hitchcock Algorithms, Discrete Simulation, Integer Programming – Cutting Plane Methods, Separable Programming, Stochastic Programming, Goal Programming, Integer Linear Programming, Pure and Mixed Strategy in theory of Games, Transshipment Problems, Heuristic Methods.

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			END SEM University Exam	Two Term Exam	Teachers Assessment*	END SEM University Exam	Teachers Assessment*				
MTRE121	DSE	Optimization Techniques	60	20	20	0	0	3	0	0	3

Legends: **L** - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; **C** - Credit;
***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

Textbooks:

1. S.S. Rao, Optimization: Theory and Applications, New Age International P. Ltd.
2. Ravindren Philips and Solberg, Operation Research Principles and Practice (Second Edition) John Wiley & Sons.

References:

1. G.L. Nemhauser and L.A. Wolsey: Integer and Combinational Optimization, Wiley.
2. R.G. Parker and R.L. Rardin: Discrete Optimization, Academic Press.

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MTRE122	DSE	Energy Storage System	60	20	20	0	0	3	0	0	3

Legends: **L** - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; **C** - Credit;
***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

Course Educational Objectives (CEOs):
Coverage of energy storage techniques involving electrochemical, mechanical, and emerging options. Integration of the energy storage media, its effects on the bulk power system, and design trade-offs to understand environmental impacts, cost, reliabilities, and efficiencies for commercialization of bulk energy storage.

Course Outcomes (COs):
Upon completion of this course students will be able to:
1. Compare and contrast methods of energy storage management in terms of cost, size, weight, reliability, efficiency, and lifetimes.
2. Describe the energy storage need of the smart grid, both present and future.
3. Define the advantages and disadvantages of storage integration in various energy distribution systems, e.g., facility/home, substation, generation facility.
4. Summarize the impact of energy storage in an electric power system on power quality, power reliability and overall system efficiency.

Syllabus

UNIT I **9 Hrs.**
Energy Storage Need of energy storage, Different modes of Energy Storage. Potential energy: Pumped hydro storage; KE and Compressed gas system: Flywheel storage, compressed air energy storage; Electrical and magnetic energy storage: Capacitors, electromagnets; Chemical Energy storage: Thermo-chemical, photo-chemical, bio-chemical, electro-chemical, fossil fuels and synthetic fuels. Hydrogen for energy storage. Solar Ponds for energy storage.

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MTRE122	DSE	Energy Storage System	60	20	20	0	0	3	0	0	3

Legends: **L** - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; **C** - Credit;
***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

UNIT II **7 Hrs.**
Electrochemical Energy Storage Systems Batteries: Primary, Secondary, Lithium, Solid-state and molten solvent batteries; Lead acid batteries; Nickel Cadmium Batteries; Advanced Batteries. Role of carbon nanotubes in electrodes.

UNIT III **8 Hrs.**
Magnetic and Electric Energy Storage Systems Superconducting Magnet Energy Storage(SMES) systems; Capacitor and Batteries: Comparison and application; Super capacitor: Electrochemical Double Layer Capacitor (EDLC), principle of working, structure, performance and application, role of activated carbon and carbon nanotube.

UNIT IV **7 Hrs.**
Sensible Heat Storage SHS mediums; Stratified storage systems; Rock-bed storage systems; Thermal storage in buildings; Earth storage; Energy storage in aquifers; Heat storage in SHS systems; Aquifers storage.

UNIT V **9 Hrs.**
Latent Heat Thermal Energy Storage Phase Change Materials (PCMs); Selection criteria of PCMs; Stefan problem; Solar thermal LHTES systems; Energy conservation through LHTES systems; LHTES systems in refrigeration and air-conditioning systems; Enthalpy formulation; Numerical heat transfer in melting and freezing process. Some Areas of Application of Energy Storage Food preservation; Waste heat recovery; Solar energy storage; Greenhouse heating; Power plant applications; Drying and heating for process industries.

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MTRE122	DSE	Energy Storage System	60	20	20	0	0	3	0	0	3

Legends: **L** - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; **C** - Credit;
***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

Textbooks:

1. H.P.Garg et al, D Reidel (1885)"Solar Thermal Energy Storage", Publishing Co.
2. V Alexiades&A.D.Solomon(1993) "Mathematical Modeling of Melting and Freezing Proces" , Hemisphere Publishing Corporation,
3. WashingtonNarayan R, Viswanath B(1998), Chemical and Electro Chemical Energy System, Universities Press

References:

1. Ter-Gazarian(1994), "Energy Storage for Power Systems", Peter Peregrinus Ltd.London
2. B.Kilkis and S.Kakac (1989),"Energy Storage Systems",(Ed),KAP,London,1989

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MTRE123	DSE	Waste Management and Energy Generation Technologies	60	20	20	0	0	3	0	0	3

Legends: **L** - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; **C** - Credit;
***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

Course Educational Objectives (CEOs):
To prepare the students to have a basic knowledge of waste management and energy generation technologies. To prepare the students to have a basic knowledge of Waste minimization and recycling of Municipal Waste.

Course Outcomes (COs):
Upon completion of this course students will be able to:

1. Understand the environmental monitoring System for Land Fill Gases.
2. Understand and analyse environmental effects due to Incineration.
3. Demonstrate Sources and Nature of Hazardous Waste.
1. Understand Industrial Applications of Gasifiers

Syllabus

UNIT I **9 Hrs.**
Sources, Types, Compositions, Properties Physical, Chemical and Biological -Collection - Transfer Stations - Waste minimization and recycling of Municipal Waste.

UNIT II **8 Hrs.**
Size Reduction - Aerobic Composting - Incineration for Medical /Pharmaceutical Waste - Environmental Impacts -Environmental Effects due to Incineration.

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			THEORY			PRACTICAL		L	T	P	CREDITS
			END SEM University Exam	Two Term Exam	Teachers Assessment*	END SEM University Exam	Teachers Assessment*				
MTRE123	**DSE**	**Waste Management and Energy Generation Technologies**	60	20	20	0	0	3	0	0	3

Legends: **L** - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; **C** - Credit;
***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

UNIT III **9 Hrs.**

Land Fill Method - Types, Methods & Siting Consideration - Composition, Characteristics, generation, Control of Landfill Leachate & Gases –Environmental monitoring System for Land Fill Gases.

UNIT IV **8 Hrs.**

Sources and Nature of Hazardous Waste - Impact on Environment - Hazardous Waste - Disposal of Hazardous Waste, Underground Storage Tanks Construction, Installation & Closure.

UNIT V **9 Hrs.**

Biochemical Conversion - Industrial , Agro Residues - Anaerobic Digestion -Biogas Production - Types of Biogas Plant-Thermo-chemical Conversion -Gasification - Types - Briquetting - Industrial Applications of Gasifiers -Environment Benefits.

References:

1. Parker, Colin, & Roberts, Energy from Waste - An Evaluation of Conversion Technologies, Elsevier Applied Science, London, 1985.
2. Shah, Kanti L., Basics of Solid & Hazardous Waste Management Technology, Printice Hall, 2000.

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MTRE221	DSE	Life Cycle Assessment of Renewable Energy Systems	60	20	20	0	0	3	0	0	3

Legends: L - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; **C** - Credit;
***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

Course Educational Objectives (CEOs):
Governments are setting challenging targets to increase the production of energy and transport fuel from sustainable sources. The emphasis is increasingly on renewable sources including wind, solar, geothermal, biomass-based biofuel, photovoltaics, or energy recovery from waste

Course Outcomes (COs):
Upon completion of this course students will be able to:
1. Financial evaluation.
2. Study of energy analysis methodologies.
3. Environmental analysis.
4. Data quality of embodied energy.

Syllabus

UNIT I **8 Hrs.**
Financial evaluation: simple pay back analysis, return on investment, time-based value of money, NPV method, annuity method, calculation of IRR.

UNIT II **7 Hrs.**
Energy analysis: concept of embodied energy, energy analysis methodologies: process chain analysis.

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MTRE221	**DSE**	**Life Cycle Assessment of Renewable Energy Systems**	60	20	20	0	0	3	0	0	3

Legends: L - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; **C** - Credit;
***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

UNIT III **8 Hrs.**

Input-output method, inventory method; cumulative energy demand, energy yield ratio, energy payback.

UNIT IV **9 Hrs.**

Environmental analysis: concept of carbon footprint of materials and systems, cumulative emission for renewable energy systems, environmental indicators of RE systems.

UNIT V **8 Hrs.**

Data quality of embodied energy, and specific emission of materials.

References:

1. Life Cycle Analysis of Renewable Energy Systems ISBN 978-1-4471-5363-Authors Eduardo Martínez, Emilio Jiménez, Julio Blanco, Mercedes Pérez. Designing Renewable Energy Systems: A Life Cycle Assessment Approach, Leda Gerber, December 23, 2014 by EPFL Press Reference - 224 Pages - 160 B/W Illustrations ISBN 9781498711272 - CAT# N11224.
2. Life Cycle Analysis of Renewable Energy Systems Due: July 7, 2020, ISBN 978-1-4471-6247-6, Authors: Martínez, E., Jiménez, E., Blanco, J., Pérez, M.

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MTRE222	DSE	Industrial and Commercial Applications of Renewable Energy Sources	60	20	20	0	0	3	0	0	3

Legends: **L** - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; **C** - Credit;
***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

Course Educational Objectives (CEOs):
There is vast potential of usage of renewable energy in industries and commercial sector. With the study of this course one can quantify the energy saved and carbon dioxide mitigation impact. Related latest technologies and economics of renewable energies would also be studied.

Course Outcomes (COs):
Upon completion of this course students will be able to

1. Evaluation of commercial and industrial energy demand.
2. Study of different energy systems for heating.
3. Use of renewable in commercial and industrial buildings.
4. Economics of renewable energy based commercial and industrial installations.

Syllabus

UNIT I **8 Hrs.**
Commercial and industrial energy demand; Qualitative and quantitative features and characteristics, Renewables & electricity for a growing economy

UNIT II **7 Hrs.**
Water heating, process heating and drying applications, Solar, Biomass, and geothermal energy-based systems.

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MTRE222	DSE	Industrial and Commercial Applications of Renewable Energy Sources	60	20	20	0	0	3	0	0	3

Legends: **L** - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; **C** - Credit;
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UNIT III **9 Hrs.**

Combined space and building service hot water systems, Electricity generation from renewable to meet commercial and industrial power requirement, stand alone and grid connected systems, Ethanol, and methanol from cellulosic biomass

UNIT IV **8 Hrs.**

Use of renewable in commercial and industrial buildings for load levelling, lighting and space heating and cooling.

UNIT V **9 Hrs.**

Economics of renewable energy based commercial and industrial installations case studies, Thermal low and medium energy requirements of different industries

References:

1. J. D. Myers, Solar Applications in Industry and Commerce, Prentice-Hall, 1st edition, 1984.
2. A. V. Da Rosa, Fundamentals of Renewable Energy Processes, Academic Press, 2nd edition, 2009.

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MTRE223	**DSE**	**Energy Policy and Planning**	60	20	20	0	0	3	0	0	3

Legends: **L** - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; **C** - Credit;
***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

Course Educational Objectives (CEOs):
This course provides a framework for understanding the subject energy policy and planning, and for acting. First, we want students to understand the strategic role that policies play in the formation of energy systems. Secondly, we want to increase awareness among energy professionals about how encompassing the challenges are that they have to face as they enter professional life.

Course Outcomes (COs):
Upon completion of this course students will be able to:

1. Understand how energy policy is designed and implemented
1. Identify policy processes.
2. Identify the role of different stakeholders.
3. Understand how energy policy instruments affect energy system investment decisions and public behaviour.

Syllabus

UNIT I **9 Hrs.**
Energy and Environment Basic Issues: Criteria for Economic Growth; Energy-Economy Environment Linkages; Emissions Inventories: Assessment and Policy Relevance.

UNIT II **7 Hrs.**
Issues for Developing Countries: Energy and Environment Policies from Urban and Rural perspectives.

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MTRE223	DSE	Energy Policy and Planning	60	20	20	0	0	3	0	0	3

Legends: **L** - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; **C** - Credit;
***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

UNIT III **8 Hrs.**
Analysis Methodologies: Scenarios and Models, Global and Local Environmental Issues

UNIT IV **7 Hrs.**
Climate Change Negotiations Technological Options.

UNIT V **9 Hrs.**
Energy-Efficiency and New Energy Technologies; Renewable Energy: Issues, Prospects and Policies.

References:

1. Energy Sources & Policies in India by Rishi Muni Dwivedi.
2. Energy Economic by Parag Diwan.
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