Central University of Haryana

(‘A’ Grade, NAAC Accredited)

DEPARTMENT OF ELECTRICAL ENGINEERING (DEE)

NEP 2020/LOCF/OBE/NBA CURRICULUM (2021 -2022)

Program Name: M. Tech. - Energy System and Management

NEP 2020/LOCF/OBE/NBA CURRICULUM (2021 -2022)

Program Name: M. Tech. - Energy System and Management

- **Background**
- **Vision and Mission**
- **Programme Educational Objectives (PEOs):**
- **Program Specific Outcomes (PSO's)**
- **Program Outcomes (PO)**
- **Semester-wise courses and credit distribution**
- **Course Level Learning outcome**

NEP 2020/LOCF/OBE/NBA CURRICULUM (2021 -2022)

Program Name: M. Tech. - Energy System and Management

Background

Considering the curricular reforms as instrumental for desired learning outcomes, all the academic departments of Central University of Haryana made a rigorous attempt to revise the curriculum of undergraduate and postgraduate programmes in alignment with National Education Policy-2020 and UGC Quality Mandate for Higher Education Institutions-2021. The process of revising the curriculum could be prompted with the adoption of "Comprehensive Roadmap for Implementation of NEP-2020" in 32nd meeting of the Academic Council of the University held on April 23, 2021. The Roadmap identified the key features of the Policy and elucidated the Action Plan with well-defined responsibilities and indicative timeline for major academic reforms.

The process of revamping the curriculum started with the series of webinars and discussions conducted by the University to orient the teachers about the key features of the Policy, enabling them to revise the curriculum in sync with the Policy. Proper orientation of the faculty about the vision and provisions of NEP-2020 made it easier for them to appreciate and incorporate the vital aspects of the Policy in the revised curriculum focused on 'creating holistic, thoughtful, creative and well-rounded individuals equipped with the key 21st century skills' for the 'development of an enlightened, socially conscious, knowledgeable, and skilled nation'.

With NEP-2020 in background, the revised curricula articulate the spirit of the policy by emphasising upon— integrated approach to learning; innovative pedagogies and assessment strategies; multidisciplinary and cross-disciplinary education; creative and critical thinking; ethical and Constitutional values through value-based courses; 21st century capabilities across the range of disciplines through life skills, entrepreneurial and professional skills; community and constructive public engagement; social, moral and environmental awareness; Organic Living and Global Citizenship Education (GCED); holistic, inquiry-based, discovery-based, discussion-based, and analysis-based learning; exposure to Indian knowledge system, cultural traditions and classical literature through relevant courses offering 'Knowledge of India'; fine blend of modern pedagogies with indigenous and traditional ways of learning; flexibility in course choices; student-centric participatory learning; imaginative and flexible curricular structures to enable creative combination of disciplines for study; offering multiple entry and exit points initially in undergraduate programmes; alignment of Vocational courses with the International Standard Classification of Occupations maintained by the International Labour Organization; breaking the silos of disciplines; integration of extra-curricular and curricular aspects; exploring internships with local industry, businesses, artists and crafts persons; closer collaborations between industry and higher education institutions for technical , vocational and science programmes; and formative assessment tools to be aligned with the learning outcomes, capabilities, and dispositions as specified for each course. In case of UG/PG programmes in Engineering and Vocational Studies, it was decided that the departments shall incorporate pertinent NEP recommendations while complying with AICTE, NBA, NSQF, International Standard Classification of Occupations, Sector Skill Council and other relevant agencies/sources. The University has also developed consensus on adoption of Blended Learning with 40% component of online teaching and 60% face to face classes for each programme.

The revised curricula of various programmes could be devised with concerted efforts of the faculty, Heads of the Departments and Deans of Schools of Study. The draft prepared by each department was discussed in series of discussion sessions conducted at Department, School and the University level. The leadership of the University has been a driving force behind the entire exercise of developing the uniform template and structure for the revised curriculum. The Vice Chancellor of the University conducted series of meetings with Heads and Deans to deliberate upon the vital parameters of the revised curriculum to formulate a uniform template featuring Background, Programme Outcomes, Programme Specific Outcomes, Postgraduate Attributes, Structure of Masters Course, Learning Outcome Index, Semester-wise Courses and Credit Distribution, Course-level Learning Outcomes, Teaching-Learning Process, Blended Learning, Assessment and Evaluation, Keywords, References and Appendices. The experts of various Boards of Studies and School Boards contributed to a large extent in giving the final shape to the revised curriculum of each programme.

To ensure the implementation of curricular reforms envisioned in NEP-2020, the University has decided to implement various provisions in a phased manner. Accordingly, the curriculum may be reviewed annually.

Program Name: M. Tech. - Energy System and Management

Vision and Mission

UNIVERSITY VISION

To develop enlightened citizenship of a knowledge society for peace and prosperity of individuals, nation and the world, through promotion of innovation, creative endeavours, and scholarly inquiry.

UNIVERSITY MISSION

To serve as a beacon of change, through multi-disciplinary learning, for creation of knowledge community, by building a strong character and nurturing a value-based transparent work ethics, promoting creative and critical thinking for holistic development and self-sustenance for the people of India. The University seeks to achieve this objective by cultivating an environment of excellence in teaching, research and innovation in pure and applied areas of learning.

DEPARTMENT VISION AND MISSION

VISION

- To strive incessantly for excellence towards education and research in electrical technologies by nurturing and contributing to state of art perspectives useful to industry and society.

MISSION

- **M1:** To prepare the students for fundamentals in Electrical, Electronics and computational technology.
- **M2:** To prepare the foundation for undertaking the research for systems involving emerging field of Electrical Engineering.
- **M3:** To prepare the professional skill for undertaking consultancy assignments for solving Industrial & Non- industrial problems.
- **M4:** To prepare dynamic entrepreneurial resources, useful for the society.

Mapping of University Vision and Mission to Department Vision and Mission

University Vision and Mission	Department Vision and Mission
High quality knowledge society creation for peace and prosperity of individuals, nation and the world, through and scholarly inquiry	**Yes**
Promotion of innovation, creative endeavours, research and development	**Yes**
Students excellence through multi-disciplinary learning, value-based transparent work ethics, creative and critical thinking	**Yes**
Environment of excellence in teaching, research and innovation in pure and applied areas of learning	**Yes**

Program Name: M. Tech.- Energy System and Management

Programme Educational Objectives (PEOs):

The Department of Electrical Engineering in consultation with various stakeholders have formulated the Programme Educational Objectives (PEO's) that are broad statements that describe the career and professional accomplishments that the program is preparing its graduates to achieve in few years, subsequent to receiving the degree. The PEO's of the M. Tech. programme in Energy System and Management are as follows:

- **PEO1:** To impart knowledge on various recent developments in the energy sector, with a prime focus on non-conventional energy sources, including resource management and assessment.
- **PEO2:** To develop the Graduates into effective collaborators/innovators in efforts to address social, technical and engineering challenges being faced by Energy and Management sector
- **PEO3:** To prepare Graduates for innovative and independent research work in academia/industry to develop and maintain energy systems and processes and to deploy the wisdom.
- **PEO4:** To prepare Graduates to exhibit a high level of professionalism, integrity, environmental and social responsibility, and life-long independent learning ability.

Program Specific Outcomes (PSO's):

- PSO1 Basic Science: The ability to remember and understand the basic concept of electrical and electronic engineering, computer programming, design and analyze different electrical network and basics of physics, chemistry and knowledge of mathematics.
- PSO2 Core Competence: The proficiency to understand, evaluate and analyze the design concepts of electrical circuits and remember fundamentals and designing concept of electrical machines, power system, power electronics, control system and electrical drives, analog electronics and other electrical core subjects.
- PSO3 Interdisciplinary Skills: The ability to design and solve problems in the field of Interdisciplinary subjects by applying the knowledge acquired from communication system, DBMS, artificial intelligence, renewable energy system, & other allied topics.
- PSO4 Successful Career and Entrepreneurship: The skills to develop, adopt, assess the latest innovative industry best practices and to analyze, comprehend the young mindsets accordingly in their attitude for higher studies, research and to possess successful path as young entrepreneur.

PEOs to Mission statement mapping

PEO's	MISSION OF THE DEPARTMENT			
	M1	M2	M3	M4
PEO1	3	3	1	
PEO2	2	3	2	
PEO3	2	2	3	
PEO4	2	2	2	3

Program Name: M. Tech.- Energy System and Management

Program Outcomes - M.Tech (Energy System and Management)

The course would enable the students to

PO1: Resource assessment and mapping, energy planning and implementation techniques including basics of various energy systems and devices with specialization in one of the areas/subareas of various renewable energy technologies,

PO2: Understand the contemporary developments and evolve innovative methods/techniques to address the challenges being faced/anticipated to be faced to bring the research and developments into actual use,

PO3: Conduct independent experimental and numerical research, as well as to organize, analyze and present data to produce meaningful conclusions.

PO4: Understand professional, legal and ethical issues and responsibilities.

PO5: Address the environmental issues arose due to conventional energy based economy and to address them with renewable energy for sustainable development.

PO6: Acquire skills to share ideas through technical reports, presentations and journal publications.

PO7: Learn the project planning and development, project management techniques including financial and economic analysis

PO8: Understand the need for, and an ability to engage in life-long learning and continual updating of professional skills.

PO9: Work as a team member with leadership skills.

PO10: Understand and take active part understanding, formulation and implementation of Govt policies and suggest modification / up gradation time to time.

Mapping of PEO's with PO's

S. No.	*Program Educational Objectives*	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PSO1	PSO2	PSO3	PSO4
1	To build a strong foundation in the students in Mathematics, Science and Engineering fundamentals so as to enable them apply the same to analyze, design, innovate and develop products for real life applications	√	√	√	√	√	√	√	√	√	√	√	√	√	√
2	To foster and imbibe values and ethics, positive attitude, effective communication skills, leadership qualities and team spirit for a rewarding personal and professional career with a deep commitment and concern for the society.	√	√	√	√	√	√	√	√	√	√	√	√	√	√
3	To provide a holistic academic environment befitting research, academic excellence, entrepreneurship and desire for creating new knowledge so as to become industry and professionally ready to meet global challenges			√	√		√	√	√	√		√	√	√	√

M.Tech. (Energy System and Management) Semester – I
Choice Based Credit System Scheme of Studies w.e.f. 2021-22

Sl. No.	Course Code	Course Title	Teaching Schedule			Credits
			L	T	P	
Core Courses (Compulsory)						
1	MTESM-101	Energy conservation and management	3	1	0	4
2	MTESM-102	Introduction to Renewable Energy Systems	3	1	0	4
3		Program Elective - 1	3	1	0	4
4		Program Elective - 2	3	1	0	4
5	MTEMS-111	Energy laboratory -1	0	0	4	2
6	MTEMS-112	Specialization specific Current Topic Presentation -1	0	2	0	2
7		**General Elective or Open Elective-1**	3	1	0	4
8	MTEMS-113	Social & Extra Activity	0	0	2	1
9		Audit-I/MOOC	-	-	-	-
List of Program Electives (Any two electives to be chosen)						
10	MTESM-103	Energy Storage Systems for Electric Vehicles				
11	MTEMS-104	Bio Fuels & Bio Energy				
12	MTEMS-105	Renewable Energy Generation and Control				
13	MTEMS-106	Operation of Restructured Power System Protection				
14	MTEMS-107	Advanced Power System Analysis				
15	MTEMS-108	Digital Signal Processing				
16	MTEMS-109	Reactive Power Control and FACTS Devices				
17	MTESM-110	Advanced Control System				
Total			**15**	**07**	**06**	**25**

L= Lecture, T = Tutorial, P = Practical, & C = Credits

Central University of Haryana, Mahendergarh
M.Tech. (Energy System and Management) Semester – II
Choice Based Credit System Scheme of Studies w.e.f. 2021-22

Sl. No.	Course Code	Course Title	Teaching Schedule			Credits
			L	T	P	
Core Courses (Compulsory)						
1	MTESM-201	Management of Rural Energy System	3	1	0	4
2	MTESM-202	Solar Thermal Technologies & Application	3	1	0	4
3		Program Elective – 2	3	1	0	4
4		Program Elective – 3	3	1	0	4
5	MTEMS-211	Energy laboratory -2	0	0	4	2
6	MTESM-212	Specialization specific Current Topic Presentation -2	0	2	0	2
7		**General Elective or Open Elective-2**	3	1	0	4
8		Audit-II/MOOC	-	-	-	-
List of Program Electives (Any two electives to be chosen)						
8	MTESM-203	Electric Drive System				
9	MTESM-204	Power Quality				
10	MTESM-205	Smart Grids				
11	MTESM-206	Wind and Small Hydro Energy Systems				
12	MTESM-207	Electric and Hybrid Vehicles				
13	MTESM-208	Industrial Load Modelling and Control				
14	MTESM-209	Engineering Optimization				
15	MTESM-210	Nonlinear and Digital Control Systems				
Total			**15**	**07**	**04**	**24**

L= Lecture, T = Tutorial, P = Practical, & C = Credits

LIST OF AUDIT/MOOC COURSES 1 & 2

S. No.	Subject Code	Subject Title	Credits
1	MT AU 101	English for Research Paper Writing	0
2	MT AU 102	Disaster Management	0
3	MT AU 103	Sanskrit for Technical Knowledge	0
4	MT AU 104	Value Education	0
5	MT AU 105	Constitution of India	0
6	MT AU 106	Pedagogy Studies	0
7	MT AU 107	Stress Management by Yoga	0
8	MT AU 108	Personality Development through Life Enlightenment Skills	0

Central University of Haryana, Mahendergarh
M.Tech. (Energy System and Management) Semester – III
Choice Based Credit System Scheme of Studies w.e.f. 2021-22

Sl. No.	Course Code	Course Title	Teaching Schedule			Credits
			L	T	P	
1		Program Elective – 4	3	1	0	4
2		Open Elective-3/MOOCs	3	1	0	4
3	MTESM-305	M.Tech Dissertation-I: Group A/ Group B	-	-	-	10
4	MTESM-306	Specialization specific Current Topic Presentation -3	0	2	0	2
Elective Courses (Program Elective - 4)						
5	MTESM-301	Energy Auditing And Management				
6	MTESM-302	Waste to Energy Conversion				
7	MTESM-303	Economics and Financing of Renewable Energy Systems				
8	MTESM-304	Life Cycle Assessment of Renewable Systems				
Total			**06**	**04**	**0**	**20**

L= Lecture, T = Tutorial, P = Practical, & C = Credits

Group A= Research Based Projects, **Group B=** Industrial Based Projects/ Training
General Elective or Open Elective = Offer by other departments, MOOCs= relevant to Branch

Central University of Haryana, Mahendergarh
M.Tech. (Energy System and Management) Semester – IV
Choice Based Credit System Scheme of Studies w.e.f. 2021-22

Sl. No.	Course Code	Course Title	Teaching Schedule			Credits
			L	T	P	
1	MTESM-400	M.Tech Dissertation-II	-	-	-	30
Total			**-**	**-**	**-**	**30**

L= Lecture, T = Tutorial, P = Practical, & C = Credits

GRAND TOTAL CREDITS = 99

MTESM-101 ENERGY CONSERVATION AND MANAGEMENT
Semester - I

L	T	P	Credits		
3	1	0	4	Class works Marks:	30
				Exam Marks:	70
				Total Marks:	100
				Duration of Examination:	3 Hrs

Course Outcomes:
At the end of this course students will demonstrate the ability to

1. Understand the concept of energy scenario
2. Understand the theory of tariff and thermal management in electrical system.
3. Understand the basic concepts of energy audit& management.
4. Analyze energy saving opportunities.

UNIT I

Energy scenario:
Commercial and Non-commercial energy, primary energy resources, commercial energy production, final energy consumption, energy needs of growing economy, long term energy scenario, energy pricing, energy sector reforms, energy and environment, energy security, energy conservation and its importance, restructuring of the energy supply sector, energy strategy for the future, air pollution, climate change. Energy Conservation Act-2001 and its features.

UNIT II

Basics of Energy and its various forms:
Electricity tariff, load management and maximum demand control, power factor improvement, selection & location of capacitors, Thermal Basics-fuels, thermal energy contents of fuel, temperature & pressure, heat capacity, sensible and latent heat, evaporation, condensation, steam, moist air and humidity & heat transfer, units and conversion.

UNIT III

Energy Management & Audit:
Definition, energy audit, need, types of energy audit. Energy management (audit)approach understanding energy costs, bench marking, energy performance, matching energy use to requirement, maximizing system efficiencies, optimizing the input energy requirements, fuel & energy substitution, energy audit instruments.

UNIT IV

Energy Efficiency in Electrical Systems:
Electrical system: Electricity billing, electrical load management and maximum demand control, power factor improvement and its benefit, selection and location of capacitors, performance assessment of PF capacitors, distribution and transformer losses. Electric motors: Types, losses in induction motors, motor efficiency, factors affecting motor performance, rewinding and motor replacement issues, energy saving opportunities with energy efficient motors.

UNIT V

Energy Efficiency in Industrial Systems:

Pumps and Pumping System: Types, performance evaluation, efficient system operation, flow control strategies and energy conservation opportunities. Cooling Tower: Types and performance evaluation, efficient system operation, flow control strategies and energy saving opportunities, assessment of cooling towers.

UNIT VI

Energy Efficient Technologies in Electrical Systems:

Maximum demand controllers, automatic power factor controllers, energy efficient motors, soft starters with energy saver, variable speed drives, energy efficient transformers, electronic ballast, occupancy sensors, energy efficient lighting controls, energy saving potential of each technology.

TEXT BOOKS:

1. "Optimizing Energy Efficiencies in Industry", G. G. Rajan, Tata McGraw Hill.
2. Energy Auditing and Conservation; Methods, Measurements, Management and Case Study"", Hemisphere Publishers.
3. "Industrial Energy Conservation", Charles M. Gottschalk, John Wiley and Sons.

REFERENCE BOOKS:

1. “Utilization of Electrical Energy and Conservation”, S. C. Tripathy, McGraw Hill, 1991.
2. “Success stories of Energy Conservation by BEE”, New Delhi (www.bee-india.org).
3. “Guide books for National Certification Examination for Energy Manager / Energy Auditors Book-1”, General Aspects (available online)
4. “Guide books for National Certification Examination for Energy Manager / Energy Auditors Book-3”, Electrical Utilities (available online).

MTEMS-102 INTRODUCTION TO RENEWABLE ENERGY SYSTEMS
Semester - I

L	T	P	Credits		
3	1	0	4	**Class works Marks:**	**30**
				Exam Marks:	**70**
				Total Marks:	**100**
				Duration of Examination:	**3 Hrs**

Course Outcomes:
At the end of this course students will demonstrate the ability to
1. To provide knowledge of solar energy concept and applications.
2. To impart knowledge of geothermal, ocean and tidal energy and their applications.
3. To understand the design of wind mills and applications.
4. To understand the turbines and generators for small scale hydroelectric generation.
5. To understand the important parts of a biogas plant, design and principle of bio-diesel.

UNIT I

Need of sources of renewable energy: Introduction to different sources of renewable energy, e.g., Solar Energy, Wind Energy, Bio-mass, Geothermal Energy, Ocean energy, Solar Energy and Applications.

Basic concepts of radiations: Solar radiation, Direct and Indirect radiation, Radiation measuring instrument, applications etc.

Solar Energy: Basics of solar thermal applications both low and high temperature ranges such as water heating, air heating, steam generation, desalination of water, crop drying and power generation, Principle of photovoltaics including introduction to various components of a photovoltaic systems for standalone/hybrid/grid connected systems

UNIT II

Wind Energy: Wind Resource assessment including instrumentation used in resource assessment, basic theory of wind, wind power generators both for decentralized applications and grid connected systems, performance characteristics, Augmentation of wind power, Betz criteria

Bioenergy: Types and availability of biomass resources, various methods of biomass utilisation for energy generation: gasification, briquette, palatization, syn-gas, Anaerobic/Aerobic digestion, ethanol and biodiesel production, types of Bio-gas digesters, Combustion characteristics of biogas and its different utilizations,

UNIT III

Geothermal Energy: availability and methods of utilisation of geothermal resource for thermal applications and electricity generation

Hydro Energy: Basic principle of hydroelectric power generation, classification of hydropower projects (pico, micro, mini, small hydro sand large hydro projects), types of hydro turbine, various components of hydropower projects.

Ocean Energy: Principles utilization, thermodynamic cycles, tidal and wave energy, potential and conversion technique, Principle of ocean thermal energy conversion system.

UNIT IV

Fuel Cells and Hydrogen Energy: Introduction, principle of fuel cells, thermodynamic analysis of fuel cells, types of fuel cells, fuel cell batteries, applications of fuel cells. Hydrogen as a renewable energy source, sources of hydrogen, fuel for vehicles, hydrogen production- direct electrolysis of water, thermal decomposition of water, biological and biochemical methods of hydrogen production.

Text/References:

1. Duffie, J. A., & Beckman, W. A. (2013). Solar engineering of thermal processes, fourth edition, Wiley.
2. Tiwari, G. N., & Ghosal, M. K. (2007). Fundamentals of renewable energy sources. Alpha Science International Limited.
3. Mukherjee, D., & Chakrabarti, S. (2004). Fundamentals of renewable energy systems. New Age International.
4. Sukhatme, S. P. (2005). Solar Energy Principles of Thermal Collection and storage Tata McGraw Hill Publishing Company Ltd. New Delhi.
5. Kothari, D. P., Singal, K. C., & Ranjan, R. (2011). Renewable energy sources and emerging technologies. PHI Learning Pvt. Ltd.

MTEMS-103 ENERGY STORAGE SYSTEMS FOR ELECTRIC VEHICLES

Semester - I

L	T	P	Credits	
3	1	0	4	Class-work Marks: 40
				Exam Marks: 60
				Total Marks : 100
				Duration of Examination: 3 Hrs

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. To provide knowledge of energy storage system concept and applications.
2. To understand the design of Electric Vehicles and applications.
3. To impart knowledge of Hybrid Electric Vehicles and different batteries and their applications

Unit 1

Introduction of Energy Storage Systems and Vehicle Dynamics

General background on alternative energy sources and sustainability, Introduction to electric-based transportation, Overview of Land-Marine-Space vehicle electrification, Description of vehicle dynamics and dynamic equations, Vehicle performance, and fuel economy characteristics, Basic concept of regenerative braking energy

Unit 2

Electric Vehicles

Electric vehicles configuration Energy and power requirements for various HEVs and EVs Vehicle performance and driving cycles

Unit 3

Hybrid Electric Vehicles

Fundamentals of hybrid electric vehicles Series hybrid electric vehicles Parallel hybrid electric vehicles Start – stop hybrids, Mild hybrids, strong and full hybrids, Extended range hybrid vehicles, and full electric vehicles (BEV)

Unit 4

Energy Storage Systems Batteries

Supercapacitors, Fuel Cells and Hydrogen Storage, Battery Recycling Technologies, Battery Applications for Stationary and Secondary Use, Battery Chargers and Battery Testing Procedures, Battery Management Systems (BMS), Battery Thermal Management, Regulations and Safety Aspects of High Voltage Batteries.

References:

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.
2. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
3. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.
4. Huggins R. A., Energy Storage: Fundamentals, Materials and Applications. Springer ,2015.

5. O'Hayre R., Cha S., Colella W., and Prinz F. B, Fuel Cell Fundamentals, Second Edition, Wiley, 2009.

MTESM-104 BIO FUELS AND BIO ENERGY

Semester - I

L	T	P	Credits		
3	1	0	4	**Class works Marks:**	**30**
				Exam Marks:	**70**
				Total Marks:	**100**
				Duration of Examination:	**3 Hrs**

Course Outcomes:

At the end of this course students will demonstrate the ability to

To enable students to acquire knowledge on cutting-edge technologies for conversion of various biomass feedstock to bioenergy / biofuel production and their utilization in combustion engines / devices and fuel cells. On successful completion of the course, the students would be able to contribute towards providing biomass based sustainable energy solutions.

UNIT I

Biomass resource assessment: Introduction, Classification and properties of biomass, Biomass characterization, different energy conversion methods, Bio Energy Resources, World Bio Energy

Potential, India's Bio Energy Potential, Biomass Resources and classification, Physio-chemical characteristics. Biomass Combustion, Loose biomass densification, Biomass based power generation and utilization for domestic cooking, Improved biomass cookstoves.

UNIT II

Biogas Systems: Technology of Biogas production, Biogas Plants, Digester types, Digester design, Chemical kinetics and mathematical modeling of bio methanation process, Dung, Vegetable Waste and Municipal Waste based Biogas plants, Biogas as fuel for transportation, Lighting, Running Dual Fuel Engines, Electricity generation, Biogas Bottling Plant Technology, Application of Biogas slurry in agriculture, Design of Biogas for cold climates. Case studies and numerical.

UNIT III

Biomass Gasifiers: History , Principle , Design of Bio mass Gasifiers , updraft gasifier, down draft gasifier, zero carbon biomass gasification plants, Gasification of plastic-rich waste, applications for cooking, electricity generation, Gasifier Engines, Operation of spark ignition and compression ignition engine with wood gas, methanol, ethanol and biogas, Biomass integrated gasification/combined cycles systems, gasification, pyrolysis, liquification, biomass pretreatment and processing, Case studies, biodiesel, improved biomass cookstove, biohydrogen generation, electricity generation from biomass gasifier, engine systems, bio-gasoline, bio-diesel and duel fuel engine, case studies.

UNIT IV

Biofuel: Bioethanol production from lignocelluloses, waste material, including crop residue, sugar and starch; biodiesel production from vegetable oil and animal fat, algae; biofuel derived from; economics of biofuel production; environmental impacts of biofuels; biofuel blends; green diesel from vegetable oil; biodiesel production process, by-product utilization**.** Production of butanol and propanol; Production of biohydrogen; production of hydrogen by fermentative bacteria.

Bio-refinery concept: Bio-refinery concept: definition; different types of bio-refinery; challenge and opportunities; Fuel and chemical production from saccharides, lingocellulosic biomass, protein; vegetable oil; algal biorefinery.

Text/References:

1. Mutha, V. K. (2010). Handbook of bioenergy and biofuel SBS Publishers, Delhi
2. Clark, J. H., &Deswarte, F. (Eds.). (2014). Introduction to chemicals from biomass. John Wiley & Sons.
3. Klass, D. L. (1998). Biomass for renewable energy, fuels, and chemicals. Elsevier.
4. Mukunda, H. S. (2011). Understanding clean energy and fuels from biomass. Wiley India.
5. Higman C. and Burgt M v d (2003); Gasification, Elsevier Science
6. Speight, J. (2008). Synthetic fuels handbook: properties, process and performance. McGraw-Hill
7. Dahiya, A. (Ed.). (2014). Bioenergy: Biomass to biofuels. Academic Press.
8. Hall, D. O., &Overend, R. P. (1987). Biomass: regenerable energy.
9. San Pietro, A. (Ed.). (2012). Biochemical and photosynthetic aspects of energy production. Elsevier. New York

MTESM -105 RENEWABLE ENERGY GENERATIONS AND CONTROL

Semester - I

L	T	P	Credits		
3	1	0	4	Class-work Marks	: 40
				Exam Marks	: 60
				Total Marks	: 100
				Duration of Examination	: 3 Hrs

Course Outcomes:

At the end of this course students will demonstrate the ability to

An undergraduate student taking this course will have foundation knowledge of various forms of renewable energy sources. Students will be able to learn about the solar energy and their utilization, wind energy and its applications, fuel cells, biomass, geothermal energy, MHD generation and ocean thermal energy, and hybrid renewable energy sources and technology.

UNIT 1

Introduction to energy sources: Primary and secondary energy sources, limitations to primary sources, Indian Energy Scene, Conventional and non-conventional energy sources, Prospects of renewable energy sources, MNRE and various schemes for promotion of Renewable Energy utilization.

Photo-voltaic, Fuel cells Powered generation: Distributed generation versus traditional power systems, Basic characteristics of sunlight - solar energy resource - photovoltaic cell - cell efficiency – characteristics - equivalent circuit – photo voltaic for battery charging – charge regulators – PV modules – battery backup – limitations – equipment's and systems – types of fuel cells – losses in fuel cells – solar- thermal power generation

UNIT 2

Wind Turbines and Embedded Generation: Wind Source- Wind statistics- energy in the wind- aerodynamics- rotor types- forces developed by blades- aerodynamic modelsbraking systems- tower- control and monitoring systems- power performance – wind driven induction generators – power circle diagram- steady state performance- modelling- integration issues- impact on central generation- transmission and distribution systems- wind farm.

UNIT 3

Isolated generation and Energy storage for Distributed Generation: Wind- diesel systems- fuel savings- permanent magnet alternators- modelling- steady state equivalent circuit- self excited induction generators- integrated wind- solar systems, battery energy storage, SMES, capacitor and other energy storage systems.

UNIT 4

Gas turbine powered Distributed generators and other Renewable Sources: Gas turbine types, mini and micro gas turbine generators, micro- hydel electric systems- power potential- scheme layout- generation efficiency and turbine power flow, isolated and parallel operation of generators- tidal and other sources and applications.

Text/ Reference books:

1. G.D. Rai, “Non-Conventional Energy Sources”, Khanna Publications, 1st Edition 2011
2. B.K.Khan, “Non-Conventional Energy Resources”, Tata McGraw-Hill Education. 2006
3. L.E. Ferris and D. Infield , “Renewable Energy in Power Systems”, Wiley, 1st Edition, 2008,
4. M.R. Patel, “Wind and Solar Power System, Design, Analysis and Operation”, CRC Press, 2nd Edition 2006.
5. John F. Walker & Jenkins, N., “Wind Energy Technology,” John Wiley and sons, Chichester, U.K., 1997.
6. Van Overstraeton R. J and Mertens R P., “Physics, Technology and use of photovoltaic”, AdemHilger, Bristol, 1996.

MTESM-106 OPERATION OF RESTRUCTURED POWER SYSTEM PROTECTION

Semester - I

L	T	P	Credits		
3	1	0	4	Class-work Marks	: 40
				Exam Marks	: 60
				Total Marks	: 100
				Duration of Examination	: 3 Hrs

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. To provide in-depth understanding of operation of deregulated electricity market systems.
2. To examine topical issues in electricity markets and how these are handled world-wide in various markets.
3. To train the students to analyze various types of electricity market operational and control issues under congestion management.
4. To understand the operation of ancillary
5. To learn different pricing mechanism and power trading in restructured power system.

UNIT -1

Deregulation of Electricity Supply Industries: Introduction to deregulation, different entities in deregulated electricity markets, background of deregulation around the world, benefits from competitive electricity markets, different key issues of competitive electricity markets, market Clearing Price(MCP) - Market operations: Day-ahead and Hour-Ahead Markets, Elastic and Inelastic demand, technical challenges, Power System Restructuring and electricity reforms in India, key features of electricity act 2003.

UNIT-2

Market Models: Market Models based on energy trading, contractual agreement: Pool & Bilateral models, different independent models, role of ISO, market power, Bidding and auction mechanisms, optimal power flow, economical load dispatch and unit commitment in deregulated environment, market models in Indian market context, and power trading in India.

UNIT-3

Transmission Open Access and pricing issues: Power wheeling, transmission open access, cost component in transmission pricing, basic objectives, different methods of transmission pricing, Short run and long run marginal transmission price structure, development in international transmission pricing, reactive power pricing structure, and its calculation for generator's reactive support, numerical examples, impact of FACTS devices on transmission pricing.

Transmission congestion management: Transmission congestion, impact of transmission congestion, different methods of congestion management, financial transmission right, flow gate rights, market power and congestion issues, numerical examples, international experiences of transmission congestion management, security management: spinning reserves, interruptible load options.

UNIT-4

Available transfer capability determination: Definitions, principles of ATC determination, factors affecting ATC, static and dynamic ATC, static ATC determination using DC power transfer distribution factors, AC power transfer distribution factors, ATC with line outage contingencies, LODFs with DC and AC, dynamic ATC and its determination, ATC enhancement with FACTS controllers, numerical examples.

Ancillary Services management: Description of ancillary services, types of ancillary services, ancillary service management in US, UK, Austrailia, Sweden etc., reactive power as an ancillary service and its management, AGC as an ancillary service, AGC pricing, spinning reserve, black start capability, ancillary services auction.

Text/ Reference books:

1. Lio Lee Lai, Power System restructuring and deregulation. John Wiley and Sons, UK. 2001.

2. K. Bhattacharya, MHT Bollen and J.C Doolder, Operation of Restructured Power Systems, Kluwer Academic Publishers, USA, 2001.

3. Shahidehpour, Mohammad, Hatim Yamin, and Zuyi Li. *Market operations in electric power systems: forecasting, scheduling, and risk management*. John Wiley & Sons, 2003.

4. M. Shahedehpor, ‘Restructured Electric Power Systems,: Operation, trading and volatility’, Marcel Dekker, Inc.

5. M. Ilic, ‘Power Systems Restructuring-Engineering and Economics’, Kluwer Int. Series, 2000.

6.A.J Wood and B.F Wollenberg. Power System Operation and Control, John Wiley and Sons.

7.S.A Soman, S.A Khaperde, Shubha Pandit, Computational Methods for large Sparse Power System Analysis: An Object Oriented Approach. Kluwer Academic Publishers.

8.Understanding electric utilities and de-regulation, Lorrin Philipson, H. Lee Willis, Marcel Dekker Pub., 1998.

9.Power system economics: designing markets for electricity Steven Stoft, John Wiley & Sons, 2002

MTESM-107 ADVANCED POWER SYSTEM ANALYSIS

Semester - I

L	T	P	Credits		
3	1	0	4	Class-work Marks	: 40
				Exam Marks	: 60
				Total Marks	: 100
				Duration of Examination	: 3 Hrs

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. To develop a detailed understanding of the range of analysis tools applied to the operation, design and investigation of modern electric power systems.
2. To Model and predict the operation of power system components, including three phase fault studies, stability studies and power system security.
3. To enable the students to understand the load flow techniques and monitoring of power system that causes the smooth and reliable operation of complex power system.

UNIT-1

Bus Impedance Algorithm: Partial network, building algorithm for bus impedance matrix, Addition of links, addition of branches, (considering mutual coupling) removal of links, modification of bus impedance matrix for network changes, Formation of bus admittance matrix and modification, Gauss elimination, Node elimination (Kron reduction), LU factorization, Schemes of Ordering, Sparsity, Calculation of Z bus elements for Y bus, Numerical examples

UNIT-2

Balanced and unbalanced network elements: Representation of three phase network elements, representation under balanced and unbalanced excitation, transformation matrices, symmetrical components, sequence impedances, unbalanced elements, three phase power invariance.

UNIT-3

Short circuit studies: Network representations for single line to ground fault, line to line fault, LL-G fault, and 3-phase faults, network short circuit studies using Z bus, Short circuit calculations for various types of faults in matrix form, numerical examples. Load flow studies: Load flow and its importance. classification of buses, load flow techniques, Iterative solutions and computer flow charts using Gauss-Seidel and Newton-Raphson methods, Decoupled and fast decoupled methods, representation of regulating and off nominal ratio transformers and modification of Ybus, comparison of methods, numerical examples.

UNIT-4

Introduction to AC-DC load flow problems: formation and solutions. Power system security: Introduction to Power system security, Adding removing multiple lines, piece-wise solution of interconnected systems, analysis of single and multiple contingencies, analysis with sensitivity factors, system reduction for contingency and fault analysis.

Text/ Reference books:

1. G.W. Stagg & A.H EI-Abaid, 'Computer methods in Power system analysis', McGraw Hill, New York.
2. M. A. Pai, 'Computer Techniques in Power System Analysis', 2nd Edi., TMH-New Delhi.
3. Kusic., 'Computer-Aided Power System Analysis', Prentice Hall of India, New Delhi.
4. John J.Grainger and W.D.Stevenson, 'Power System Analysis', McGraw Hill, New York, 1994.
5. A.J. Wood & W.F. Wollenberg, 'Power Generation, Operation, and Control', 2nd Edn, John Wiley & Sons, New York, 1996.
6. O.I. Elgerd, 'Electric Energy Systems Theory: An Introduction', McGraw Hill, New York, 1982.

MTESM-108 **DIGITAL SIGNAL PROCESSING**

Semester - I

L	T	P	Credits		
3	1	0	4	Class-work Marks	: 40
				Exam Marks	: 60
				Total Marks	: 100
				Duration of Examination	: 3 Hrs

Course Outcomes:

At the end of this course students will demonstrate the ability to

- To enable the students to understand and review the concept of DT Signals and DT Systems.
- To understand and analyze discrete time signals and systems using Z-transform, DTFT, DFT and FFT.
- To understand and analyze FIR & IIR filters
- To build the concept of Adaptive and Multi-rate Digital Signal Processing
- To apply DSP tools in different types of digital signals in real life such as Speech signal, Image signal, Biomedical signals etc.

UNIT I

Discrete Signals: **Review** of discrete–time sequences and systems, Linearity, Shift invariance, Causality and Stability Criterion.

UNIT 2

Z-Transforms and System Function : **Review** of Z-Transforms, Region of convergence, Relation between Z-transform and Fourier transform, Inverse Z-Transform and its evaluation; System Function.

Discrete Fourier Transform and FFT: Discrete Fourier Transform (DFT), Fast Fourier Transform (FFT) algorithms using decimation in time and decimation in frequency techniques, Chirp Z- Transform.

UNIT 3

IIR and FIR Filter design: Basic structures of digital filters; Review of Approximation of filter functions; IIR filter design based on analog filter functions- Invariant and modified invariant response techniques, Bilinear transformation method, Design based on least square method. Significance of Linear phase .response, FIR filters design - Frequency sampling and Windowing techniques, Computer aided design.

UNIT 4

Adaptive and Multi-rate Digital Signal Processing: Introduction to adaptive filters, Application of adaptive filters; **Multi-rate processing -** Decimation & Interpolation, Filter design with sampling rate conversion, by a rational factor I/D.

DSP Applications: Applications in speech and image processing, Biomedical signal and power spectrum estimation.

Text/ Reference books:

1. Li Tan, Digital Signal Processing Fundamentals and Applications, Academic Press, 2008.
2. J.G.Proakis & D.G.Manolakis, Digital Signal Processing, Principles, algorithms and Applications, Fourth edition, PHI, 2007.
3. Texas Instruments: Digital Signal Processing Applications with TMS 320 Family, Second edition, PHI, 2005.
4. Mitra, S.K, Digital Signal Processing: A Computer Based Approach, Third Edition, TMH, 2006.

MTESM-109 REACTIVE POWER CONTROL AND FACTS DEVICES

Semester - I

L	**T**	**P**	**Credits**	**Class-work Marks**	**: 40**
3	**1**	**0**	**4**	**Exam Marks**	**: 60**
				Total Marks	**: 100**
				Duration of Examination	**: 3 Hrs**

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. An ability to apply knowledge of FACTS Controllers.
2. An ability to design a Compensators within realistic constraints.
3. An ability to identify, model, and solve real network problems with FACTS controllers
4. The broad education necessary to understand the impact of engineering solutions in a global perspective
5. A knowledge of recent trend in FACTS controllers and application of FACTS controllers.

UNIT-1

Reactive Power Control in Electric Transmission Systems, Loading Capability and Stability Considerations, Introduction to related concepts and systems requirements. Flexible AC Transmission Systems (FACTS) Devices: Configuration of FACTS devices, Principles of operation and control techniques.

UNIT-2

Static Series Compensators, TCSC and Applications: Objectives of series compensation, Operation of the TCSC, Different modes of operation, Modelling of TCSC and their comparison, Variable reactance model, Modelling for Power Flow and stability studies. Applications: Improvement of the system stability limit, Enhancement of system damping-SSR Mitigation.

UNIT-3

Voltage Source Converter Based FACTS Controllers: Static Synchronous Compensator (STATCOM), Principle of operation, V-I Characteristics. Comparison with SVC, Applications: Steady state power transfer, Enhancement of transient stability, Prevention of voltage instability. SSSC-operation of SSSC and the control of power flow, Modelling of SSSC in load flow and transient stability studies, Comparison with TCSC, Applications: SSR Mitigation-UPFC and IPFC operating principles and their characteristics, Control structure, Applications.

UNIT-4

Co-Ordination of FACTS Controllers: Controller interactions, SVC, SVC interaction, Coordination of multiple controllers using linear control techniques, Control coordination using genetic algorithms.

Application of FACT devices in: Power System Satiability analysis, Reactive power control, Optimal power flow analysis, Wide area monitoring.

Text/ Reference books:

1. Arrillaga J, HVDC transmission, IET
2. Padiyar K R, HVDC Power transmission System, New age International
3. Padiyar K R, FACTS Controllers in Power Transmission and Distribution, New Age International (P) Limited, Publishers, New Delhi
4. John A T, Flexible A.C. Transmission Systems, Institution of Electrical and Electronic Engineers (IEEE) .
5. Sood V K, HVDC and FACTS controllers – Applications of Static Converters in Power System, Kluwer Academic Publishers

MTESM-110 ADVANCED CONTROL SYSTEM

Semester - II

L	T	P	Credits		
3	1	0	4	**Class-work Marks**	**: 40**
				Exam Marks	**: 60**
				Total Marks	**: 100**
				Duration of Examination	**: 3 Hrs**

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. Apply linear algebra to complex real world problems in order to obtain models that are expressed using state space equations.
2. Analyze the system behaviour based on the mathematical model of that system where the model may be expressed in state-space domain
3. Analyze the behaviour of closed loop systems using tools like Matlab
4. Design controllers using the concept of state feedback and pole placement tech.
5. Write a report that effectively communicates the results of an analysis or design

Unit 1

Math Modelling of Dynamical Systems: Newtonian and Lagrangian approaches, Concept of dynamical state of a system, Concept of equilibrium point, linearization of non-linear model.

Review of Linear Algebra concepts: Field, Vector space, linear combination, linear independence, bases of a vector space, representation of any vector on different basis, matrix representation of a linear operator, Change of basis, rank, nullity, range space and null space of a matrix, Eigen value and Eigen vector of a matrix, similarity transform, Diagonalisation.

Unit 2

Modern Control Analysis: Concept and computation of systems modes, controllability theorem and its proof, Observability theorem and its proof, Controllable and observable subspaces.

Stability Analysis: Stability of linear systems, stability types and their definitions for any general system, Stability of an equilibrium point, Lyapunov stability theory for LTI systems, Quadratic forms and Lyapunov functions.

Unit 3

Modern Control Design: Converting the math model to controllable canonical form and its use for pole placement, Concept of linear observer and its design, Design of reduced order observer, Compensator design using separation principle, Poles of compensator, Open loop and close-loop systems.

Unit 4

Optimal Control Theory: Introduction to the philosophy of optimal control, formulation of optimal control problem, different performance criterion, Linear quadratic regulator (LQR) and optimum gain matrix, Riccati equations, conceptual models and statistical models for random processes, Kalman filter.

Suggested reading

1. Bernard Friedland, “Control System Design: An Introduction to State-Space Methods”, Dover Publications, Inc. Mineola, New York, 2012

2. Thomas Kailath, “Linear Systems”, Prentice-Hall Inc., New Jersey, 1986

3. M. Gopal, “Modern Control System Theory”, New Age International (P) Limited, New Delhi, 2000

MTESM-111 ENERGY LABORATORY-1

Semester - I

L	T	P	Credits		
0	0	4	2	Class-work Marks	: 30
				Exam Marks	: 70
				Total Marks	: 100

Course Outcome: Upon completion of the course, the students will be able to:
1. Understand the working of solar PV and wind energy technology to generate electricity.
2. Measure solar radiation and wind standalone and do technical analysis.
3. Conduct experiments related to wind and solar PV do technical analysis to study their characteristics.

List of Experiments:

1. To determine I-V & P-V characteristics of PV module by varying radiation and temperature.
2. To determine I-V & P-V characteristics of series and parallel combination of PV modules
3. To show the effect of variation of tilt angle on PV module power.
4. Analysis and characterization of wind standalone system.
5. Evaluation of cut-in speed and cut-off speed.
6. I-V characteristics of wind turbine at different wind speed.
7. Impact of load and wind speed on power output and its quality.
8. Evaluation of the active, reactive power and net energy flow between grid tied inverter, artificial grid & load.

Note:

1. At least 7 experiments are to be performed by students in the semester.
2. At least 6 experiments should be performed from the above list; remaining two experiments may either be performed from the above list or designed and set by the Dept. as per the scope of the syllabus

MTESM-201 MANAGEMENT OF RURAL ENERGY SYSTEM
Semester - II

L	T	P	Credits		
3	1	0	4	Class works Marks:	30
				Exam Marks:	70
				Total Marks:	100
				Duration of Examination:	3 Hrs

Course Outcomes:
At the end of this course students will demonstrate the ability to

1. To impart knowledge about the planning and design aspects of electrification of rural areas.

UNIT I

Electrical load survey and forecasting, rural load management. Route survey and profiling of transmission and distribution lines.

UNIT II

Mechanical design of low-tension distribution lines, selection of poles/supports etc. Electrical design of low-tension distribution lines: selection of conductors and insulators etc.

UNIT III

Planning, selection and design of substations for rural electrical system. Load flow methods for transmission and distribution system; fault analysis: different types of faults and their calculation procedures

UNIT IV

Co-ordination between power and tele-communication lines Maintenance of transmission and distribution lines Case study of a typical system

Text/References:

1. Kamaraju, V., "Electric Power Distribution System", Tata McGraw Hill Education Private Limited.
2. Grainger, J.J. and Stevenson, W.D., "Power System Analysis", Tata McGraw Hill Publishing Company Limited.
3. Jangwala, N.K., "Modern Trends and Practices in Power Subtransmission and Distribution Systems", Vol.-I and II, CBIP Publication.
4. Widmer, P. and Arter, A., "Village Electrification", MHPG, SKAT Publication.
5. Pabla A.S., "Electric Power Distribution",5th edition,Tata McGraw Hill Publishing Company.
6. Harker, K., "Power System Commissioning and Maintenance Practice", The

MTESM-202 SOLAR THERMAL TECHNOLOGIES AND APPLICATIONS
Semester - II

L	T	P	Credits		
3	1	0	4	Class works Marks:	30
				Exam Marks:	70
				Total Marks:	100
				Duration of Examination:	3 Hrs

Course Outcomes:

At the end of this course students will demonstrate the ability to

Various types of solar thermal collectors. Details of thermal performance of different thermal collector configurations are included. Emphasis has been given to the concentrating collector for power generation and the application of solar energy for industrial process heat. Solar thermal energy storage through different mechanics and processes and also discussed. The course is designed with objectives to make the students capable to analyze the performance of solar thermal systems.

UNIT I

Basics for solar thermal system: Different design and components; Radiation transmission and absorption through glazing; Selective surfaces: Ideal coating characteristics, Anti reflection coating;

Flat plate collector: Theory and basic design aspects; Thermal analysis and effective heat loss; Performance analysis methods; Thermal analysis and effective energy loss of evacuated tube collector; Flat plate solar dryer: Issues and challenges.

UNIT II

Concentrating collector: Classification of concentrating collector; concentrating collector configurations; concentration ratio: optical, geometrical; Thermal performance of concentrating collector; Optical and thermal performance of different concentrating collector designs; Parabolic trough concentrators; Compound parabolic concentrator; Concentrators with point focus.

UNIT III

Solar thermal power plant: Central receiver systems; Heliostats; Comparison of various designs: Parabolic trough systems, Rankine cycle, Parabolic Dish - Stirling System, Combined cycle

UNIT IV

Solar industrial process heat: Integration of solar thermal system with industrial processes; Mechanical design considerations; Economics of industrial process heat

Solar thermal energy storage: Sensible storage; Latent heat storage; Thermo-chemical storage; High temperature storage; Designing thermal storage systems

Text/References:

1. Duffie J. A. and Beckman W. A. (2013), Solar Engineering of Thermal Processes, John Wiley
2. Garg H. P. and Prakash S. (2000), Solar Energy: Fundamental and Application, Tata McGraw Hill
3. Goswami D. Y. (2015), Principles of Solar Engineering, Taylor and Francis

4. Tiwari G. N. (2002), Solar Energy: Fundamentals, Design, Modeling and Applications, Narosa
5. Nayak J. K. and Sukhatme S. P. (2006), Solar Energy: Principles of Thermal Collection and Storage, Tata McGraw Hill
6. Serrano, M. I. R. (2017). Concentrating solar thermal technologies. In Concentrating Solar Thermal Technologies (pp. 11-24). Springer, Cham.
7. Tyagi, H., Chakraborty, P. R., Powar, S., & Agarwal, A. K. (Eds.). (2019). Solar Energy:

MTESM-203 ELECTRIC DRIVE SYSTEM

Semester - II

L	T	P	Credits		
3	1	0	4	Class-work Marks	: 40
				Exam Marks	: 60
				Total Marks	: 100
				Duration of Examination	: 3 Hrs

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. Model and simulate electric drive systems
2. Design modulation strategies of power electronics converters, for drives application
3. Design appropriate current/voltage regulators for electric drives
4. Select and implement the drives for Industrial Process
5. Implement various variable speed drives in Electrical Energy Conversion System

Unit 1

Dynamics of Electric Drives: Fundamentals of torque equation. Speed torque convention and multi-quadrant operation, components of load torques. Classification of load torques steady state stability. Load equation, Speed control and drive classification. Close loop control of drives.

Unit 2

DC motor Drives-Modelling of DC machines. • Steady state characteristics with armature and speed control. Phase controlled DC motor drives, chopper controlled DC motor drives.

Unit 3

Poly-phase induction machines- Dynamic modelling of induction machines. • Small signal equations, control characteristics of induction machines.

Phase-controlled induction machines. Stator voltage control. Slip energy recovery scheme, frequency control and vector control of induction motor drives.

Unit 4

Traction motor: Starting.Speed-Time characteristics.Braking. Traction motors used in practice.

Industrial Drives-Digital Control of Electric Drives. Stepper motor.Servo motor and their Applications.

Suggested reading

1. G.K, Dubey, "Power semiconductor controlled Drives", Prentice Hall international, New Jersey, 1989.

2. R.Krishanam, “Electric motor drives modelling, analysis and control”, PHI-India-2009.

3. G. K. Dubey,“Fundamentals of electric Drives”, Narosa Publishing House, 2nd edition, 2011.

4. W. Leonhard, “Control of Electrical drives”, Springer, 3rd edition, 2001.

5. P.C. Krause –, “Analysis of Electric Machine”, Wiley-IEEE press 3rdedition.

6. K. Bose,“Modern Power Electronics and AC Drives”, Prentice Hall publication, 1st edition, 2001.

MTESM-204 **POWER QUALITY**

Semester - II

L	T	P	Credits		
3	1	0	4	Class-work Marks	: 40
				Exam Marks	: 60
				Total Marks	: 100
				Duration of Examination	: 3 Hrs

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. Identify different power quality problems present in residential, commercial and industrial power systems.
2. Understand the waveform processing techniques and their applications for power quality assessment.
3. Apply basic principles to carry out harmonic load flow studies and the filter design concepts to mitigate harmonics.
4. Design a grounding mat for a substation

Unit 1

Introduction-power quality-voltage quality-overview of power, Quality phenomena classification of power quality issues, Power quality measures and standards-THD-TIF-DIN-C-message weights, Flicker factor transient phenomena-occurrence of power quality problems, Power acceptability curves-IEEE guides, Standards and recommended practices

Unit 2

Harmonics-individual and total harmonic distortion, RMS value of a harmonic waveform, Triplex harmonics. Important harmonic introducing devices.SMPS, Three phase power converters-arcing devices saturable devices, Harmonic distortion of fluorescent lamps-effect of power system harmonics on power system equipment and loads.

Unit 3

Modelling of networks and components under non-sinusoidal conditions, Transmission and distribution systems, Shunt capacitors-transformers.Electric machines, Ground systems loads that cause power quality problems, Power quality problems created by drives and its impact on drive.

Unit 4

Power factor improvement- Passive Compensation, Passive Filtering.Harmonic Resonance. Impedance Scan Analysis, Active Power Factor Corrected Single Phase Front End, Control Methods for Single Phase APFC, Three Phase APFC and Control Techniques, PFC based on Bilateral Single Phase and Three Phase Converter, Hamilton-Jacobi-Bellman equation - model reference adaptive systems (MRAS) - Design hypothesis.

Suggested reading

1. G.T. Heydt, “Electric power quality”, McGraw-Hill Professional, 2007

2. Math H. Bollen, “Understanding Power Quality Problems”, IEEE Press, 2000

3. J. Arrillaga, “Power System Quality Assessment”, John wiley, 2000

4. J. Arrillaga, B.C. Smith, N.R. Watson & A. R.Wood ,”Power system Harmonic Analysis”, Wiley, 1997

MTESM-205 **SMART GRIDS**

Semester - II

L	T	P	Credits		
3	1	0	4	Class-work Marks	: 40
				Exam Marks	: 60
				Total Marks	: 100
				Duration of Examination	: 3 Hrs

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. To understand the basic concepts, components and architecture of smart grid
2. To understand the various measurement technologies in smart grid
3. To educate the importance of renewable energy in smart
4. To know about battery technology and energy storage
5. To brief about role of Electric Vehicles in smart grid

Unit 1

Introduction to Smart Grid, Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Concept of Robust &Self-Healing Grid, Present development & International policies in Smart Grid , Introduction to Smart Meters, Real Time Prizing, Smart Appliances, Automatic Meter Reading (AMR), Outage Management System (OMS).

Unit 2

Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid, Smart Sensors, Home & Building Automation, Smart Substations, Substation Automation, Feeder Automation, Geographic Information System (GIS), Intelligent Electronic Devices (IED) & their application for monitoring & protection, Smart storage like Battery, SMES, Pumped Hydro, Compressed Air Energy Storage, Wide Area Measurement System (WAMS), Phase Measurement Unit (PMU).

Unit 3

Concept of micro-grid, need & applications of micro-grid, Formation of micro-grid, Issues of interconnection, Protection & control of micro-grid, Plastic & Organic solar cells, Thin film solar cells, Variable speed wind generators, fuel-cells, micro-turbines, Captive power plants, Integration of renewable energy sources.

Unit 4

Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit, Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighbourhood Area Network (NAN), Wide Area Network (WAN), Bluetooth, ZigBee, GPS, Wi-Fi, Wi-Max based communication, Wireless Mesh Network.Basics of CLOUD Computing &Cyber Security for Smart Grid, Broadband over Power line (BPL). IP based protocols

Suggested reading

1. Ali Keyhani, “Design of smart power grid renewable energy systems”, Wiley IEEE,2011.

2. Clark W. Gellings, “The Smart Grid: Enabling Energy Efficiency and Demand Response”, CRC Press, 2009.

3. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, “Smart Grid: Technology and Applications”, Wiley 2012.

4. Stuart Borlas’e, “Smart Grid:Infrastructure, Technology and solutions “CRC Press.

5. A.G.Phadke , “Synchronized Phasor Measurement and their Applications”,Springer

MTESM-206 WIND AND SMALL HYDRO ENERGY SYSTEMS

Semester -II

L	T	P	Credits		
3	1	0	4	Class-work Marks	: 40
				Exam Marks	: 60
				Total Marks	: 100
				Duration of Examination	: 3 Hrs

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. To understand wind and hydro energy resource assessment techniques.
2. To understand the principles of conversion to useful form of energy from these resources.
3. To understand the working principles of the conversion devices, limitations, cost of energy generation and environmental issues

Unit 1

Basics of Wind Energy: Atmospheric circulations, classification, factors influencing wind, wind shear, turbulence, wind speed monitoring, Wind resource assessment, Weibull distribution, Betz limit, Aerodynamic theories, Axial momentum, Blade element and combine theory, Rotor characteristics, Maximum power coefficient, Tip loss correction

. **Unit 2**

Wind energy conversion systems: Classification, applications, power, torque and speed characteristics Aerodynamic design principles etc, wind turbine design considerations: methodology, theoretical simulation of wind turbine characteristics.

Principle of WEG: Stand alone, grid connected; Hybrid applications of WECS; Wind pumps, performance analysis of wind pumps, design concept and testing, economics of Wind energy utilization, Wind energy Program in India.

Unit 3

Hydrology: Resource assessment, Potential of hydropower in India, Classification of Hydropower Plants, Small Hydropower Systems, Overview of micro, mini and small hydro systems, Status of Hydropower Worldwide and India

Hydraulic Turbines: types and operational aspects, classification of turbines, elements of turbine, selection and design criteria, geometric similarity operating characteristic curves; Speed and voltage regulation Selection of site for hydroelectric plant, Essential elements of hydroelectric power plant.

Unit 4

Economics: cost structure, Initial and operation cost, environmental issues related to large hydro projects, Potential of hydro power in North East India

Suggested reading

1. 1 Johnson G. L. (2006). Wind Energy Systems (Electronic Edition), Prentice Hall
2. Wagner H. and Mathur J. (2011). Introduction to Hydro Energy Systems: Basics, Technology and Operation, Springer Reference Books
3. Hau E. (2000). Wind Turbines: Fundamentals, Technologies, Application and Economics, Springer
4. Mathew S. (2006). Wind Energy: Fundamentals, Resource Analysis and Economics, Springer
5. Burton T. Sharpe D. Jenkins N. and Bossanyi E. (2001). Wind Energy Handbook, John Wiley
6. Nag P. K. (2008). Power Plant Engineering, Third Edition, Tata McGraw Hill
7. Jiandong T. (et al.) (1997). Mini Hydropower, John Wiley

MTESM-207 ELECTRIC AND HYBRID VECHILES

Semester - II

L	T	P	Credits		
3	1	0	4	Class-work Marks	: 40
				Exam Marks	: 60
				Total Marks	: 100
				Duration of Examination	: 3 Hrs

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. Develop the electric propulsion unit and its control for application of electric vehicles.
2. Analyze different power converter topology used for electric vehicle application.

Unit 1

History of hybrid and electric vehicles, Social and environmental importance of hybrid and electric vehicles, Impact of modern drive-trains on energy supplies, Basics of vehicle performance, vehicle power source characterization, Transmission characteristics, Mathematical models to describe vehicle performance

Unit 2

Basic concept of hybrid traction, Introduction to various hybrid drive-train topologies, Power flow control in hybrid drive-train topologies, Fuel efficiency analysis, Basic concept of hybrid traction, Introduction to various hybrid drive-train topologies, Power flow control in hybrid drive-train topologies, Fuel efficiency analysis.

Unit 3

Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Introduction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency

Unit 4

Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, Selecting the energy storage technology, Communications, supporting subsystems, Introduction to energy management and their strategies used in hybrid and electric vehicle, Classification of different energy management strategies, Comparison of different energy management strategies, Implementation issues of energy strategies

Suggested reading

1.Sira -Ramirez, R. Silva Ortigoza, “Control Design Techniques in Power Electronics Devices”, Springer.

2. Siew-Chong Tan, Yuk-Ming Lai, Chi Kong Tse, “Sliding mode control of switching Power Converters”

MTESM-208 INDUSTRIAL LOAD MODELING AND CONTROL

Semester - II

L	T	P	Credits		
3	1	0	4	**Class-work Marks**	**: 40**
				Exam Marks	**: 60**
				Total Marks	**: 100**
				Duration of Examination	**: 3 Hrs**

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. Knowledge about load control techniques in industries and its application.
2. Learn different types of industrial processes and optimize the process using tools like LINDO and LINGO.
3. Apply load management to reduce demand of electricity during peak time.
4. Apply different energy saving opportunities in industries.

Unit 1

Electric Energy Scenario-Demand Side Management-Industrial Load Management, Load Curves-Load Shaping Objectives, Methodologies-Barriers, Classification of Industrial, Loads, Continuous and Batch processes -Load Modelling

Unit 2

Electricity pricing – Dynamic and spot pricing -Models, Direct load control- Interruptible load control, Bottom up approach- scheduling- Formulation of load, Models, Optimization and control algorithms - Case studies

Unit 3

Cooling and heating loads, load profiling, Modelling- Cool storage, Types-Control strategies, Optimal operation, Problem formulation- Case studies, power units, Operating and control strategies, Power Pooling- Operation models

Unit 4

Energy banking, Industrial Cogeneration, Selection of Schemes Optimal Operating Strategies, Peak load saving, Constraints Problem formulation- Case study, Integrated Load management for Industries

Suggested reading

1. C.O. Bjork " Industrial Load Management - Theory, Practice and Simulations", Elsevier, the Netherlands,1989

2. C.W. Gellings and S.N. Talukdar,. Load management concepts. IEEE Press, New York, 1986, pp. 3-28

3. Y. Manichaikul and F.C. Schweppe ," Physically based Industrial load", IEEE Trans. on PAS, April 1981

4. H. G. Stoll, "Least cost Electricity Utility Planning", Wiley Interscience Publication, USA, 1989.

5. I.J.Nagarath and D.P.Kothari, .Modern Power System Engineering., Tata McGraw Hill publishers, NewDelhi, 1995

6. IEEE Bronze Book- “Recommended Practice for Energy Conservation and cost effective planning in Industrial facilities”, IEEE Inc, USA

MTESM-209 ENGINEERING OPTIMIZATION

Semester -II

L	T	P	Credits		
3	1	0	4	**Class-work Marks**	**: 40**
				Exam Marks	**: 60**
				Total Marks	**: 100**
				Duration of Examination	**: 3 Hrs**

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. Knowledge about vector spaces, linear transformation, Eigen values and Eigen vectors of linear operators.
2. To learn about linear programming problems and understanding the simple method for solving linear programming problems in various fields of science and technology.
3. Acquire knowledge about nonlinear programming and various techniques used for solving constrained and unconstrained nonlinear programming problems.
4. Understanding the concept of random variables, functions of random variable and their probability distribution.
5. Understand stochastic processes and their classification

Unit 1

Concepts of optimization: Engineering applications, Statement of optimization, Problem, Classification - type and size of the problem, Classical Optimization Techniques: Single and multi-variable problems, Types of Constraints, Semi definite case-saddle point

Linear programming: Standard form-Geometry of LP problems-Theorem of LP, Relation to convexity - formulation of LP problems - simplex method and algorithm, Matrix form- two phase method. Duality, dual simplex method- LU Decomposition

Unit 2

Sensitivity analysis: Artificial variables and complementary solutionsQP, Engineering Applications:Minimum cost flow problem, Network problems-transportation, assignment & allocation, scheduling,Karmarkar method-unbalanced and routing problems.

Nonlinear programming: Non linearity concepts-convex and concave functions, non-linear programming -gradient and Hessian, Unconstrained optimization, First & Second order necessary conditions- Minimisation & Maximisation, Local & Global convergence, Speed of convergence

Unit 3

Basic decent methods: Fibonacci & Golden section search - Gradient methods – Newton, Method-Lagrange multiplier method - Kuhn-tucker conditions, Quasi-Newton method-separable, convex programming -Frank and Wolfe method, Engineering Applications

Nonlinear programming- Constrained optimization: Characteristics of constraints-Direct methods- SLP,SQP-Indirect, Methods, Transformation techniques-penalty function-Langrange multiplier methods checking convergence- Engineering applications

Unit 4

Dynamic programming: Multistage decision process- Concept of sub optimization and principle of optimality, Computational procedure- Engineering applications, Genetic algorithms, Simulated, Annealing Methods - Optimization programming, tools and Softwarepackages

Suggested reading

1. David G Luenberger, “Linear and Non Linear Programming”, 2nd Ed, Addison-Wesley Pub.Co.,Massachusetts, 2003

2. W.L.Winston, “Operation Research-Applications & Algorithms”,2nd Ed., PWS-KENT Pub.Co.,Boston, 2007

3. S.S.Rao, “Engineering Optimization”, 3rd Ed.,New Age International (P) Ltd,New Delhi, 2007

4. W.F.Stocker, “Design of Thermal Systems”, 3rd Ed., McGraw Hill, New York. 1990

5. G.B.Dantzig, “Linear Programming and Extensions” Princeton University Press, N.J., 1963.

6. L.C.W.Dixton, ”Non Linear Optimisation: theory and algorithms” Birkhauser, Boston, 1980

MTESM-210 **NON-LINEAR AND DIGITAL CONTROL SYSTEMS**

Semester - II

L	T	P	Credits		
3	1	0	4	**Class-work Marks**	**: 40**
				Exam Marks	**: 60**
				Total Marks	**: 100**
				Duration of Examination	**: 3 Hrs**

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. The ability to understand the characteristics of various types of nonlinearities present in physical systems.
2. The ability to carry out the stability analysis of non-linear control systems.
3. The ability to carry out the analysis and design of digital control systems.
4. The ability to design compensators for digital control system to achieve desired specifications.
5. The ability to represent digital control systems using state space models.
6. The ability to analyze the effect sampling on stability, controllability and observability.
7. The ability to design digital controllers for industrial applications.

Unit 1

Overview of nonlinear Control-Introduction to Advanced Calculus, Elementary notions of Topology, Smooth Manifolds, Sub-manifolds, Tangent Vectors, Vector Fields, Lyapunov stability for autonomous and non-autonomous systems, Input-Output Stability and Input-to-State Stability, Absolute Stability

Unit 2

Passivity analysis and applications to control design, Lyapunov-based feedback control design, Feedback linearization and back stepping, Sussmann‘s Theorem and global Decompositions, The Control Lie Algebra, the observation space, Local Co-ordinates, Transformations, Exact Linearization Via Feedback

Unit 3

Introduction to discrete-time systems, Frequency domain approach – Analysis and discretization, Time domain approach, analysis and discretization, State space formulation for discretized systems

Unit 4

Engineering aspects of computer controlled systems, Sampled data systems, Control of Sampled data systems, Concept of differential sampling, Closed loop analysis of differentially sampled systems, Control design based on differential sampling, Recent applications of Digital Control

Suggested reading

1. H. K. Khalil, “Nonlinear Systems”, 3rd edition, Prentice Hall, 2001
2. H. K. Khalil, “Nonlinear Control”, Pearson, 2015
3. J. J. E. Slotine and W. Li, “Applied nonlinear systems”, Prentice Hall, 1991

4. A. Nijemjer and A. van der schaft, “Nonlinear dynamical control systems”, Springer, 1989 5.
5. M. Vidyasagar, “Nonlinear Systems Analysis, Society for Industrial and Applied Mathematics”, 2002
6. Alberto Isidori, “Nonlinear Control Systems”, Third Edition, Springer, 1995

MTESM-211 ENERGY LABORATORY-2

Semester - I

L T P Credits Class-work Marks : 30

0 0 4 2 **Exam Marks : 70**
Total Marks : 100

Course Outcome: Upon completion of the course, the students will be able to:
1. Understand the working of solar PV and wind energy technology to generate electricity.
2. Measure solar radiation, sunshine hours, and do technical analysis of photovoltaic system.
3. Conduct experiments related to wind standalone as well as hybrid wind solar system, do technical analysis to study their characteristics.
4. Apply the concept to end use applications

List of Experiments:

1. To show the effect of variation of tilt angle on PV module power.
2. Workout power flow calculations of stand- alone PV system of DC load with battery
3. Workout power flow calculations of stand- alone PV system of AC load with battery.
4. To demonstrate the effect of shading on module output power.
5. Synchronization of grid tied inverter, observation of current waveform and calculations for distortion and power factor of grid tied inverter
6. Recording of bright sunshine hours using Campbell-Stokers recorder.
7. To measure the solar radiation using Thermoelectric pyranometer in different global sunshine conditions.
8. P,V and f measurement of output of wind generator.

Note:

1. At least 7 experiments are to be performed by students in the semester.
2. At least 6 experiments should be performed from the above list; remaining two experiments may either be performed from the above list or designed and set by the Dept. as per the scope of the syllabus

MTESM-301 ENERGY AUDITING AND MANAGEMENT

Semester - II

L T P Credits **Class-work Marks : 40**

3 1 0 4 **Exam Marks : 60**

Total Marks : 100

Duration of Examination : 3 Hrs

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. To enable the students to understand the concept of energy management and energy management opportunities
2. To understand the different methods used to control peak demand
3. To know energy auditing procedure
4. To understand the different methods used for the economic analysis of energy projects

Unit 1

System approach and End use approach to efficient use of Electricity, Electricity tariff types, Energy auditing: Types and objectives - audit instruments, ECO assessment and Economic methods, Specific energy analysis-Minimum energy paths-consumption models, Case study

Unit 2

Electric motors-Energy efficient controls and starting efficiency-Motor Efficiency and Load, Analysis Energy efficient /high efficient Motors-Case study, Load Matching and selection of motors, Variable speed drives; Pumps and Fans-Efficient Control strategies, Optimal selection and sizing, Optimal operation and Storage; Case study

Unit 3

Transformer Loading/Efficiency analysis, Feeder/cable loss evaluation, case study, Reactive Power management-Capacitor, Sizing-Degreeof Compensation-Capacitor losses, Location-Placement, Maintenance ,Case study

Peak Demand controls- Methodologies, Types of Industrial loads-Optimal Load, scheduling-case study, Lighting- Energy efficient light sources-Energy conservation in Lighting, Schemes, Electronic ballast-Power quality issues-Luminaries, case study

Unit 4

Cogeneration-Types and Schemes, Optimal operation of cogeneration plants-case study, Electric loads of Air conditioning &Refrigeration, Energy conservation measures- Cool storage, Types-Optimal operation case study

Electric water heating, Geysers-Solar Water Heaters, Power Consumption in Compressors, Energy conservation measures, Electrolytic Process, Computer Controls- software-EMS

Suggested reading

1. Anthony J. Pansini, Kenneth D. Smalling, .Guide to Electric Load Management., Pennwell Pub; (1998)
2. Howard E. Jordan, .Energy-Efficient Electric Motors and Their Applications., Plenum Pub Corp; 2ndedition (1994)
3. Giovanni Petrecca, .Industrial Energy Management: Principles and Applications., The Kluwerinternational series -207,1999
4. Handbook on Energy Audit and Environment Management , Y P Abbi and Shashank Jain, TERI,2006
5. Handbook of Energy Audits Albert Thumann, William J. Younger, Terry Niehus, 2009

MTESM-302 WASTE TO ENERGY CONVERSION

Semester - II

L	T	P	Credits	Class works Marks:	30
3	1	0	4	Exam Marks:	70
				Total Marks:	100
				Duration of Examination:	3 Hrs

Course Outcomes:

At the end of this course students will demonstrate the ability to

- To enable students to understand of the concept of waste to energy.
- To learn about the best available technologies for waste to energy.
- To link legal, technical & management principles for production of energy from waste.

UNIT I

Introduction to energy from waste: characterization and classification of waste as fuel; agrobased, forest residues, industrial waste, Municipal solid waste

Solid Waste Sources: Solid Waste Sources, types compositions and Properties, Municipal Solid Waste, Physical, chemical and biological properties, Waste Collection and transfer stations, Waste minimization and recycling of municipal waste, Segregation of waste, Size Reduction, Managing Waste, Status of technologies for generation of Energy from Waste.

UNIT II

Waste Treatment and Disposal: Aerobic composting, Furnace types and designs, Medical waste /Pharmaceutical waste treatment Technologies, concept of Bioremediation, Incineration, Environmental impacts, Measures to mitigate environmental effects due to incineration

Land Fill method of Solid waste disposal: Land fill classifications, Types, methods and Siting consideration, Layout and preliminary design of landfills: Composition, characteristics, generation, movement and control of landfill leachate and gases, Environmental monitoring system for land fill gases.

UNIT III

Energy Generation from Waste (Biochemical Conversion): Sources of energy generation, Anaerobic digestion of sewage and municipal wastes, Direct combustion of MSW-refuse derived solid fuel, Industrial waste, Agro residues, Anaerobic Digestion: Biogas production, Land fill gas generation and utilization, Thermochemical conversion: Sources of energy generation, Gasification of waste using gasifiers, Briquetting, Utilization and advantages of briquetting, Case studies of Commercial Waste to Energy Plants , Present status (National and International) of Technologies for Conversion of Waste into Energy, Design of Waste to Energy Plants for Cities, small townships and villages.

UNIT IV

Waste to energy options: Biochemical and Thermochemical routes; Biochemical Options – Anaerobic Digestion, Fermentation; Thermochemical Options – Pyrolysis, Gasification and Incineration; Other options – Biodiesel synthesis, Briquetting and Torrefaction, Hazardous waste management;

Properties of fuels derived from waste to energy: Producer gas, Biogas, Ethanol and Briquettes, Comparison of properties with conventional fuels; Landfills: Gas generation and collection in landfills, Introduction to transfer stations

Environmental Impact: Benefits of Biochemical and Thermochemical conversions

Text/References:

1. Energy from Waste - An Evaluation of Conversion Technologies by C Parker and T Roberts (Ed),
2. Parker, C., & Roberts, T. (1985). Energy from waste: an evaluation of conversion technologies. Elsevier Applied Science, London.
3. Shah, K. L. (2000). Basics of solid and hazardous waste management technology, Prentice Hall.
4. Christensen, T. H., Cossu, R., & Stegmann, R. (Eds.). (2005). Landfilling of waste: leachate. CRC Press.
5. White, P., Dranke, M., &Hindle, P. (2012). Integrated solid waste management: a lifecycle inventory. Springer Science & Business Media.
6. Klinghoffer, Naomi B., and Marco J. Castaldi, eds. Waste to energy conversion technology. Elsevier, 2013.
7. Kalogirou, E. N. (2017). Waste-to-Energy technologies and global applications. CRC Press.

MTESM-303 ECONOMICS AND FINANCING OF RENEWABLE ENERGY SYSTEMS

Semester – II

L	T	P	Credits		
3	1	0	4	Class-work Marks	: 40
				Exam Marks	: 60
				Total Marks	: 100
				Duration of Examination	: 3 Hrs

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. To impart knowledge on fundamentals of economic principles and their applications in the broad field of supply and demand of energy
2. To make students inquisitive about the problems of energy economics and arousing their interest on practical problem solving skills.

Unit 1

Energy economics: Basic concepts, energy data, energy cost, energy balance. Relevance of economic and financial viability evaluation of renewable energy technologies, Basics of engineering economics

Unit 2

Energy accounting framework: Economic theory of demand, production and cost market structure; National energy map of India, Energy subsidy – National and international perspectives

Unit 3

Concepts of economic attributes: Calculation of unit cost of power generation from different sources with examples, different models and methods, Social cost – benefit analysis of renewable energy technologies. Financial feasibility evaluation of renewable energy technologies, Technology dissemination models, Volume and learning effects on costs of renewable energy systems, Dynamics of fuel substitution by renewable energy systems and quantification of benefits

Application of econometrics: input and output optimization; energy planning and forecasting - different methods, Economic approach to environmental protection and management.

Unit 4

Financial incentives: Fiscal, financial and other incentives for promotion of renewable energy systems and their effect on financial and economic viability, electricity tariff types. Financing of renewable energy systems, Carbon finance potential of renewable energy technologies and impact of other incentives. Software for financial evaluation of renewable energy systems. Case studies on financial and economic feasibility evaluation of renewable energy projects

Suggested reading

1. Campbell, H. F., & Brown, R. P. (2003). Benefit-cost analysis: financial and economic appraisal using spreadsheets. Cambridge University Press.
2. Kandpal, T. C., & Garg, H. P. (2003). Financial evaluation of renewable energy technologies. MacMillam India Limited.
3. Park, C. S. (2002). Contemporary engineering economics (Vol. 4). Upper Saddle River, NJ: Prentice Hall.
4. Kroemer, K. H., Kroemer, H. B., & Kroemer-Elbert, K. E. (2001). Ergonomics: how to design for ease and efficiency. Pearson College Division.
5. Dorsman, A. B., Ediger, V. Ş., & Karan, M. B. (Eds.). (2018). Energy Economy, Finance and Geostrategy. Springer.
6. Banks, F. E. (2012). Energy economics: a modern introduction. Springer Science & Business Media.
7. Thuesen G. J. and Fabrycky W. J. (2001); Engineering Economy, Ninth Edition, Prentice Hall India
8. Ayyub, B. M. (2014). Risk analysis in engineering and economics. CRC Press.

MTESM-304 LIFE CYCLE ASSESSMENT OF RENEWABLE SYSTEMS

Semester – II

L	T	P	Credits		
3	0	0	3	Class-work Marks	: 40
				Exam Marks	: 60
				Total Marks	: 100
				Duration of Examination	: 3 Hrs

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. Understand the characteristics of life cycle assessment
2. Understand the risk and life cycle framework for sustainability
3. Understand the life cycle assessment of renewable energy sources

Unit 1

Life Cycle Analysis: An introduction to sustainability concept and life cycle analysis, introduction to material flow and waste management, study of water resources and food nexus.

Main Characteristics of Life Cycle Assessment: What is LCA?, role of LCA in relation to products, role of LCA in wider applications, strength and limitations of LCA, LCA as part of a tool box, management of LCA projects.

Unit 2

Life Cycle Framework: Risk and life cycle framework for sustainability: introduction, risk, environmental risk assessment, example chemicals and health effects, character of environmental problems

Unit 3

Life Cycle Assessment of Renewable Energy Sources: Life cycle assessment of biodiesel from palm oil, life-cycle assessment of bio methane from lignocelluloses biomass, application of life cycle assessment on agricultural production systems with reference to lignocelluloses biogas and bio ethanol production as transport fuels.

Unit 4

Life Cycle Inventory and Impact Assessments: Life cycle inventory and impact assessments, unit processes and system boundary, data quality, procedure for life cycle impact assessment, LCIA in practice with examples, interpretation of LCIA results.

Unit 5

ISO Terminologies: Factors for good LCA study, ISO terminologies, LCA steps recap, chemical release and fate and transport, and green sustainable materials

Suggested reading:

1. B. Jeroen, Guinee, “Hand Book on Life Cycle Assessment”, Kluwer Academic Publications, 2001.
2. K.Walter, “Background and Future Prospects in Life Cycle Assessment”, Springer,2004.
3. Anoop Singh ,“Life Cycle Assessment of Renewable Energy sources”, Springer, 1995.