ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus (Effective from 2023-24)

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Energy System and Management (ESM),
Duration: 2 years (Four Semesters)

Abbreviation used:

AC	Audit course	LC	Lab Course	PA	Practical Assessment
PC	Professional Core	PR	Project/ Practical/ Internship	L	Lecture
PE	Professional Elective	SE	Seminar/ Expert Lecture/ Etc.	T	Tutorial
OE	Open Elective	IA*	Internal Assessment	P	Practical
MC	Mandatory/ Common Course	EA	End-Semester Assessment		

Subject Code Format:

A1	A2	B3	C4	C5	C6
School/ Dept. (Offering) **BH:** Basic Sciences and Humanities **CS:** Computer Sciences **EE:** Electrical Sciences **EI:** Electronic Sciences **IP:** Infrastructure and Planning **MS:** Mechanical Sciences **BT:** Biotechnology **TE:** Textile Engineering		**Level** **1:** UG/ Int. Msc. (1st Year) **2:** UG/ Int. Msc. (2nd Year) **3:** UG/ Int. Msc. (3rd Year) **4:** UG/ Int. Msc. (4th Year) **5:** UG/ Int. Msc. (5th Year) **6:** PG (1st Year) **7:** PG (2nd Year) **8:** Ph.D.	**0:** AC **1:** PC **2:** PE **3:** OE **4:** MC **5:** LC **6:** PR **7:** SE **8:** **9:**	**Serial Number (01 to 99)** 01/ 03/…/ 19: Odd Sem. (ESM) 21/ 23/…/ 39: Odd Sem. (PED) 41/ 43/…/ 59: Odd Sem. (PSE) 61/ 63/…/ 79: Odd Sem. (Prog-4) 81/ 83/…/ 99: Odd Sem. (Prog-5) 02/ 04/…/ 20: Even Sem. (ESM) 22/ 24/…/ 40: Even Sem. (PED) 42/ 44/…/ 60: Even Sem. (PSE) 62/ 64/…/ 80: Even Sem. (Prog-4) 82/ 84/…/ 98: Even Sem. (Prog-5)	

1st Semester

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours			Credit	Maximum Marks			
				L	T	P		IA	EA	PA	Total
1	PC 1	EE6101	Advanced Power Electronics Converter	3	0	0	3	40	60	-	100
2	PC 2	EE6103	Alternate Energy Sources	3	0	0	3	40	60	-	100
3	PE 1 (Any One)	EE6201	Storage Technology	3	0	0	3	40	60	-	100
		EE6203	Economics and Planning of Energy System								
		EE6205	Hydrogen and Fuel Cells								
4	MC 1	BH6401	Mathematical Methods in Engineering	3	0	0	3	40	60	-	100
5	MC 2	MS6403	Research Methodology and IPR	2	0	0	2	40	60	-	100
6	LC 1	EE6501	Energy System Simulation Lab	0	0	4	2	-	-	100	100
7	LC 2	EE6503	Energy System Control Lab	0	0	4	2	-	-	100	100
8	AC 1	Any One from the List of AC 1 (Appendix-I)		2	0	0	0	40	60	-	100
			Total	**16**	**0**	**10**	**18**	**240**	**360**	**200**	**800**

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus (Effective from 2023-24)

School/ Department: School of Electrical Sciences

Course: M. Tech., Programme: Energy System and Management (ESM),

Duration: 2 years (Four Semesters)

2nd Semester

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours L	T	P	Credit	Maximum Marks IA	EA	PA	Total
1	PC 3	EE6102	Wind and Solar Energy System	3	0	0	3	40	60	-	100
2	PC 4	EE6104	Power System Planning	3	0	0	3	40	60	-	100
3	PE 2 (Any One)	EE6202	AI and Machine Learning	3	0	0	3	40	60	-	100
		EE6204	Energy Audit and Management								
		EE6206	Climate Change and Carbon Trading								
4	PE 3 (Any One)	EE6208	Economics of Power Management	3	0	0	3	40	60	-	100
		EE6210	Advanced DSP								
		EE6212	Smart Grid Technology								
5	OE 1	Any One from the List of OE 1 (Appendix-I)		3	0	0	3	40	60	-	100
6	PR 1	EE6602	Project (Specialization Related)	0	0	4	2	-	-	100	100
7	LC 3	EE6502	Renewable Energy System Lab/ Design of Smart Energy System Lab	0	0	4	2	-	-	100	100
8	AC 2	Any One from the List of AC 2 (Appendix-I)		2	0	0	0	40	60	-	100
			Total	**17**	**0**	**8**	**19**	**240**	**360**	**200**	**800**

3rd Semester

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours L	T	P	Credit	Maximum Marks IA	EA	PA	Total
1	PE 4* (Any One)	EE7201	Grid Integration of Renewable Sources	3	0	0	3	40	60	-	100
		EE7203	Electric and Hybrid Vehicles								
		EE7205	Energy Efficient Building								
		EE7207	FACTS and Customer Power Devices								
2	PR 2	EE7601	Dissertation (Phase-I)	0	0	24	12	-	-	100	100
			Total	**3**	**0**	**24**	**15**	**40**	**60**	**100**	**200**

* Virtual/Online Course either offered by OUTR or available in MOOCs platform (No physical class)

4th Semester

Sl. No.	Subject Type	Subject Code	Subject Name	Teaching Hours L	T	P	Credit	Maximum Marks IA	EA	PA	Total
1	PR 3	EE7602	Dissertation (Phase-II)	0	0	32	16	-	-	100	100
			Total	**0**	**0**	**32**	**16**	**-**	**-**	**100**	**100**

Credits and Maximum Marks

Sl. No.	Semester	Credits	Maximum Marks
1	1st	18	800
2	2nd	19	800
3	3rd	15	200
4	4th	16	100
	Total	68	1900

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus (Effective from 2023-24)

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Energy System and Management (ESM),
Duration: 2 years (Four Semesters)

1st Semester

PC 1	EE6101	Advanced Power Electronics Converter	3	0	0	3

Module-I

Power Switching Devices - MOS Field Effect Transistor (MOSFET), Switching Characteristics of the MOSFET, Insulated Gate Bipolar Transistor (IGBT), Switching Characteristics of the IGBT

Gate Drive Circuits for MOSFET, IGBT, Requirements of Gate Drive Snubber Circuits for Power Switching Devices. Turn-off Snubber, Turn-on Snubber

Switched Mode Rectifier - Operation of Single/Three Phase Bridges in Rectifier Mode. Control Principles. Control of the DC Side Voltage. Voltage Control Loop. The inner Current Control Loop.

Module II

Multi-Level Inverters of Diode Clamped Type, Flying Capacitor Type and Cascaded type; Basic Topology and waveforms, Improvement in harmonics, suitable modulation strategies -Space Vector Modulation, Minimum ripple current PWM method.

Hybrid Multilevel Inverters: Hybridization of Fundamental frequency switching (FFS) and PWM switching inverters: inverter topologies with an isolation transformer, PWM switching strategy; Transformerless hybrid inverter

Current Regulated Inverte*r* -Current Regulated PWM Voltage Source Inverters.

Methods of Current Control. Hysteresis Control. Variable Band Hysteresis Control. Fixed Switching Frequency Current Control Methods.

Module III

Resonant converters: Zero Voltage Switching Clamped Voltage Topologies. Resonant DC Link Inverters with Zero Voltage Switching, Zero current switching resonant inverter.

Introduction to matrix converter and Z-source inverter: Principle and control strategy

Text:

1. Ned Mohan et. al : Power Electronics ,John Wiley and Sons
2. B K Bose : Modern Power Electronics and AC Drives, Pearson Edn (Asia)
3. M.H Rashid: Power Electronics, Pearson
4. M.H Rashid: Digital Simulation of Power Electronics, Pearson

References:

1. G K Dubey et. al :Thyristorised Power Controllers , Wiley Eastern Ltd.
2. P C Sen : Power Electronics , TMH

COURSE OUTCOMES:

At the end of the course, the students will be able to

CO1: Analyze and understand the switching characteristic of power MOSFET and IGBT, Design their gate drive and protection circuits.

CO2: Understand the operation of Switch Mode Rectifiers and application

CO3: Understand the concepts of different modulation techniques applied to multilevel inverters, Analyze the operation of various types of MLIs and different current regulated techniques in Current regulated inverters

CO4: Understand operation of different Resonant Converter topologies, Matrix converters and Z-source Converters and design and simulation of their performances

MAPPING OF COs WITH POs

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PO-7	PO-8
CO-1		X	X				X	X
CO-2	X	X		X	X	X	X	
CO-3	X	X	X	X	X	X	X	X
CO-4		X	X	X	X		X	X

PC 2	EE6103	Alternate Energy Sources	3	0	0	3

Module I:
Introduction: Principles of renewable energy; energy and sustainable development, fundamentals, and social implications. worldwide renewable energy availability, renewable energy availability in India, brief descriptions on solar energy, wind energy.
Geothermal Energy: Geothermal sources, hydrothermal resources – vapor dominated and liquid dominated systems, hybrid plants – geothermal preheat and fossil superheat; applications of geothermal energy, advantages, and disadvantages of geothermal energy.

Module II:
Energy from Biomass: Biomass conversion technologies, photosynthesis, biogas generation, factors affecting biogas generation, classification of biogas plants – floating drum plants and fixed dome plants, selection of site for biogas plant, utilization of biogas; Methods for obtaining energy from biomass, biomass gasification, classification of biomass gasifiers, fixed bed gasifiers and fluidized bed gasifiers, applications of gasifiers, advantages and limitations of gasifiers;
Chemical Energy sources: Fuel cells -principle of operation of fuel cell, types of fuel cells –hydrogen oxygen, solid-oxide, alkaline, polymer electrolyte membrane fuel cells, advantages, disadvantages and conversion efficiency of fuel cells, applications of fuel cells.

Module III:
Small Hydro Energy systems: Introduction -overview and analysis small, mini and micro hydro energy systems. Site selection and civil works, penstock and turbine.
Energy from the oceans: Ocean thermal energy conversion-open cycle and closed cycle systems, energy from tides – basic principle of tidal power, components of tidal power plants, single basin and double basin systems, ocean waves – wave energy conversion systems
Magneto Hydro Dynamic (MHD), Thermo-electric and Thermo-ionic Power Generations: Principles of MHD power generation – open cycle and closed cycle – advantages and limitations. Basic principles of thermo-electric and thermo-ionic power generation – advantages and limitations.

Text/ Reference books:
1. D. Rai, Non-Conventional energy sources, 5th Edition, Khanna Publishers, 2011.
2. D.P. Kothari, R. Rakesh and K.C. Singal, Renewable Energy Resources and Emerging Technologies, 2nd Edition, Prentice India Pvt. Ltd, 2011.
3. G.S. Sawhney, Non-Conventional Energy Sources, 1st Edition, Prentice India Pvt. Ltd, 2012.
4. G.N. Tiwari and M.K. Ghosal, Renewable Energy Resources: Basic Principles and Applications, 1st Edition, Alpha Science International Ltd, 2004.
5. Micro -Hydro Design Manual: A Guide to Small-Scale water power Schemes, Adam Harvey, Intermediate Technology Publications, 1993.

COURSE OUTCOMES
1. Know the need of renewable energy resources, historical and latest developments.
2. Understand the concept of Biomass energy resources and their classification, types of biogas Plants applications
3. Acquire the knowledge of fuel cells, wave power, tidal power, and geothermal principles and applications.
4. Understand the concept and design of Small hydro energy systems.

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus (Effective from 2023-24)

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Energy System and Management (ESM),
Duration: 2 years (Four Semesters)

PE 1	EE6201	Storage Technology	3	0	0	3

Module I
Introduction to energy storage technology and energy storage processes
The need for energy storage - Types and general concepts Energy storage processes:

- Electrical energy storage – Super capacitors: Fundamentals and types of super capacitors
- Magnetic Energy Storage – superconducting systems,
- Thermal Energy Storage – phase change materials,
- Mechanical - Pumped hydro, Flywheels and Compressed air energy storage,
- Chemical - Hydrogen Storage, Production and storage alternatives, Other approaches to hydrogen storage.

Module II
Electrochemical energy storage
Thermodynamics, Kinetics and electrochemistry of battery Systems Primary, secondary and Flow batteries.

Module III
System design & Applications

- Energy storage for renewable energy sources - Battery sizing and stand-alone Applications
- Large scale applications/ Stationary (Grid applications) – Power and energy applications
- Small scale applications - Portable storage systems/medical devices
- Mobile storage applications
    - Electric vehicles - Introduction and types of EV's
    - Batteries and fuel cells – future technologies
- Hybrid systems for energy storage

Books and References:

1. Energy Storage - Technologies and Applications, Ed: Ahmed Faheem Zobaa, ISBN 978-953-51-0951-8, 328 pages, Publisher: InTech, 2013.
2. J. Jensen and B. Sorenson. Fundamentals of Energy Storage. Wiley-Interscience, New York (1984)
3. Handbook of battery materials, Ed: C. Daniel, J. O. Besenhard, 2nd Edition, Wiley- VCH Verlag GmbH & Co. KgaA, 2011.
4. Electric & Hybrid Vehicles, G. Pistoia, Elsevier B.V, 2010.

COURSE OUTCOMES:

CO1: Understand various storage technologies.
CO2: Able to analyze the reliability, technical efficiency and economic efficiency of an integrated system.
CO3: Exposure to modern innovative technologies applied for energy storage in fuel cell, hydrogen storage, electromagnetic storage etc.
CO4: Design of battery in electric vehicles and hybrid systems

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Energy System and Management (ESM),
Duration: 2 years (Four Semesters)

PE 1	EE6203	Economics and Planning of Energy System	3	0	0	3

Module I:
Introduction: Genesis of the term 'Energy Economics', Law of demand, Elasticities of demand, Theory of firm: Production function, output maximization, cost minimization and profit maximization principles. Theory of market,
Basic concepts of Energy Economics: Calculation of unit cost of power generation from different sources with examples, Ground rules for investment in Energy sector, Payback period, NPV, IRR and Benefit-cost analysis with example.
Socio-economic evaluation of Energy Conservation Programmes: Net Social Benefit incorporating Free riding concept and Rebound effects, Energy-GDP elasticity. Basic concept of Input-Output analysis

Module II:
Overview of Energy Policy and Plan:
National income and other macroeconomic parameters, Tariff Policy, National Electricity Plan (Generation & Transmission), Transnational Grid Connectivity for Ensuring Energy Security, Renewable Policy, Govt. of Odisha, Accelerating the production and use of Green Hydrogen, Hydrogen Policy, Energy Storage System and Road Map for India, Electric Power Survey Report, Resource Adequacy concept of CEA

Module-III
Models and Analysis:
Analysis of Environmental Pollution through decomposition of different sectors using I-O model, Interdependence of energy, economy and environment, Modeling concepts and application of SIMA model and Input-Output model for energy policy analysis, Concept of energy multiplier and implication of energy multiplier for analysis of regional and national energy policy.

COURSE OUTCOMES:
At the end of the course, the student will be able to
CO 1: learn about the application of Economic Principles to the Energy Sector
CO 2: learn about the different Policies and Plans related to the Energy Sector.
CO 3: Learn about different models for energy analysis
CO 4: know about the future roadmap for India in the energy sector

Reference Books and Study Materials:

1. EA Diulio, Macroeconomic Theory, Schaum's Outline Series, 2nd Ed, McGraw-Hill Publishing Company (1990)
2. R Loulou, P R Shukla and A Kanudia, Energy and Environment Policies for a sustainable Future, Allied Publishers Ltd, New Delhi, 1997
3. J Parikh, Energy Models for 2000 and Beyond, Tata McGraw-Hill Publishing Company Ltd, New Delhi,1997
4. National El Plan (Generation)-Govt. of India
5. Trans-National Grid Connectivity for ensuring Energy Security – Govt. of India
4. Energy Economics -A.V.Desai (Wieley Eastern) Energy Economics - Simple Payback Period, Time Value of Money, IRR, NPV, Life Cycle Costing, Cost of Saved Energy, Cost of Energy generated, Examples from energy generation and conservation.

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus (Effective from 2023-24)

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Energy System and Management (ESM),
Duration: 2 years (Four Semesters)

PE 1	EE6205	Hydrogen and Fuel Cells	3	0	0	3

Module I:
Hydrogen energy
Production of hydrogen, steam reforming, water electrolysis, gasification and woody biomass conversion, biological hydrogen production, photo dissociation, direct thermal or catalytic splitting of water, hydrogen storage options, compressed gas, liquid hydrogen, hydride, chemical storage, safety and management of hydrogen, the economics of Application and advantages of hydrogen (liquid hydrogen) as fuel for IC engines/ hydrogen car, layout of a hydrogen car.

Module II
Fuel Cells Types
Concept of fuel cell, Principle of working of various types of fuel cells, types: AFC, PAFC, SOFC, MCFC, DMFC, PEMFC – relative merits and demerits, performance evaluation of fuel cell, performance and limitations. power rating, heat dissipation, layout of fuel cell vehicle. comparison of battery Vs fuel cell, future technologies

Module III
Fuel Cells -Application and Economics:
Fuel cell usage for domestic power systems, large scale power generation, automobile, space applications, economic and environmental analysis on usage of fuel cell, future trends of fuel cells.

Reference Books: -

1. Fuel cell Fundamentals, John Wiley and sons, Willey
2. Viswanathan B and AuliceScibioh, Fuel cells: Principles and Applications, , University Press
3. Prashukumar G P, Hydrogen – A fuel for Automatic Engines, ISTE
4. Peter Hoffman, Tomorrow's Energy – Hydrogen Fuel Cells and the Prospects for Cleaner Planet, MIT
5. Rebecca L. and Busby, Hydrogen and Fuel Cells: A Comprehensive Guide, Penn Well Corporation, Oklahoma
6. Hart, A. B and G. J. Womack, Fuel Cells: Theory and Application, Prentice Hall, New York Ltd., London
7. Jeremy Rifkin, The Hydrogen Economy, Penguin Group, USA

COURSE OUTCOME: Students will be able to
1. The students will have the general knowledge of Fuel Cells as a promising technology in the context of clean power sustainability and alternative fuels for shipping.
2. The students will know different specific developments on Fuel Cells which are available today.
3. Apply fundamental concept and working of various fuel cells in real worlds applications.
4. Analyze relative advantages / disadvantages and hydrogen generation/storage technologies.
5. Compare and select appropriate hydrogen cell technologies for the various applications

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Energy System and Management (ESM),
Duration: 2 years (Four Semesters)

MC 1	BH6401	Mathematical Methods in Engineering	3	0	0	3

Refer Appendix-I for detailed Syllabus.

MC 2	MS6403	Research Methodology and IPR	2	0	0	2

Refer Appendix-I for detailed Syllabus.

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Energy System and Management (ESM),
Duration: 2 years (Four Semesters)

LC 1	EE6501	Energy System Simulation Lab	0	0	4	2

LIST OF EXPERIMENTS:

1. Modeling and simulation of a solar PV system different irradiance levels and different temperature.
2. Modeling and simulation of wind energy conversion system for different wind speeds.
3. Modeling and simulation standalone wind -PV hybrid system.
4. simulation of the MPPT for solar PV systems
5. Design and simulation of grid connected wind energy systems with MPPT.
6. Simulation of Load forecasting in micro-grid environment
7. Simulation of Wind power forecasting in micro-grid environment
8. Simulation of Solar power forecasting in micro-grid environment.

COURSE OUTCOMES:
At the end of the course, students will be able to
CO1: simulate and characterize Solar PV systems at different environmental situation
CO2: Synthesize and harness maximum power at different irradiances and wind velocities
CO3: Design wind- PV hybrid systems

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus (Effective from 2023-24)

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Energy System and Management (ESM),
Duration: 2 years (Four Semesters)

LC 2	EE6503	Energy System Control Lab	0	0	4	2

LIST OF EXPERIMENTS:

1 To Study single-phase (i) fully controlled (ii) Half controlled bridge rectifiers with resistive and inductive loads
2 To Study three-phase (i) fully controlled (ii) Half controlled bridge rectifiers with resistive and inductive loads.
3 To study operation of IGBT/MOSFET based Buck chopper
4 To study operation of Dual Converter with resistive and inductive loads.
5 To Study single-phase AC voltage regulator with resistive and inductive loads
6 To Study Three-phase AC voltage regulator with resistive and inductive loads
7 To Study various pwm based single-phase bridge inverter
8 To Study pwm based three-phase bridge inverter
9 Calculation of input power factor and displacement factor for single phase rectifier circuit
10 Development of firing angle table for +ve, -ve and zero sequence voltage for 3-ph inverter circuits
11 Performance calculation of various rectifier circuits

COURSE OUTCOMES:

CO1: Understand and Analyze the performance parameters of converters.
CO2: Analyze Spectral content for Various PWM schemes.
CO3: Design the firing circuits employed for Power Electronic Converters.

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Energy System and Management (ESM),
Duration: 2 years (Four Semesters)

AC 1	Any One from the List of AC 1 (Appendix-I)	2	0	0	0

Refer Appendix-I for detailed Syllabus.

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Energy System and Management (ESM),
Duration: 2 years (Four Semesters)

2nd Semester

PC 3	EE6102	Wind and Solar Energy System	3	0	0	3

Module-I:
Wind and Solar PV System Fundamentals: Wind Energy, Wind Speeds and Scales, Terrain, Turbulence, Roughness, Site Selection, Principles of Aerodynamics of wind turbine blade, Power Content, Betz's Limit, Wind measurements, Wind data analysis, Wind resource estimation.
Photovoltaic effect: Principle of direct solar energy conversion into electricity in a solar cell. Solar cells, modules and arrays, fill factor, efficiency.
Solar PV modules: series and parallel connection of cells, modules and arrays and its mismatch. PV Modelling: Equivalent circuit of PV cell, output characteristics, Double and single diode models, PV module equivalent parameters, effect of solar irradiance and temperature on PV.

Module-II:
Classification of Wind Turbines, Vertical and Horizontal Axis types, Torque-Speed and Power-Speed Characteristics WT, Constant Speed and Frequency, Variable Speed and Frequency, Up Wind, Down Wind; Wind Turbine Control Systems: Pitch Angle Control, Stall Control, Yaw Control and Power Electronic Control, Control strategy.
Control of Solar PV System
Incremental conductance algorithm, Perturb and observe approach, improvements of P&O algorithm, MPPT for rapidly changing irradiance conditions. Design of dc/dc converter, single phase and three-phase inverter with PV as a source. Grid support features of utility-scale PV with storage, Micro-grids, and frequency/voltage control in islanded mode of operation. Three phase PV inverters, Response of Abnormal Grid Conditions.

Module-III:
Wind Turbine Generators and Power Electronics Control: Gear and Rotor Coupled Generator Type WT, Conversion to Electrical Power: Excited Rotor Synchronous Generator/Permanent Magnet Synchronous Generator, Constructional Features, Steady State Equivalent Circuit Model and Equations, Doubly Fed Induction Generator, Induction Generator. Power Electronics Converters, Reactive Power Compensation and Grid Connection Issues.
APPLICATION AND DESIGN OF PV SYSTEMS: Stand-alone, Grid Interactive and Hybrid solar PV system and its cost estimation. Solar Water Pumping System and Net Power Metering. Design of Solar Parks and use of Solar Electricity in solar cars, aircraft, space solar power satellites.

Text books :
1. S. N. Bhadra, D. Kastha, S. Banerjee, Wind Electrical Systems, Oxford Univ. Press, New Delhi, 2005.
2. Wind energy Handbook, Edited by T. Burton, D. Sharpe, N. Jenkins and E. Bossanyi, John Wiley & Sons, 2001.
3. L .L. Freris, Wind Energy Conversion Systems, Prentice Hall, 1990.
4. D. A. Spera, Wind Turbine Technology: Fundamental concepts of Wind Turbine Engineering, ASME Press.
5. Chetan Singh Solanki., Solar Photovoltaic: "Fundamentals, Technologies and Application", PHI Learning Pvt., Ltd., 2009.
6. Nicola Femia, Giovanni Petrone, Giovanni Spagnuolo, Massimo Vitelli, Power Electronics and control for maximum Energy Harvesting in Photovoltaic Systems, CRC Press,2013.
7. Remus Teodorescu, Marco Liserre, Pedro Rodriguez, Grid Converters for Photovoltaic and Wind Power Systems, John Wiley and Sons, Ltd., 2011.

References:
1. Wind Energy Explained – Theory, Design and Application by J. F. Manwell, J. G. McGowan and A. L. Rogers, John Wiley & Sons, Ltd., 2002.

2. Aerodynamics of Wind turbines by Martin O. L. Hansen, Earthscan, 2008.
3. Anna Mani &Nooley, "Wind Energy Data for India", 1983.
4. Wind Turbine Control Systems- Principles, Modelling and Gain Scheduling Design by Fernando D. Bianchi, Hernan De Battista and Ricardo J. Mantz, Springer, 2007.
5. S. Rao & B. B. Parulekar, "Energy Technology", 4th edition, Khanna publishers, 2005.
6. B.H.Khan, Non-Conventional Energy Resources, Tata McGrawHill, 2009.
7. John R. Balfour, Michael L. Shaw, Sharlave Jarosek., "Introduction to Photovoltaics", Jones & Bartlett Publishers, Burlington, 2011.
8. Partain .L.D, Fraas L.M., "Solar Cells and Their Applications", 2nd ed., Wiley, 2010.
9. Sukhatme .S.P, Nayak .J.K, "Solar Energy", Tata McGraw Hill Education Private Limited, New Delhi, 2010.
10. Sudipta Chakraborty, Marcelo G. Simões, and William E. Kramer. Power Electronics for Renewable and Distributed Energy Systems: A Sourcebook of Topologies, Control and Integration. Springer Science & Business, 2013.

COURSE OUTCOMES:

At the end of this course, students will be able to,

CO 1: Conduct a basic wind and solar resource estimation, site assessment, and conversion of wind & solar energy to electricity.

CO 2: Understand the fundamentals of design, characteristics, operation and issues subject to on- and off-grid.

CO 3: Analyze the implementation and role of power electronic converters with grid and without grids.

CO4: Evaluate economies and ecology of the system in singular and hybrid modes.

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus (Effective from 2023-24)

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Energy System and Management (ESM),
Duration: 2 years (Four Semesters)

PC 4	EE6104	Power System Planning	3	0	0	3

Module I:
Basic Elements Power System Planning: Various issues relating to power system planning: an overview of the generation, transmission, and distribution aspects of planning, Long term, and short- term planning; Growth and development of the Electrical Power Industry Global and Indian scenario, 5-year plans. Indian power industry and current developments, Role of key institutions in power system planning in the Indian context.

Module II:
Generation Planning: Load forecasting, importance, and various methodologies, power system reliability, indices, Markov two-state model for generating systems availability, upgradation of old power stations; technical and economic issues
Transmission Line Planning: Selection of voltage levels and type of system (EHV AC or HVDC), Corona losses and Radio interference, Right –of-way requirements, Routing of transmission lines, methods, Line congestion in deregulated systems, and their minimization Grid issues and regulations. Transmission line reliability evaluation.
Distribution Planning: Distribution systems; ring and radial systems, loss minimization by reconfiguration; substation location and planning, Distributed automation and loss minimization in feeders by reactive power compensation: series and shunt compensation, Improved billing Strategies.

Module III:
Miscellaneous issues: Deregulation of power systems, energy conservation and audits, Security and contingency analysis

References
Sl No ***Name of Authors / Books / Publishers***

1. Pabla. A.S. " Electrical Power Distribution Systems ", Tata-McGraw Hill, New Delhi.
2. National Power Plan (1985 -2000AD) Central Electricity Authority, Ministry of Power, Govt. of India,, New Delhi
3. Sullivan W. and Wayne, W, "Fundamentals of Forecasting" , Reston Publishing Company. Virizinia
4. Billington, Roy and Allen , R. N. " Reliability Evaluation of Power Systems", Pitman, London (U.K.)
5. Weedy, B.M. " Electrical Power Systems" John Wiley and Sons, Singapore

COURSE OUTCOMES:
At the end of the course, students will be able to:
CO1: Gain knowledge on the generation, transmission, and distribution aspects of planning, the Indian power industry, and current developments
CO2: Gain knowledge on Generation Planning, Transmission Line Planning, Distribution
CO3: Gain knowledge on energy conservation and audits, Security, and contingency analysis

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Energy System and Management (ESM),
Duration: 2 years (Four Semesters)

PE 2	EE6202	AI and Machine Learning	3	0	0	3

Module I

Artificial Neural Networks and Deep Learning

Neural Network representations, appropriate problems for neural network learning

Supervised Learning: Perceptrons, representational power of perceptrons, perceptron training rule, Gradient Descent and Delta rule, Multilayer perceptron and backpropagation algorithm

Linear Regression: Linear regression and prediction of continuous data values, Recurrent Neural Networks, RBFN

Unsupervised Learning: Competitive Learning, K-Means clustering, Hierarchical Clustering

Support Vector machines: Classification of data points using support vectors

Module II

Fuzzy Inference Systems:

Basic Concepts of Fuzzy Logic, Fuzzy vs Crisp Set, Linguistic variables, Membership Functions, Operations of Fuzzy Sets, Fuzzy If-Then Rules, Variable Inference Techniques, Defuzzification, Basic Fuzzy Inference Algorithm, Fuzzy Neural Network, System Identification using Fuzzy and Neural Networks

Module III

Genetic Algorithm:

Representing Hypothesis, Genetic operators, Population Evolution, Genetic programming,
Introduction to other evolutionary Algorithms like PSO, BFO etc

Text Books

1. Tom M Mitchell, Machine Learning, PHI LEARNING PVT. LTD-NEW DELHI, 2015
2. Ethem Alpaydin, Introduction to Machine Learning , The MIT Press, 3rd Edition, 2015
3. Simon Haykins, Neural Networks, Prentice Hall
4. Timothy Ross, Fuzzy Logic with Engineering Application- McGraw Hill Publishers

Reference Books

1. R. Duda, P. Hart, and D. Stork. "Pattern Classification", 2nd edition, Wiley Interscience, 2001.
2. C. M. Bishop. "Neural Networks for Pattern Recognition", Oxford University Press, 1995.
3. T. Hastie, R. Tibshirani and J. Friedman, "Elements of Statistical Learning: Data Mining, Inference and Prediction". Springer-Verlag, 2001.
4. T. Cover and J. Thomas. "Elements of Information theory", Wiley Interscience, 1991.
5. Golding, “Genetic Algorithms”, Addison Wesley
6. Junhong NIE & Derek Linkers, “Fuzzy Neural Control”, PHI

COURSE OUTCOME.

On successful completion, students will have the ability to

CO1 Apply the concepts of Neural network for pattern recognition andclassification

CO2 Apply Fuzzy logic principles to take decisions and design controllers

CO3 Apply GA principles for solving optimization problems

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH
Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.
Syllabus (Effective from 2023-24)

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Energy System and Management (ESM),
Duration: 2 years (Four Semesters)

PE 2	EE6204	Energy Audit and Management	3	0	0	3

Module I
Introduction
Energy and Sources of energy, Energy consumption and GDP, Costs of exploration and utilization of resources, Energy pricing, Energy demand and supply, National energy plan, Need for Energy Policy, National and State Level Energy Policies. Basic concepts of Energy Conservation and its importance, Energy Strategy for the Future, The Energy Conservation Act and its Features, Energy conservation in household, Transportation, Agricultural, Service and Industrial sectors, Lighting, HVAC Systems.

Module II:
Energy Audit
Energy audit concepts, Definition, Need and Types of energy audit. Energy Audit Approach and Methodology. Systematic procedure for technical audit. Understanding energy audit costs, Benchmarking and Energy Performance. Energy audit based on First law and Second law of thermodynamics, Mass and Energy balances, Availability analysis, Evaluation of energy conserving opportunities, Economic analysis and life cycle costing. Duties and responsibilities of energy auditors. Energy audit instruments and their usage for auditing. Report writing, preparations and presentations of energy audit reports.

Module III:
Energy Management
History of Energy Management, Definition and Objective of Energy Management and its importance. Need of energy management, General Principles of Energy Management, Energy Management Skills, and Energy Management Strategy. Energy Management Approach. Understanding Energy Costs, Benchmarking, Energy performance, matching energy usage to requirements, Maximizing system efficiency, Optimizing the input energy requirements, Fuel and Energy substitution. Organizing, Initiating and Managing an energy management program. Roles, responsibilities and accountability of Energy Management

Books

[1]. Anil Kumar, Om Prakash, Prashant Singh Chauhan, Samsher, Energy Management: Conservation and Audits, 1st Edition, CRC Press, Taylor & Francis.
[2]. Amlan Chakrabarti, Energy Engineering and Management, PHI, Eastern Economy Edition.
[3]. Smith CB, Energy Management Principles, Pergamon Press, New York.
[4]. Hamies, Energy Auditing and Conservation; Methods, Measurements, Management & Case study, Hemisphere, Washington
[5]. L. C. Witte, P. S. Schmidt and D. R. Brown, Industrial Energy Management and Utilization, Hemisphere Publications, Washington.
[6]. W.R.Murphy, G.Mckay, Energy Management, Butterworths.
[7]. C.B.Smith Energy Management Principles, Pergamon Press.
[8]. L.C. Witte, P.S. Schmidt, D.R. Brown, Industrial Energy Management and Utilization, Hemisphere Publication, Washington
[9]. Archie, W Culp, Principles of Energy Conservation, McGraw Hill.
[10]. Munasinghe, Mohan Desai, Ashok V, Energy Demand: Analysis, Management and Conservation, Wiley Eastern Ltd., New Delhi.

COURSE OUTCOMES: On successful completion, students will have the ability to
- **CO 1:** Analyze the concepts, methodology of energy audit and energy management
- **CO 3:** Understand the objectives, skills and economics of Energy management.
- **CO 4:** Able to know the roles, responsibilities and accountability of Energy Management.

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Energy System and Management (ESM),
Duration: 2 years (Four Semesters)

PE 2	EE6206	Climate Change and Carbon Trading	3	0	0	3

Module I:
Introduction, The Changing Climate and issues raised, Corporate Climate Risk, Climate Policies, Role of the Financial Services Sector, The Energy Chain and the Value Chain, Carbon Policies, Impacts of Different Users and Uses on Climate Change, Climate compatible resources and technologies. The Role of Venture Capital Change on the Evolution of Carbon Finance, Competitive Implications of Climate Risk in regulated and energy-intensive sectors.

Module II:
The role of weather derivatives, Severe weather: the role of catastrophe bonds, Basic elements of the market, key private sector players, key players from the public sector. How carbon is traded now, key issues, the carbon offset market, the role of insurance in emissions trading, issues for dispute resolution. Climate change and environmental security: Individuals, communities, nations, direct effect of extreme weather events, health effects of climate change, Polar Regions, climate systems and national sovereignty.

Module III:
Trading Volumes in Carbon and Weather Markets, What can be traded where. The evolution of products for carbon finance, litigation over responsibility for climate change; is carbon finance likely to help us avert dangerous levels of climate change, carbon finance within the broader field of environmental finance.

Text books/ References:

1. Carbon Finance: The Financial Implications of Climate Change, Sonia Labatt, Rodney R. White, Published by John Wiley and Sons, 2007.
2. Environmental Finance: A Guide to Environmental Risk Assessment and Financial Products, Sonia Labatt, Rodney R. White, Published by John Wiley and Sons, 2002.
3. Carbon Markets: An International Business Guide, by Arnaud Brohe, Nick Eyre and Nicholas Howarth, 2009.
4. A Guide to Carbon Finance: Carbonomics for a Credit Constrained World by Kenny Tang, 2009.

COURSE OUTCOMES:
At the end of this course, students will be able to,
CO 1: Assess the degree of climate change with respect to time and its severity to the human being.
CO 2: Provide the nomenclature of carbon finance and a broad understanding of the regulatory, financial and competitive risks of a carbon constrained economy.
CO 3: Develop various facets of carbon finance, their role and implications.
CO 4: Introduce and analyze cap and trade and carbon tax as mechanisms to limit and reduce GHGs in the atmosphere and asses real-world application of cap and trade in the EU Emissions Trading Scheme.

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus (Effective from 2023-24)

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Energy System and Management (ESM),
Duration: 2 years (Four Semesters)

PE 3	EE6208	Economics of Power Management	3	0	0	3

Module I:
Economics of Electricity Supply:
Basic Concepts Related to Electricity Systems, Alternative Electricity Generation Options, Generation Capacity Reserve, Economic Dispatch - Merit Order Dispatch & Incremental Cost Method, Unit Commitment, Investment Decisions in the Power Sector - Levelised Bus–Bar Cost & Screening Curve Method

Module II:
Electricity Market Design:
Types of market, Optimal Dispatch in real time, Spot Market, Price formation in Market, Imbalance (Deviation) Settlement and Forward Market, Operation of Green Day-Ahead Market (G-DAM) and Term-Ahead Market (TAM), Idea of Power Exchange, Congestion Management and pricing, Market Splitting, Capacity Market, Mandatory Long-term Contract (PPA), Ancillary Services and its market
Controlling Emission and Carbon Pricing, Variable Renewable Energy and Battery Energy Storage Pricing

Module III:
Regulation and Tariff Setting
Traditional Regulation, Price Cap Regulation, Revenue Cap Regulation, Yardstick Competition, Performance Based Regulation, Loss in the Power System (AT&C Loss), CEA Guideline on Medium and Long-Term Power Demand Forecast, Multi-Year Tariff Principle (MYT), Cost Plus Tariff Determination, Levelised Tariff Concept, Profit Sharing, Peak and Off-Peak Pricing- Peak Load Pricing Principle & Short-Run Versus Long-Run Debate, Concept of Open Access, Concept of Cross-subsidy in Tariff and Determination of Cross-Subsidy Surcharge

Recommended Books:

1. Energy Economics Concepts, Issues, Market and Governance
   by Subesh C. Bhattacharyya, Centre for Energy, Petroleum and Mineral Law and Policy, University of Dundee, UK, Springer Publication
2. CEA Guideline on Medium and Long-Term Power Demand Forecast (www.cea.nic.in)
3. CERC (Deviation Settlement Mechanism) Regulation, 2022 (www.cerc.gov.in)
4. OERC (Retail Supply and Wheeling) Regulation, 2022 (www.orierc.org)

COURSE OUTCOMES:
After studying this course, students would be able to know
CO1: The economic generation of power and its dispatch
CO2: Availability of power at optimum price at substation busbar
CO3: Different types of electricity market
CO4: Regulatory Governance principle and tariff setting

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Energy System and Management (ESM),
Duration: 2 years (Four Semesters)

PE 3	EE6210	Advanced DSP	3	0	0	3

Module I:
Classification of Signals: Multichannel and Multidimensional Signals, Continuous-Time Versus Discrete-Time Signals, Continuous-Valued Versus Discrete-Valued Signals, Deterministic Versus Random Signals, Concept of frequency in Continuous-Time and Discrete-Time Signals
Analysis of Discrete-Time LTI Systems:
Resolution of a Discrete-Time Signal into impulses, Response of LTI Systems to Arbitrary Inputs: The convolution sum, Causal LTI Systems, systems with Finite-Duration and Infinite-Duration Impulse Response, Recursive and Non-Recursive Discrete-Time Systems, LTI Systems characterized by Constant Coefficient Difference Equations
Correlation of Discrete-Time Signals:
Cross-correlation and Auto-Correlation Sequences, Properties of Cross-correlation and Auto-Correlation Sequences, Correlation of Periodic Sequences, Input-Output Correlation Sequences

Module II
Transforms used in Signal Processing:
Discrete Fourier Transform, Its Properties, Use of DFT in Linear Filtering
Discrete Cosine Transform: Forward DCT, Inverse DCT, DCT as an Orthogonal Transform
Fast Fourier Transform: Divide and Conquer Approach to Computation of DFT, Radix-2 and Radix-4 FFT
Brief introduction to Short time Fourier Transform, Discrete Wavelet Transform, S-Transform and their applications

Module III
Adaptive Signal Processing:
Least Mean Square Algorithm and its variants, Properties of LMS Algorithm, Recursive Least Square Algorithm and its variants, Kalman Filter
Application of Adaptive Signal Processing to Power System
Time Series Prediction:
Nature of Time Series Data, AutoRegressive Moving Average (ARMA) Models, AutoRegressive Integrated Moving Average (ARIMA) Models for Forecasting & Estimation

COURSE OUTCOMES: Upon completion of the course, the students will demonstrate the ability to:
CO1 Learn about analysis and correlation of discrete-time signals
CO2 Learn about different Transforms used in signal processing
CO3 Learn about different estimation techniques
CO4 Know about time series prediction

TEXT/ REFERENCE BOOKS:

1. J. G. Proakis and D. G. Manolakis, “Digital Signal Processing”, Fourth Edition, Pearson
2. Simon Haykin, “Adaptive Filter Theory”, Fourth Edition, Pearson
3. A. Nagoor Kani, “Discrete-Time Signal Processing”, Prentice Hall
4. Alan V. Oppenheim, Ronald W. Schafer, “Discrete-Time Signal Processing”, Prentice Hall
5. S. Mallat, “A wavelet Tour of Signal Processing: The sparse way: Academic Press, 2010

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus (Effective from 2023-24)

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Energy System and Management (ESM),
Duration: 2 years (Four Semesters)

PE 3	EE6212	Smart Grid Technology	3	0	0	3

Module-I:
Evolution of Electric Power Grid, introduction to smart Grid Concept, definitions, architecture and functions of Smart Grid. Need of Smart Grid. Difference between conventional & smart grid. Opportunities & Challenges of Smart Grid, Introduction to Smart Meters, Real Time Pricing, Smart Appliances. Automatic Meter Reading(AMR). Outage Management System(OMS). Home & Building Automation, Substation Automation, Feeder Automation, Smart Sensors, Phase Shifting Transformers, Volt/VAR control, High Efficiency Distribution Transformers

Module-II:
Geographic Information System(GIS). Intelligent Electronic Devices(IED) & their application for Monitoring & Protection, Storage systems including Battery, SMES, Pumped Hydro. Compressed Air Energy Storage. Phasor Measurement Units (PMU), Wide Area Measurement System(WAMS), Wide-Area based Protection and Control Micro-grid concepts, evolution of microgrid, need and application, Issues of Interconnection. Protection control systems for micro-grid. Variable speed wind generators, fuel-cells, micro-turbines. Captive power plants, Integration of renewables and issues involved, Advantages and disadvantages of Distributed Generation.

Module-III:
Power Quality & EMC in smart Grid. Power Quality issues of Grid connected Renewable Energy Sources. Power Quality Conditioners for micro-grid. Web based Power Quality monitoring, Power Quality Audit. Advanced Metering Infrastructure(AMI). Home Area Network (HAN), Neighborhood Area Network (NAN), Wide Area Network (WAN), Energy Management Systems (SCADA).

Suggested Books:
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. Stuart Borlase, “ Smart Grid: Infrastructure,Technology and solutions “ CRC Press.
4. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama,“Smart Grid: Technology and Applications”, Wiley.
5. Andres Carvallo, John Cooper, “The Advanced Smart Grid: Edge Power Driving Sustainability: 1”, Artech House Publishers July 2011
6. MladenKezunovic, Mark G. Adamiak, Alexander P. Apostolov, Jeffrey George Gilbert “Substation Automation (Power Electronics and Power Systems)”, Springer

COURSE OUTCOMES:
After successfully completing this course a student will able to:
CO 1: Understand the fundamental element of the smart grid
CO 2: Explain various communication, networking, and sensing technologies involved in smart grid
CO 3: Explain various integration aspects of conventional and non-conventional energy sources.
CO 4: Explain distributed generation coordination including monitoring of smart grid using modern communication infrastructure
CO 5: Analyze Micro-grid as a hybrid power system with advantages and challenges in future.
CO 6: Be able to apply this knowledge in analysis and problem solving of smart grid architectures needs and challenges

OE 1	Any One from the List of OE 1 (Appendix-I)	3	0	0	3

Refer Appendix-I for detailed Syllabus.

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Energy System and Management (ESM),
Duration: 2 years (Four Semesters)

PR 1	EE6602	Project (Specialization Related)	0	0	4	2

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Energy System and Management (ESM),
Duration: 2 years (Four Semesters)

LC 3	EE6502	Renewable Energy System Lab/ Design of Smart Energy System Lab	0	0	4	2

LISTS OF EXPERIMENTS (Renewable Energy System Lab)

Sl. No.	Name of the Experiment
1.	Calculate the efficiency of solar PV module of your laboratory.
2.	Calculate the fill factor of a solar PV cell.
3.	Develop the P-V and I-V graphs at different insolations/irradiances.
4.	Develop the P-V and I-V graphs at different insolations/irradiances.
5.	Realise the hot spot effect of your laboratory solar PV module.
6.	Calculate the performance parameter of the solar cooker system of your laboratory.
7.	Study and performance analysis of wind power system under various loads.
8.	Study the supply side and load side power factors of a solar PV system.
9.	Study the harmonics present in grid tied solar PV system.
10.	Develop the power curve of wind turbine at various wind velocities.
11.	Study of various softwares related to laboratory experiments
12.	Simulation of power flow of a standalone PV system with a DC load and battery
13.	Simulation of power flow of a standalone PV system with a AC load and battery
14.	Develop the energy density of various energy crops and residues.
15.	Calculate the GCV and NCV of a wood specimen.

COURSE OUTCOMES:

At the end of the course, the student will be able to
CO1: Gain knowledge of different renewable sources and its energy content.
CO2: Perform experiments to measure energy content.
CO3: Develop the characteristics and performance of renewable technologies devoted to production of electricity.
CO4: Design various loads and characterise its better performance.

OR

LISTS OF EXPERIMENTS (Design of Smart Energy System Lab**)**

Sl. No.	Name of the Experiment
1.	Study and analysis of series and parallel connections of solar PV cells and modules.
2.	I-V and P-V characteristics of solar PV under different conditions (ambient, shading, different tilt angle conditions etc.)
3.	Study and performance analysis of single phase inverter for solar PV systems.
4.	Study and performance analysis of battery connected to solar PV systems.
5.	Study and analysis of solar PV grid-connected system.
6.	Study and analysis of wind turbine characteristics.
7.	Study and performance analysis of wind energy system under various loading conditions.
8.	Study of weather condition using different measurement sensors (thermometer, anemometer, pyranometer and humidity sensor).
9.	Study and performance analysis of fuel cells.
10.	Study and performance analysis of hybrid energy system
11.	Study and performance analysis of smart-grid system
12.	Study and performance analysis of micro grid integrated with renewables.

COURSE OUTCOMES: After completion of course students will be able to:
1. Apply the knowledge of solar PV system in home integrated system and commercial application of it.
2. Understand the characteristic wind electricity system and hybrid system.
3. Conduct practical integration of hybrid system to grid.
4. Understand various smart devices and its interfacing for smart energy system.

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Energy System and Management (ESM),
Duration: 2 years (Four Semesters)

AC 2	Any One from the List of AC 2 (Appendix-I)	2	0	0	0

Refer Appendix-I for detailed Syllabus.

ODISHA UNIVERSITY OF TECHNOLOGY AND RESEARCH

Techno Campus, Mahalaxmi Vihar, Ghatikia, Bhubaneswar-751029.

Syllabus (Effective from 2023-24)

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Energy System and Management (ESM),
Duration: 2 years (Four Semesters)

3rd Semester

PE 4	EE7201	Grid Integration of Renewable Sources	3	0	0	3

Module-I

Introduction to distributed generation/Micro Grid: General introduction to the concept of distributed generation, Standalone System, Integration of distributed renewable generation into the electricity system (Current status, challenges and prospects) and its impacts on the electrical system.

Network topologies with distributed generation: Description of the different network topologies where distributed renewable generation (Wind, Solar, Hydro, Tidal power) can be connected. Principles of design, operation.

Module II

Power system Performance:

Impact of distributed generation on power system in terms of changes taking place and severity imposed, power quality issues, voltage quality issues, design of distributed generation.

Impact of distributed generation on power system in terms of overloading and losses, radial distribution networks, redundancy and meshed operation, losses, increasing the hosting capacity.

Module-III

Control of standalone system and Grid connected system (Voltage and frequency control). Phase Locked Loop, Islanding and reconnecting. Primary frequency control in large systems, Fault ride through.

Transmission system operation: Fundamental operation, Frequency control, Balancing and Reserves, Prediction of production and consumption, Restoration, Voltage stability, Angular stability.

Textbooks:

1. Bollen M.H.J., Hassan F., Integration of distributed generation in the power system. IEEE Press Series on Power Engineering. Wiley. Hoboken 2011.
2. Jenkins N., Allan R., Crossley P., Kirschen D., Strbac G., Embedded generation. IEE Power and Energy Series 31. London, 2000.
3. Jenkins N., Ekanayake J.B., Strbac G., Distributed generation. IET Renewable Energy Series 1. London 2010.
4. Keyhani A., Marwali M.N., Dai M., Integration of green and renewable energy in electric power systems. Wiley. Hoboken 2010.

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Energy System and Management (ESM),
Duration: 2 years (Four Semesters)

PE 4	EE7203	Electric and Hybrid Vehicles	3	0	0	3

COURSE OBJECTIVE:
1. Explain the fundamentals of electric and hybrid electric vehicle, their architecture and technologies.
2. Explain the design of converters and drives used for electric and hybrid electric vehicles
3. Discuss different converters used in electric vehicles and battery charging circuits.
4. Demonstrate different storage systems and its management.

Module-I

Introduction to Hybrid Electric Vehicles: Past, Present & Future of EV, Current Major Issues, Recent Development Trends, EV Concept, Key EV Technology, State-of-the Art EVs & HEVs, Comparison of EV Vs IC Engine.
Hybridization of the Automobile: Basics of the EV, HEV, PHEV and vehicle architectures. Power flow control in hybrid drive-train topologies and Fuel efficiency analysis. Fixed & variable gearing, single & multiple motor drive, In-wheel drives.
Vehicle Dynamics Fundamentals: Vehicle Kinematics, Vehicle Resistance: Rolling Resistance, Aerodynamic Drag, Grading Resistance, Dynamic Equation Tire–Ground Adhesion and Maximum Tractive Effort, Power Train Tractive Effort and Vehicle Speed.

Module-II

Power Electronics in HEVs: Rectifiers used in HEVs, voltage ripples; Buck converter used in HEVs, non-isolated bidirectional DC-DC converter, regenerative braking, voltage source inverter, current source inverter, isolated bidirectional DC-DC converter, PWM rectifier in HEVs, EV and PHEV battery chargers.
Electric Machines and Drives in HEVs: Fundamental of Drives and Control of EV Using Induction Motor, Permanent Magnet Motor, Switched Reluctance Motor, BLDC motor, Sizing of Traction Motors.

Module-III

Battery and Storage Systems: Different batteries for EV, Battery Characterization, Comparison of Different Energy Storage Technologies for HEVs.
EV Charging Technologies: Classification of different charging technology for EV charging station, introduction to Grid-to-Vehicle, Vehicle to Grid (V2G) operations.
Battery Management System (BMS): Need of BMS, Converter control for power management, Software-based high-level supervisory control, Mode of power transfer, Behaviour of drive motor.
Fuel Cell based energy storage and its analysis

Text Book:
1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003
2. Ali Emadi, Advanced Electric Drive Vehicles, CRC Press, 2014.

References:
1. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 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. hris Mi, M. Abul Masrur, David Wenzhong Gao, Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives, John Wiley & Sons Ltd., 2011
4. C.C Chan, K.T Chau: Modern Electric Vehicle Technology, Oxford University Press Inc., New York 2001

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Energy System and Management (ESM),
Duration: 2 years (Four Semesters)

PE 4	EE7205	Energy Efficient Building	3	0	0	3

Module I:
Introduction: -Energy in building construction, Building energy use, Embodied energy and operational energy, Life cycle assessment, Parameters affecting energy consumption in buildings, Energy efficient lighting, Electric Lighting control for day lighted buildings,
Energy audit and Conservation: Phases of energy audit, Energy conserving opportunities, Energy audit instruments and measurements, Energy audit checklist, Energy conservation Building codes.

Module II:
Building Integrated Renewable and alternate energy systems - Possibilities of using renewable energy resources in building, HVAC design, Passive building design concepts, Solar thermal option, Solar water heating systems in buildings, small wind turbines, standalone PV, Hybrid systems for residential buildings with economics.

Module III:
Building automation and control and best management practices Fundamentals of control systems, Types of control systems, Impact of automation, Application and components of building automation systems, Methods to reduce energy consumption of buildings, commonly used software packages in energy efficient building analysis and design.
Energy efficient design - Site planning and design methods to reduce energy consumption, Energy management in vernacular building, Techniques to manage energy post occupancy, Design of Energy Efficient Buildings for Various Zones, Case studies of best management practices.

Text/Reference Books:
1. Energy Conservation Building Code, Bureau of Energy Efficiency, New Delhi, 2018.
2. Residential Energy: Cost Savings and Comfort for Existing Buildings by John Krigger and Chris Dorsi, Published by Saturn Resource Management, 2013.
3. Brown, G.Z. and DeKay, M., Sun, Wind and Light – Architectural Design Strategies, John Wiley and Sons Inc,3rd Edition, 2014
4. Majumdar, M (Ed), Energy – Efficient Buildings in India, Tata Energy Research Institute, Ministry of Non-Conventional Energy Sources, 2009.
5. Krieder. J., and Rabi. A., Heating and cooling of buildings: design for efficiency, McGraw Hill, 1994

COURSE OUTCOMES
1. To be able to discuss the concept of energy in buildings.
2. Enumerate the manner by which energy is consumed in building materials, building construction `and building energy use.
3. To be able to illustrate methods to reduce energy consumption of buildings
4. To understand application of building automation for energy reduction in buildings

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Energy System and Management (ESM), Duration: 2 years (Four Semesters)

PE 4	EE7207	FACTS and Customer Power Devices	3	0	0	3

Module I:

<u>**Flexible AC Transmission System:**</u> Transmission inter connections, flow of power in ac systems, loading capability, dynamic stability considerations, basic types of FACTS controllers.

Module II:

<u>**Static Shunt and Series Compensators:**</u> Objectives of shunt compensation, Static VAR compensators (SVCs), STATCOM configuration, Characteristics and control, Comparison between STATCOM and SVC.Objectives of series compensation, Variable Impedance type series compensators, switching converter type series compensators, external control for series reactive compensators.

Module III:

<u>**Power Flow Control Techniques:**</u> Principle of operation and characteristics, independent active and reactive power flow control, comparison of UPFC with the series compensators and phase angle regulators, Principle of operation, characteristics and control aspects of IPFC.

<u>**Custom Power Devices:**</u> Introduction to custom power devices, DSTATCOM and DVR operating principles, Applications of DSTATCOM and DVRs in Distribution Systems.

Suggested Books:

1. Hingorani ,L.Gyugyi, ‘ Concepts and Technology of Flexible AC transmission system’, IEEE Press New York, 2000.
2. K.R.Padiyar, “FACTS controllers in power transmission and distribution”, New Age International Publishers, Delhi, 2007.

<u>**COURSE OUTCOMES (CO’S)**</u>

At the end of the course, the students will be able to

CO1: gain knowledge on flexible AC transmission system criteria, advantages, and control parameters.

CO2: gain knowledge on various compensation techniques for control of FACTs devices.

CO3: gain knowledge on various practices being followed in the real system scenario.

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Energy System and Management (ESM),
Duration: 2 years (Four Semesters)

PR 2	EE7601	Dissertation (Phase-I)	0	0	24	12

School/ Department: School of Electrical Sciences
Course: M. Tech., Programme: Energy System and Management (ESM),
Duration: 2 years (Four Semesters)

4th Semester

PR 3	EE7602	Dissertation (Phase-II)	0	0	32	16