Shri Vaishnav Vidyapeeth Vishwavidyalaya, Indore
Shri Vaishnav Institute of Technology and Science
Choice Based Credit System (CBCS) in the Light of NEP-2020
M.Tech. in Renewable Energy
(2021-2023)

COURSE CODE	CATEGORY	COURSE NAME	TEACHING &EVALUATION SCHEME								
			THEORY			PRACTICAL		L	T	P	CREDITS
			END SEM University Exam	Two Term Exam	Teachers Assessment*	END SEM University Exam	Teachers Assessment*				
MTRE201	DCC	Wind Power Generation	60	20	20	30	20	2	0	2	3

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

Course Educational Objectives (CEOs):
This course aims to give students in depth understanding of wind generators, their integration to electric grid, related technical and economic challenges and also develop capability in the students to design wind power generation systems and make students aware with the challenges of the field,

Course Outcomes (COs):
Upon completion of the course, the student will be able to
1. Adequately trained to research Wind power generation systems,
2. Skilled both theoretically and practically to use this subject for the application in wind power generation systems.

Syllabus

UNIT I **8 Hrs.**
Introduction: Review of wind resource assessment, basic laws and concepts of aerodynamics (2-D, 3-D aerodynamics). Description and performance of the horizontal–axis wind machines, description and performance of the vertical–axis wind machines. Site Selection – Wind climatology, terrain features, surface roughness etc.

UNIT-II **8 Hrs.**
Micro siting of wind turbines, site Identification, wind mast installation. Annual Energy Output Estimation Uncertainties in estimation. Probabilities of Estimation. Betz criterion, Analysis of wind regimes – statistical analysis of wind regimes, Dynamics of data acquisition. Time distribution, Frequency distribution. Statistical Modelling.

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MTRE201	DCC	Wind Power Generation	60	20	20	30	20	2	0	2	3

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UNIT III **8 Hrs.**

Wind Power Project Planning & Structuring: Bank ability of Projects: Promoters, Financing, Balance Sheet, Non-Recourse or Project Finance, Leasing, Taxation Issues. Electricity off Take Arrangements & Structures: PPA with utility, Captive, Group Captive, Open Access & Merchant Sale Project Contracts: Wind Turbine Supply Contracts, Works Contracts, E&C Contract, O&M Contract.

UNIT IV **7 Hrs.**

Risk Mitigation Indemnities & Liabilities Power Curve Measurement, Project Management: Project Implementation Activities, Pert/ CPM/ MS Projects, Quality Assurance in Project Implementation. Evaluation & analysis, Implementation & monitoring, Performance indices.

UNIT V **7 Hrs.**

Wind Turbine Generators: Induction, Synchronous machine, constant V & F and variable V & F generations, Reactive power compensation. Site Selection, Concept of wind form & project cycle, Cost economics & viability of wind farm.

Textbooks:

1. Jain P. "Wind Energy Engineering", McGraw-Hill, 2011.
2. Johnson GL. "Wind Energy Systems, (Electronic Edition)", Prentice Hall Inc, 2006
3. Burton T. Sharpe D. Jenkins N. Bossanyi E. "Wind Energy Handbook", John Wiley, 2001 Jha AR. Wind Turbine Technology, CRC Press, Taylor & Francis, 2011.

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MTRE201	DCC	Wind Power Generation	60	20	20	30	20	2	0	2	3

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***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

References:

1. Nag P K. Power Plant Engineering, 3rd Edition, Tata McGraw Hill, 2008.
2. Bansal RK, "A textbook of fluid mechanics and hydraulic machines", Laxmi Publications, 2005, New Delhi.
3. Hussian Z. Abdullah MZ. Alimuddin Z, "Basic Fluid Mechanics and Hydraulic Machines".

List of Experiments:

1. Study of the aero generator operation in function of the wind speed variation.
2. Generator angle of incidence variation.
3. Operation differences using the three available blades configurations (aero generator with 6, 3 or 2 blades).
4. Operation differences depending on the angle of the blades.
5. Load variation influence on the aero generator.
6. Study of the voltage, power and current.
7. Study of V, I, W in function of different loads.
8. Efficiency experimental determination (depending on: number of blades, angle of the blades, generator´s angle; among others).
9. Wind energy measurement.
10. Familiarization with the regulator parameters.
11. Study of the power generated by the aero generator depending on the wind speed.
12. Study of the power generated by the aero generator depending on the air incident angle.
13. Connection of loads to direct voltage.

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MTRE202	DCC	Hydro Power Generation	60	20	20	30	20	2	0	2	3

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Course Educational Objectives (CEOs):

This course aims to make students aware about the uses of small and micro hydro plants and also identification of hydro as a competitive conventional source of energy.

Course Outcomes (COs):

Upon completion of the course, the student will be able to

1. Adequately trained to research hydro power generation systems.
2. Skilled both theoretically and practically to use this subject for the application in hydro power generation systems.
3. Aware about the implications and new techniques for their mitigations, for the operation of a hydro power plant.

Syllabus

UNIT I **7 Hrs.**

Introduction to Hydropower, Hydrology – descriptive hydrology, hydrograph, mass curve, storage, dams, Classification of Hydropower Plants, Small Hydropower, Systems: Overview of micro, mini and small hydro systems Status of Hydropower Worldwide Advantages and Disadvantages of Hydropower, Selection of site for hydroelectric plant, Hydrological cycle, Essential elements of a hydroelectric power plant.

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MTRE202	DCC	Hydro Power Generation	60	20	20	30	20	2	0	2	3

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UNIT II **7 Hrs.**

Classification of Fluids, Characteristic of Water, units of Pressure, Pascal's law, applications of Pascal's law, Hydraulic press, Pressure measurement Types of fluid flow, streamline and turbulent flow Velocity Equation, Bernoulli's Equation, Power Equation, Continuity Equation, Cavitations, venturi meter, orifice meter, Pitot tube.

UNIT III **9 Hrs.**

Components of hydropower plants Hydraulic Turbines: Types and Operational Aspects Classification of Hydraulic Turbines, Theory of Hydro turbines; Francis, Pelton, Kaplan and Propeller Turbine; differences between impulse and reaction turbines; Operational Aspects of Turbines Efficiency and selection of turbines, Types of generators - synchronous and induction, transformers, protection & control, transmission and distribution system. Dam and Spillway, Surge Chambers, Penstock, Tailrace.

UNIT IV **7 Hrs.**

Site selection, environmental aspect, run-of-the-river and storage schemes; diversion structures, power channels, desilting arrangements, forebay tank and balancing reservoir, penstock and powerhouse; transmission and distribution system.

UNIT V **7 Hrs.**

Economics: cost structure, Initial and operation cost. Environmental issues related to small and large hydropower plants, Potential of hydro power in Northeast India.

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MTRE202	DCC	Hydro Power Generation	60	20	20	30	20	2	0	2	3

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***Teacher Assessment** shall be based following components: Quiz/Assignment/ Project/Participation in Class, given that no component shall exceed more than 10 marks.

Textbooks:

1. Wagner H. Mathur J. "Introduction to Hydro energy Systems: Basics, Technology and Operation", Springer, 2011.
2. S. Rao & B. B. Parulekar, "Energy Technology", 4th edition, Khanna publishers, 2005.

References:

1. Jack J. Fritz, "Small and Mini HydroPower Systems", McGraw-Hill.
2. Bryan Leyland, "Small Hydroelectric Engineering Practice", CRC Press; 1 edition (11 February 2014)

List of Experiments:

1. To perform a detailed study on the pumped storage hydro power plant.
2. To operate the given hydropower plant and find out the terminal voltage and frequency.
3. To synchronize the given power plant with grid system.
4. Determine the active, reactive, and apparent power of given power plant.
5. Detect of mains harmonics oscillations and neutral conductor current.
6. To regulate the power both in generator and motor of given power plant.

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MTRE203	DCC	Issues in Grid Integration of Power from Renewable Energy Sources	60	20	20	30	20	3	0	0	3

Legends: **L** - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; **C** - Credit;
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Course Educational Objectives (CEOs):
Grid integration is an important power system aspect. The various challenges and related issues must be addressed to the students for better understanding of the renewable energy sources and their applications. Keeping this in mind, the course has been developed to make students conversant with various devices / machines used for solar / wind power generation. Also, the integration related aspects will be discussed in detail.

Course Outcomes (COs):
After the successful completion of this course students will be able to

1. Understand the logic of mini/micro grids, and smart grids
2. Understand the issues in integration of synchronous generator, Induction Generator, Converter based sources.
3. Manage Network voltage, power quality , frequency mismatch issues

Syllabus

UNIT-I **7 Hrs.**

Introduction
Introduction to renewable energy grid integration, concept of mini/micro grids, and smart grids.

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MTRE203	DCC	Issues in Grid Integration of Power from Renewable Energy Sources	60	20	20	30	20	3	0	0	3

Legends: **L** - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; **C** - Credit;
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UNIT-II **10 Hrs.**

Synchronous Generator Based Sources

Review of synchronous generators, Introduction to power system stability problems: rotor angle stability, voltage stability and voltage collapse, classification of stability. Modelling of synchronous machines: d-q transformations, synchronous machine representation in stability studies.

UNIT- III **9 Hrs.**

Induction Generator Based Sources

Introduction to induction machines: electrical characteristics, slip, speed-torque characteristics etc. Self excited induction generator, Constant speed Induction generators, and Variable speed Induction generators, doubly fed Induction generators.

UNIT-IV **9 Hrs.**

Converter Based Sources

Introduction to power electronic devices, AC/DC converters, PWM, THD. Permanent magnet synchronous generator, solar PV systems, fuel cell, aquaelectrolizer.

UNIT-V **9 Hrs.**

Grid Integration

Issues in integration of synchronous generator based, induction generator based and converter-based sources together. Network voltage management (discusses the issue of voltage levels). Power quality management (voltage dips, harmonics and flickers). Frequency management. Influence of WECS on system transient response.

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MTRE203	DCC	Issues in Grid Integration of Power from Renewable Energy Sources	60	20	20	30	20	3	0	0	3

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

Textbooks:

1. Brendan Foxet. al.: Wind Power Integration connection and system operational aspects, IET Power and Energy Series 50 2007.
2. Marco H. Balderas (ed.): Renewable Energy Grid Integration, Nova Science Publishers, New York, 2009
3. Nick Jenkin, Janaka Ekavayake: Wind Energy Generation Modeling and Control,Wiley and Sons

References:

1. M. Klobasa, "Analysis of demand response and wind integration in Germany's electricity market" IET Renew. Power Generation., Vol. 4, No.1, pp. 55–63 55, 2010
2. A. Helander1, H. Holttinen, J. Paatero," Impact of wind power on the power system imbalances in Finland" IET Renew. Power Generation., Vol. 4, No. 1, pp. 75–84, 2010
3. B.V. Mathiesen H. Lund," Comparative analyses of seven technologies to facilitate the integration of fluctuating renewable energy sources", IET Renew. Power Generation. Vol. 3, NO. 2, pp. 190–204, 2009.
4. Morales1, X. Robe1, M. Sala, P. Prats, C. Aguerri, E. Torres," Advanced grid requirements for the integration of wind farms into the Spanish transmission system" IET Renew. Power Generation, Vol. 2, No. 1, pp. 47–59, 2008.

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MTRE204	SEC	Software Simulation Lab	0	0	0	30	20	0	0	4	2

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List of Experiments:

1. Write a program on MATLAB to Compute cell's current from voltage ,suns and temp
2. Write a program on MATLAB to plot PV curves
3. Design a Simulink model on Single diode photovoltaic generator with MPPT (Maximum Power Point Tracking)
4. Design a Simulink model on PV string partial shading and plot its I-V and P-V curve
5. Implement model of variable pitch wind turbine
6. Simulation of Solar cell on PC1D Software
7. Study of software HOMER and its different models of renewable energy for Simulation of major energy equipments.
8. Use of application software RET Screen Simulation of major energy equipments.

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MTRM301	AECC	Research Methodology in Engineering	60	20	20	0	0	3	1	0	4

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Course Educational Objectives (CEOs):

1. The course has been developed with orientation towards research related activities and recognizing the ensuing knowledge as property.
2. To analyze and evaluate research works and to formulate a research problem to pursue research.
3. To develop skills related to professional communication and technical report writing.

Course Outcomes:

At the end of the course, students will demonstrate their ability to:

1. Understanding and formulation of research problem.
2. Apply quantitative and qualitative methods used in engineering research.
3. Analyze interpret and evaluate data that relate to engineering problems.
4. Develop skills related to professional communication, technical report writing and publishing papers.
5. Act professionally, autonomously, ethically and in teams to produce a professional product.

Syllabus

Unit-I

Introduction to Research Methodology: - An overview of Research process, Types of research; Approaches to research, Importance of criticism in Literature review, identifying research gaps; Formulation of research problem; Research design,

Data: Primary and secondary data-sources, advantages/disadvantages; Sampling and primary data collection, sampling size, random and structured sampling

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MTRM301	AECC	Research Methodology in Engineering	60	20	20	0	0	3	1	0	4

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Unit-II

Measurement and Scaling Techniques: - Types of scales, Criteria for good measurement, Attitude measurement - Likert's scale, Semantic differential scale, Thurstone-equal appearing interval scale.

Statistical Tools for Data Analysis: - Measure of central tendency, Measures of dispersion, Correlation and Regression, Formulation of hypothesis, Type I & Type II error, Parametric test, non-parametric test.

Unit-III

Research Methods I - Use of computer software in research and understanding the limitations. Multi-attribute decision making methods, Data envelopment analysis, Grey relational analysis etc., Multidisciplinary research problems, Synthesis of disciplinary research findings; Reliability and sensitivity analysis.

Unit-IV

Research Methods II - Modeling and simulation of engineering problem; Mathematical modeling-formulation, calibration, validation, application; measurement design – validity, reliability, scaling and sources of error. Mathematical programming methods, Numerical analysis, Optimization techniques, Design of laboratory experiments and field tests.

Unit-V

Academic Writing Skills and Presentation - Layout of a Research paper, research report, Thesis structure, Impact factor of Journals, Ethical issues related to publishing, Plagiarism and Self-Plagiarism. Reference Management Software like Mendeley, Software for paper formatting like LaTeX/MS Office, Software for detection of Plagiarism. Guidelines on how to write research papers. Content of Poster presentation, Power point presentation, Oral presentation

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MTRM301	AECC	Research Methodology in Engineering	60	20	20	0	0	3	1	0	4

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Text Books -

1. C.R. Kothari, 2012. Research Methodology Methods and Techniques, 3/e, Vishwa Prakashan,
2. Montgomary, Douglas C., 2007. Design and Analysis of Experiments (Wiley India).
3. Chawla, D. and Sodhi, N., 2011. Research methodology: Concepts and cases. Vikas Publishing House.

Reference:

1. Donald H.McBurney, "Research Methods", 5th Edition, Thomson Learning, ISBN: 81-315-0047.
2. Donald R. Cooper, Pamela S. Schindler, "Business Research Methods", 8/e, Tata McGraw-Hill Co. Ltd.,
3. Timothy J. Ross, "Fuzzy Logic with Engg Applications", , Wiley Publications, 2nd Ed[d]
4. Thiel D.V. "Research Methods for Engineering", Published by Cambridge University Press, UK
5. P.J. van Laarhoven & E.H. Aarts, "Simulated Annealing: Theory and Applications" (Mathematics and Its Applications).

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COURSE CODE	CATEGORY	COURSE NAME	TEACHING &EVALUATION SCHEME								
			THEORY			PRACTICAL		L	T	P	CREDITS
			END SEM University Exam	Two Term Exam	Teachers Assessment*	END SEM University Exam	Teachers Assessment*				
MTRE211	DSE	Batteries and Fuel Cells	60	20	20	0	0	3	0	0	3

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

Course Educational Objectives (CEOs):
The course aims to provide students with the fundamental knowledge on the emerging energy technologies. This course is an elementary introduction to batteries and fuel cell, the cornerstone of electro-mobility and renewable energy, the main drivers of sustainable development.

Course Outcomes (COs):
After the successful completion of this course students will be able to:

1. Understand the operation of electrochemical systems for the production of electric energy, i.e., batteries.
2. Analyse the underlying concepts, design, working and applications of fuel cell technology.
3. Understand the emerging trends in batteries.
4. Analyse the different types of fuel cells like acidic fuel, storage cell, lithium technology etc. and its commercial and industrial applications.
5. Apply further innovations in battery design, including novel battery and fuel cell technology which led to vast new applications.

Syllabus

UNIT -I **9 Hrs.**

Battery- Storage Cell Technologies, Storage cell fundamentals, Characteristics, Emerging trends in batteries.

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UNIT –II **9 Hrs.**

Specifications-Storage cell definitions & specifications, Carbon-zinc & alkaline cells, Mercury, zinc-air, & silver oxide button cells, Lead acid, Edison, NiCad & NiMH cells, Lithium technology.

UNIT -III **9 Hrs.**

Applications- Storage cell summary, Industrial applications of storage cell.

UNIT –IV **9 Hrs.**

Fuel cell fundamentals, Alkaline fuel cell, Acidic fuel cells, SOFC- Emerging areas in Fuel cells

UNIT –V **9 Hrs.**

Fuel cell outlook, Sources, Comments, & Revision history, Applications–Industrial and commercial.

Textbooks:

1. David Linden and Thomas. B. Reddy, "Hand Book of Batteries and Fuel cells", McGraw Hill Book Company, 3rd Edition, N.Y.2002.
2. Vladimir S. Bagotsky, Alexander M. Skundin, Yurij M. Volfkovich, "Electrochemical Power Sources: Batteries, Fuel Cells, and Supercapacitors", John Wiley & Sons, Inc., 2015
3. Xianguo Li, "Principles of Fuel Cells", Taylor & Francis, 2006
4. Viswanathan B. and Scibioh, Aulice M, "Fuel Cells, Principles and Applications", Universities Press, 2006

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References:

1. R.M. Dell, David Anthony James Rand, "Understanding Batteries", RSC (RSC Paperbacks), 1st Edition, 2001.
2. Vielstich, "Handbook of fuel cells: Fuel cell technology and applications", Wiley, CRC Press, 2003.
3. Erik Kjeang, "Microfluidic Fuel Cells and Batteries", Springer, 2014.

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MTRE212	DSE	Sustainable Building and Cogeneration	60	20	20	0	0	3	0	0	3

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Course Educational Objectives (CEOs):
The objective of the course is to Critically analyse, synthesise and reflect on sustainable building theory and recent developments, both local and international, To extend and challenge knowledge and practice, Professionally communicate and justify sustainable building design principles, strategies, solutions and/or outcomes,

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

1. Explain basic concepts related to sustainability and environmental concerns.
2. Identify major steps involved in the construction and commissioning of sustainable buildings.
3. Apply analytical, design and communication skills to devise and justify design solutions for sustainable building projects.
4. Understand the concept of cogeneration and its design parameters.

Syllabus

UNIT I **9 Hrs.**
Concept of green buildings features of green building rating systems in India: LEED, GRIHA. Sustainable site, water, energy, material and indoor environment issues for green buildings.

UNIT II **9 Hrs.**
Intent and documentation for credits/points for green rating systems; Difference in evaluation and documentation for new construction, existing buildings, core and shell projects. Green home rating system, green factory rating, green neighbourhood concept; Concept of Net zero energy building, net zero community

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MTRE212	DSE	Sustainable Building and Cogeneration	60	20	20	0	0	3	0	0	3

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UNIT III **9 Hrs.**

Energy Conservation Building Code: requirements of code, applicability, compliance options: prescriptive, trade-off, whole building performance routes for compliance

UNIT IV **9 Hrs.**

The concept of cogeneration, main design parameters for cogeneration, cogeneration alternatives, Bottoming and topping cycles, Steam turbine plants, Gas turbine plant, Diesel and gas engine plants,

UNIT V **9 Hrs.**

Thermodynamic evaluation, Combined cycle applications, Sterling engine, Industry / utility cogeneration, Trigeneration, Techno economic and Environ-mental aspects, Cogeneration in sugar, textile, paper and steel industry.

Textbooks:

1. C. J. Kibert, "Sustainable Construction: Green Building Design and Delivery, 2nd Edition, Wiley 2008.
2. M.M. EI Wakil, "power plant Technology", McGraw hill.

References:

1. David JC Maykay, "Sustainable Energy", version 3.5.2.
2. Energy Cogeneration Hand Book for Central Plant Design by George Polimeros

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MTRE213	DSE	Geo Thermal and Ocean Energy	60	20	20	0	0	3	0	0	3

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Course Educational Objectives (CEOs):
The objective of the course is toto understand the importance of geothermal energy derived from the interior heat of the Earth, utilisation of geothermal resources, construction of geothermal power plant, concepts of different ocean energy conversion systems and OTEC resources, site selection.

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

1. Explain the principles that underlie the ability of geothermal energy to deliver useable energy.
2. Outline the technologies that are used to harness the power of geothermal energy
3. Different ocean energy conversion systems and OTEC resources and geothermal energy conversion systems.
4. Understand and pursue further research work behind the development of non-conventional energy sources as a part of their research work.

Syllabus

UNIT I **8 Hrs.**
Introduction of Geothermal Energy, Geothermal resources; definition and classification.

UNIT II **9 Hrs.**
Hydrothermal system, hot dry rock systems, Geo-pressured reservoirs, Magma energy, Dry rock and hot aquifer analysis.

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MTRE213	DSE	Geo Thermal and Ocean Energy	60	20	20	0	0	3	0	0	3

Legends: **L** - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** – Practical; **C** - Credit;
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UNIT III **7 Hrs.**

Utilization of geothermal resources, Direct utilization; Swimming bathing & balneology, space conditioning, district heating.

UNIT IV **9 Hrs.**

Geothermal heat pump; basic concept of heat pump, air conditioner, heating and cooling mode in heat pump, Heat pump with geothermal resources; typical GHP loop configuration

UNIT V **8 Hrs.**

Ocean Thermal: Introduction, OTEC history and technology progress, working principle, resources & site requirement.

Textbooks:

1. G.N.Tiwari & M.K. Ghosal. "RenewableEnergy Resourses", Alpha science International,2005.
2. Godfrey Boyle, "Renewable energy", Oxford University Press, 2nd edition, 2010

References:

1. Roland Wengenmayr, Thomas Buhrke," Renewable energy: Sustainable energy concepts for the future", Wiley-VCH, 1st edition, 2008.

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