RENEWABLE ENERGY SOURCES

Subject code: ME853PE
Regulations: R16-JNTUH
Class: IV Year B. Tech MECH II Sem

Department of Mechanical Engineering
BHARAT INSTITUTE OF ENGINEERING AND TECHNOLOGY
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RENEWABLE ENERGY SOURCES (ME853PE)

COURSE PLANNER

I. COURSE PURPOSE:

As humanity progresses in the 21st century, it would in future encounter major challenges in terms of ensuring adequate and equitable provision of energy. While the 20th century was characterized by growing dependence on fossil fuels, the current century would have to deal with the depletion of reserves of fossil fuels, growing environmental problems as a result of production and use of these fuels as well as the threat of climate change, which results from the emissions of GHGs (greenhouse gases) due to the combustion of fossil fuels. There are, therefore, several reasons for the world to explore with some urgency alternative sources of energy supply.

Renewable energy is an option that promises a clean and healthy environment for future generations. The use of renewable energy offers countries around the world the chance to improve their energy security and spur economic development. Renewables solve the two-way problem faced by us today in the energy sector - first it solves the problem depleting stock (that is the reason they are called renewable) and secondly, they do not cause any significant pollution.

The module 'Renewable Energy Sources' describes the various renewable energy sources available to us. Also, discusses the current and future prospective, uses, and challenges.

SCOPE OF COURSE:

This course explores each of the principal renewable energy sources in turn. Each technology is examined in terms of the relevant physical principles; the main technologies involved; their costs and environmental impact; the size of the potential renewable resource; and their future prospects.

II. PRE REQUISITES:

Knowledge of thermodynamics, heat transfer, energy engineering, applied thermodynamics and heat cycles.

III. COURSE OBJECTIVE:

This course explores each of the principal renewable energy sources in turn. Each technology is examined in terms of the relevant physical principles; the main technologies involved; their costs and environmental impact; the size of the potential renewable resource; and their future prospects.

- To explain the concepts of Non-renewable and renewable energy systems
- To outline utilization of renewable energy sources for both domestic and industrial applications
- To analyse the environmental and cost economics of renewable energy sources in comparison with fossil fuels.

IV. Course Outcomes

Sl.NO	Description	Bloom's Taxonomy level
CO1.	Understanding of renewable energy sources	**L2: Understanding**
CO2.	Knowledge of working principle of various energy systems	**L2: Understanding**
CO3.	Capability to carry out basic design of renewable energy systems	**L2: Understanding**

V. HOW PROGRAM OUTCOMES ARE ASSESSED:

Program Outcomes (POs)		Level	Proficiency assessed by
PO1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.	3	Assignment/ Exam
PO2	**Problem analysis**: Identify, formulate, review research literature, and analyze engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	2	Assignment/ Exam
PO3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.	2	Assignment/ Exam
PO4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.	2	Assignment/ Exams
PO5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	1	Assignment/ Exams
PO6	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.	1	Assignment/ Exams
PO7	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.	1	Assignment/ Exams
PO8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.	1	Assignment/ Exams
PO9	**Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.	3	Assignment/ Exams
PO10	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.	1	Assignment/ Exams
PO11	**Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.	-	-
PO12	**Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	3	Assignment/ Exams

VI. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

Program Specific Outcomes (PSOs)		Level	Proficiency assessed by
PSO1	The student will be able to apply the knowledge of Mathematics, Sciences and engineering fundamentals to formulate, analyze and provide solutions for the problems related to Mechanical engineering and communicate them effectively to the concerned.	3	Lectures, Assignments
PSO2	Design mechanical systems in various fields such as machine elements, thermal, manufacturing, industrial and inter-disciplinary fields by using various engineering/technological tools to meet the mercurial needs of the industry and society at large.	2	Lectures, Assignments
PSO3	The ability to grasp the latest development, methodologies of mechanical engineering and posses competent knowledge of design process, practical proficiencies, skills and knowledge of programme and developing ideas towards research.	2	Lectures, Assignments

VII. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

CO's	Program Outcomes (PO's)												PSO ATTAINMENT		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1.	**3**	**2**	**2**	**2**	**2**	**1**	**1**	**1**	**3**	**1**	**--**	**3**	**3**	**2**	**2**
CO2.	3	2	2	2	2	1	1	1	3	1		3	3	2	2

VIII. JNTUH SYLLABUS

UNIT-I

Global and National Energy Scenario: Over view of conventional & renewable energy sources, need & development of renewable energy sources, types of renewable energy systems, Future of Energy Use, Global and Indian Energy scenario, Renewable and Nonrenewable Energy sources, Energy for sustainable development, Potential of renewable energy sources, renewable electricity and key elements, Global climate change, CO2 reduction potential of renewable energy- concept of Hybrid systems.

UNIT-II

Solar Energy: Solar energy system, Solar Radiation, Availability, Measurement and Estimation, Solar Thermal Conversion Devices and Storage, Applications Solar Photovoltaic Conversion solar photovoltaic, solar thermal, applications of solar energy systems.

UNIT-III

Wind Energy: Wind Energy Conversion, Potential, Wind energy potential measurement, Site selection, Types of wind turbines, Wind farms, wind Generation and Control. Nature of the wind,

power in the wind, factors influencing wind, wind data and energy estimation, wind speed monitoring, classification of wind, characteristics, applications of wind turbines, offshore wind energy – Hybrid systems, wind resource assessment, Betz limit, site selection, wind energy conversion devices. Wind mill component design, economics and demand side management, energy wheeling, and energy banking concepts. Safety and environmental aspects, wind energy potential and installation in India.

UNIT-IV

Biogas: Properties of biogas (Calorific value and composition), biogas plant technology and status, Bio energy system, design and constructional features. Biomass resources and their classification, Biomass conversion processes, Thermo chemical conversion, direct combustion, biomass gasification, pyrolysis and liquefaction, biochemical conversion, anaerobic digestion, types of biogas Plants, applications, alcohol production from biomass, bio diesel production, Urban waste to energy conversion, Biomass energy programme in India..

UNIT-V

Ocean Energy: Ocean wave energy conversion, principle of Ocean Thermal Energy Conversion (OTEC), ocean thermal power plants, tidal energy conversion, Tidal and wave energy its scope and development, Scheme of development of tidal energy. 1. Small hydro Power Plant: Importance of small hydro power plants and their Elements, types of turbines for small hydro, estimation of primary and secondary power. 2. Geothermal Energy: Geothermal power plants, various types, hot springs and steam ejection.

SUGGESTED BOOKS:

TEXT BOOK:

1. Non-Conventional Energy Sources by G.D Rai
2. Twidell, J.W. and Weir, A., Renewable Energy Sources, EFN Spon Ltd., 1986

REFERENCES:

1. Kishore VVN, Renewable Energy Engineering and Technology, Teri Press, New Delhi, 2012
2. Godfrey Boyle, Renewable Energy, Power for a Sustainable Future, Oxford University Press, U.K, 1996.

NPTEL WEBSITES

https://nptel.ac.in/courses/112104225/22

https://nptel.ac.in/courses/112104225/1

GATE SYLLABUS: NOT APPLICABLE

IES SYLLABUS: NOT APPLICABLE

IX. COURSE PLAN:

Lecture No.	TOPIC	Course Learning Outcomes	Teaching Methodology	Reference
UNIT - 1				
1	**Global and National Energy Scenario:** Over view of conventional & renewable energy sources	Explain the Over view of conventional & renewable energy sources	Chalk & Talk	**Book No. 1, 3**

2	Need & development of renewable energy sources	Explain the Need & development of renewable energy sources	Chalk & Talk	
3	Types of renewable energy systems, Future of Energy Use, Global and Indian Energy scenario	Explain the types of renewable energy systems	Chalk & Talk	
4	Renewable and Nonrenewable Energy sources,	Explain the Renewable and Nonrenewable Energy sources,	Chalk & Talk	
5	Energy for sustainable development	Explain the Energy for sustainable development	Chalk & Talk	
6	Potential of renewable energy sources	Explain the potential of renewable energy sources	Chalk & Talk	
7	Renewable electricity and key elements, Global climate change	Understanding of renewable electricity and key elements,	Chalk & Talk	
8	CO2 reduction potential of renewable energy-concept of Hybrid systems.	Understanding CO2 reduction potential of renewable energy	Chalk & Talk	
UNIT – 2				
9	**Solar Energy:** Solar energy system	Explain Solar Energy & Solar energy system	Chalk & Talk	**Book No. 1, 2, 3**
10	Solar Radiation, Availability	Explain solar radiation and availability	Chalk & Talk	
11	Measurement and Estimation	Explain measurement and estimation	Chalk & Talk	
12	Solar Thermal Conversion Devices and Storage	Classification of the Solar Thermal Conversion Devices and Storage	Chalk & Talk	
13	Applications Solar Photovoltaic	Analyze applications Solar Photovoltaic	Chalk & Talk	
14	Conversion solar photovoltaic	Explain conversion solar photovoltaic	Chalk & Talk	
15	Solar thermal	Explain Solar thermal energy	Chalk & Talk	
16	Applications of solar energy systems	Explain Applications of solar energy systems	Chalk & Talk	
UNIT – 3				
17	**Wind Energy:** Wind Energy Conversion,	Explain Wind Energy & Wind Energy Conversion,	Chalk & Talk	**Book No. 2, 5**

	Potential,	Potential,		
18	Wind energy potential measurement, Site selection,	Understanding of the Wind energy potential measurement, Site selection,	Chalk & Talk	
19	Types of wind turbines, Wind farms	Analyze the types of wind turbines, wind farms	Chalk & Talk	
20	Wind Generation and Control. Nature of the wind, power in the wind, factors influencing wind	Analyze the wind generation and control.	Chalk & Talk	
21	Wind data and energy estimation, wind speed monitoring, classification of wind	Explain the wind data and energy estimation	Chalk & Talk	
22	Characteristics, applications of wind turbines, offshore wind energy – Hybrid systems	Understanding the characteristics, applications of wind turbines	Chalk & Talk	
23	Wind resource assessment, Betz limit, site selection, wind energy conversion devices.	Understanding of wind resource assessment	Chalk & Talk	
24	Wind mill component design, economics and demand side management, energy wheeling	Understanding of the wind mill component design	Chalk & Talk	
25	Energy banking concepts. Safety and environmental aspects,	Analyze Energy banking concepts	Chalk & Talk	
26	Wind energy potential and installation in India.	Understanding wind energy potential	Chalk & Talk	
UNIT – 4				
27	**Biogas:** Properties of biogas (Calorific value and composition)	Understanding of the Biogas &Properties of biogas	Chalk & Talk	**Book No. 2, 5**
28	Biogas plant technology and status	Explain Biogas plant	Chalk & Talk	
29	Bio energy system, design and constructional features.	Understanding of the Bio energy system	Chalk & Talk	
30	Biomass resources and their classification, Biomass conversion processes	Understanding of the Biomass resources	Chalk & Talk	

31	Thermo chemical conversion, direct combustion, biomass gasification	Understanding of the Thermo chemical conversion	Chalk & Talk	
32	Pyrolysis and liquefaction, biochemical conversion	Understanding of Pyrolysis	Chalk & Talk	
33	Anaerobic digestion, types of biogas Plants	Understanding of the Anaerobic digestion	Chalk & Talk	
34	Applications, alcohol production from biomass, bio diesel production,	Understanding of the Applications, alcohol production	Chalk & Talk	
35	Urban waste to energy conversion, Biomass energy programme in India.	Explain Urban waste to energy conversion	Chalk & Talk	
UNIT – 5				
36	**Ocean Energy:** Ocean wave energy conversion	Understanding of the Ocean wave energy conversion	Chalk & Talk	**Book No. 2, 5**
37	Principle of Ocean Thermal Energy Conversion (OTEC)	Understanding the principle of Ocean Thermal Energy Conversion	Chalk & Talk	
38	Ocean thermal power plants	Understanding the Ocean thermal power plants	Chalk & Talk	
39	Tidal energy conversion	Analyze tidal energy conversion	Chalk & Talk	
40	Tidal and wave energy its scope and development	Understanding the Tidal and wave energy	Chalk & Talk	
41	Scheme of development of tidal energy.	Understanding the Scheme of development of tidal energy.	Chalk & Talk	
42	**Small hydro Power Plant:** Importance of small hydro power plants and their Elements	Understanding of the small hydro power plant	Chalk & Talk	
43	Types of turbines for small hydro, estimation of primary and secondary power.	Analyze types of turbines for small hydro	Chalk & Talk	
44	**Geothermal Energy:** Geothermal power plants, various types	Understanding the geothermal energy	Chalk & Talk	

45	Hot springs and steam ejection.	Expalin the Hot springs and steam ejection.	Chalk & Talk	

X. QUESTION BANK: (JNTUH)

DESCRIPTIVE QUESTIONS:

UNIT-I

Short Answer Questions-

Sl.No	Question	Blooms Taxonomy Level	Course Outcome
1	What are conventional & renewable energy sources?	**L2**	**CO 1**
2	Explain types of renewable energy systems?	**L2**	**CO 2**
3	What is Future of Energy Use?	**L2**	**CO 1**
4	What is Global and Indian Energy scenario?	**L2**	**CO 2**
5	What is the concept of Hybrid systems?	**L2**	**CO 1**

Long Answer Questions-

1	Explain need & development of renewable energy sources?	**L2**	**CO 2**
2	Explain types of renewable energy systems?	**L2**	**CO 1**
3	Explain Renewable and Nonrenewable Energy sources?	**L2**	**CO 2**
4	Explain in brief Energy for sustainable development, Potential of renewable energy sources?	**L2**	**CO 1**
5	Explain in detail about renewable electricity and key elements?	**L2**	**CO 2**
6	Explain the Global climate change, CO2 reduction potential of renewable energy	**L2**	**CO 2**

UNIT-II

Short Answer Questions-

Sl.No	Question	Blooms Taxonomy Level	Course Outcome
1	What is the standard value of solar constant?	**L2**	**CO 1**
2	Classify focusing type collectors.	**L2**	**CO2**
3	What is the role and potential of renewable source?	**L2**	**CO 1**
4	State the principle of solar radiation.	**L2**	**CO 2**
5	State the environmental impact of solar power.	**L2**	**CO 2**

Long Answer Questions-

1	Derive the expression for monthly average of hourly global radiation on a tilted surface.	**L2**	**CO 1**
2	Explain about Beam and Diffuse radiation.	**L2**	CO2
3	Define the following: i. Declination ii. Altitude angle iii. Solar Constant.	**L2**	**CO 1**
4	Explain extraterrestrial and terrestrial Radiation.	**L2**	**CO 2**

5	Explain the principle of conversion of solar energy into heat.	**L2**	**CO 2**
6	What features of solar energy make it attractive for use in irrigation water pump?	**L2**	**CO 1**
7	Explain the following terms (a) Flat plate (b) Paraboloidal dish.	**L2**	CO2
8	Explain in brief the Environmental impact of solar power.	**L2**	**CO 1**
9	Explain the role and potential of new and renewable energy sources.	**L2**	**CO 2**
10	With neat sketch explain the instrument for measuring solar radiation and sun shine.	**L2**	**CO 2**

UNIT-III

Short Answer Questions-

Sl.No	Question	Blooms Taxonomy Level	Course Outcome
1	Explain Wind Energy Conversion?	**L2**	**CO 2**
2	Explain Nature of the wind?	**L2**	**CO 1**
3	What is energy wheeling, and energy banking concepts?	**L2**	**CO 2**
4	Explain the – Hybrid systems of wind energy?	**L2**	**CO 1**
5	What is meant by Betz limit?	**L2**	**CO 2**

Long Answer Questions-

1	Write short notes on: i Wind Energy Conversion, Potential ii. Wind energy potential measurement?	**L2**	**CO 2**
2	Explain about types of wind turbines?	**L2**	**CO 1**
3	Explain Wind farms, wind Generation and Control?	**L2**	**CO 2**
4	Explain wind speed monitoring, classification of wind and its characteristics?	**L2**	**CO 1**
5	List out and explain Safety and environmental aspects, wind energy potential and installation in India?	**L2**	**CO 2**
6	Enumerate applications of wind turbines, offshore wind energy?	**L2**	**CO 2**
7	Explain site selection, wind energy conversion devices?	**L2**	**CO 1**
8	Explain Wind mill component design, economics and demand side management?	**L2**	**CO 2**

UNIT-IV

Short Answer Questions-

Sl.No	Question	Blooms Taxonomy Level	Course Outcome
1	Explain Calorific value and composition of Biogas?	**L2**	**CO 1**
2	How do you get biogas from plant wastes?	**L2**	**CO 2**
3	What are the most favorable sites for installing of wind turbines?	**L2**	**CO 1**
4	State the merits and demerits of Horizontal and Vertical windmills.	**L2**	**CO 2**
5	What are the various advantages of anaerobic digestion?	**L2**	**CO 1**

Long Answer Questions-

1	Describe the main applications of wind energy.	**L2**	**CO 2**
2	Describe with a sketch the working of a wind energy system with main Components.	**L2**	**CO 1**
3	Derive the expression for power developed due to wind.	**L2**	**CO 2**
4	Explain the various factors a affecting the generation of biogas.	**L2**	**CO 1**
5	Explain various dry processes of bioenergy conversion in brief.	**L2**	**CO 2**
6	Draw the sketches of Digester suitable for high water table.	**L2**	**CO 2**
7	Explain with neat sketch Absolute segregation of slurry.	**L2**	**CO 1**
8	Explain about two chamber rectangular digester with floating gas holder and water seal.	**L2**	**CO 2**
9	Explain Biomass energy programme in India?	**L2**	**CO 1**
10	With neat sketch explain the types of Bio gas digesters.	**L2**	**CO 2**

UNIT-V

Short Answer Questions-

Sl.No	Question	Blooms Taxonomy Level	Course Outcome
1	State the fundamental principle of tidal energy generation.	**L2**	**CO 1**
2	What is small hydel development?	**L2**	**CO 2**
3	What is the fundamental principle in energy conversion from ocean waves?	**L2**	**CO 1**
4	What are the civil works design considerations for mini and micro hydel power plants?	**L2**	**CO 2**
5	Classify small hydel power stations?	**L2**	**CO 1**

Long Answer Questions-

1	Explain the difference between geothermal plant and thermal plant.	**L2**	**CO 2**
2	Explain the various methods to extract geothermal energy.	**L2**	**CO 1**
3	Explain the potential of geothermal resources in India.	**L2**	**CO 2**
4	Explain Liquid dominated geothermal power plant with neat sketch.	**L2**	**CO 1**
5	Draw the diagram of geothermal field.	**L2**	**CO 2**
6	Explain the working of Anderson cycle OTEC system with neat sketch.	**L2**	**CO 2**
7	Explain the fundamental principle of tidal energy generation.	**L2**	**CO 1**
8	Explain vapor dominated geothermal power plant with neat sketch.	**L2**	**CO 2**
9	Explain the power generation from single ebb cycle system.	**L2**	**CO 1**
10	Explain the potential of geothermal energy in India.	**L2**	**CO 2**

OBJECTIVE QUESTIONS:

JNTUH:

UNIT-1

1. A photovoltaic cell converts _____.
   (a) Heat energy into mechanical energy (b) Chemical energy into electrical energy
   (c) solar energy into electrical energy (d) electrical energy into chemical energy
2. The value of solar constant is _____.
3. The highest rank of coal in which carbon content is about 90% is _____.
4. Non - conventional energy sources are available in form of _____.
5. The sun's outer visible layer is called _____ and has temperature of about _____.
6. An artificial or natural body of water for collecting and absorbing solar radiation energy and storing it as heat is known as _____.
7. Solar heat is directly converted into electricity by _____ converters.
8. Photovoltaic cell is a device which converts directly sunlight into _____.
9. The current and voltage relationship in a solar cell is given by _____.
10. The two basic instruments that are employed for solar radiation measurement are _____ and _____.
11. The relation between zenith (θ_z) and solar altitude (α) angles is _____.
    (a) $\theta_z + \alpha = 60^0$ (b) $\theta_z + \alpha = 90^0$ (c) $\theta_z + \alpha = -90^0$ (d) $\theta_z + \alpha = 0^0$.

UNIT-2

1. On September 22nd, 2001, the declination angle will be _____.
   (a) zero (b) $+23.45^0$ (c) -23.45^0 (d) $+180^0$
2. Darrius type of rotor mill is used for _____ velocity wind.
3. The amount of electromagnetic energy incident on a surface per unit time per unit area is known as _____.
4. A flat plate collector is used for many applications such as _____.
5. The efficiency of a concentrating collector is _____.
6. The basic components of solar water heater are _____.
7. Which of the following is not a concentrating type of solar collector?
   (a) Parabolic trough collector (b) liquid heating collector
   (c) Fresnel lens collector (d) Mirror strip reflector
8. In a solar pond , the concentration and temperature are nearly constant in
   (a) Surface convective zone (b) non convective zone
   (c) storage zone (d) All the above
9. Which of the following is not a concentrating type of solar collector?
   (a) Parabolic trough collector (b) liquid heating collector
   (c) Fresnel lens collector (d) Mirror strip reflector
10. The collector area is same as absorber area in _____.
    (a) Non concentrating collector (b) Flat plate type solar collector
    (c) Concentrating type solar collector (d) both (a) & (b)

UNIT-3

1. The phenomenon in which a lot of turbulence ensues, the lift decreases and drag increases quite substantially is called _____.
2. Wind aero generators of WECS are generally classified as _____ and _____.
3. The expression for monthly average horizontal solar radiation H_{av} is given by _____.
4. Efficiency of SPV module is typically _____%.
5. A fuel cell is an electrochemical device that converts _____ into _____
6. The total power of a wind stream is proportional to _____.
   (a) velocity of stream (b) $(\text{velocity of stream})^2$

(c) (velocity of stream)^3 (d) 1 / velocity of stream

7. The two primary mechanisms for producing forces from the wind are _____ and _____.
8. The kinetic energy of wind can be changed into _____ or _____ energy.
9. Bio gas obtained from cattle dung contains methane about _____ to _____ percent.
10. Kinetic energy of the wind is given by _____.
11. Wind speed at which wind energy starts delivering shaft power is called _____.
12. Vertical axis Wind machine among the following
    (a) Sail type wind machine (b) Multi-bladed wind machine
    (c) Darrius type rotor (d) both (a) & (b)

UNIT -4

1. The value of Betz coefficient (Cp) for a horizontal axis wind machine is _____.
   (a) 16 / 27 (b) 2 / 3 (c) 8 / 27 (d) None
2. The different types of wells for geo thermal energy are _____.
3. The two primary mechanisms for producing forces from the wind are _____ and _____.
4. Bio gas is known as _____.
5. The two types of OTEC systems are _____ and _____.
6. A limitation of ocean thermal energy power plant is _____.
7. The rise and fall of water level follows a _____ curve.
8. Total energy and power density can be written as _____.
9. The average rate of release of geothermal energy from within the earth is around _____ W/m^2.
10. _____ is most important fuel as its component is able to release more energy per unit weight.

UNIT -5

1. At the altitude angle of 30^0, the magnitude of zenith angle will be _____.
2. The angle between the direction of wind and direction perpendicular to the plane of blade is called _____.
3. HAWT stands for _____.
4. Okha wind farm in Gujarat has _____ units of _____ kw each.
5. Maximum power output of MHD generator is given by _____.
6. The main causes of energy crisis are _____.
7. Conventional energy sources are available in form of _____.
8. Gaseous product consisting of methane and carbon dioxide is known as _____.
9. Dissociation and Ionization are the principles for _____.
10. The thermodynamic aspect for DEC is _____.

XI. WEBSITES:

1. www.power-eng.com
2. www.rwe.com
3. www.iaea.org
4. www.powerplantengineering.com
5. www.nae.edu
6. www.power-gen.com

XII. EXPERT DETAILS:

1. Dr B.Sudheer Prem Kumar, Professor & HOD (Mech), JNTU, Hyderabad
2. Dr AVSSK Gupta, Professor (Mech), JNTU, Hyderabad

3. Dr E.Ramjee, Professor (Mech), JNTU, Hyderabad
4. Dr M.V Ramana Murthy, Associate Professor (Mech), OU, Hyderabad
5. Dr Raja Banerjeee, Associate Professor, IIT Hyderabad

XIII. JOURNALS:

1. International Journal of Energy Engineering
2. Nuclear Engineering and Design
3. International Journal of Energy Engineering

XIV. LIST OF TOPICS FOR STUDENT SEMINARS:

1. Indian Energy Scenario and World Energy resources
2. Solar Thermal Energy conversion
3. Design of Wind Power Turbines
4. Bio Mass Energy from Municipal Waste
5. Thermo Electric Power Generation
6. Fuel cell Technology

CASE STUDIES / SMALL PROJECTS:

1. Preparing an automobile using solar energy
2. Preparing an turbine blade model using wind energy