CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MET445	RENEWABLE ENERGY ENGINEERING	OEC	2	1	0	3

Preamble: The course is intended to give knowledge of various renewable energy sources, systems and applications and the need in the present context. Students will be able to compare different renewable energy techniques and choose the most appropriate based on local conditions. To equip students in working with projects and to take up research work in connected areas.

Prerequisite: Nil

Course Outcomes: After completion of the course the student will be able to

CO1	Explain renewable energy sources and evaluate the implication of renewable energy. To predict solar radiation at a location
CO2	Explain solar energy collectors, storages, solar cell characteristics and applications
CO3	Explain the different types of wind power machines and control strategies of wind turbines
CO4	Explain the ocean energy and conversion devices and different Geothermal sources
CO5	Explain biomass energy conversion devices. Calculate the Net Present value and payback period

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3											3
CO 2	3	3			1	1	1				1	3
CO 3	3	3			1	1	1				1	3
CO 4	3	3			1	1	1				1	3
CO 5	3	3			1	1	1				1	3

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

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Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions:

Course Outcome 1 (CO1):

1. What are the main renewable energy sources? Advantages and limitations
2. What is energy efficiency? How is it different from renewable energy use?
3. Define terms : Angle of Incidence, Declination, Solar constant

Course Outcome 2 (CO2):

1. Discuss different types of solar collectors
2. Discuss about different types of thermal storage devices
3. Draw the I-V characteristics of Solar cell under varying temperature and irradiation level

Course Outcome 3 (CO3):

1. Types of wind turbine and components
2. Difference between wind mill and wind turbine
3. Explain importance of drag and lift force in wind power generation.

Course Outcome 4 (CO4):

1. Explain with neat sketch the working of hybrid OTEC system
2. Explain with neat sketch the vapour dominated geothermal system

Course Outcome 5 (CO5):

1. Distinguish between Fixed dome plant and floating dome type biomass plant.
2. Write a short note on solar saving.
3. Derive expression for payback period

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Model Question Paper

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

VII SEMESTER B.TECH DEGREE EXAMINATION

MET445 RENEWABLE ENERGY ENGINEERING

Maximum: 100 Marks **Duration: 3 hours**

PART A

Answer all questions, each question carries 3 marks

1. Discuss in brief advantages of renewable energy.
2. Explain the following terms related to solar geometry (i) Hour Angle ((ii) Zenith Angle (iii) Surface azimuth angle
3. List different types of solar collectors
4. Discuss about solar pond
5. List the different methods used to estimate wind speed at a location.
6. What are the advantages of wind energy conversion systems?
7. List the geothermal resources.
8. Discuss advantages and disadvantages of a tidal power plant
9. Name the different processes used for hydrogen production
10. List the need for economic analysis of renewable energy system.

(10 X 3 = 30 marks)

PART B

Answer one full question from each module

Module 1

11. Elucidate the necessity of energy storage in the context of renewable sources of energy (14 Marks)
12. (a) Calculate the number of daylight hours in Srinagar for 22nd June .The latitude of Srinagar as 34º05'N. (4 Marks)

    (b) Compare the construction and working of Pyranometer and Pyrheliometer. (10 Marks)

Module 2

13. (a) How solar thermal power plants classified. List the methods for converting solar energy into electric power (10 Marks)

    (b) Briefly explain the applications of a solar PV system.. (4 Marks)
14. (a) Draw and explain the operation of flat plate collectors. (10 Mark

    (b) Explain the thermal methods of energy storage (4 Marks)

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Module 3

15. With a neat diagram explain the construction of a propeller type wind power system (14 marks)
16. (a) Derive the expression for power in the wind turbine. (7 marks)

b) Explain control mechanism in wind turbines (7 marks)

Module 4

17. State the principle of Ocean Thermal Energy Conversion (OTEC). Explain working of closed cycle OTEC system. (14 marks)
18. . Explain binary cycle Geothermal system (14 marks)

Module 5

19. Explain the construction and working of KVIC (floating type) bio gas plant (14 marks)
20. a.Define (1) Payback time (2) Return on investment .
    (3) Life cycle cost (6 marks)
    b. A solar PV system consisting with two lamps, a battery and other associated components cost Rs. 55000. The cost of conventional energy saved due to its installation is Rs. 4000 in the first year and this cost inflates at the rate of 5 % per year. Assume discounting rate is 9%. Calculate the payback period of the system with and without discounting (8 marks)

Syllabus

Module 1

The Energy Scenario- Commercial energy sources -World's production and reserves-India' Production and reserves, Energy Alternatives, Need for alternatives –solar option-nuclear options

Principles of solar radiation : Solar radiation outside the earth's atmosphere and at the earth's surface , Solar Constant, Basic Sun-Earth Angles, Instruments for measuring solar radiation and sunshine , Solar radiation data

Module 2

Solar Energy collectors: Solar thermal collectors -Flat plate collectors –Solar concentrators (parabolic trough, parabolic dish, Central Tower Collector) –Solar Air Heaters

Solar thermal electric power generation -Thermal Energy storage, sensible heat storage, latent heat storage , Thermo chemical storage , photovoltaic system for power generation , Solar pond -Solar Cells-Types of solar cells , principle of working and performance characteristics, Production process- Block diagram only

Applications- Solar space heating and cooling of buildings, solar pumping, solar cooker, solar still, solar drier, solar refrigeration and air-conditioning, heliostat, solar furnace

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Module 3

Wind Energy- classification of wind turbines and power performance curve, Energy in wind, calculation of energy content, Power coefficients, Betz limit theory, , tip speed ratio, solidity of turbine' power control strategies, Basic principles of Wind Energy Conversion Systems (WECS), Classification of WECS, Parts of WECS

Module 4

Ocean Energy – Devices for Wave Energy conversion, Ocean Thermal Energy Conversion (OTEC): Principle of OTEC system, Methods of OTEC power generation – Open Cycle (Claude cycle), Closed Cycle (Anderson cycle) and Hybrid cycle (block diagram description of OTEC); Geothermal energy: Introduction, hot dry rock resources, magma resources, vapor and liquid dominated systems, binary cycle, advantages and disadvantages

Module 5

Bio Mass Energy- Biomass conversion technologies –Bio Gasification, Bio ethanol, Bio Diesel , Biogas production from waste biomass, factors affecting biogas generation Bio Gas -KVIC and Janata model ,Hydrogen Energy – various routes for production of Hydrogen energy,

Economic Analysis – Initial and annual cost, basic definitions, present worth calculations, repayment of loan in equal annual installments, annual savings, cumulative saving and life cycle cost, economic analysis of add on solar system, payback period(derivation)

Text Books:

1. S P Sukhatme , J K Nayak, Solar Energy: Principles of Thermal Collection and Storage, Mc Graw Hill ,2015
2. Tiwari G N, Ghosal M K ,Fundamentals of renewable energy sources, Alpha Science International Ltd.,2007
3. Jefferson W Tester et.a., Sustainable Energy Choosing among options,PHI,2006

Reference Books:

1. D.P. Kothari Renewable energy resources and emerging technologies, Prentice Hall of India Pvt. Ltd,2011
2. Mehmet KanoğluYunus A. Çengel John M. Cimbala , Fundamentals and Applications of Renewable Energy, Mc Graw Hill ,2019
3. Roland Wengenmayr, Thomas Buhrke, 'Renewable Energy: Sustainable energy concepts for the future, Wiley – VCH, 2012

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Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**The Energy Scenario**	**(5)**
1.1	Commercial energy sources -World's production and reserves India' Production and reserves	**1**
1.2	,Energy Alternatives- Need for alternatives –solar options	**1**
	Principles of solar radiation	
1.3	Solar radiation outside the earth's atmosphere and at the earth's surface , Solar Constant,	**1**
1.4	Basic Sun-Earth Angles, Instruments for measuring solar radiation and sunshine , Solar radiation data	**2**
2	**Solar Energy**	**(11)**
2.3	Solar thermal collectors -Flat plate collectors	**2**
2.4	Solar concentrators (parabolic trough, parabolic dish, Central Tower Collector	**2**
2.5	Solar Air Heaters-types - Solar thermal electric power generation Thermal Energy storage, sensible heat storage, latent heat storage , Thermo chemical storage	**2**
2.7	Photovoltaic system for power generation	**2**
2.8	Solar Cells-Types of solar cells , principle of working and performance characteristics, Production process- Block diagram only	**2**
2.9	Applications- Solar space heating and cooling of buildings, solar pumping, solar cooker, solar still, solar drier, solar refrigeration and air-conditioning, heliostat, solar furnace	**1**
3	**Wind Energy**	**(6)**
3.1	Classification of wind turbines	**1**
3.2	power performance curve, Energy in wind, calculation of energy content,	**2**
3.3	Power coefficients, Betz limit theory, , tip speed ratio, solidity of turbine' power control strategies	**2**
3.4	Basic principles of Wind Energy Conversion Systems (WECS), Classification of WECS, Parts of WECS	**1**
4	**Ocean Energy**	**(6)**
4.1	Devices for Wave Energy conversion Ocean Thermal Energy Conversion (OTEC): Principle of OTEC system,	**1**

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4.2	Methods of OTEC power generation – Open Cycle (Claude cycle), Closed Cycle (Anderson cycle) and Hybrid cycle (block diagram description of OTEC)	**2**
4.3	Geothermal energy: Introduction , hot dry rock resources, magma resources	**1**
4.4	vapor and liquid dominated systems, binary cycle, advantages and disadvantages	**2**
5	**Bio Mass Energy**	**(8)**
5.1	Biomass conversion technologies –Bio Gasification, Bio ethanol, Bio Diesel	**1**
5.2	Biogas production from waste biomass, factors affecting biogas generation Bio Gas -KVIC and Janata model.	**2**
5.3	Hydrogen Energy – various routes for production of Hydrogen energy	**1**
5.3	**Economic Analysis – I**nitial and annual cost, basic definitions,	**1**
5.4	present worth calculations, repayment of loan in equal annual installments, annual savings, cumulative saving and life cycle cost	**2**
5.5	economic analysis of add on solar system, payback period(derivation)	**1**

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