CODE	COURSE NAME	CATEGORY	L	T	P	CREDITS
EET322	RENEWABLE ENERGY SYSTEMS	PEC	2	1	0	3

Preamble : This course introduces about different new and renewable sources of energy. Design of some of the systems are also discussed

Prerequisite : **Power Systems I**

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

CO 1	Describe the environmental aspects of renewable energy resources.
CO 2	Explain the operation of various renewable energy systems.
CO 3	Design solar PV systems.
CO 4	Explain different emerging energy conversion technologies and storage.

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										2
CO 2	3	3										2
CO 3	3	3										2
CO 4	3	3										2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember (K1)	10	10	10
Understand (K2)	20	20	40
Apply (K3)	20	20	50
Analyse (K4)	-	-	-
Evaluate (K5)	-	-	-
Create (K6)	-	-	-

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. Explain the environmental impacts of wind energy systems. (K1)
2. Explain the limitations of renewable energy systems (K2)

Course Outcome 2 (CO2):

1. With the help of a block diagram, explain the working of a wind energy conversion system. (K2)
2. Explain the working of a small hydro power plant with the help of a diagram. (K2)

Course Outcome 3 (CO3):

1. Design a grid connected solar photovoltaic system. (K3).
2. Design a solar photovoltaic system for a water pumping system. (K3).

Course Outcome 4 (CO4):

1. Explain how energy can be generated from alcohol. (K2)
2. Explain the need for energy storage systems. Discuss how energy can be stored in batteries. (K2).

Model Question paper

QP CODE:

PAGES: 2

Reg. No:_____
Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH DEGREE EXAMINATION,
MONTH & YEAR
Course Code: EET322

Course Name: RENEWABLE ENERGY SYSTEMS

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks

1. What do you mean by global warming? Explain its adverse effects.
2. Write notes on Indian energy scenario.
3. Determine the local apparent time corresponding to 11.30 IST on July 1, at Delhi (280 35' N,770 12'E). The equation of time correction on July 1 is -4 minutes.
4. Draw and explain the V- I characteristics of a solar cell.
5. Define tip speed ratio, cut in speed and cut out speed of a wind turbine.

6. Explain the factors to be considered for the selection of small hydro plants.
7. Discuss the advantages and disadvantages of tidal power plants.
8. Explain the principle of operation of an OTEC plant. What are its advantages?
9. Explain how power can be derived from satellite stations.
10. Explain how energy can be stored using flywheels.

PART B (14 x 5 = 70 Marks)

Answer any one full question from each module. Each question carries 14 Marks

Module 1

11. a. Illustrate the relation between energy and sustainable development. **(4)**
    b. Compare the advantages and disadvantages of different conventional sources ofenergy. **(10)**

12. a. Write notes on Kyoto protocol. **(4)**
    b. List out the advantages and disadvantages ofdifferent non-conventional sourcesof energy. **(10)**

Module 2

13. a. With the help of a diagram, explain the working of a pyrheliometer. **(7)**
    b. Explain how a standalone solar PV system can be designed. **(7)**

14. a. With the help of a diagram, explain the working of a flat plate collector. **(7)**
    b. Explain how Maximum Power Point Tracking can be done using a buck boostconverter. **(7)**

Module 3

15. a. Derive an expression for power derived from wind. Explain the characteristic of awind turbine. **(7)**
    b. A propeller wind machine has rotor diameter of 40 m. It is operating at location having wind speed of 35kmph and rotating at 20 rpm. Calculate theoretically the power which the machine can extract from the wind considering both wake rotation and effect of drag. Assume ξ=.012. **(7)**

16. a. With the help of a diagram, explain a wind energy conversion system with variablespeed drive scheme. **(8)**
    b. Explain the different types of turbines used in small hydro plants. **(6)**

Module 4

17. With the help of a diagram, explain the working of different types of tidal powerplants. **(14)**

18. a. With the help of a diagram, explain the working of an OTEC system using hybridcycle. **(10)**
    b. Write notes on the factors to be considered for site selection of OTEC plants. **(4)**

Module 5

19. a. With the help of a diagram, explain biomass gasification based electric powergeneration. **(8)**
    b. Explain the working of a fuel cell with the help of a diagram **(6)**

20. a. With the help of a diagram, explain the working of KVIC model biogas plant. **(10)**
    b. Write notes on pumped storage plants **(4)**

Syllabus

Module 1

Introduction, Environmental Aspects Of Energy-Ecology-Greenhouse Effect-Global Warming-Pollution-Various Pollutants and their Harmful Effects-Green Power-The United Nations Framework Convention On Climate Change (UNFCC)- Environment-Economy-Energy and Sustainable development-Kyoto Protocol -Classification of Energy Resources; Conventional Energy Resources -Availability and their limitations; Non-Conventional Energy Resources –Classification, Advantages, Limitations; Comparison of Conventional and Non-Conventional Energy Resources; World Energy Scenario; Indian Energy Scenario.

Module 2

SOLAR THERMAL SYSTEMS: Introduction, Solar Constant, Basic Sun-Earth Angles, Measurement of Solar Radiation Data(Numerical Problems)–Pyranometer and Pyrheliometer -Solar Thermal Collectors –General description and characteristics –Flat plate collectors –Heat transfer processes –Solar concentrators(Parabolic trough, Parabolic dish, Central Tower Collector)

SOLAR ELECTRIC SYSTEMS: Introduction- Solar Photovoltaic –Solar Cell fundamentals, characteristics, classification, construction of Module, Panel and Array-Effect of shadowing-.Maximum Power Point Tracker (MPPT) using buck-boost converter. Solar PV Systems –stand-alone and grid connected-Design steps for a Stand-Alone system; Applications –Street lighting, Domestic lighting and Solar Water pumping systems.

Module 3

Wind Energy–Introduction–Wind Turbine Types (HAWT and VAWT) and their construction- Wind power curve-Betz's Law-Power from a wind turbine(Numerical Problems)-Wind energy conversion system(WECS) – Fixed–speed drive scheme-Variable speed drive scheme.-Effect of wind speed and grid condition(system integration).

Small hydro power: Classification as micro, mini and small hydro projects -Basic concepts and types of turbines - Classification, Characteristics and Selection

Module 4

ENERGY FROM OCEAN: Tidal Energy –Principle of Tidal Power, Components of Tidal Power Plant (TPP), Classification of Tidal Power Plants, Advantages and Limitations of TPP. 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); Site-selection criteria, Biofouling, Advantages & Limitations of OTEC.

Module 5

BIOMASS ENERGY: Introduction, Photosynthesis process, Biomass fuels, Biomass conversion technologies, Urban waste to Energy Conversion, factors affecting biogas generation, types of biogas plants –KVIC and Janata model;.

EMERGING TECHNOLOGIES: Fuel Cell, Hydrogen Energy, alcohol energy and power from satellite stations.

ENERGY STORAGE: Necessity Of Energy Storage-Pumped storage-Compressed air storage-Flywheel storage-Batteries storage-Hydrogen storage.

References:

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2. Abbasi S. A. and N. Abbasi, Renewable Energy Sources and Their EnvironmentalImpact, Prentice Hall of India, 2001.
3. Thomas E. Kissell, David M. Buchla, Thomas L. Floyd, Renewable energy systems,Pearson 2017
4. Boyle G. (ed.), Renewable Energy -Power for Sustainable Future, Oxford University Press, 1996
5. Earnest J. and T. Wizelius, Wind Power Plants and Project Development, PHI Learning, 2011.
6. F. Kreith and J.F. Kreider: Principles of Solar Engineering, McGraw Hill, 1978
7. G.N. Tiwari: Solar Energy-Fundamentals, Design, Modelling and Applications, Narosa Publishers, 2002
8. J.A. Duffie and W.A. Beckman: Solar Energy Thermal Processes, J. Wiley, 1994
9. Johansson T. B., H. Kelly, A. K. N. Reddy and R. H. Williams, Renewable Energy – Sources for Fuel and Electricity, Earth scan Publications, London, 1993.
10. Khan B. H., Non-Conventional Energy Resources, Tata McGraw Hill, 2009.
11. D.P.Kothari, K.C.Singal, RakeshRanjan, *Renewable Energy Sources and Emerging Technologies*, Prentice Hall of India, New Delhi, 2009
12. Rao S. and B. B. Parulekar, Energy Technology, Khanna Publishers, 1999.
13. Sab S. L., Renewable and Novel Energy Sources, MI. Publications, 1995.
14. Sawhney G. S., Non-Conventional Energy Resources, PHI Learning, 2012.
15. Tiwari G. N., Solar Energy-Fundamentals, Design, Modelling and Applications, CRC Press, 2002.

Course Contents and Lecture Schedule:

No	Topic	No. of Lectures
1	**Environmental impacts of various energy resources. (7 hours)**	
1.1	Introduction, Environmental Aspects Of Energy-Ecology-Greenhouse Effect-Global Warming	1
1.2	Pollution-Various Pollutants and their Harmful Effects-Green Power - The United Nations Framework Convention On Climate Change (UNFCC)	2
1.3	Environment-Economy-Energy and Sustainable development-Kyoto Protocol -Classification of Energy Resources	1
1.4	Conventional Energy Resources -Availability and their limitations	1
1.5	Non-Conventional Energy Resources –Classification, Advantages, Limitations; Comparison of Conventional and Non-Conventional Energy Resources; World Energy Scenario; Indian Energy Scenario.	2
2	**Solar radiation data, solar thermal and electric systems. (7 hours)**	

2.1	Introduction, Solar Constant, Basic Sun-Earth Angles, Measurement of Solar Radiation Data(Numerical Problems)–Pyranometer and Pyrheliometer	2
2.2	Solar Thermal Collectors –General description and characteristics –Flat plate collectors –Heat transfer processes	1
2.3	Solar concentrators(Parabolic trough, Parabolic dish, Central Tower Collector)	1
2.4	Solar Photovoltaic –Solar Cell fundamentals, characteristics, classification, construction of Module, Panel and Array-Effect of shadowing	1
2.5	Maximum Power Point Tracker (MPPT) using buck-boost converter. Solar PV Systems –stand-alone and grid connected-Design steps for a Stand-Alone system	1
2.6	Applications –Street lighting, Domestic lighting and Solar Water pumping systems.	1
3	**Wind energy and small hydro plant (6 Hours)**	
3.1	Wind Energy–Introduction–Wind Turbine Types (HAWT and VAWT) and their construction	1
3.2	-Wind power curve-Betz's Law-Power from a wind turbine(Numerical Problems)	1
3.3	Wind energy conversion system(WECS) – Fixed–speed drive scheme-	1
3.4	Variable speed drive scheme.-Effect of wind speed and grid condition(system integration)	1
3.5	Small hydro power: Classification as micro, mini and small hydro projects -Basic concepts and types of turbines - Classification, Characteristics and Selection	2
4	**Energy from ocean (7 Hours)**	
4.1	Tidal Energy –Principle of Tidal Power, Components of Tidal Power Plant (TPP)	2
4.2	Classification of Tidal Power Plants, Advantages and Limitations of TPP.	1
4.3	Ocean Thermal Energy Conversion (OTEC): Principle of OTEC system, Methods of OTEC power generation	1
4. 4	Open Cycle (Claude cycle), Closed Cycle (Anderson cycle)	1
4. 5	Hybrid cycle (block diagram description of OTEC)	1
4. 6	Site-selection criteria, Biofouling, Advantages & Limitations of OTEC.	1
5	**Emerging technologies (9 Hours)**	
5.1	Introduction, Photosynthesis process, Biomass fuels, Biomass conversion technologies	2
5.2	Urban waste to Energy Conversion, factors affecting biogas generation, types of biogas plants –KVIC and Janata model	2

5.3	Types of biogas plants –KVIC and Janata model	1
5.4	Fuel Cell, Hydrogen Energy	1
5.5	Alcohol energy and power from satellite stations.	1
5.6	Necessity Of Energy Storage-Pumped storage-Compressed air storage	1
5.7	Flywheel storage-Batteries storage-Hydrogen storage.	1