

# GUJARAT TECHNOLOGICAL UNIVERSITY

**SUBJECT NAME: RENEWABLE ENERGY SYSTEMS**

**BRANCH NAME: Electrical Engineering**

**SUBJECT CODE: 3710715**

**M.E. 1<sup>st</sup> SEMESTER**

**Type of course: Program Elective**

**Prerequisite: Basic knowledge of electrical engg.**

**Rationale:** The objective of this course is to provide basic understanding of the upcoming technology of renewable energy systems and to have an overall understanding of energy systems. To provide exposure to different aspects like policy, design control and grid integration of renewable energy systems. The students will be able to find the reasonableness of the use of renewable energy after comparing the available resources.

**Teaching and Examination Scheme:**

Teaching Scheme			Credits C	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
			ESE(E)	PA (M)	PA (V)	PA (I)		
3	0	2	4	70	30	30	20	150

**Content:**

Sr. No.	Content	Total Hrs	% Weightage
1	<b>Introduction</b> <ul style="list-style-type: none"><li>• Energy Use – Reserves of Energy Resources – Environmental Aspects Of Energy Utilization</li><li>• Renewable Energy Seasonal variations and availability, Scenario In Gujarat, India and Around The World – Potentials – Achievements / Applications, Resources and features. Hybrid energy systems</li><li>• Distributed energy systems and dispersed generation (DG)</li></ul>	4	10
2	<b>SOLAR ENERGY</b> <ul style="list-style-type: none"><li>• Solar radiation spectrum.</li><li>• Radiation measurement. Technologies.</li><li>• Applications: Heating, Cooling, Drying, Distillation,</li><li>• Power generation</li><li>• Solar Photovoltaic Systems Operating principles.</li><li>• Photovoltaic cell concepts. Cell, module, array. Series and parallel connections.</li><li>• Maximum power point tracking. (MPPT)</li><li>• Applications: Battery charging, Pumping, Lighting</li><li>• Sizing residential systems</li><li>• Batteries and Inverters</li></ul>	12	25

	<ul style="list-style-type: none"> <li>• Governmental incentives</li> <li>• Grid connection issues</li> </ul>		
<b>3</b>	<b>WIND ENERGY</b> <ul style="list-style-type: none"> <li>• Types of Wind Energy Systems, Comparison of Performance</li> <li>• Site Selection, Wind Data and Energy Estimation</li> <li>• Details Of Wind Turbine Generator and comparison</li> <li>• Safety and Environmental Aspects</li> <li>• Grid Connection issues</li> <li>• Governmental Incentives/policies</li> <li>• Wind energy Potential and Installation in India.</li> </ul>	<b>10</b>	<b>20</b>
<b>4</b>	<b>BIOMASS</b> <ul style="list-style-type: none"> <li>• Operating principles. Combustion and fermentation.</li> <li>• Anaerobic digester. Wood gasifier. Pyrolysis.</li> <li>• Applications: Biogas, Wood stoves, Bio diesel, Combustion engine</li> <li>•</li> </ul>	<b>4</b>	<b>10</b>
<b>5</b>	<b>OTHER RENEWABLE ENERGY SOURCES</b> <ul style="list-style-type: none"> <li>• Tidal Energy, Wave Energy, Open And Closed OTEC Cycles</li> <li>• Small Hydro</li> <li>• Geothermal Energy</li> <li>• Hydrogen And Storage</li> <li>• Fuel Cell Systems</li> </ul>	<b>10</b>	<b>20</b>
<b>6</b>	<b>HYBRID SYSTEMS</b> <ul style="list-style-type: none"> <li>• Need for Hybrid Systems</li> <li>• Range and type of Hybrid systems</li> <li>• Case studies of Diesel-PV, Wind-PV, Micro hydel PV, Biomass-Diesel systems, electric and hybrid electric vehicles</li> </ul>	<b>4</b>	<b>10</b>
<b>7</b>	<b>COSTING</b> <ul style="list-style-type: none"> <li>• Life cycle costing (LCC)</li> <li>• Solar thermal system LCC</li> <li>• Solar PV system LCC</li> <li>• Micro hydel LCC</li> <li>• Wind system LCC</li> <li>• Biomass system LCC</li> </ul>	<b>2</b>	<b>5</b>

**Suggested reading:**

1. Rai. G.D., "Non-Conventional Energy Sources", Khanna Publishers, New Delhi, 2011.
2. Twidell, J.W. & Weir, A., "Renewable Energy Sources", EFN Spon Ltd., UK, 2006.
3. Renewable Energy Engineering and Technology, Kishore VVN, Teri Press, New Delhi, 2012
4. Alternative Energy Sources, Veziroglu, T.N., Vol 5 and 6, McGraw-Hill, 1990
5. C. S. Solanki, "Solar Photovoltaics: Fundamental Applications and Technologies, Prentice Hall of India, 2009.
6. Godfrey Boyle, "Renewable Energy, Power For A Sustainable Future", Oxford University Press, U.K., 1996.

7. Tiwari. G.N., Solar Energy – “Fundamentals Design, Modelling & Applications”, Narosa Publishing House, New Delhi, 2002
8. L.L. Freris, Wind Energy Conversion Systems, Prentice Hall, 1990.
9. D. A. Spera, Wind Turbine Technology: Fundamental concepts of Wind Turbine Engineering, ASME Press.
10. David M. Mousdale – “Introduction To Biofuels”, CRC Press, Taylor & Francis Group, USA 201[.

**Course Outcomes :-**

Students will be able to:

Describe the principles of operation of the renewable energy technologies.

Understand and evaluate different types of renewable energy sources, calculate the performance and compare it from design view point

Analyze energy technologies from a systems perspective.

Articulate the technical challenges for each of the renewable sources

Discuss economic, technical and sustainability issues involved in the integration of renewable energy system to the grid

Design an electrical storage and its control system

**List of Experiments:**

Suggested Lab experiments shall target the following

Modelling of Solar PV sub-systems

Modelling of wind generation sub-systems

Control of Power generation from various renewable energy systems

Simulation of power electronics converter/inverter used for grid integration of wind and solar

Energy management strategies for grid integration and exchange of power between renewable energy sources and grid

Design examples

**It is suggested to arrange field visit of nearby renewable energy generation plant for the students and submit the report of the visit.**

**in this course, The student required to work together (team of two or three) on a feasibility study for a renewable energy development project in a location of their choice using the technologies and tools available in the institute.**

**Major Equipment:**

Simulation software like MATLAB along with necessary toolbox, PSIM or Scilab

The working model of above renewable energy sources with necessary equipment used for measurement and analysis

**List of Open Source Software/learning website:**

1. Courses available through NPTEL.

- website : nptel.ac.in (<https://nptel.ac.in/syllabus/108108078>)