Post graduate program for engineering leading to M.Tech in renewable energy systems with specialization in solar energy

1.0 Introduction

India’s growing energy needs mixed with world’s order for reducing environmental emissions by fossil energy sources require the use of environmental friendly new and renewable energy sources having no environmental emissions. The thrust given by the Govt. of India under National Climate Plan and Jawahar Lal Nehru National Solar Mission has suddenly created the need to train large human resource in the field of new and renewable energy especially with expertise in solar energy. While this needed manpower has to be trained at various levels starting from field mechanic, field engineer to expertise in design, planning, management and financing. Considering this urgent requirement course curriculum was developed for solar mechanics as well as solar engineers for solar photovoltaic as well as solar thermal technologies and systems.

The present document is prepared to enable engineering institutions offering post graduate degree adopt a curriculum, which addresses the need of human skills for executing JNNSM. The aspiring students must have completed their basic engineering UG degree in mechanical/electrical/chemical engineering or M.Sc. in physics.

The M.Tech in renewable energy engineering is design to equip graduates and working professionals with a broad training understanding of energy production, delivery, consumption, efficiency, economics, policy, regulation and environmental impact. These are considered in context of sustainable renewable energy supply with emphasis on solar energy systems. The course is engineering based but also covers wide range of topics including economics, environment and policy aspects.
2. Course Objective

The course Objective is to equip the student with technology, economics and policy involving energy systems and supply with renewable energy sources. Detail expertise will be offered in solar energy systems involving photovoltaic as well as thermal energy systems. On successful completion of this course, the student will be able to

- Understand and evaluate basic engineering processes.
- Understanding and evaluate alternative modes of energy supply.
- Appreciate the development of and constraints on carbon and non-carbon based energy resources.
- Understand the economics and planning of energy supply-demand chain.
- Appreciate the policy, financing and regulatory frameworks within which decisions on energy future are made.
- Articulate environmental sustainability of energy supply system.
- Assimilate and acquire the skills for design and engineering of solar thermal and solar photovoltaic technology and systems.
- Analyze the technoeconomics interaction of developments in the energy systems.

3.0 Course structure and assessment

The curriculum has a modular structure with the award of credits for successful completion of each module and the project. A total of 90 credits are required for M.Tech degree, the courses are designed to accommodate graduates with a bachelor degree in engineering or Master degree in Physics.
4.0 Program: Master of Technology (M.Tech) in Renewable Energy Engineering

Eligibility

Programme is open to graduates holding B.Tech degree in Mechanical/Electrical/Chemical engineering or M.sc in physics.

Duration of the course

Four semesters (full time basis)

Semester wise course contents

M.Tech (full time)

First semester (basic foundation module)

<table>
<thead>
<tr>
<th>Course</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>Credits</th>
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<tbody>
<tr>
<td>1. Principles of energy conversion systems</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>2. Basic electrical engineering * (open to non electrical students)</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>3</td>
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<tr>
<td>3. Basic thermal engineering * (open to non mechanical students)</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>4. Basic chemical engineering* (open to non chemical students)</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>3</td>
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<tr>
<td>5. Quantitative methods of energy planning and management</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
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<tr>
<td>6. Manufacturing engineering</td>
<td>3</td>
<td>0</td>
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<td>7. Instrumentation and control in energy systems</td>
<td>3</td>
<td>0</td>
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Total semester credits 21 or 24*

*all courses compulsory for M.Sc (Physics) students.
Second semester (Renewable Energy, Engineering & and Management)

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<tr>
<th>Course Description</th>
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<th>Credits</th>
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<tbody>
<tr>
<td>8. Renewable energy sources</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>4</td>
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<tr>
<td>Conversion and technology</td>
<td></td>
<td></td>
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<tr>
<td>9. Industrial energy management</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>10. Energy economics and planning</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>4</td>
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<tr>
<td>11. Power plant engineering</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>4</td>
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<tr>
<td>12. Energy laboratory</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>3</td>
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<td><strong>total</strong></td>
<td></td>
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<td><strong>19</strong></td>
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Summer training (two months) 9 Credits

(Essential in a Industry or institutions involved in production, design, planning and policy)
### Third semester (Design of Renewable Energy Systems)

<table>
<thead>
<tr>
<th>Course Description</th>
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<th>T</th>
<th>P</th>
<th>Credits</th>
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<tbody>
<tr>
<td>13. Wind energy: design and project planning</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>14. Solar thermal applications: Low and medium temperatures</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>15. Concentrators and solar thermal power plants</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>16. Photovoltaics: solar cell and photovoltaic technologies</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>17. Solar photovoltaic power plants: planning, design, and balance of systems</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total credits</strong></td>
<td></td>
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<td><strong>20</strong></td>
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### Fourth semester (Economics, Environment, Financing & Project)

<table>
<thead>
<tr>
<th>Course</th>
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<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>18. Economics and financing a solar power plant: develop project report</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>19. Energy and environmental analysis of renewable energy systems</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>4</td>
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<tr>
<td>20. Major Project</td>
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<td>15</td>
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<tr>
<td>Semester total credits</td>
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<td>22</td>
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<tr>
<td>.G. Total of credits</td>
<td></td>
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<td>90 or 93 for M.Sc. students</td>
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Individual course details

1. Principles of energy conversion systems:

Energy classification, sources and utilization, direct and indirect energy conversion, thermodynamic cycles, thermoelectric and thermionic converters, photovoltaic and solar thermal energy conversion, hydrogen energy, fuel cells, thermal and electrical storage.

2. Basic electrical engineering:

Power circuits, electrical motors, single phase and three phase circuits, power circuit components, demand controls, transmission and distribution.

3. Basic thermal engineering:

Thermodynamics cycles, energy and energy, thermal fluid systems, heat transfer fundamentals, fluid dynamics.

4. Basic chemical conversion & fuel technology:

Solid, liquid and gaseous fuels, combustion process, boiler and combustion appliances, coal liquefaction and gasification, biofuels, environmental considerations.

5. Quantitative methods of energy planning and management:

Energy forecasting and decision making, econometrics, reference energy systems, demand side management and MARKET allocations, linear programming, micro and macro level energy planning, queing theory, social costs and environmental considerations.

6. Manufacturing engineering:

Statistical modeling and controlling manufacturing processes, experimental design and response surface modeling, parametric yield modeling and optimization, various forms
of processes control including statistical control, adaptive control, real time feedback control.

Application content: semiconductor for manufacturing, metal and polymer processing, micro and nano manufacturing.

7. Instrumentation and Control in Energy Systems

Basic Measurement Concepts, Error analysis, Transducer classification, Static and dynamic characteristics of transducers, Real time Monitoring and data processing, energy audit instruments, measuring temperature, humidity, radiation, flow, pressure, thermal conductivity, sp. Heat etc., measurement of electrical quantities i.e. current, voltage, power, power factor, stability and transient analysis of power producing systems.

8. Renewable energy sources and conversion technology:

Earth sun energy flux diagram, overview of renewable energy conversion, energy resource assessment: solar, biomass, wind, solar thermal collectors, low temperature systems, solar heat pumps & refrigeration, concentrating collectors, overview of solar thermal power systems, photovoltaic energy conversion, physical and thermo chemical methods of bioconversion, wind energy convertors, basics of wave, tidal, OTEC, hydrogen and fuel cells.

9. Industrial energy management:

Energy audit and energy conservation, management and organization of energy conservation programs, analysis of thermal fluid systems, energy conservation in combustion systems, fuels and their properties, combustion systems efficiency calculations, testing efficiency, steam and condensate systems, heat exchangers, heat recovery, industrial insulation, industrial buildings, power circuits, electrical machines, power factor, power circuit compensation, electrical energy conservation.

10. Energy economics & planning:

Financial and economic feasibility, evolution of energy technology and systems, basics of engineering economics, financial evaluation, energy demand forecasting, econometrics, demand and supply balancing, energy models, energy economy
interaction, energy-environment interaction, impact on policy, MARKET allocation modeling, acts and regulations.

11. Power plant engineering:
Introduction to different power plants, steam power plant, gas turbine power plant & diesel power plant, steam & gas turbine, hydroelectric power plants, hydro turbine and characteristics parameters. Turbine and generator, synchronous and asynchronous generator, induction generator, introduction to transmission and distribution.

12. Energy laboratory: Experiment on:
- Resource assessment
- Flat plate collector testing
- Water heating system
- Concentrator evaluation
- PV cell characterization
- PV module characterization
- 500W PV power plant, DC/AC
- Boiler characteristics
- Wind convertor characterization
- Fuel cell & hydrogen cell
- Biogas\ biofuel generators
- Biofuel & IC engine
- Turbines
13. Wind Energy:

Wind characteristics:

Sources of wind, wind classification, sitting in flat terrain, sitting in non-flat terrain, ecological indicators of site suitability, site analysis methodology.

**Wind energy system:** energy from the wind, work-energy and power, different types of rotors, over speed control, electric power generation and storage. Water pumping, systems-major components-lift-transport-storage sitting and sizing.

**Applied aerodynamics:** Role of dynamics in wind power- cross wind axis machines, wind axis machines- general momentum theory- vortex strip theory, forces and moments due to vertical wind gradient, control mechanism.

**Towers and systems installation:** Specific types of towers, tower height, tower and system raising, wiring, lightening protection, installation, maintenance of other equipments.

**Energy conversion and storage:** synchronous inverters, DC/AC inverters, battery storage, battery characteristics, battery system installation, other types of storage systems.

**Wind energy conversion systems:** Specification and characteristics of commercial water-pumping wind mills, electricity producing wind energy, conversion systems, selection of system case study, Environment aspects.

Project planning and DPR

14. Solar thermal applications:
Temperature & choice of collectors, swimming pool heating, domestic and process heat, characteristic equation, mathematical modeling, simulation, storage tank; (pressurized vs. non pressurized), storage with stratification, storage tank with gas as auxiliary, heat exchangers, corrosion and antifreeze, dimensioning, connecting pipe circuit, expansion tank sizing, concentrating collectors, process heat, air heating collectors, solar drying, solar distillation.

15. Solar thermal power plants:
Concentration and temperatures, error in concentration, parabolic geometries, paraboloid geometries(dish), heliostats, lay out, central receiver, factors influencing power and energy, design process and parameters, thermodynamic basis for receiver design, tube receiver concept. Volumetric receiver, direct absorption receiver, receiver loss calculations, thermal storage for solar power plants, experience on solar thermal power plants, techno economic evaluation, market considerations.

16. Solar photovoltaics
Fundamentals of solar cell, semiconductors as basis for solar cells materials and properties, P-N junction, sources of losses and prevention, monocrystalline solar cell technology ingot and water production, processes in solar cells, sawing and surface texturing, diffusion process, metal contact, thin film solar cells, deposition techniques, evaporation, LPCVD and APCVD, hot wire CVD, ion assisted deposition, amorphous Si solar cell, Cd Te solar cells and solar cell, Concentration and PV cell, PV modules, PV generator

Estimating power and energy demand, site selection, land requirements, choice of modules, economic comparison, balance of systems, off grid systems, grid interface, Preparing DPR, Supporting structures, mounting and installation, junction boxes, battery storage, power condition unit, selection of cables and balance of systems, planning with software, maintenance and schedule, SCADA system, Sensors, Data logger, Monitoring, Data Management, Analysis and
18. Economics and financing:

Financial evaluation and RE viability, basics of engineering economics, social cost benefit analysis, technology dissemination models, dynamics of fuel substitution, fiscal, financial and other benefits of renewable energy systems, financing of RE systems, carbon financing of renewable energy, software evaluation, case studies.

19. Energy and environmental analysis:

Energy and environment correlation, the green house gas effect, energy and environmental management, energy in manufacturing processes, net energy analysis, net emission analysis, whole system analysis, examples of renewable energy systems, contamination of general water, hazardous waste management.