Course title : Solar Photovoltaic & Thermal Technologies
Course credits : 2
No. of modules : 2
Module 1: Solar Photovoltaic Technology
Module 2: Solar Thermal Technology

Detailed syllabus:

Module 1: Solar Photovoltaic Technology

I. Physics of solar cells

Crystal structure, band theory, energy band diagrams, Fermi level, intrinsic and extrinsic semiconductor, doping, n-type and p-type silicon, p-n junctions, drift and diffusion current, absorption of radiation and excess minority carriers, generation, recombination and carrier separation.

Standard solar cell structure, I-V characteristics, FF, V_{oc}, I_{sc}, Pmax, conversion efficiency, losses in solar cell, R_s, R_{sh}, impact of radiation and temperature, PC1D simulation of industrial solar cell structure.

Concepts of heterojunctions, multi junction and concentrated solar cell, Introduction to advanced softwares used in solar cell simulation.

II. Solar PV module technologies

First generation: Silicon wafer based technology: Materials and process requirements for solar cell fabrication, process flow, process control measures, quality control techniques Single and poly crystalline silicon solar cells, Materials and process requirements for module assembly, routine and type tests, qualification test standards, types of degradation.

Second generation: Thin film technologies: Merits and demerits of thin film technologies, amorphous-Si, CdTe and CIGS solar cell module, manufacturing steps.

Third generation/emerging PV technologies: Organic PV, Dye sensitized PV, Quantum-dot,Hot-carrier, Up conversion and down conversion.

Latest benchmark efficiencies – laboratory and manufacturing.

III. Solar PV systems

Balance of System (BoS) components: battery, PCU (charge controller, inverter, data logger), transformer, cables and connectors, switches/circuit breakers, energy meters, bypass and blocking diodes.

Types of PV systems: Standalone, grid-connected, hybrid, rooftop business models – CAPEX and RESCO, canal top, floating PV system.

System design: SPV system design guideline and methodologies, introduction to PVSyst, designing of standalone/grid-connected PV systems for domestic/commercial use.

IV. Solar PV applications

Lighting, agriculture, refrigeration, telecommunications, space, BIPV, fencing, water purification, navigation, defence, offshore, etc.

Module 2: Solar Thermal Technology

I. Solar Radiation review

Solar radiation on the collector, Liu & Jordan relation.

II. Solar Thermal collectors

Flat plate collectors: general design features and characteristics, materials.

Unglazed, Single and double glazed solar collectors, Optical losses and thermal losses,thermal analysis and performance characteristics.

Design of water and air heating collectors: their specific features. Short term and long term performance.

Evacuated tube collectors: general design features, characteristics, materials, thermal analysis Thermo siphon system and forced convection system, Concentrating solar collectors:

General description; concentrators, receivers, Orienting/tracking requirements, Materials.

General characteristics Optical features of solar concentrators: II Law of thermodynamics for solar concentrators. Optical and thermal losses, Thermal performance characteristics parabolic trough collectors (PTC), Paraboloid dish collectors, Scheffler dish, Linear Fresnel Reflector Collector.

III. Application

Solar hot water/steam systems, Solar cookers: box type, dish type and others; dryers; desalination systems; absorption cooling; furnace, Process heating systems, community cooking system.

Power generation: Concentrator based system, Fresnel system, central tower, distributed line focus and point focus systems, Hybrid solar thermal.

IV. Energy Storage

Sensible heat storage, latent heat storage (PCM), thermo-chemical storage

Organic & inorganic PCMs, properties, characterization.

Applications in power generation, green building, cooking, cold storage, transportation,district heating & cooling, salinity gradient solar pond.

Evaluation/Assessment scheme:

1. Quizzes – 40% (one at the end of each module)
2. End semester exam – 60% (at the end of course)

Learning outcomes:

At the end of the course the student will be able to:

- Understand the physics and technology of solar PV and solar thermal technologies
- Apply system design approaches for various application of solar PV and thermal technologies