

# **SELCO FOUNDATION: SOLAR Technician Program Course Module for 3 weeks**

## **Session 1: Overview of the course (15 min)**

- Course Module Explanations

### **Theory:**

Presentation: To get a gist of the course, Introduction - SELCO Foundation

Video: SELCO Foundation

- Expected outcome of the course

### **Theory:**

Presentation: The subjects that the trainees will be aware of after the course and how to implement them

## **Session 2: Introduction (25 min)**

Interaction between the trainer and trainees

The trainer introduction

Group activity: For the students' introduction

## **Session 3: Introduction to Conventional and Non-conventional sources of energy (70 min)**

- Difference between Conventional & Non-Conventional Energy, Limitations, Advantages & Disadvantages, Barriers.
- Need & Potential for clean energy systems.
- Global Scenario for decentralized systems.
- Government Policy & Schemes for Renewable energy.

**Theory:** Presentation on Available sources of energy and energy depletion of various energy sources; MNRE, JNNSM, other Government Schemes, etc. **Video:** Documentary on Climate change, etc.

**Assignment 1:** to find the current scenario with each state with the MW solar plants details.

## **Session 4: Introduction to solar energy (40 min)**

- Solar -Thermal & Light energy, Insolation
- Thermal Systems: Principle of thermal systems

- Photo Voltaic Systems: Semiconductors, Photovoltaic Effect, PV Cell Concepts
- Advantages & Disadvantages of Solar PV Systems.

**Theory:**

Presentation: How much solar energy is available to the earth atmosphere, Insolation, Theory on heat absorption, Semiconductors, Doping; show the flow of electrons in PV cell in PPT

Video: Photovoltaic effect; Manufacturing process of panels.

**Session 5: Types of PV Systems (60 min)**

- Types of PV Systems: Off Grid, Hybrid, Grid Tie Systems
- AC & DC systems differentiation.

**Theory:**

Presentation: Show the flow diagram in each system. Show flow of current in AC & DC and differentiate systems.

**Session 6: Components in a PV System (420 min)**

- **Major Components in AC & DC Systems: (20 min)**

PV Panels, Module Mounting Structure, Charger Controlling Unit, Batteries, Power Conditioning Unit, Cables

**Theory:**

Presentation: Show Flow Chart with purpose of each unit.

- **PV Panels: (170 min)**

- Parts of a solar panel, Types of panels, Efficiency, Market Scenario, MNRE standards, Panel ratings, Fill Factor, Factors affecting Panels: Temperature effects, Shadow effects, STC & NOTC, Air Mass, Dust in Panels, Derating of panels, Placing of solar panels, mismatch, MPPT Characteristics.
- Hands on Exercise in the rooftop or open ground with different types of the panels, Evaluation of the results of the practical exercise.

Presentation with Demonstration: Parts of panel with a panel

**Theory:**

Presentation on Parts of Panel with **Demonstration of a panel**, Types of panels: Explanation, Efficiency & Rate, Market Scenarios.

### **Practical:**

**Experiment 1:** Placing of panel, tilt, Insolation in one demonstration kit.

**Experiment 2:** Shadow effect hiding parts of the panel, dust effect.

**Experiment 3:** Connect two panels in series, same in parallel to get V & I readings.

**Experiment 4:** Plotting of IV Characteristics with a rheostat in combination with the panel

**Experiment 5:** Demonstration of the working of blocking & Bypass diode

**Experiment 6:** Different types of panels: Take readings with amorphous, Mono crystalline, Poly crystalline, CdTe & Compare the voltage, current, size & power in each of them.

### **Equipment needed:**

1. One panel with special set up having a light source that can be moved with different angles & Structure with different tilts
2. Two 50 W Polycrystalline panel (Not a part of the main Solar PV system)
3. Demonstration Poly Crystalline & Mono Crystalline Each 36 Cell & 72 Cell.
4. Rheostat (Rating 5 A for 50 W panel)
5. Types of panels: Monocrystalline, Amorphous, CdTe??

- **Batteries: (60 min)**

- Types of Batteries: Lead Acid - Flooded & SMF, Li Ion, etc., Lifetime, DOD, SOC, Weight, Power Density, Specific Gravity
- Demonstration and experiments to find parameters of various batteries.

### **Theory:**

**Presentation:** Types of Batteries: Lead Acid - Flooded & SMF, Li Ion, etc., Lifetime, DOD, SOC, Weight, Power Density, Specific Gravity

**Practical: Demonstration:** Various Types of batteries: Lead acid: Flooded, SMF Battery, Li Ion Battery with Battery Box & Battery Rack

**Equipment needed:** Lead Acid Flooded Battery, SMF Battery, and Lithium Ion Battery- 2 V, 6V, 12 V with Battery Rack & Battery box

**Experiment 7:** Measuring Specific Gravity with hydrometer, to find voltage of the batteries; to estimate SOC. (Not a part of the main Solar PV system)

**Equipment Needed:** Hydrometer

- **Charge Control Unit: (60 min)**

- Operation of a Charge Controller; PWM, MPPT; Market Scenario.
- Demonstration of various Charge Controllers and experiment on finding the parameters of charge controller.
- DC - DC Converters: Purpose of DC -DC converters, Market scenario.
- Demonstration of DC-DC converter.

**Theory:**

**Presentation:** Operation of Charge controller; PWM MPPT, DC- DC Converter, Available in Market & Prices, 3 Stage & 2 stage Charging, Constant current & Constant Voltage

**Practical: Demonstration:** Normal Charge controller, MPPT & PWM Charge controllers

**Equipment needed:** Different types of Charge controllers: Normal, MPPT & PWM (Not a part of the main Solar PV system)

**Experiment 8:** Finding Power-On Voltage, Load Disconnect Voltage, Load Reconnect Voltage, Battery Charging Profile, Self Consumption of a charge controller.

**Equipment needed:** Need Data Logger, Variable supply, Variable Load.

**Demonstration:** Demonstration of a DC-DC Converter: Input & Output voltage, Efficiency.

**Equipment needed:** DC- DC Converter

- **Module Mounting Structure: (30 min)**

- Roof top Structures & Ground Mount Structures, Materials used in the Structures, Good & Bad Installations of Structures, Importance of a Good structure, Module Mounting Structures available in the market. (Different Types of Coating used to cater with harsh conditions).
- Tracking: Types of Tracking: Seasonal, One axis, Two axis tracking. Cost variation and Energy production<sup>2</sup>
- Demonstration of various Module Mounting Structures.

**Theory:** Presentation: Roof top Structures & Ground Mount Structures, Materials used in the Structures, Good & Bad Installations of Structures, Importance of a Good structure, Module Mounting Structures available in the market. (Different Types of Coating used to cater with harsh conditions)

**Video on Types of Tracking:** Seasonal, One axis, Two axis tracking.

**Practical: Demonstration:** Roof Top Structure, Aluminium- Cement Structures, Galvanised Iron Structures.

**Equipment needed:** Roof Top Structure, Aluminium- Cement Structures, Galvanised Iron Structures (not a part of the main PV system).

- **Cables: (30 min)**

- IEC Standards for wiring, parameters causing losses in Cables, Cable prices, Demonstration of Cables, Consideration of DC & AC Cabling.
- Demonstration of various cables used in installation.

**Theory:** Presentation: IEC Standards for wiring, parameters causing losses in Cables, Cable prices, Demonstration of Cables, Consideration of DC & AC Cabling.

**Practical: Demonstration:** Various sizes of DC & AC Cables available for solar.  
**Equipment needed:** Various sizes of DC & AC Cables available for solar: 2.5 sq. mm, 4 sq. mm, 10 sq. mm, 16 sq. mm Copper wires & Aluminium Wires , Single & Multi Strand (Not a part of the main PV system)

- **Power Conditioning Unit: (30 min)**

- Inverters: Micro Inverters, String inverters & Central Inverters. Ranges of Inverters, Ingress Protection.
- Hybrid Inverters, Grid Tie inverters, etc.
- Demonstration and exercise on finding the parameters of the inverter.
- Demonstration of various inverters and finding the parameters of the inverters.

**Theory:**

**Presentation:** Types of Inverters: Micro Inverters, String inverters & Central Inverters; Ranges of Inverters; Ingress Protection; Hybrid Inverters, Grid Tie inverters, etc. Based on Logic: Priority, Online inverters, Based on phases: 1 phase, 3 phase, PWM & MPPT, Sine wave & Square Wave, Concept of wide window & narrow window, Specification sheet of an inverter (Efficiency, Overload, Logic, rating)

**Practical:**

**Demonstration:** Various types of inverters

**Equipment Needed:** PCUs.

**Experiment 9:** Find parameters in a PCU: DC- AC conversion Efficiency, No load power consumption, Voltage range, Grid Charging Efficiency, charger Efficiency, Maximum loading capacity, Power Quality, Inverter Logic, Islanding, Frequency Measurement, Ingress protection, MPPT, Synchronisation & operation.

**Equipment Needed:** PCU (Not a part of the main solar PV system), Variable AC Supply, Digital Oscilloscope.

- **Array Combiner Box: (20 min)**

- Parts of an Array Combiner Box, Protection Devices.
- Types of MCBs
- Demonstration of MCBs and specifications.

**Theory:**

**Presentation:** Parts of an Array Combiner Box, Protection Devices, Types of MCBs **Practical:**

**Demonstration:** Array Combiner Box, Various types of MCBs; finding the parts of the Array Combiner Box.

**Equipment Needed:** Array Combiner Box, Various types of MCBs (Not a part of the main solar PV system)

- **Consumables (5 min)**

**Practical:**

**Experiment 10:** Connecting cables using connectors.

**Equipment Needed:** Different types of connectors: MC 4, Block connector, (Not a part of the main solar PV system)

**Session 7: Site Analysis & Load Analysis (300 min)**

- **Load Analysis: (120 min)**

Measuring Loads using Multimeter, Power Guard Meter, Clamp meter, Energy Meter

**Experiment 11:** Measuring Current, Voltage, Power, Power Factor of Various loads: LEDs, Tubelights, Fans, and other appliances available. Estimating Load Consumptions

**Equipment Needed:** Lights, Fans, Solar refrigerator, other possible usual loads; Multimeter, Power Guard Meter, Clamp Meter, Energy meter.

- **Site Survey: (120 min)**

Process of site survey, Space Requirements, Energy Consumption, Enquiring in a site and filling up a Site Survey Form

**Group Activity:** Enquiring the customer and filling up the site survey form; Finding the energy consumption; Understanding space availability and layout.

- **Types of Loads: (60 min)**

Types, Efficiency of Loads, (Table of loads with equivalent efficient load), Loads AC & DC, Suitable for Solar PV Thermal

**Theory:** Presentation: Types, Efficiency of Loads, (Table of loads with equivalent efficient load), Loads AC & DC, And Suitable for Solar PV Thermal.

**Assignment 2:** Observe a home and check for energy efficiency of the loads.

**Session 8: Solar PV System Designing: (480 min)**

- **Solar PV System Designing for an Off- Grid System: (240 min)**

Sizing of the panels, Array Configurations, Battery Sizing, Parallel & Series Connections, Charge Controller & Inverter sizing, Array Junction Box, Wiring, IEC Standards for wiring, Bill of Materials for an Off- Grid System.

- **Solar PV System Designing for an On Grid System: (240 min)**

Panel Array Configurations, Inverter selection for a Hybrid or a Grid Interactive System, Net meter, Guidelines form DISCOM, Bill of Materials for an On - Grid System, Pay Back Calculation.

**Theory:** Problem Solving: with Different requirements and **Assignment 3.**

**Session 9: Solar for a Home Lighting System: (360 min)**

- **Installation of an Off- Grid System: (180 min)**

- Understanding of Layout Diagrams.
- Practical Installation of a Roof Top PV Panel with Structures.
- Batteries and Inverter Connections, Laying Cables, Wiring in a house.

## Practical:

**Experiment 12:** Installation of the PV system: Connecting string to combiner box, Connection to Charge controller, Battery, Inverter with grid input. (Equipment same used in the previous experiments)

Testing array Power, and testing the proper connections. (Show in the main PV system)

**Experiment 13:** Installation of the structures: Measuring Distance for Structures, Drilling holes in Structure, Fixing Structures with the ground / Rooftop, Fixing the panels in Structure. (Separate & away from the main PV system; Equipment used in the previous systems)

**Experiment 14:** Laying Cables in open space: Cutting, Laying and fixing pipes on the ground for cables, Crimping, Using Connectors, Connecting cables to the modules, Connecting to the Array Combiner Box, testing continuity in cables. (Separate & away from the main PV system; Equipment used in the previous systems)

**Experiment 15:** Laying Cables underground: Practice on underground cabling, Trenching, Understanding Cable Layout, Cable trays.

**Experiment 16:** Understanding House wiring circuit: Switches, Sockets, Plugs, House wiring accessories, Tube light circuit, finding faults.

**Equipment Needed:** tools for civil work, marking tools, measuring tools, Switches, Sockets, & other house wiring accessories.

- **Earthing: Why earthing? Types of earthing, Earthing kit available**

**Experiment 17:** Installation of Earthing kit, Testing the earthing.

**Equipment Needed:** Earthing kit (Not a part of the main system)

- **IEC Standards:** IEC standards for Solar PV Panels, Combiner Box, Cables, Charge controllers, Earthing, Lightning Protection, & Inverters.
- **Trouble shooting of the Home Lighting PV System: (180 min)**
  - Trouble Shooting of PV Modules: Checking the quality of the panels, Trouble Shooting the problems in panels.
  - Trouble shooting of Batteries: Checking quality of a battery, Using Hydrometer, Measuring Voltage, Refilling of Water, etc.
  - Dismantling and Re arrangement of an Array Junction Box, Replacing Fuses.



- Trouble Shooting Inverters and Charge controllers

**Experiment 18:** Servicing the battery

**Experiment 19:** Replacing Fuses in an Array Combiner Box

**Session 10: Street Lighting Systems: (60 min)**

- **Theory:** Mounting Poles, Structures for street Lighting, Placing of the Batteries & Inverters.
- Practical Installation of a Street Lighting System.

**Activity:** Site survey for a solar street lighting system.

**Practical 20:** Installation of a street lighting system: Erecting the poles, connecting the poles and lights, setting up batteries and Charge Controller.

**Equipment Needed:** Poles and lights.

**Session 11: Solar Water Pumps: (300 min)**

- **Theory:** Solar Water Pumps: Well Characteristics, Storage Tank, Hydraulic Circuit, Hydraulic Circuit, Pipe Length, Water Need & Solar PV Designing, Site Survey for Solar Pump, Retrofitting & problems.
- **Practical** Installation of a Solar Water Pump

**Activity:** Site survey for a Solar Water Pump.

**Practical 21:** Practical Installation of a Solar Water Pump. Explanation of bore, Drive, types of pumps, Solar PV Installation for pumps.

**Equipment Needed:** One Pump set up, Solar PV installation for a pump.

**Session 12: Solar Thermal Water Heating Systems: (300 min)**

- **Theory:** Types of solar thermal Concentrators
- Evacuated Tube collectors: Parts of the Solar Thermal System: Storage Tank, thermal collectors, Control Valve, Heat protection.
- Flat Tube Collectors.
- **Practical** Installation of a Solar Thermal Evacuated tube Collector System & a Flat Plate collector.

**Experiment 22:** Practical Installation of a Solar Thermal Evacuated Tube collector System & a Flat Tube Collector system.

**Equipment Needed:** One Evacuated Tube Collector System, One Flat Tube Collector System.

**Session 13: Solar for Motorised applications: (60 min)**

- Sewing Machines, Roti Making machines, Power Looms, Flour mill, Carpenter tools, etc.
- SELCO Examples: Microenterprise Special Projects
- Understanding of different unusual loads.

**Experiment 23:** Measuring Surge current in motors, measuring RPM with tachometer, using Torquemeter.

**Equipment Needed:** Sewing Machines, Roti Making machines, Power Looms, Flour mill, Carpenter tools, Tachometer, Torquemeter.

**Session 14: Other Applications (60 min)**

- Solar cookers

**Experiment 24:** Demonstration of a Solar Box Cooker.

**Equipment Needed:** Solar Box Cooker

- Solar dryers

**Experiment 25:** Demonstration of a Solar Dryer

**Equipment Needed:** Solar Dryer

- Other applications

**Session 15: Introduction to Installation for a Grid Interactive System. (360 min)**

(Hands on with a bigger KW system)

- Planning for an installation
- Site Survey for a grid interactive System.
- Procedure (Application to the DISCOM) & Timeline for installation.
- Understanding of the Single line Diagram
- Tools required for installation

**Activity:** Site survey for a grid interactive system.

**Session 16: Safety (60 min)**

- Safety aspects during installation

- Possible issues with installations.
- Demonstration of safety tools.

**Theory:** Presentation/videos: Case study

**Practical Demonstration:** Safety Tools

**Equipment Needed:** Safety Wears & Tools

### **Session 17: Practical Installation of a Grid Interactive System (1020 min)**

- **Mounting Modules:**  
Laying the Module Mounting Structure, Mechanical Strength of an MMS, Mounting the panels.
- **Laying Cables:**  
Laying Cables between modules, between modules and inverter, Laying Cables in Pipes, Laying Cables Underground, Trenching for cables
- Panel Array Testing
- **Earthing:** Types of Earthing, Earthing Testing.
- Technical Standards of the inverter for a grid interactive system. Installation of the inverter
- Inverters for hybrid systems.
- AC and DC power distribution boxes, LT /HT Panel Transformers and other electric components.
- Testing for islanding protection.
- Testing of DC and AC side and commissioning, Installation of a net meter (**can be shown in a video of real time implementation**).
- Performance Analysis.

### **Session 18: Operation and Maintenance (180 min)**

- Standards for operation of the PV system.
- **Manual for maintenance** of PV power plant. Maintaining Panels, Batteries, Inverters, etc.,
- Maintaining report of the system condition

### **Session 19: Trouble Shooting: (180 min)**

- **Procedures for trouble shooting** and repairs during the maintenance.

- Guidelines to handle emergency situations.
- Handling the customer complaints & Servicing; Usual Customer complaints.

**Activity: Case study / Customer Complaint Scenario**

**Session 20: Entrepreneur Skills (240 min)**

- Entrepreneurship
- Occupational safety, Health and Environment Education
- SELCO Examples on Entrepreneurship, Energy & Livelihoods.

**Session 21: Evaluation (360 min)**

**Session 22: Valedictory (180 min)**

**Total: 5195 minutes = 86.5 hours.**