Solar Photovoltaic (PV) System Design, Simulation and Engineering

Target Audience

This course is designed for electrical engineers, renewable energy professionals, diploma and engineering students, project engineers, EPC professionals, consultants, technicians, entrepreneurs, and individuals seeking a career in the solar photovoltaic (PV) industry. It is suitable for beginners with basic electrical knowledge as well as professionals looking to enhance their expertise in designing, sizing, installing, and analyzing residential, commercial, and industrial solar PV systems using industry-standard software and engineering practices.

Course Outcomes

Upon successful completion of this course, participants will be able to:

- Understand the fundamentals of solar energy and photovoltaic technology.
- Identify different types of PV modules, batteries, inverters, and charge controllers.
- Analyze solar resource data and determine optimal installation parameters.
- Design complete off-grid, on-grid, and hybrid solar PV systems.
- Size PV arrays, batteries, inverters, and charge controllers accurately.
- Select appropriate protection devices and grounding systems.
- Create professional Single Line Diagrams (SLDs) for PV installations.
- Develop solar layouts using AutoCAD.
- Perform detailed PV simulations using PVSyst software.
- Evaluate system performance, energy yield, and losses.
- Troubleshoot common PV system design and installation issues.
- Prepare industry-ready solar PV designs following engineering standards.

Course Objectives

By the end of this course, learners will:

- Build a strong foundation in solar photovoltaic technology and system components.
- Learn the complete workflow for designing residential and commercial PV systems.

- Gain practical knowledge of industry-standard software tools including AutoCAD and PVSyst.
- Develop competency in sizing and selecting all major PV system components.
- Understand electrical protection, grounding, and safety requirements.
- Perform real-world PV design calculations through practical examples.
- Interpret manufacturer datasheets and technical specifications.
- Generate professional engineering drawings and system documentation.
- Simulate and optimize PV system performance.
- Prepare participants for careers in solar PV design, installation, and consultancy.

Course Outline

The course comprises **40 hours** of theory and hands-on labs and is divided into 17 different modules. Each module will be followed by practical exercises and design activities to reinforce learning and evaluate the participant's understanding of the concepts covered.

Table of Contents

- Busbars and Cell Interconnections
- Electrical Characteristics of PV Modules
- I-V and P-V Curves
- Series and Parallel Connections
- Effects of Irradiance and Temperature
- Partial Shading Effects
- Reading PV Module Datasheets
- Solar Cables and Connectors

Module 3: Solar Panel Installation

- Mounting Structures
- Fixed and Tracking Systems
- Tilt Angle Calculation
- Azimuth Angle Selection
- Sun Path Analysis
- Row Spacing Calculations
- Global Solar Atlas
- Site Assessment
- Installation Best Practices

Module 4: Types of Solar PV Systems

- Off-Grid Systems
- On-Grid Systems
- Hybrid Systems
- Grid-Tied with Battery Backup
- Comparison of PV System Configurations
- Applications of Different System Types

Module 5: Batteries in Solar Energy Systems

- Battery Fundamentals
- Battery Voltage Selection
- Battery Capacity Calculations
- Battery C-Rate
- State of Charge (SOC)
- Depth of Discharge (DOD)
- Cycle Life
- Calendar Life
- Self-Discharge
- Lead-Acid Batteries
- Lithium-Ion Batteries
- Nickel-Based Batteries
- Flow Batteries
- Battery Connections
- Battery Charging Methods
- Reading Battery Datasheets

Module 6: Solar Charge Controllers

- Introduction to Charge Controllers
- PWM Charge Controllers
- MPPT Charge Controllers
- Controller Working Principles
- Controller Sizing
- Selection Criteria
- Installation Considerations

Module 7: Solar Inverters

- Introduction to Solar Inverters
- Types of Inverters

- Grid-Tied Inverters
- Off-Grid Inverters
- Hybrid Inverters
- Inverter Specifications
- Reading Inverter Datasheets
- Inverter Selection Criteria

Module 8: Off-Grid PV System Design

- Load Assessment
- Daily Energy Consumption Calculation
- Battery Bank Sizing
- PV Array Sizing
- Charge Controller Selection
- Inverter Selection
- Cable Selection
- Design Example – Residential System
- Design Example – Commercial System

Module 9: PV System Protection

- Electrical Protection Requirements
- Overcurrent Protection
- DC and AC Isolators
- String Protection
- Fuse Selection
- Circuit Breakers
- Surge Protection Devices (SPD)
- PV Combiner Boxes
- Cable Sizing
- Protection Design Examples

Module 10: PVSyst Software for Off-Grid Systems

- Introduction to PVSyst
- Software Interface
- Creating a New Project
- Meteorological Data
- Component Selection
- Off-Grid Simulation
- Result Interpretation
- 3D Shading Analysis
- Performance Reports

Module 11: Hybrid PV System Design

- Hybrid System Architecture
- Load Management
- Battery Integration
- PV Array Design
- Component Selection
- Hybrid Design Example
- Performance Analysis

Module 12: On-Grid PV System Design

- Grid-Tied System Fundamentals
- Energy Yield Estimation
- PV Array Design
- Inverter Selection
- Grid Connection Requirements
- Net Metering Concepts
- System Performance Evaluation

Module 13: Solar Water Pumping Systems

- Introduction to Solar Water Pumps
- Types of Solar Pumps
- Pump Selection
- Water Demand Calculation
- PV Sizing for Pumps
- System Design Example
- Installation Considerations

Module 14: Grounding and Earthing

- Importance of Earthing
- Equipment Grounding
- System Grounding
- Lightning Protection
- Earthing Design
- Safety Standards
- Best Practices

Module 15: Single Line Diagram (SLD)

- Introduction to SLD
- Electrical Symbols
- PV System Representation
- AC and DC Circuits
- Protection Devices in SLD
- Preparing Professional SLDs
- Documentation Standards

Module 16: AutoCAD for Solar PV Design

- AutoCAD Interface
- Basic Drawing Tools
- PV Layout Preparation
- Roof Layout Design
- Electrical Layout Drawing
- Single Line Diagram Drafting
- Plotting and Exporting Drawings

Module 17: PVSyst for On-Grid Systems

- Creating Grid-Connected Projects
- Weather Data Import
- PV Array Configuration
- Inverter Configuration
- System Simulation
- Energy Yield Analysis
- Loss Analysis
- Financial Evaluation
- Report Generation
- Performance Optimization