

Solar PV Fundamentals and System Components

Target Audience

This course is designed for electrical engineers, diploma and engineering students, technicians, renewable energy professionals, project engineers, EPC professionals, consultants, entrepreneurs, and individuals seeking foundational knowledge of solar photovoltaic (PV) technology. It is particularly suitable for participants who want to understand solar energy fundamentals, PV system components, system configurations, solar panel characteristics, basic installation principles, and the functional role of batteries, charge controllers, and inverters in practical solar PV applications.

Course Outcomes

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

- Understand the fundamentals of solar energy and photovoltaic technology.
- Identify major components used in solar PV systems.
- Differentiate between various types of solar cells and PV modules.
- Analyze basic electrical characteristics of PV modules.
- Interpret I-V and P-V characteristics of solar panels.
- Evaluate the effects of irradiance, temperature, and partial shading on PV performance.
- Analyze different solar PV system configurations and their applications.
- Identify suitable batteries, charge controllers, and inverters for different PV applications.
- Understand basic solar panel installation parameters including tilt, azimuth, and row spacing.
- Interpret PV module, battery, charge controller, and inverter datasheets.

Course Objectives

By the end of this course, learners will:

- Establish a strong technical foundation in solar photovoltaic technology.
- Understand the construction and operating principles of PV cells and modules.
- Develop familiarity with major solar PV system components and their functions.
- Learn to interpret electrical specifications and manufacturer datasheets.
- Understand the operating characteristics and limitations of PV modules.

- Gain practical knowledge of off-grid, on-grid, and hybrid PV configurations.
- Develop foundational understanding of solar panel site assessment and installation parameters.
- Build awareness of battery technologies and energy storage fundamentals.
- Understand the operating principles and selection considerations of charge controllers and solar inverters.
- Apply foundational PV knowledge to practical solar energy applications.

Course Outline

The course comprises **16-hours** of theory and labs and is divided into 4 different chapters. Each chapter will be followed by hands-on lab exercises to reinforce learning and gauge understanding of the topics covered.

Table of Contents

Chapter 1: Solar Energy and Photovoltaic Technology

- Overview of Renewable Energy
- Introduction to Solar Energy
- History and Growth of Photovoltaic Technology
- Applications of Solar PV Systems
- Advantages and Limitations of Solar Energy
- Solar Energy Terminology
- Components of a Solar PV System
- Fundamental Solar PV System Architecture

Chapter 2: Solar Panels and PV Module Technology

- Solar Cell Construction
- Types of Solar Cells
- PV Module Construction
- Half-Cut Cell Technology
- 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

Chapter 3: Solar PV System Configurations and Installation

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

Chapter 4: Solar PV Energy Storage, Charge Controllers and Inverters

- 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
- Introduction to Charge Controllers
- PWM Charge Controllers
- MPPT Charge Controllers
- Controller Working Principles
- Controller Sizing
- Selection Criteria
- Installation Considerations
- Introduction to Solar Inverters
- Types of Inverters
- Grid-Tied Inverters
- Off-Grid Inverters
- Hybrid Inverters
- Inverter Specifications
- Reading Inverter Datasheets
- Inverter Selection Criteria