



5 Day PV System Theory-Sizing-Installation Workshop

This **5 Day PV Systems Theory, Sizing, and Installation Workshop** is the most comprehensive workshop in the market. It is designed to provide detailed renewable energy systems theory with detailed calculations and hands-on practical. Focus is photovoltaic (PV) (80% plus of the course) with Solar Thermal, PV Thermal, Energy Conservation, Geothermal and Wind systems essentials.

Course binder, refreshment and lunch included in the course fee.

Audience

- Anyone - No pre-requisite or background

5 Day Outline

Day 1: 9:00 AM – 4:00 PM

LECTURE 1.1: Electrical and Renewable Energy Systems Overview

- Electrical power generation, transmission, distribution, and utilization
- Renewable power generation, transmission, distribution, and utilization
- Grid tied, off grid, and hybrid PV systems
- FIT, Net-Metering, and Off grid PV systems
- Renewable energy applications, market, and future

LECTURE 1.2: Electrical Theory

- Current, voltage, resistance, ohms law and period/frequency
- Circuits: short, open, and typical circuit
- Series, parallel, and series-parallel configurations
- Power, energy, generation, consumption, metering, generation vs consumption
- AC vs DC, AC vs DC generation, and AC vs DC consumption
- Active, reactive, apparent powers, and power factor
- Energy conversion, distribution, losses, efficiency
- Single vs three phase systems, grid, PV, and inter-connection

LAB 1.1: Key Components

- Hands-on: PV module, charger, battery, combiner, inverter
- Hands-on: Cable types and sizes, fuse, breaker, disconnect
- Hands-on: Tools and Meters

LAB 1.2: PV Modules

- Hands-on: Series, parallel, series-parallel connections/measurements/comparison/applications



LECTURE 1.3: PV Theory

- Earth, sun, sun path (summer, winter, yearly)
- Irradiance, irradiation, direct, diffuse, albedo, and PSH
- Sun path chart and optimum operation window
- Shade, far, near, inter-row, and optimization
- Adjustable, single axis, dual axis systems
- Continuous, algorithmic and MLD tracking algorithms plus backtracking
- PV, ST, PVT orientation (tilt/azimuth), magnetic declination, and optimization
- Production, load matching, energy shift and optimization

LECTURE 1.4: Codes and Process

- Electrical: (NEC, CEC)
- Administrative: Ministry of Energy and Independent Electricity System Operator (IESO)
- Electrical AHJ: Local Distribution Company (LDC) and Electrical Safety Authority (ESA)
- Non-Electrical AHJ: Building Department (BD), Municipality, Fire, Provincial, and Environmental
- Pre-screening, application, connection impact assessment (CIA), ESA plan review (IFR)
- Issue for construction (IFC), Construction/Installation, Inspection/Commissioning

DAY 2: 9:00 AM – 4:00 PM

LECTURE 2.1: Safety

- Electrical, falling, and tripping Safety, tools safety
- Personal Protective Equipment (PPE)
- Signs, Signals, Tags, Barricades, Lock Out, Tag Out
- First Aid & CPR Overview

LECTURE 2.2: PV Modules

- PV cells, module, diodes
- PV module types, efficiency, ratings
- Standards and label/datasheet
- PV module IV curve, parameters, MPP/MPPT
- Light, temperature, and PV module
- String, array, sizing, and optimization
- Applicable code and requirements

LAB 2.1: PV Modules

- Calculations: Temperature based system
- Calculations: Irradiance based system calculations
- Hands-on: Series, parallel, series-parallel issues, effects, resolution, and optimization
- Hands-on: Near and Inter-row shade effects and optimization
- Hands-on: Tilt/Azimuth effects and optimization, seasonal adjustment

LAB 2.2: System Sizing

- Calculations: string and array sizing



- Calculations: system sizing (PVW)

LECTURE 2.3: Battery

- Battery and battery types
- Capacity, charge, discharge, Ah, C/#
- Battery SOC, DOD, cycles, life, battery charging (3 stage)
- Sulfation and equalization
- Battery selection and connections/configurations
- Applicable code and requirements

LECTURE 2.4: Charger

- Charger, functions, features, type
- 3 stage charging (bulk, Absorption, float)
- Ratings, label/datasheet & sizing and selection

LAB 2.3: Off Grid DC PV System

- Calculations: Battery sizing
- Calculations: Charger sizing calculations
- Hands-on: Simplest/Cheapest off grid DC PV system
- Hands-on: Typical off grid DC PV system

DAY 3: 9:00 AM – 4:00 PM

LECTURE 3.1: Energy Conservation

- Energy loss, systems inefficiency, and conservation
- IESO and LDC incentives
- Site assessment, energy audit, and application example
- Facility load distribution/types and light retrofitting
- Present and future trends

LECTURE 3.2: Inverter

- DC-AC conversion and operation, single and three phase
- Types: central, string, and micro
- Types: square, modified and sine
- Types: off grid, grid tied, and hybrid
- Ratings, labels/datasheet, and selections
- Anti-islanding, control, monitoring and communications

LAB 3.1: Off Grid AC System

- Calculations: Inverter and string sizing calculations
- Hands-on: Off grid AC PV system

LECTURE 3.3: System Sizing

- Typical grid tied system sizing
- Load analysis, estimation, and optimization



- Self regulating system sizing
- Typical off grid system sizing
- Typical hybrid system sizing (Net-Metering)
- Typical hybrid system sizing with weak grid (service reliability)
- Identifying and selecting components, code, safety, autonomy, critical load, critical time

LAB 3.2: Hybrid System

- Hands-on: Off grid AC-DC system

DAY 4: 9:00 AM – 4:00 PM

LECTURE 4.1: Site Survey

- Site survey/assessment and hazard assessments, Safety and local codes
- Components installation locations identification, Orientation (tilt/azimuth), shading
- Survey Tools (inclination meter, compass, path finder, camera, tape, software)
- Documentation, energy modelling, and financial assessment

LECTURE 4.2: Structural, Civil Analysis and Mechanical Integration

- Site assessment (geo survey and structural analysis)
- Static, dynamic, snow and wind load and PSF
- Location specific mounting/racking systems, support, and attachments
- Flashing, sealing, and weatherproofing

LAB 4.1: Shade and Load Analysis

- Calculations: Snow and wind load
- Hands-on: Solar path finder

LECTURE 4.3: Electrical Integration

- DC voltage, temperature, and AC voltage requirements
- Cables, AWG, and voltage drop
- Fuse/Breakers, cables, sizing, and calculations
- Grounding, bonding, AFCI, and light arrestor
- Disconnect, combiner, and transformer
- Voltage, current, power quality standards, CSA-UL-CUL, LDC-ESA, safety, and condition of use

LAB 4.2: Installation

- Calculations: Fuse/Breakers and Cables
- Hands-on: Ground mount installation
- Hands-on: Mock shingle roof installation
- Hands-on: Mock flat roof installation

DAY 5: 9:00 AM – 4:00 PM

LECTURE 5.1: Inspection, Commissioning and Monitoring

- Punch-list, inspection/check for safety and code compliance



- System isolation/integration, testing, and commissioning & Monitoring

LECTURE 5.2: Thermal Systems

- Solar Thermal (ST) systems and applications
- PV Thermal (PVT) systems and applications
- Geothermal (GT) systems and applications

LAB 5.1: ST and PVT

- Calculations: ST system & GT system
- Hands-on: ST and/or PVT

LECTURE 5.3: Wind Energy

- Wind energy (WE), wind turbine, generator, converters
- Control (PWM, SVPWM, MPC)
- WE type and applications

LAB 5.2: WE and PV

- Calculations: Off grid WE system & Off grid Complimentary PV and WE system
- Hands-on: Off grid WE system
- Hands-on: Off grid Complimentary PV and WE system

Workshop Closure

- Feedback forms collection (Anonymous)
- 1 – 2 Hour(s) Exam
- Certificates Awarding Ceremony

Workshop Instructor

Dr. Irtaza Syed, PhD, P. Eng., PMP, PVIP, CEA has modeled, simulated, designed, procured, managed, installed, tested and commissioned 100's of Megawatts of renewable energy systems in Canada, USA & Pakistan. Systems include Off-grid, On-grid and Hybrid residential, commercial, institutional and utility scale, ranging from few kW to few MW in size.

Dr. Syed has hand-on experience of the US National Electric, Canadian Electric and Pakistan Electric and Telecommunications Safety Codes. He is teaching these PV courses since 2011 and is very aware of the FIT/Net-Metering rules (Canada / USA / Pak) beside UL/CSA/IEEE/IET standards, LDC/DISCOs and Electrical Safety/Inspection Authorities requirements.

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