CONCEPT

Renewable Energy Systems: Solar PV, Wind and Grid Integration

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Introduction:

Utility-scale renewable energy systems lose value when solar and wind yields are overestimated, storage is sized by rule of thumb and grid connection requirements surface late in development. This Core Concept course takes engineers and developers from solar and wind resource data through PV plant design, turbine selection and wind farm layout in week one, then adds battery storage, grid integration, project development, construction and O&M, with a green hydrogen overview, in week two. Participants build a Renewable Energy Project Feasibility Study for a site of their own.

Course Objectives:

- Assess solar and wind resource data and convert it into long-term energy yield estimates with P50 and P90 exceedance values
- Design a utility-scale PV plant layout, selecting mounting, inverter architecture and DC/AC ratio against a quantified loss budget
- Plan a wind farm layout that balances turbine spacing, wake losses and site constraints for a selected turbine model
- Size battery energy storage for time shifting, peak shaving and curtailment reduction and compare it with other storage options
- Specify grid connection, forecasting and ancillary service capabilities a renewable plant needs to meet the grid code at its connection point
- Evaluate project viability through site screening, permitting, PPA structure, LCOE sensitivity and an O&M and monitoring plan

Target Audience:

- Engineers who design and model solar PV, wind and storage plants for utility-scale projects
- Project developers who screen sites, secure permits and land and prepare projects for investment decisions
- Utility and grid planners who assess connection requests and integrate variable generation into system operation
- Asset managers who run operating renewable plants and track availability, yield and maintenance cost
- Owner's engineers and consultants who review designs, energy yield reports and EPC contractor submissions

Course Outline:

Day 1: Energy Transition Context and Renewable Technology Landscape

- Energy Transition Drivers: Technology Cost Curves, Decarbonisation Targets and Demand Growth
- Electricity System Basics: Load Curves, Merit Order and Economic Dispatch
- Renewable Technology Portfolio Comparison: PV, CSP, Onshore and Offshore Wind
- Capacity Factor, Specific Yield and Firm Capacity Metrics
- Utility-Scale Project Lifecycle Map from Screening to Decommissioning

Day 2: Solar Resource Assessment and Photovoltaic Technology

- Solar Irradiance Components: GHI, DNI and DHI Datasets
- Typical Meteorological Year Files and Satellite versus Ground Measurement Data
- PV Cell and Module Technologies: Monocrystalline, Bifacial and Thin-Film
- Module Datasheet Parameters: Temperature Coefficient, Degradation Rate and Warranty Curve
- Concentrated Solar Power with Parabolic Trough, Tower and Molten Salt Storage

Day 3: PV Plant Design and Energy Yield Estimation

- Mounting Selection: Fixed Tilt, Single-Axis and Dual-Axis Trackers
- Row Spacing, Ground Coverage Ratio and Land Use per Megawatt
- Central versus String Inverter Architecture and DC/AC Ratio Sizing
- PV Loss Diagram: Soiling, Shading, Temperature, Mismatch and Cabling Losses
- Energy Yield Simulation with Performance Ratio and P50/P90 Exceedance Values

Day 4: Wind Resource Measurement and Turbine Technology

- Met Mast and Remote Sensing Wind Measurement Campaign Design
- Long-Term Correction with the Measure-Correlate-Predict Method
- Weibull Distribution, Wind Shear and Turbulence Intensity Analysis
- Turbine Components: Rotor, Drivetrain, Pitch and Yaw Systems
- Power Curve Interpretation and Turbine Class Selection for Site Conditions

Day 5: Week-One Integration: Wind Farm Layout and Yield Case

- Wind Farm Micro-Siting: Rotor Diameter Spacing, Setbacks and Access Roads
- Wake and Blockage Loss Modelling for Turbine Array Layouts
- Onshore versus Offshore Capacity Factor and Roughness Comparison
- Case Study: PV Plant Layout and Yield Review for an Arid Site
- Case Study: Wind Farm Gross-to-Net Energy Yield and Uncertainty Budget

Day 6: Battery Energy Storage Systems and Green Hydrogen Overview

- Lithium-Ion Chemistry Options: LFP versus NMC for Stationary Storage
- BESS Sizing: Power Rating, Energy Capacity, Depth of Discharge and Round-Trip Efficiency
- Storage Use Cases: Time Shifting, Peak Shaving and Curtailment Reduction
- Pumped Hydro and Thermal Storage Comparison Matrix
- Green Hydrogen Overview: Electrolyser Types and Renewable Power Supply Profiles

Day 7: Grid Integration: Variability, Forecasting, Grid Codes and Ancillary Services

- Variability and Predictability Analysis with Ramp Rate Statistics
- Solar and Wind Power Forecasting for Day-Ahead and Intraday Horizons
- Grid Code Requirements: Fault Ride-Through, Reactive Power and Frequency Response
- Ancillary Services: Operating Reserves, Frequency Regulation and Voltage Support
- Grid Connection Study Scope: Load Flow, Short Circuit and Available Transfer Capability

Day 8: Project Development: Site Selection, Permitting, PPAs and LCOE

- Site Selection Screening Matrix: Resource, Land, Grid Distance and Constraints
- Permitting Pathway: Environmental and Social Impact Assessment and Land Rights
- Power Purchase Agreement Structures: Pay-as-Produced, Baseload and Curtailment Clauses
- LCOE Sensitivity Model on Capacity Factor, Capex and Discount Rate
- Stakeholder Engagement Plan for Landowners, Communities and Grid Operators

Day 9: Construction, Commissioning, O&M and Performance Monitoring

- EPC Interface Matrix and Construction Quality Checkpoints
- Commissioning Tests and Performance Acceptance Criteria
- O&M Strategy: Preventive, Corrective and Condition-Based Maintenance Plans
- SCADA Monitoring with Performance Ratio, Availability and Capacity Factor KPIs
- Drone Thermal Imaging and Module Cleaning Schedule Optimisation

Day 10: Capstone: Renewable Energy Project Feasibility Study

- Capstone Build: Resource Assessment and Technology Selection for a Participant Site
- Capstone Build: PV or Wind Layout with Energy Yield and BESS Sizing
- Capstone Build: Grid Connection Requirements and PPA Structure
- Capstone Build: LCOE Estimate, Risk Register and Implementation Schedule
- Feasibility Study Presentation and Technical Panel Review

Skills You Will Gain:

- Solar Resource Assessment
- PV Plant Layout Design
- Wind Resource Analysis
- Wake Loss Modelling
- Battery Storage Sizing
- Renewable Power Forecasting
- Grid Code Compliance Review
- LCOE Sensitivity Analysis

Why Attend This Course:

- Return with a Renewable Energy Project Feasibility Study built for a solar, wind or hybrid site from your own portfolio
- Move from resource, PV and wind design in week one to storage, grid integration, development and O&M in week two
- Challenge energy yield reports and contractor designs with loss budgets, exceedance values and performance KPIs
- Compare project experience with engineers, developers and utility planners working on solar, wind and storage in several markets

Conclusion:

Renewable plants deliver their expected value only when resource, design, grid and commercial decisions are made together. Week one builds solar and wind capability from resource data through PV plant design, turbine technology and wind farm layout, closing with a guided yield case. Week two adds battery storage, a green hydrogen overview, grid integration, project development with PPAs and LCOE, and construction, O&M and monitoring. The final day produces a Renewable Energy Project Feasibility Study ready for technical review.