MERCURY

Substation Engineering for Renewable Grid Integration and Generation Economics

18 – 22 July 2027
Cairo (Egypt)



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Substation Engineering for Renewable Grid Integration and Generation Economics

Ref: 6029_300569 **Date:** 18 – 22 July 2027 **Location:** Cairo (Egypt) **Fees:** 4000 Euro

Substation Engineering for Renewable Grid Integration and Generation Economics is a 1-week professional course on designing utility substation interfaces, managing power factor correction, and modeling operational dispatch costs for hybrid utility assets. It is designed for electrical utility engineers, substation protection specialists, and utility asset planners integrating renewable resources with thermal assets. You will complete and take back the Substation Interconnection and Generation Economics Assessment Plan. The course is delivered by Mercury Training Center.

About This Course

Integrating distributed solar arrays and wind installations with existing thermal utility assets introduces severe voltage stability risks, protection relay challenges, and complex dispatch dispatching economics. To follow this course, you should already understand three-phase alternating-current electrical theory, single-line diagrams, and basic utility dispatch principles. You practice by sizing substation busbars, configuring transformer protection, and computing levelized production expenses.

Who It Is For

- Electrical utility engineers responsible for substation layout, busbar sizing, and high-voltage transformer specification
- Substation protection specialists responsible for relay coordination, anti-islanding schemes, and fault clearance around renewable interconnects
- Utility operations analysts responsible for evaluating heat rates, fuel pricing variations, and dispatch merit-order curves
- Interconnection planning coordinators responsible for grid code compliance, voltage support, and reactive capability verification
- Industrial energy managers responsible for cogeneration interconnection switchgear, district thermal networks, and private distribution networks

This course is not for civil construction personnel seeking switchyard foundation excavation tutorials, who are better served by a substation structural engineering course, nor for retail energy billing analysts needing customer metering overviews, who are better served by an introductory utility tariff course.

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Competencies You Will Build

- Substation Interconnection Topology: you configure high-voltage switchgear arrangements and busbar topologies for renewable feed-in and thermal output
- Transformer Assessment: you determine transformer ratings, impedance values, vector groups, and tap-changer control settings for fluctuating inverter flows
- Reactive Compensation Management: you calculate capacitor bank ratings and dynamic reactive support needs to maintain statutory voltage profiles
- Dispatch Economic Appraisal: you model marginal operating costs, heat rates, and levelized production metrics across diverse supply resources
- Protection Scheme Alignment: you establish differential, overcurrent, and directional relay coordination across distributed utility switchyards
- Emissions and Auxiliary Optimization: you assess environmental compliance limits, auxiliary house loads, and deaerator and condenser thermal penalties

What You Will Be Able to Do

By the end of the course you will be able to:

- From utility interconnection requirements, design an electrical substation single-line diagram incorporating solar photovoltaic, wind, and thermal energy assets
- Given fluctuating intermittent generation profiles, compute power factor correction and capacitor bank sizing to satisfy point-of-interconnection grid codes
- Using thermodynamic heat balance reports, evaluate heat recovery steam condenser and boiler performance losses during low-load cycling
- From transformer test certificates, determine winding insulation integrity, winding losses, and protective relay settings for synchronous machines and step-up units
- Using marginal production data, construct a unit commitment merit-order schedule that balances fuel expenses with renewable energy curtailment
- From switchyard fault level analyses, verify circuit breaker interrupting capacities, disconnect switch ratings, and surge arrester protection margins

Course Content

Day 1: Substation Architecture and Interconnection Requirements

- High-Voltage Substation Bus Configurations for Mixed Resource Integration
- Grid Interconnection Standards and Point-of-Common-Coupling Requirements
- Instrument Transformers, Switchgear Ratings, and Isolator Selection
- Grounding Grid Design and Step-and-Touch Potential Mitigation
- Single-Line Diagram Formulation for Combined Utility Feeders

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Day 2: Transformers, Synchronous Machines, and Reactive Flow

- Step-Up Transformer Specification, Vector Group Selection, and Tap Changers
- Synchronous Machine Excitation Systems and Voltage Regulation Loops
- Harmonic Distortion and Resonance Analysis from Inverter-Based Sources
- Capacitor Banks, Static Var Compensators, and Power Factor Correction
- Insulation Resistance and Frequency Response Analysis for Utility Transformers

Day 3: Thermal Recovery Units, Cogeneration, and Balance of Plant

- Heat Recovery Steam Generators, Steam Drums, and Condenser Balance
- Auxiliary Feedwater Heaters, Deaerators, and Boiler Feed Pump Losses
- District Cogeneration Configurations and Thermal Energy Offtake Balancing
- Vibration Diagnostics and Dynamic Balancing on High-Speed Rotors
- Emissions Monitoring and Flue Gas Abatement Auxiliary Loads

Day 4: Renewable Resources, Wind Aerodynamics, and Solar Inverters

- Wind Turbine Interconnection via Doubly-Fed Induction Generators
- Solar Photovoltaic Central Inverter Substation Step-Up Arrays
- Aerodynamic Curtailment and Dynamic Active Power Curtailment Controls
- Anti-Islanding Protection Schemes and Voltage Ride-Through Verification
- Levelized Cost of Energy Calculations for Wind and Photovoltaic Assets

Day 5: Production Economics and Substation Interconnection Plan

- Exercise Calculating Transformer Tap Adjustments Under Extreme Voltage Fluctuation
- Exercise Optimizing Merit-Order Economic Dispatch with High Renewable Penetration
- Exercise Coordinating Protective Relay Clearing Times for Intertie Faults
- Sensitivity Analysis on Fuel Heat Rate Penalties and Startup Fuel Costs
- Completing and Presenting the Substation Interconnection and Generation Economics Assessment Plan

Case Studies and Exercises

The following are suggested activities used during the course.

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- Case study: a regional transmission intertie integrating a hundred-megawatt solar photovoltaic installation; you compute required reactive power support at the point of interconnection, select capacitor bank steps, and verify statutory voltage margins.
- Case study: an industrial cogeneration facility delivering steam to a district network while exporting electricity; you determine operating heat rates, evaluate deaerator thermodynamic losses, and calculate net export economics under varying fuel tariffs.
- Exercise: a utility substation experiencing harmonic distortion and reverse power flow from distributed wind farms; you evaluate transformer overheating, verify relay tripping thresholds, and configure anti-islanding protection logic.
- Exercise: a mixed-asset portfolio balancing thermal units with variable solar production; you build a one-week production dispatch model that minimizes operating expenditure while observing ramping limitations.

What You Take Back

You return with the Substation Interconnection and Generation Economics Assessment Plan to evaluate interconnection switchyards and optimize generation fleet dispatch across your organization. In your first month back, you use it to review point-of-interconnection protection settings, audit reactive power margins, and benchmark unit production heat rates against economic operating targets.

- Substation single-line interconnection assessment template with equipment rating verification tables
- Point-of-interconnection power factor correction and reactive power sizing calculation model
- Economic merit-order dispatch matrix incorporating heat rates and renewable curtailment parameters
- Protection relay coordination checklist for intertie circuit breakers and step-up transformers

Quick Answers FAQ

What should I know before Substation Engineering for Renewable Grid Integration and Generation Economics training?

You should understand three-phase electrical circuits, single-line diagrams, and basic utility dispatch concepts. Familiarity with transformer operations, protective relays, and high-voltage equipment assists your engagement with the technical calculations.

How does Substation Engineering for Renewable Grid Integration and Generation Economics differ from turbine maintenance training?

Mechanical turbine maintenance courses emphasize mechanical component teardown, bearing alignment, and casing overhauls. This course focuses on electrical substation interfaces, power factor correction, transformer protection, and dispatch production economics.

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Why do utilities re-evaluate substation engineering when adding renewable energy?

Renewable energy sources alter bidirectional power flows, introduce inverter harmonics, and affect grid voltage stability. Upgrading substation engineering ensures statutory voltage compliance, reliable relay tripping, and minimized curtailment losses.

What work product do I take back from this training?

You take back the Substation Interconnection and Generation Economics Assessment Plan, complete with reactive compensation formulas, switchgear rating criteria, and economic dispatch calculation spreadsheets.

For Your Manager

This course equips your engineer to resolve substation interface challenges created by renewable energy additions and fluctuating operational loads. The participant will complete the Substation Interconnection and Generation Economics Assessment Plan, bringing back verified methods to evaluate transformer loading, ensure power factor compliance, and calculate asset dispatch costs. The tool is first used to audit existing interconnection capacity and lower operational fuel expenditures.