CORE

CONCEPT

Economic Dispatch and Unit Commitment: Generation Scheduling and Optimisation

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Introduction:

Economic dispatch and unit commitment decisions made on rough merit order tables, outdated heat-rate curves and hand-set reserve margins waste fuel, strand units in costly starts and expose the grid when ramp capability runs short. This Core Concept course equips system operators, generation planners and utility engineers to model generator costs, solve lambda iteration dispatch with transmission losses, formulate unit commitment with reserve, ramp and minimum up and down time constraints, and schedule renewables and storage. Participants produce a Day-Ahead Unit Commitment and Dispatch Schedule for a sample generation fleet.

Course Objectives:

- Build generator input-output, heat-rate and incremental cost curves from unit test data and rank units in a merit order
- Solve economic dispatch by lambda iteration with unit limits, and extend it to loss-coordinated dispatch using B-coefficients and penalty factors
- Formulate and solve unit commitment with start-up costs, reserves, ramp rates and minimum up and down times using priority list, dynamic programming and MILP methods
- Apply security-constrained dispatch and optimal power flow concepts to keep schedules within line flow and contingency limits
- Schedule hydro, storage and variable renewable generation within day-ahead and real-time operation under forecast uncertainty
- Measure schedule performance against actual dispatch and deliver a Day-Ahead Unit Commitment and Dispatch Schedule

Target Audience:

- System operation staff responsible for real-time generation dispatch and reserve deployment in control centres
- Generation planning staff responsible for day-ahead and week-ahead unit scheduling and outage coordination
- Utility power system engineers responsible for dispatch studies, loss analysis and network constraint checks
- Plant performance staff responsible for heat-rate testing and generator cost data supplied to schedulers
- Energy management system support staff responsible for scheduling software, models and input data
- Renewable and storage integration staff responsible for forecast inputs and flexibility in operating schedules

Course Outline:

Day 1: Generation Cost Modelling and Scheduling Time Horizons

- Input-Output, Heat-Rate and Incremental Heat-Rate Curves from Unit Test Data
- Fuel Cost, Variable Operation and Maintenance and No-Load Cost Components
- Quadratic and Piecewise Linear Cost Curve Fitting in a Spreadsheet
- Scheduling Horizons: Week-Ahead, Day-Ahead, Intraday and Real-Time Dispatch
- Merit Order Stack Construction from Average and Incremental Unit Costs

Day 2: Classical Economic Dispatch and the Equal Incremental Cost Principle

- Equal Incremental Cost Criterion and Lagrange Multiplier Formulation
- Lambda Iteration Method with Generator Minimum and Maximum Limits
- Base-Point and Participation Factor Method for Load Changes
- Gradient and Newton Search Methods for Dispatch Convergence
- Worked Lambda Dispatch for a Five-Unit Thermal Fleet

Day 3: Loss-Coordinated Dispatch and Non-Ideal Cost Characteristics

- Transmission Loss Representation with the B-Coefficient Loss Formula
- Penalty Factors and Incremental Transmission Loss Calculation
- Coordination Equations for Loss-Inclusive Lambda Iteration
- Prohibited Operating Zones and Valve-Point Loading Effects
- Environmental Dispatch with Emissions-Weighted Objectives and Fuel-Limited Units

Day 4: Unit Commitment Constraints and Classical Solution Techniques

- Commitment Decision Variables: On-Off Status, Start-Up and Shut-Down Flags
- Hot, Warm and Cold Start-Up Cost Curves and Shut-Down Costs
- Minimum Up and Down Times, Ramp Rate Limits and Must-Run Units
- Priority List Method Using Full-Load Average Production Cost
- Forward Dynamic Programming Commitment over a 24-Hour Horizon

Day 5: Guided Case Study: Priority List Commitment and Hourly Dispatch

- Case Data Pack: Ten-Unit Thermal Fleet Cost Curves and Hourly Load Forecast
- Priority List Commitment Schedule with Spinning Reserve Margin Check
- Hourly Lambda Dispatch With and Without B-Coefficient Losses
- Excel Solver Model for Constrained Economic Dispatch
- Week-One Debrief: Production Cost, Marginal Unit and Schedule Sensitivity

Day 6: Optimisation Formulations, Hydro-Thermal Coordination and Storage

- Mixed-Integer Linear Programming Formulation of Unit Commitment
- Lagrangian Relaxation Dual Problem and Subgradient Multiplier Updates
- Python Optimisation Overview with Pyomo, PuLP and Open-Source Solvers
- Hydro-Thermal Coordination Overview: Water Value and Reservoir Energy Limits
- Pumped Storage and Battery Energy Storage Charge-Discharge Scheduling

Day 7: Reserves, Security-Constrained Dispatch and Optimal Power Flow

- Spinning, Non-Spinning and Operating Reserve Requirements and Allocation
- DC Power Flow Approximation and Line Flow Limits in Dispatch
- Security-Constrained Economic Dispatch with N-1 Contingency Limits
- Optimal Power Flow Objective, Control Variables and Constraint Set
- Security-Constrained Unit Commitment and Schedule Feasibility Checks

Day 8: Renewable Variability, Forecast Uncertainty and Operational Coordination

- Net Load Profiles, Midday Solar Trough and Evening Ramp Requirements
- Scenario-Based and Robust Scheduling for Wind and Solar Forecast Error
- Curtailment Decisions and Flexibility Reserve Sizing
- Day-Ahead to Real-Time Handover: Intraday Recommitment and Dispatch Instructions
- Coordination Protocols Between System Operator, Generators and Fuel Suppliers

Day 9: Schedule Performance Metrics and Continuous Improvement

- Production Cost Variance Analysis: Scheduled Versus Actual Dispatch
- Heat-Rate Deviation Tracking and Cost Curve Recalibration
- Load Forecast Error Metrics: Mean Absolute Percentage Error and Bias
- Start Count, Ramp Adequacy and Reserve Shortfall Indicators
- Post-Dispatch Review Template and Benchmarking of Scheduling Practice

Day 10: Capstone: Day-Ahead Unit Commitment and Dispatch Schedule for a Sample Fleet

- Capstone Briefing: Mixed Thermal, Renewable and Storage Fleet with Hourly Demand
- MILP Commitment Model Build in Excel Solver or Python
- Hourly Dispatch with Losses, Ramp Limits and Reserve Allocation
- Sensitivity Runs for Forecast Error, Unit Outage and Fuel Price Change
- Day-Ahead Unit Commitment and Dispatch Schedule Presentation and Peer Challenge

Skills You Will Gain:

- Generator Cost Curve Modelling
- Merit Order Ranking
- Loss-Coordinated Dispatch
- Unit Commitment Optimisation
- Reserve and Ramp Constraint Handling
- Security-Constrained Scheduling
- Renewable and Storage Scheduling
- Dispatch Performance Analysis

Why Attend This Course:

- Return with a Day-Ahead Unit Commitment and Dispatch Schedule built and tested on a sample fleet, ready to adapt to your own units
- Explain to management and plant staff why a unit was committed, held as reserve or left offline, and what it cost
- Move from spreadsheet rules of thumb to optimisation models that can be audited, rerun and improved
- Compare scheduling practice with operators and planners from utilities, independent generators and industrial power systems

Conclusion:

Generation scheduling rests on accurate cost curves, sound dispatch mathematics and commitment decisions that respect every unit and network limit. The first week builds that base through cost modelling, lambda iteration, loss coordination, priority list and dynamic programming commitment, and a guided case. The second week adds what a short course leaves out: MILP and Lagrangian methods, hydro and storage, reserves, security-constrained dispatch, renewable uncertainty and performance review. The final day produces a Day-Ahead Unit Commitment and Dispatch Schedule for peer challenge.