Integration of Real-time Unit Dispatching Optimization with SCADA and AGC

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Powel-MiniMax

- Powel-MiniMax is a US-based energy software and services provider of stand-alone and integrated energy solutions.
- Powel ASA is spin-off of EFI, the Norwegian Electric Power Research Institute, established in 1951.
- Over 35 software modules used by more than 1000 customers worldwide covering
  - Generation and Water Management
  - Transmission and Distribution Management
  - Trade and Risk Management
  - Customer Management
  - Geographic Information Systems (GIS)
- Over 25 years of water management experience ranging from hydrological analysis and forecasting, water quality modeling, hydro system planning and operational analysis.
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AGENDA

- The Project
  - Hardware Configuration
  - Data Communication
  - Unit Dispatching Optimization
  - Technical Issues
  - Future Developments
  - Conclusions
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The Project – Overview

- Three hydro plants in a thermal dominated system (hydro provides less than 5% of generation to more than 1 million customers)
  - The hydro plants provide highly valued ancillary services (spinning reserve and up/down regulation)
  - The hydro plants are on AGC to regulate the corporate system
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The Project – Scope

- Hourly scheduling optimization for the next seven days to maximize either generation or revenue
- Real-time unit dispatch optimization at plant level
- The optimization models are linked with SCADA and AGC for closed-loop control in real-time
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Hardware Configuration

EMS

AGC

Real-time Data

MW Setpoint

ISO

Real-time Data

Committed Schedule

MW Setpoint

SCADA

Proposed Schedule

HYDROPS

Start / Stop / MW

Equipment Status

RTU PLC
Current Condition (Plant, Turbine, AGC)

Forecasted Data (Flow, Price)

Data Communication Module

Data Communication

REAL-TIME UNIT DISPATCHING

Current Target Schedule

Optimal Turbine Dispatch

Final Optimal Schedule

SHORT-TERM GENERATION SCHEDULING

Optimal Time Series

Historical Time Series (Observed & Forecasted)
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Unit Dispatching Optimization

- **Objective:** To produce required power output at maximum efficiency (i.e., minimum water usage)
- Constraints: Monitoring environmental constraints (i.e., minimum flow, ramping, etc.)
- Method: Dynamic Programming (modified)
- Inputs: Turbine data and current system conditions
- Running modes: Manual (Local, Remote) and Automatic (AGC & STGS)
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Technical Issues

- **Running time**: Unit dispatching optimization in less than 4 seconds
- Data communication: Real-time data is updated every second
- Monitoring constraints: min. flow and ramping
- Unit cycling:
  - Minimum on/off time
  - Start/Stop cost
  - Efficiency differential
  - Start/Stop order
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Future Development

- **Dissolved Oxygen**: Automatically meet the DO constraint in an optimal way
  - Real-time monitoring
  - DO vs. Vent opening
  - Vent opening vs. Turbine efficiency
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Conclusions

- **Fast execution is important in real-time control**
  - Bullet-proof features, backup plans and redundancy are critical elements in closed-loop operations
  - Simple and effective integration of EMS, SCADA, and optimization models is beneficial for maintenance
  - Good compromise between practicality and theoretical optimality
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