Solutions for Power Generation

Energy Management – Smart Grid Solutions

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Spectrum Power™
Solutions for Power Generation

Challenges
• Prepare Control Area Operators and Power Producers for demanding tasks resulting from energy market liberalization (e.g., Balancing Power, Energy and Power in Emergency Situations, Black Start Capability, Congestion Management capabilities)
• Better exploit existing generation equipment according to capacity and economy
• Integrate increasing shares of renewable energy resources

Siemens solutions
• Comprehensive redundant Power Application suite for Control Area Operators and Power Producers
• Load Frequency Control for real-time balance of demand and supply
• Economic Dispatch optimally allocates the total generation requirement
• Reserve Monitor for online control of system reserve requirements
• Production Cost Monitor for online comparison of real costs using actual unit generations against the optimal costs returned by Economic Dispatch

Customer benefits
• Savings in fuel and unit maintenance costs due to detailed modeling of real situation
• Fine tuning of required system reserves helps minimize system operation and standby costs
• Real-time feedback on whether the system is operating close to economic optimum
Power Applications modes

The Spectrum Power™ Power Applications suite supports, accordingly, the following 2 modes of operation:

- **Control Area / Regional Operator**: the company is responsible for one or more control areas where generation belongs to one or more companies and regulating generation is either own or acquired in the regulating market.

- **Power Producer**: the company dispatches its generation on the basis of its own generation schedule (energy delivery contracts) and regulating generation (bid in regulating markets) requested by one or more Area Operators.
Power Applications Overview (1) – Single Control Area

- Interchange (Tie Lines)
- Control Area
- Generating Units
- Consumers
- Schedules

Power Applications
- Load Frequency Control
- Economic Dispatch
- Reserve Monitor
- Production Cost Monitor

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Power Applications Overview (2) – Multi-Area / Hierarchical model

- Remote ACE requirement
- Control Area Operator
- Control Area X
- Control Area Y
- Regional Operator
- Remote ACE requirement
- External Exchange
- Internal Exchange

Power Applications
- Generation Dispatch Control
- Economic Dispatch
- Reserve Monitor
- Production Cost Monitor
Challenge

- Trading Departments of Generation Companies and Vertical Integrated Companies face the challenge to be more profitable on the energy markets.
- Generating bids for energy on future and spot markets, system services, and bilateral trade.
- Considering constraints as contractual (gas, emissions ...), hydrological (irrigation, fishery, ecology, ...) and cogeneration (district heating, desalination, ...).
- Integration of renewable energy.

Siemens solutions

- jROS as an integrated platform for planning of resources, generation and trading activities on electricity and fuel markets.
- jROS / RO for midterm / long term optimization of resources (water, fuel) and optimal contracts (electricity, fuel) bilateral and on spot markets for the next year(s).
- jROS / HTC for short-term scheduling of hydro-thermal (cogeneration) power generation systems.

Customer benefits

- More profit on the energy markets by cost savings in generation and precise information for trading.
- Standard procedures alleviate generating the bids for:
  - Energy on future and spot markets.
  - System services.
  - Bilateral trade.
Overview

Power Applications

Generation Planning and Trading

Summary
Spectrum Power™
Power Applications

Base Functions

- Load Frequency Control (LFC)
- Economic Dispatch (ED)
- Reserve Monitor (RM)
- Production Cost Monitor (PCM)
- Report Control Performance Standard
Load Frequency Control (LFC)

LFC provides real-time (secondary) control of the generating units participating in area regulation to maintain system frequency, i.e. real-time equilibrium between generation and demand, whilst maintaining “optimum” dispatch and scheduled interchange. Accordingly,

- LFC determines the area control error, or ACE, that combines frequency and net interchange deviations plus additional corrective terms such as inadvertent energy compensation, time error correction and/or remote ACE, then

- LFC calculates the necessary total generation correction, allocates it to the individual participating units, and implements the corresponding control signals via SCADA
Load Frequency Control (LFC)

LFC supports among many other features:

• Hierarchical and multiple control areas
• 3 ACE modes: Constant Interchange (CNI), Constant Frequency (CF) & Tie Line Bias (TLB)
• 4 LFC control modes (filtered ACE bandwidth): basepoint, regulation, permissive & emergency
• Unit MWh deviation monitoring & control
• Jointly Owned Units (JOU)
• Virtual Unit
• Forbidden regions
• Net/Gross value conversion
• Performance monitoring according to NERC (CPS1 & CPS2) or UCTE requirements
• Unit Response tests
Economic Dispatch (ED)

ED allocates optimally the total generation requirement (sum of base point values + system regulation calculated by LFC) among participating generation units. This allocation either minimizes the total system production cost or maximizes the total system profit subject to:

- Total generation requirement
- Reserve (spinning) requirements
- Plant and unit limits
- Production cost characteristics

The solution is derived from an algorithm based on the nonlinear Dantzig/Wolfe decomposition principle. ED is executed cyclically, on operator request or on LFC trigger and can be executed either in normal mode or in anticipatory mode.
Economic Dispatch (ED)

ED provides 3 optimum dispatches:

1. A Control Dispatch (for LFC use), to calculate base points of all online units that are on AGC control and in Economic base point mode

2. An Advisory Dispatch, to calculate base points of all online units that are
   - on AGC control and in Economic base point mode,
   - off AGC control and in Advisory, Monitoring or Independent (Economic Dispatch) mode - base points of units in Advisory mode are communicated to the respective plant operators

3. A Target Dispatch (for PCM use), to calculate unconstrained base points for all online units whose Target Dispatch Flag is on.
**Reserve Monitor (RM)**

- RM provides the online monitoring of the system reserve requirements. It runs periodically within a configured cycle time to
  - calculate active reserves
  - compare the reserves to the requirements
  - issue an alarm upon a requirement’s violation
- RM supports reserve requirements’ schedules retrieved from an external scheduling application, e.g. unit commitment, or specified by an operator by selecting any one of the pre-defined rules.
- RM allows an operator to modify each unit’s mode (regulating, not regulating, standby, unavailable) of contribution to each reserve requirement type.
- RM can operate in one or more control area.
RM supports the following reserve classes:
- Responsive (incl. regulating) Reserve (<20s)
- Spinning Reserve (<2m)
- Operating Reserve (<10m)
- Quick Start Reserve (<30m)
- Slow Start Reserve (<2h)

RM supports the following reserve policies:
- Schedule (from a scheduling application)
- or...
  - Value (MW)
  - % of largest unit
  - % of largest tie flow
  - % of largest (largest unit, largest tie flow)
  - % of total load
Production Cost Monitor (PCM)

PCM provides the online monitoring of the actual production costs based on actual unit generations against the optimal production costs based on ED’s target dispatch results. Whenever the actual costs exceed the target costs, PM produces an alarm.

Cost calculations are made

- per unit, plant and system, and
- for current values, hourly averages and daily integrals of the hourly average values.

PCM provides also for the calculation of

- fuel consumption, including that of water, and
- startup costs including number of daily startups, etc.
Production Cost Monitor (PCM)

In some energy market context, PCM can also provide for
- cost comparison to market income (instead of target cost), and
- the calculation of lost opportunity costs for regulation service (ancillary service) based on locational marginal price (LMP) in the following 2 cases
  - for regulation in upward direction
  - for regulation in downward direction
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Power Applications – User Interface

The image shows a user interface for a power application, specifically an Automatic Generation Control (AGC) system. The interface displays various parameters and settings, including:

- **Plant Unit Configuration**: Details such as nameplate, status, and control modes (Local, Remote).
- **Output MW**: The current output power in megawatts, with ranges for different statuses (Base, Sustained, Backup).
- **Frequency**: The current frequency value, crucial for grid stability.
- **Generation**: Total generation output.
- **Interchange**: Interconnections and power exchanges.
- **ACE**: Area Control Error, indicating the deviation of the frequency from the setpoint.

The interface also includes graphical elements such as bar charts and maps, providing a visual representation of the data. The controls and indicators are designed to aid in monitoring and managing the power system efficiently. Additional features, such as update and cancel options, are included for interactive control.
jROS = joint Resource Optimization and Scheduler

- jROS is the component of Spectrum Power™ for the portfolio management of generation resources
- jROS is integrating applications for
  - Forecasting
  - Resource Optimization
  - Generation Scheduling
  - Transaction Scheduling
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Generation Planning and Trading

**Scenarios**
- Market Prices
- Inflow
- Demand
- Renewable Generation

**Forecasts**
- Inflow
- Demand
- Renewable Generation

**System State**
- Measurements
- Very Short Term Load Forecast

**Long Term Planning**

**Medium Term Planning**

**Day Ahead Planning**

**After Clearing Optimization**

**Intraday**

**Expansion Decisions**
- Hedging
- Electricity Forwards
- Fuel Forwards

**Medium Term Contracts**
- Take-or-Pay, El., Fuel Maintenance Schedule

**Day Ahead**
- Market Offer Bid Matrix

**Optimal Operation Schedule**

**Intraday**
- Market Offer Bid Matrix

**Control**
Spectrum Power™
Generation Planning and Trading

jROS is targeting 3 kind of customers

• **Vertically integrated companies**
  optimizing their generation resources,
  and exchanging energy with their neighbors or IPPs

• **Generation companies** in open markets
  optimizing their portfolio and trading decisions
  on the markets months and years ahead

• **Multi-utility companies** in open markets
  optimizing their portfolio and bidding decisions
  on the day-ahead and intraday markets
jROS supports these customers by

- **Minimizing generation costs** considering cogeneration and reserve requirements and supporting interchange transaction scheduling

- **Stochastic portfolio optimization** on electricity, fuels and hydro resources for (monthly/yearly) planning decisions

- **Generation scheduling** including the generation of volume price ladders for bidding on the spot markets
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Generation Planning and Trading

jROS as a Spectrum Power™ component

- **Can be fully integrated** in a Spectrum SCADA/EMS system for use by the operators

- **Can run together but practically independent** from the SCADA/EMS for use by planning engineers

- **Can be connected to non-Siemens SCADA/EMS** systems, but also to trading and other systems
Medium and long term decision support under uncertainty

- **Scenario generation**
  for optimization
- **Stochastic Optimization**
  done as stochastic mixed integer linear programming problem (sMILP)
- Consideration of **market price uncertainty**
- **Evaluation of renewable** energy generation
- **Option contract** evaluation
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Generation Planning and Trading - Resource Optimization (RO)

Medium and long term decision support under uncertainty

RO is the medium and long term (deterministic) optimization application supporting:

- **Expansion planning**
  considering development programs and economic effects

- **Resource scheduling and medium term trade optimization**
  of the next few years with decisions on fuel and electricity markets

- **Maintenance scheduling**
  of the next year(s) for optimized maintenance decisions
STWPF

STWPF computes the power production of regions and individual wind plants (farms) for the future hours and days combining:

- **Own forecast methods**
  - carrying out 8 methods in parallel
- **External forecast methods**
  - for total wind power forecast to be combined with result of own methods
- **Disaggregation of results**
  - to obtain better forecast per wind farm
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Generation Planning and Trading - jROS User Interface

Geographical Views
FA computes the demand (or other time series) for the future hours and days based on archived demands and archived influencing variables with statistical methods.

The following methods are provided:

- **Automatic forecast methods**
  carrying out several methods in parallel and mixed according to user-defined weights, which improves the quality of the forecast and allows to estimate the ‘forecast of the uncertainty’

- **Very Short Term Load Forecast (VSTLF)**
  adopting a moving average to minimize the forecast error of the next few hours
HTC

HTC is the short term (deterministic) optimization application supporting the

- **Day ahead scheduling and short term trade optimization**
  to provide information for bidding on the (spot) markets for energy and for regulating requirements,

- **Intraday scheduling / Final scheduling**
  to determine short term trading parameters, based on the actual parameters of the plants and feasible and optimal generation schedule to be executed by the dispatchers.
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Generation Planning and Trading - Market PROFiles (MPROF)

MPROF

is an option of HTC that determines free capacities and their marginal costs via sensitivity analysis in a post processing after the optimization by use of re-dispatch.
ITS is maintaining counterparts, transactions and their schedules providing:

- **Flexible summations**
  over the transacted energy

- **Different products**
  for the amount like blocks, periodic products and freely defined schedules

- **Different ramping strategies**
  and other details

- **Overview on active, pending, past**
  transactions with the possibility to interrupt and resume them
Spectrum Power™
Solutions for Power Generation

Overview

Power Applications

Generation Planning and Trading

Summary
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Power Applications Benefits

Load Frequency Control
- Flexible design supports **operation on all levels of system control** (area controller, plant controller and unit controller)
- **Optimum allocation of temporary generation** among regulating units using
  - operator-defined unit regulating ranges (under normal conditions) or
  - proportional to the units’ maximum regulating power limits (under stress conditions)
- Fully compensated area controller with separated small and large signal handling guarantees **minimum stress for all controlled generating units**

Economic Dispatch
- Very short calculation time allows **economic real-time dispatch** of the temporary generation
- **Cost savings in fuel cost and unit maintenance** cost due to detailed modeling of the reality
  - Handling of multiple fuels possible (up to five fuel types per generating unit)
  - Supports percentage based calculation of fuel mixtures
  - Base fuel/top fuel handling
- **Automatic consideration of uneconomic regions** (valve points) prevents both thermal and hydro generating units from being driven at power values where the throttling losses are a maximum, i.e. when a valve is nearly closed
Spectrum Power™
Power Applications Benefits

Reserve Monitor

- Suited both for *generation and transmission companies*
- Reserve Monitor generates cost savings for customers due to detailed modeling of the reality:
  - up to 5 reserve classes
  - various reserve calculation modules
  - for a wide range of reserve elements
  - Reserve policy for different emergency situations like loss of units or interchange
  - Reserve policy is *highly adaptive to the network load* on different days. It allows different reserve policies for working days, holidays and weekends, and up to 5 special days defined by certain dates.

Production Cost Monitor

- Production Cost Monitor allows online monitoring of production costs and fuel consumption
- Key benefit: *Real-time feedback* on how close the system is operated to the *economic optimum*
Spectrum Power™
Generation Planning and Trading Benefits

jROS - Mathematically optimizing resources and schedules

The clear benefit is **more profit on the energy markets** by or **cost savings in generation** and **precise information for trading**. This is provided by optimization engines based on 20 years of experience.

jROS uses state-of-the-art mathematical optimization, which lead to cost optimized generation schedules, with **improvements of 1 – 10 %** compared to manually derived schedules or old optimization techniques, like Merit-Order-Lists, or Lagrange Relaxation.

The engines use MILP algorithm (=Mixed Integer Linear Programming), with the following benefits:
• ability to handle integral constraints in a closed solution process
• ability to handle concave problems
• calculation until accuracy limit or time limits are reached
• achieved MIP-gap tells you, how near to the global optimum you are

jROS comes with an **attractive Java-based graphical user interface**.

jROS comes with a **XML-interface** for import and export of data.
Thank you.

Successfully implemented – today.