joint Resource Optimization and Scheduler

All forecasting and planning applications in one component.

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The progressive liberalisation of the energy markets does not only yield new possibilities and chances but it also raises new risks. The long-term planning of business activities is impacted by the high volatility of electricity markets as well as of the fuel market. On top of that, with the increasing share of renewable energy production, such as the generation from water, wind and solar resources, the uncertainty in the total production raises continuously. Risk Evaluation for a given portfolio under the uncertainties of the future development is therefore increasingly essential.

Spectrum Power™ jROS is a comprehensive collection of state-of-the-art applications that will support you in your tasks of Forecasting and Optimization.

Platform independent Design
jROS is based on standard products like Oracle, JBoss Application Server and Enterprise Java Beans. It provides client access by a Java-application.

jROS is designed as a shared component of Spectrum Power™. It may be used as a stand-alone planning system or integrated in a SCADA/EMS System.

jROS is platform independent and can be delivered on Windows, UNIX and LINUX platform. It may run on a single machine (e.g. a common laptop) or may be distributed on several servers for high performance requirements.

Portfolio Management
The tasks of the Portfolio Management in a power generation company can be supported by statistical algorithms and mathematical optimization resulting in clear profit benefits for the company.

These tasks are:

- Long- and Medium term planning of the next few years optimizing trading opportunities, maintenance periods, etc.
- Managing the physical risk by use of Monte Carlo Simulation or Stochastic Optimization.
- Short term scheduling for day ahead and intraday market decisions including the creation of the final schedules for up to 4 weeks.
- Short term load forecasting of area loads and/or loads of big consumers.
- Renewable energy source forecast for determination of expected generation of wind and solar power.

Spectrum Power™ jROS is a component that combines these tools on one common platform. This minimizes the administration effort of the tools as all planning activities are performed with one system so that the planner / dispatcher may concentrate on his core business. Therefore, it combines the advantages of all forecast and planning-tools.
jROS supports multi-user activities, e.g. locking data sets that are edited by one user and updating the user interface of all users after data modification.

jROS includes a model editor to add and modify the plants, units and other objects of the production system as well as the contracts for fuel and electrical energy. The users can model their power system in more or less complex models as desired for the specific task.

Manual data input is checked immediately during entering and logged automatically. Mass data input is supported by an Excel-import feature, which is also subject to data checks during import. This reduces the probability of infeasible problems in the optimization runs. Further checks are performed by the algorithms, giving clear text messages to the user guiding to the source of the problem.

An advanced variants management allows studying and comparing different data sets efficiently. Each variant is completely independent and may differ in the parameters or in the data model itself.

The user interface is ready to use, i.e. it adapts automatically to the content of the specific variant. It consists of predefined overview displays and analysis displays with full details of specific objects. Additionally, the user may define specific overview displays collecting results optimal for his workflow. All displays provide tabular and chart views and allow importing and exporting from and to Excel or CSV.

Variant Management

The Variant Management allows the variant administration of several data sets to be examined. It contains the following features:

- stores the variants into external files
- produces new variants from external files or as a copy of an existing variant
- compares the results of several variants

Calculations may be started for a list of variants. jROS creates then a queue performing the calculations sequentially or in parallel depending on the available system environment (CPUs and solver licenses).

Each variant is completely independent and can be different in the parameters or in the model (e.g. different phases/expansion variants). Different variants can include data of different companies. Defined user rights offer protection against unauthorized access.

Workspaces

Several variants can be associated to a workspace. Limiting the user permission on those workspaces allows to separate the system completely, e.g. for serving different departments or even companies by one system. jROS is therefore “client competent”.

Each Workspace contains an Archive (common for all applications). Each variant of each application (within one workspace) has access to the data of this Archive.

Audit Trail

All manual changes are logged automatically and are visible in the Variant Logs display. All changes are stored for each variant separately. Following information is included in Variant Logs display:

- Date and time of the change
- Type and name of the object
- Which user made the change
- Old value / new value (for short-term applications only)
- Activation of an application-engine
- Activation of interfaces
Expansion Planning

Expansion Planning is supported by the study of different expansion (and shutdown) scenarios under the effects of economical growth, specific development projects and the development of the fuel price, emission rights and energy markets.

As a result the user obtains the lack of supply and/or the traded volumes on the load areas together with the weekly, monthly and yearly costs to run the system. By comparing the different expansion scenarios the planner finds the optimal configuration of the new plants, the expansion schedule and the installation sites.

Planning horizons of up to 30 years into the future allow analyzing these scenarios in JROS. The built-in model editor enables the user to easily add new plants or to modify existing ones. Assigning the plants to a load area and defining the maximum power exchange between the load areas allow to consider the transmission grid (and its expansion) in a simplified form. Optionally cogeneration may be studied, assigning the plants to a supply zone for heat or desalinated water and modeling the limitations due to pipelines and pumping stations by a limitation of transfer between the zones.

The plant itself may be modeled in full details or with a simple data model for rough decisions, which are refined later-on to plan the exact configuration. All kind of plants are available for expansion planning, i.e. simple cycle thermal plants, combined cycle thermal plants, thermal cogeneration plants, run-of-river plants and pumped storage plants.

Maintenance Scheduling

It is optimizing the maintenance periods of thermal or hydro units within a certain predefined time period under the consideration of all hydro and thermal restrictions and maximization of profit / minimization of costs.

Maintenance Scheduling is fully integrated into the tool RO. It uses the same data model as Resource Optimization and is therefore able to consider the entire planning process of medium term planning.

Usually, the time horizon of the Maintenance Scheduling is 1-7 years split into daily or weekly intervals because of the consistency with the maintenance time frame.

Resource Optimization

Resource Optimization is a planning function that supports decision making for planning periods of one or more years split into time intervals corresponding to the required accuracy (1h, 3h, ... 1 week). It takes into account many different future contract conditions, the hydro, thermal and cogeneration production system.

Resource Optimization optimizes the medium-term trading positions on the fuel, emission rights and electricity markets as well as the usage of medium-term energy resources as yearly hydro reservoirs. It supports fuel procurement, fuel stock-keeping and fuel usage considering the fuel transport limits, take-or-pay fuel contracts and other kind of fuel contracts.

For a given portfolio of contracts and generating units the mathematical optimization determines the usage of this portfolio, i.e.:

- optimal generation schedules,
- consumption of resources (fuels, emission rights and/or water),
- amount of traded energy on the different markets (bilateral, forward and spot market).

Risk Evaluation and Stochastic Optimization

The long-term planning of business activities has become challenging due to volatile market prices for fuel procurement and electricity sales. Moreover, with the increasing share of renewable energy production, the uncertainty in total production rises continuously. Risk Evaluation for a given portfolio under the uncertainties of the future is especially relevant for medium- and long-term planning tasks. This is done by studying different variants for specific risk cases (deterministic case), by Monte Carlo Simulation (MCS) or by Stochastic Optimization (STO).

For this purpose Variant Management allows to specify besides the deterministic variant (DET) also variants of the types:

- VOL – volatility analysis
- MCS – Monte Carlo simulation
- STO – Stochastic Optimization

VOL and MCS calculate the predefined scenarios using the deterministic optimization. Efficient graphical and mathematical methods are used to evaluate results and represent distributions and quantiles in tabular and graphical form.

STO compresses the scenarios to a common scenario tree and calculates a complete optimization over the entire tree in a closed solution. The essential results are the decisions of the beginning of the planning horizon under the consideration of the (uncertain) developments of all branches of the scenario tree. Therefore STO allows profit maximization with respect to the risks.

The remaining risk is identified as Value-at-Risk. The hedged decisions can be sent as input for HTC.
Fuel procurement and fuel stock-keeping need to consider all possible scenarios of future market price development.

Reservoir management takes into account the different inflow scenarios.

**Short Term Generation Scheduling**

The Short Term Generation Scheduling and Trade Optimizing Scheduler (Hydro-Thermal Coordination HTC) determines the optimum generation schedules for all available units of the system for up to 30 Days in the future and calculates optionally in an hourly, 30-minutely or 15-minutely time grid.

The results are commitment and generation schedules, cogeneration production, contribution to regulation services, and reserves. From that the operating costs, fuel consumptions, water discharges, reservoir levels and flows through channels are derived according to the exact nonlinear dependencies and verified against the limits.

Generator Scheduling supports this task by scheduling the generation units for the next few days up to two weeks divided in hourly, half-hourly or quarter-hourly time grid. The regulation and reserve requirements are considered in full details. Optionally, the requirements from cogeneration production and their supply zones, storage capacities and limited transport capabilities are included in the scheduling process.

Generator Scheduling employs the same algorithm and data model as the Trade Optimizing Scheduler. The objective function is minimization of production costs under given electrical demands. The results are presented in analyst displays in full details and may be summarized in user-defined summary displays in tabular or graphical form.

**Trade Optimizing Scheduler**

Trade Optimizing Scheduler is one way of using HTC determining key figures for the short-term bilateral trading decisions and for the bidding on the spot markets.

The results of this function are the volumes to be bid on the spot markets or the marginal costs of production. Free capacities and profiles of marginal prices may be obtained by a stepwise variation of demand, which is especially suited for the intraday business. Detailed results as for Generation Scheduler are available for deeper analysis.

Free capacities and a price scale of the marginal costs are calculated with a stepwise variation of the demand (market profile analysis MPROF) so that a complete (lowest bid) offer for the Spot Market can be deduced. Other complex strategies can be adapted if needed.

Trade Optimizing Scheduler belongs to HTC. Markets and contracts are modelled and included in the optimization in addition to the portfolio of the production units so that the aggregate profit (earnings minus operating costs) is maximized. Special interfaces support the interaction of different planning tasks, e.g. between Intraday and Day-Ahead planning.

The decisions from Resource Optimization are considered wherever they are relevant. This is done by using their results as target values at the end of the short-term planning horizon, e.g. for reservoir levels and accumulated fuel consumption. Alternatively, the shadow prices or the combination of targets and price ratings can be used.

**Short Term Load Forecast**

The Short Term Load Forecast (STLF) calculates the power system load for the future hours and days. This power system load is the quantity for planning sufficient generation, spinning reserve and standby reserve. Load is the sum of all individual demands. Each demand or usage pattern is random from the point of view of the computer system. Due to the unpredictability and the diversity of the individual demands, load cannot be calculated exactly by extrapolating the estimated individual demand usage patterns. But the totality of the individual loads results in a distinct consumption pattern which is predicted with methods of different complexity:

- Manually created load values
- Rescaling of weather data
- Data Analysis
- Calculation of the short term forecast
- Manual short term forecast
- Error Analysis
Optimized generation scheduling supports the bidding process and determines cost optimal feasible schedules.

RES Forecast
The principal objective of the RES Forecast (RESF) function is to calculate the power generation from renewable energy source in an area. Two different production types are provided:
- Wind Power Forecast
- Solar Power Forecast

The same methods as used for STLF can also be used for RESF but with typically less accuracy than for STLF. A multiple regression is the fundamental of the RES Forecast.

RES Forecast – Wind Power
In addition to the historic wind generation time series other parameters need to be set up for modeling the wind regression for a wind park:
- cut-in wind speed
- rated wind speed
- rated power
- cut-out wind speed

RES Forecast – Solar Power
The Solar Power Forecast is parameterized by following input:
- Latitude in degrees
- Longitude in degrees

The generation depends on the solar irradiation which is dependent on the location, orientation and alignment of the solar farm.

Short Term Inflow Forecast
The principal objective of the Short Term Inflow Forecast (STIF) function is to calculate the local inflow forecast into a reservoir or river (set up as Inflow Area). This module forecasts the water resources for up to 7 days in a daily time grid. The same methods as used for STLF can also be used for STIF but with typically less accuracy than for STLF. The following historical data are input to STIF:
- Natural inflow to the hydrological system (daily average values)
- Precipitation (daily average values)
- Temperature (daily average values)

The following external forecasts are input to STIF:
- Precipitation (daily average values)
- Temperature (daily average values)

The Short Term Inflow Forecast applies an autoregression model with exogenous variables (ARX). This model uses observations from previous time steps and forecasts of the exogenous variable as input to a regression equation to predict the values for the next time steps.
Medium Term Load Forecast
This module is manually driven and generates an hourly load prediction with a horizon of up to 2 years (medium term load forecast), based on previous years historical load values. A trend correction may be applied to consider the yearly load growth rate. Special days (for example, holidays) are not subject to this forecasting, their forecasts are done manually by the operator.

The Medium Term Load Forecast needs an input of 1 - 5 consecutive years of historical Load in hourly time grid and delivers the hourly average load curve.

References
A team of experts takes care of Spectrum Power™ jROS development, project execution, customer service and maintenance for the last 20 years.

Spectrum Power™ jROS is in operation at more than 50 sites, including, but not limited to, EDP (Portugal), engie (Belgium), Verbund (Austria), ADWEC (Abu Dhabi), MEW (Kuwait), ENEL (Italy), DB (Germany), PLN (Indonesia), Vattenfall (Sweden).