joint Resource Optimization and Scheduler

All forecasting and planning applications in one component.

Answers for infrastructure and cities.
The progressive liberalisation of the energy markets does not only yield new possibilities and chances. It also raises new risks due to the high volatility on electricity markets as well as on 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 total production raises continuously. Risk Evaluation for a given portfolio under the uncertainties of the future development is therefore increasingly essential.

Moreover, this increasing share of renewable energy production reduces the commercial viability of conventional power plants and increases requirements of the system services and regulation reserves. These changes in the business environment of power utilities must be accounted for by the companies’ planning processes.

**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 and may be integrated in the customer’s intranet. It is designed as a shared component of Spectrum Power™. It may be used on a stand-alone base or coupled to other systems with defined interfaces. It 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.
Power System Planning, Scheduling and Forecasting

The tasks of forecasting, planning and scheduling 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.
- Short term wind power forecast for determination of expected generation of wind farms.

All these tasks require the consideration of the technical system as well as the economic and regulatory constraints under the objective of profit maximization / cost minimization. Joint Resource Optimization and Scheduler (jROS) is a component that combines specific tools on one common platform to support all these tasks. 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.

Ready to use

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.

Joint Resource Optimization and Scheduler is the 3rd generation of the forecasting and planning software joining the products

- RO - Resource Optimization
  the tool for long- and medium term planning
- ROM - Resource Opportunity Management
  the tool for managing the physical risk
- HTC - Hydro Thermal Coordination
  the tool for short term scheduling
- STWPF – Short Term Wind Power Forecast
- STLF – Short Term Load Forecast

They share the user interface, the database and run on an identical model, wherever suitable. The algorithms are improved versions of the 2nd generation solutions and specifically optimized for the individual tasks.
Variant Management

Different input parameters (variant sets) or even different data models are supported by use of complete separate copies of the database (cases). One variant may represent either one specific data set (one case) or a bundle of data sets (scenarios), where one or more parameters are varied to perform volatility analysis, Monte Carlo Simulation or Stochastic Optimization.

The user can generate a new variant by copying an existing one or by loading it from a file that was previously exported from database. Such operations are easily accomplished with a few mouse clicks. Variants may be visible for all users or specific for the user who created it.

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).

Workspaces

Several variants can be combined to a workspace. Limiting the user permission on those workspaces allows for separating the system completely, e.g. for serving different departments or even companies by one system.

Since the concept of Workspaces is not available in SCADA-systems, they are considered separate clients, assigned to a dedicated Workspace. Within this Workspace (like in any Workspace) there is only one Variant that contains the process related data, commonly named "Online Variant". This is the only variant that is connected to SCADA in the jROS-system.

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 an interface

Expansion Planning

Expansion Planning is supported by use of RO studying different expansion (and shutdown) scenarios under the effects of economical growth, specific development projects and the development of the fuel, 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 comparison of the different expansion scenarios the planner finds the optimal configuration of the new plants, the expansion schedule and the sites where to put them.

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 considering 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.

Import and export functions (from and to Excel) for demand and price data allow setting up scenarios very quickly. A simplified optimization algorithm based on weekly load duration curves allows solving even big scenarios in a short time.

Maintenance Scheduling

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.

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.

Usually, the time horizon of Maintenance Scheduling is one to several years split into daily or weekly intervals because of the consistency with the maintenance time frame.
Resource Optimization

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).

This gives the operational planner a helpful tool for fuel scheduling, reservoir management, contract management and budget planning.

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.

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

It further offers simulations of future development for market prices and weather situations by calculating scenarios using jROS/SM – Scenario Management. The purpose of the scenario manager is to create future data sets of all external influences of the optimizations, especially market prices of electricity (HPFC, Forward prices) and fuel spot market prices. Monte Carlo Simulation or Stochastic Optimization can consider following inputs as uncertain:

- Spot price schedules
- Fuel price schedules
- Load schedules
- Fixed power electricity contract schedules
- Inflow schedules

Fuel procurement and fuel stock-keeping need to consider all possible scenarios of future market price development.
Trade Optimizing Scheduling

Trade Optimizing Scheduling 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.

Trade Optimizing Scheduling supports this task by scheduling the generation units for the next few days up to one month divided in hourly time grid. A detailed data model considers non-linear efficiencies, start-up costs minimum run and stop times, etc., together with the limitations from fuel supply and the hydrological constraints. 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. The regulation and reserve requirements as primary and secondary regulation, spinning reserve, are considered as they influence the trading opportunities.

Generator Scheduling

Generator Scheduling determines the optimum generation schedules for all available units of the system. It combines the activities of finding the optimum unit commitment, hydro scheduling and hydro thermal coordination with the final load dispatch considering all relevant technical and system constraints.

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 non-linear 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.
Short Term Wind Power Forecast

The Short Term Wind Power Forecast (STWPF) is a prediction tool for transmission and generation companies to forecast the power produced by wind farms. STWPF is based on “Sipreólico”, a Matlab based kernel from Red Electrica de España. This short-term wind power prediction tool uses statistical and combined forecasting methods. STWPF requires historical weather data, forecasted weather data, real time power and weather measurements so it can produce a forecast. STWPF can combine its own forecast with external ones (e.g. provided from agents on the market).

The STWPF Inputs are:

- Meteorological forecasts: STWPF receives files with wind forecasts (wind speeds and wind directions) in a distributed set of geographical coordinates (longitude, latitude and altitude) and close to the location of the wind farms.
- Real time measurements (RTM): these values are received every 15/20/30 or 60 minutes (depending on the time grid) and give the power production of each wind farm. These data are coming from a SCADA system.
- Total wind power estimations: these data are received every hour and give an estimation of the last 24 hours of total wind power produced by the whole system.
- Total external wind power forecasts (optional): these files are received every hour and give a forecast of the total wind power produced by the system. These files can come from an external forecasting tool or from weather forecast agents on the market.

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
- Daytype specific consumption profiles
- Search for historic weather patterns.
- Correlating load values with weather values.

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, GdF-Suez (Belgium), Verbund (Austria), ADWEC (Abu Dhabi), ENEL (Italy), E.ON (Germany), DB (Germany), PLN (Indonesia).
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