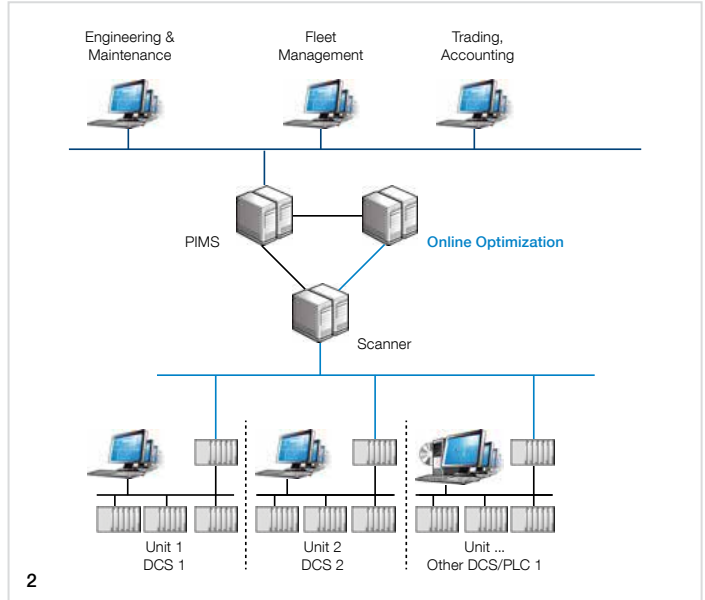
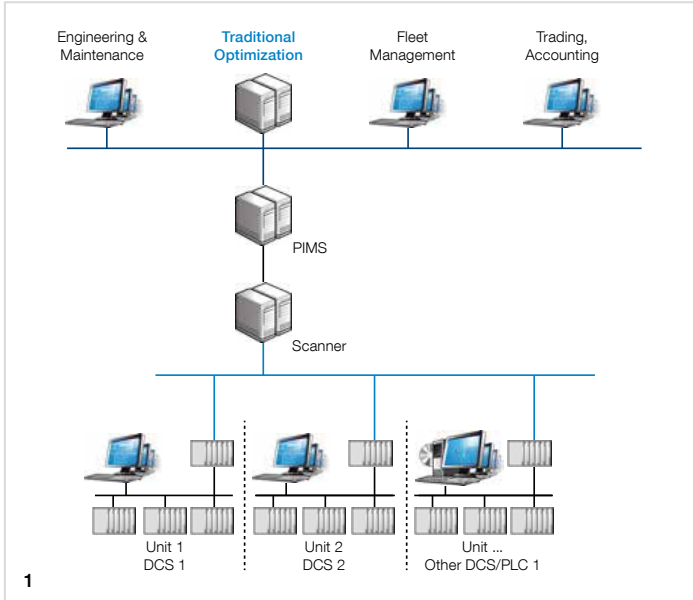


PowerFit

Real-time and intraday optimization of multiple power generation units



1 Classical layout | 2 Today's layout

Traditional multi-unit optimization has become insufficient for companies operating a large number of units under fluctuating market conditions. The required optimization cycle times reduce from daily planning cycles down to seconds, e.g. for pooling of secondary frequency control. The role of human operators changes from being part of the loop to supervision.

OPTIMAX® PowerFit supports the maximization of generation profits of power plants in the dynamically changing utility sector by way of optimized combination of generated power and/or district heating or drinking water, to satisfy the load demands posed by customers. PowerFit is used by municipalities, industrial power plants, and power generation companies, as well as water utilities.

Challenge

With increasing use of renewable energy:

- The number of power production units significantly increases
- The power production needs to be re-planned frequently during a day, in order to account for more fluctuations
- The use of optimization tools shifts to automated optimization in the real-time control system

New opportunities

Facing increasing penetration of renewable energy, new opportunities arise for the trading of power:

- Particularly the increased participation in grid services and intraday trading becomes crucial for the economical result

- Combined heat and power generation is changed from heat driven to electricity driven, exploiting storage capacities on the heat side
- The controllability of renewable generation units is increased
- Pool multiple units and form virtual power plants

This raises the requirement for increased flexibility on the power generation side. Frequent updates during the day complement traditional day-ahead plans for conventional power generation.

ABB introduces a new optimization method that is placed in the real-time control of power plants. This enables the pooling of individual power generation units and their management like one large plant. The real-time optimization receives overall set points and distributes them to each individual power generation unit, considering actual efficiencies, process constraints and temporary limitations. The introduced hierarchy reduces overall complexity and increases the flexibility. Moreover, it solves the power generation task at the best point for the considered units.

Optimization method

Mathematical optimization technology has matured during the last years. Modern optimization solvers treat large optimization programs, including also integers, reliably in fractions of seconds. Even quadratic and nonlinear optimization algorithms perform well in model predictive control applications in real-time.

The mixed continuous/discrete optimal control problem is implemented with mathematical programming and described declaratively using a target function and constraints.

Constraints arise from process equipment and commercial issues. The target function usually minimizes an economic measure like fuel costs or costs for deviations from overall balance.

Continuous-time parts describe the process like boiler or energy storage using continuous-time differential equations. Discrete parts, resulting from switching and from the 15-minute sampling of schedules are described with difference equations. The time horizon typically begins at actual time and reaches to the end of the prediction after e.g. 24 hours.

ABB uses Modelica with pre-defined model libraries, graphical model representation and embedded HTML documentation. This way the details of mathematical programming are hidden from engineers that connect and configure the system model in a graphical user interface.

Application examples

Application	Benefits
Internal optimization of multi-unit plants	Plant efficiency Secondary and tertiary control Flexibility with pools / hierarchy
Combined heat and power	Plant efficiency Secondary and tertiary control Trading
Real-time optimization of pools of biogas plants	Secondary control Minute reserve Direct trading of renewables
Renewable power feed-in management	Grid stability Compliance with laws
Intraday optimization of municipal power	Planned production Direct trading Self-sufficient energy regions

Internal optimization of multi-unit plants

Two large power plants with an installed capacity of 6 x 500 MW and 2 x 500 MW / 1 x 890 MW / 1 x 600 MW, respectively, run a real-time optimization for plant set points and secondary frequency control. The plants units are pooled and multiple units are optimized locally. At the same time, the optimization system automates the communication from the load dispatcher to the control systems of the power generation units, in order to enable the reaction on increasingly frequent updates.

Combined heat and power

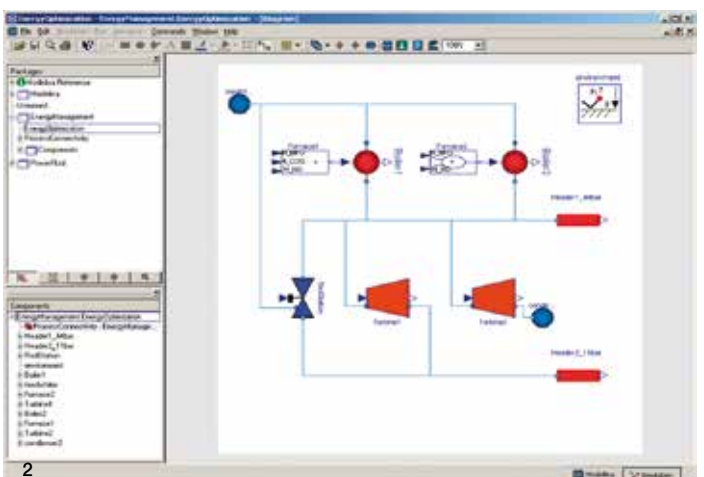
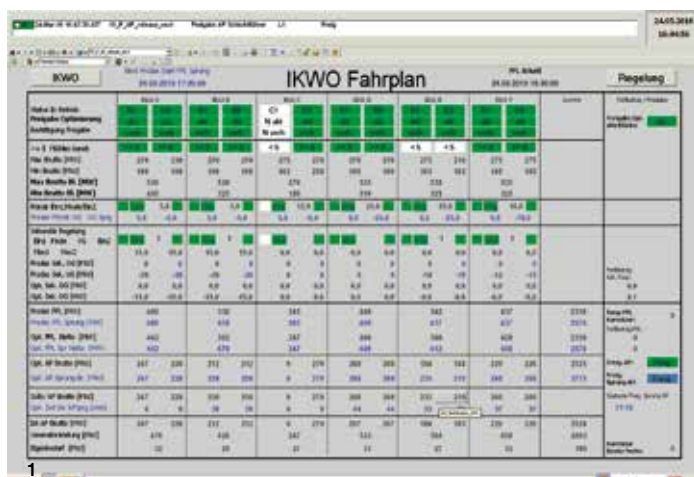
Combined heat and power production is key to improving energy efficiency. The physical interaction between different components on heat side and on electricity side results in complex constraints for the plant operation.

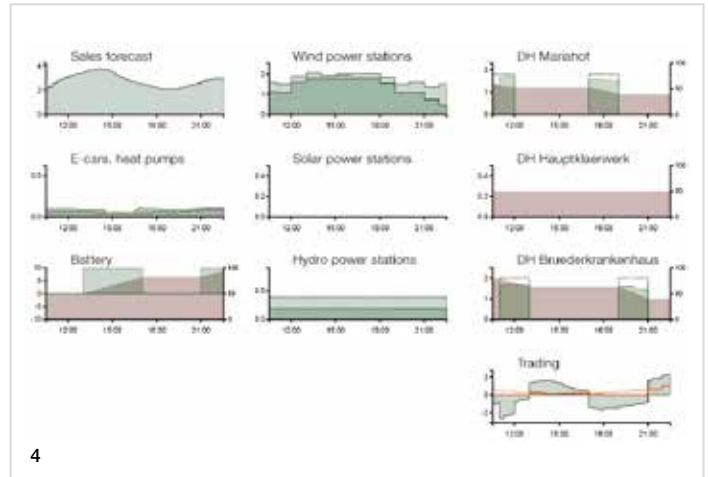
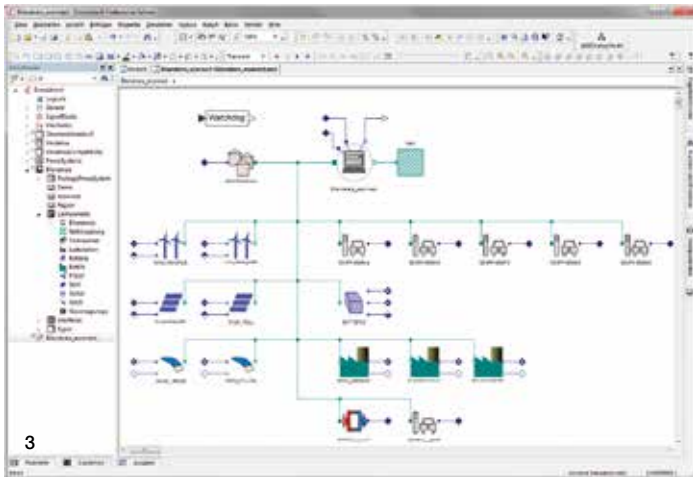
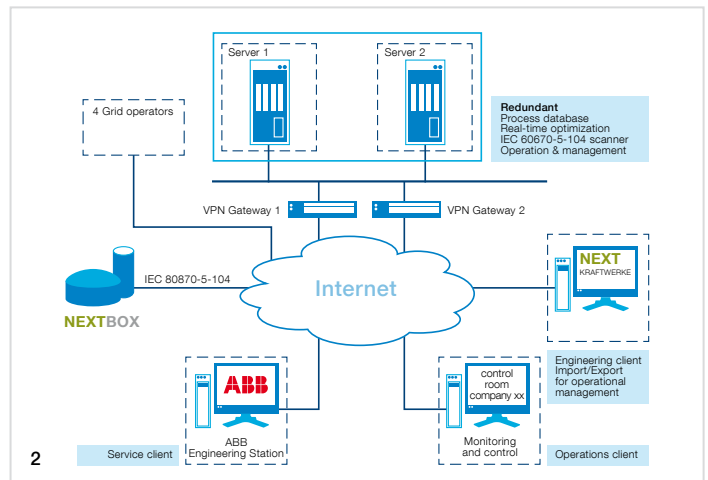
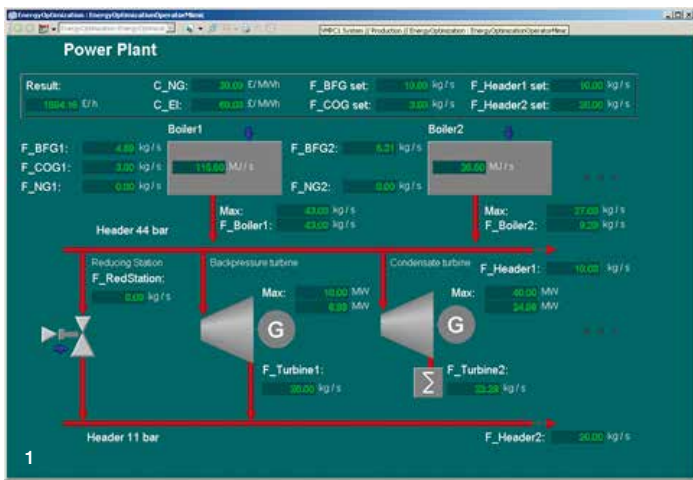
The optimization constraints and the objective cover:

- Constraints per plant component (e.g. min and max load)
- Demands for steam and electricity
- Externally given set points for the recovery boilers
- Fuel costs for coal and biomass

The optimization is integrated into the regular control system and the plant is controlled using regular operator graphics.

1 Operator screen | 2 Plant model





1 Operator screen | 2 Overview Virtual Power Plant (Next Kraftwerke) | 3 Model flowsheet | 4 Intraday optimization result

Real-time optimization of pools of renewable units

Comparable fast load ramps make renewable generation units well suited for the provision of grid services. This is why the direct marketing of renewable power is becoming increasingly attractive. Individual renewable power plants are too small though. The pooling of many small units is required, in order to form a so called virtual power plant with a capacity that is sufficient for the participation in the electricity market.

Intraday optimization of municipal power

Storage capacities enable the temporal decoupling of power production and consumption. Typical storages are latent heat stores of combined heat and power production and pump stores. Moreover, the emerging electric mobility offers a huge potential for future storage capacities.

From a control point of view, storages require a shift from real-time optimization of actual set points to predictive planning of load trajectories. The planning needs to consider a multitude of constraints. For instance, heat storages primarily need to ensure the supply of heat and car batteries primarily have to power the engines.

Intraday optimization enables the optimal use of power generation units and storage capacities, considering constraints and maximizing the economic result. It reacts on new conditions, like updated weather forecasts, by re-planning the power production. This maintains the overall balance and avoids the purchase of expensive regulating power from the transmission net.

The figures show a graphical system model of generation units, consumers and available storages as well as exemplary intraday optimization results. Under the condition that more renewable power than planned is available; the production of the combined heat and power units is reduced (see green filled areas vs. dotted green lines of original plan for BHKWs). The solid red line under Handel, compared to the dotted red line, shows that the overall balance can be kept this way. This leads to a discharge of the heat buffers though (filled red are as under BHKWs). The battery is charged at times when too much power is available.

The intraday optimization runs regularly during a day. The results are used as set points for the control system.

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