

Tapping technology

Optimizing the water supply for the city of Basel
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Tap water is not guaranteed to everyone on the globe. But in places with guaranteed access, tap water is a normal part of households. Its average consumption lies at around 120–160 litres per person and per day (trend decreasing).

In the western world, tap water is expected to be of drinking quality and permanently available. However, the quality of water collected from sources or ground water rarely meets the strict demands of water authorities.

To make the production and supply of high-quality water economical, a process of production and distribution is required that is well controlled and supervised.

Automation permits operation and maintenance costs to be reduced and simplifies cooperation between water supply installations over larger areas.



Process collaboration

Natural drinking water is collected from springs and from the ground water. In most cases the amount of natural drinking water collected is insufficient and additional water must be procured from other sources. During its production, this water passes several treatment stages in which its quality is improved until it reaches drinking quality. After having passed the filters to eliminate rough particles, the water is drained into forest areas to enrich the ground water. The water is biologically and physically treated during this draining process. By using low-pressure pumps the water is carefully extracted from the ground. Some chemical post-processing is performed – if required – before the water is pumped into the pipe distribution system. The topology of the pipe system and the area to be supplied with water determine the pump strategy.

Powerful diagnostic tools help identify performance deviations permitting corrective actions to be taken early.

Plant optimization solutions

In order to be cost-efficient, utilities are constantly striving to optimize plant operation and to reduce life-cycle costs. Powerful diagnostic tools help identify performance deviations permitting corrective actions to be taken early.

The ABB OPTIMAX® Plant Optimization range offers a variety of products and solutions to address these requirements in the power generation and water business [1]. These systems may offer utilities complex generation portfolios which are seeking to optimize the costs and energy generation, whether they relate only to electrical energy or to a combination of electrical energy and other forms of energy (heat, water, waste, etc.).

Modernization of the water supply automation at IWB

The municipal utility of Basel (IWB) **Factbox** currently oper-

ates a water supply system consisting of:

- 12 high pressure pumps
- One internal ground water drainage and collection area, including 12 wells (with low pressure pumps)
- One external supplier
- Three double chamber reservoirs
- Roughly 26 million m3 of annual delivery

Apart from wishing to modernize the automation system for water production, IWB also required a solution for optimizing its operation and maintenance activities. The IWB concept is called “optimized unattended operation” and is characterized by its ability to function without the presence of an operator at the remote pumping (or reservoir) stations; permitting this to

fulfil other important tasks in the overall operations and maintenance activities.

Control systems in large municipal utilities or power plants usually involve an investment of several millions of dollars for hardware and engineering.

As part of this concept, IWB requested an optimized solution that can take a given load demand (water consumption) and determine the best operating schedule of pumps and wells, taking into account a set of infrastructure-defined constraints. Such a task can be formulated as a load scheduling problem. The operations and maintenance staff expected the new solution to be at least as good as their previous practice.

In unattended operation, an intelligent controller has to deliver schedules for the set points of pumps and wells that were previously defined by the operators. The optimization criteria are:

- the water supply itself
- achieving the required water quality
- keeping the costs for operation and maintenance as low as possible

In other words – and this time in mathematical terms – the optimizer solves a hybrid problem consisting of continuous variables (eg, flows, levels, energy etc.) and discrete variables (as for example switching the plant equipment on/off). By using Model Predictive

Control (MPC) and more recent developments, such as Mixed Logical Dynamic (MLD) Systems [2], this solution can be implemented as part of the ABB OPTIMAX® software applications.

Close cooperation between IWB and ABB

When the plant is operated in unattended mode, it must fulfil the same performance criteria as a manually operated plant. To define the design concepts and guarantee that the necessary intelli-

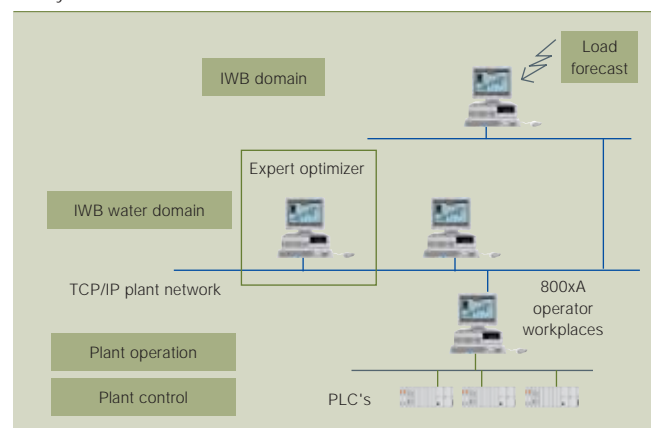
Factbox IWB

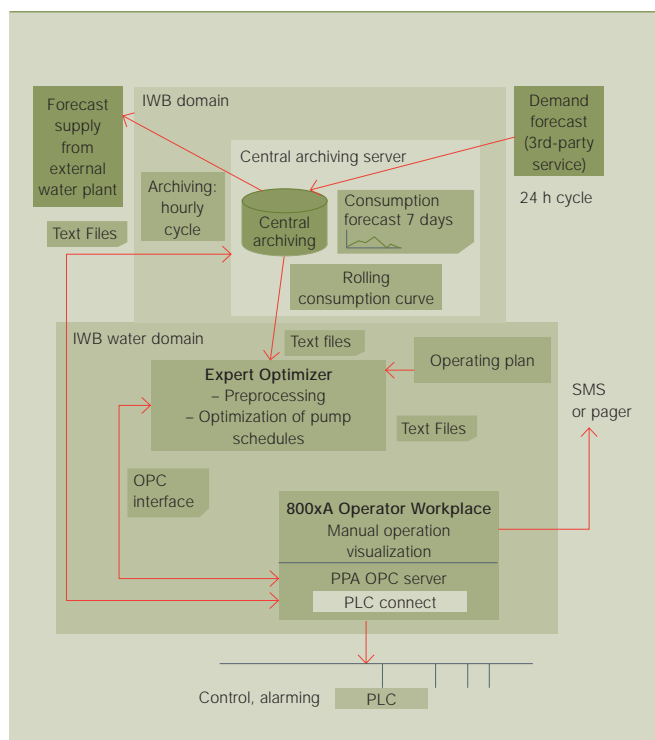
IWB (Industrielle Werke Basel) provides the canton of Basel and the location of Binningen with high quality drinking water. Since the 1st January 2007 the drinking water from IWB has its own designation: bälAqua.

One thing that is special in Basel is the so-called biological treatment after the fast filtering plant. This means that woodland areas with groundwater are flooded from time to time with Rhine water for a mechanical and biological purification. This biological purification process is unique in the world and has potential for adaptation for the needs of other locations.

For further information see www.iwb.ch

System architecture






gence is implemented in the optimizer software, IWB and ABB cooperated closely from the launch of the project. While ABB mainly contributed the automation and optimization know-how, IWB provided the specific plant knowledge and operational experience.

A customized solution

The underlying automation system
ABB's System 800xA includes functionalities of common operator consoles and provides access to any customer's hardware, allowing the integration of all equipment already installed in a typical plant.

Control systems in large municipal utilities or power plants usually involve an investment of several millions of dollars for hardware and engineering. Rather than calling for total replacement, ABB's system safeguards this investment. By selecting ABB's system 800xA, IWB opted for a process control system with a broad range of new functions while maintaining a uniform user interface over different underlying controller families.

The developed solution: optimizer

The solution is based on 800xA and the ABB Expert Optimizer . From an

operator workplace the plant's past and predicted trends can be monitored. If desired, the operator can switch the optimizer from closed loop to open loop, which means switching to manual control mode.

Deviations from the schedule are continuously monitored and schedules are adapted where necessary.

The unattended operation is influenced by the operating plan which may contain some given pump set points or constraints (for example: restricted pump or reservoir availabilities due to maintenance work). The water demand forecast is received every day with an hourly resolution. This forecast is determined by prognosis software which considers the SwissMeteo weather forecast for the next 7 days. These data are provided to IWB through an online email service. Based on these data and constraints, the Expert Optimizer calculates the optimal operation schedules for pumps and wells.

The communication from the data archive and the operating plan to the

Expert Optimizer is via text files, and the data exchange between the Expert Optimizer and the 800xA workplace goes via OPC²⁾. The pumps and wells set point schedules are sent to the PLC¹⁾ well in advance for safety reasons.

Since the water demand forecast is subject to some uncertainty – and since wells and pumps may potentially trip – the levels of reservoirs and wells are supervised and checked against alarm limits by the PLC. An alarm triggers a recalculation of the optimization and generates new scheduled set points, which take into account the changed conditions. In parallel, the operating personnel is informed by SMS or alarmed by pager in case their action or approval is required.

After detailed design specifications, jointly discussed between IWB and ABB during regular review meetings, the basic software functions were tested at ABB works during the factory acceptance test and were then installed on site. The system was extensively tested by the customer in the open

Footnote

¹⁾ PLC: Programmable Logic Controller

²⁾ OPC: OLE for Process Control

Process collaboration

2 Status of water wells. In this example, the flows from the different wells (blue, green and yellow) are equal



3 Filling the virtual reservoir: the actual level (green) follows the optimal set-point (yellow) and stays within the tolerance limits (orange)



loop mode, the optimizer's recommendations were checked and adaptations were made, if required. After having successfully finalized this trial period, the optimizer will be switched to closed loop operation.

2 and 3 show examples of the optimizer's displays.

Summary

The municipal utility of Basel (IWB) required a solution to significantly increase the degree of automation and optimization of water production – optimized “unattended operation”. Based on an online water consumption forecast, the ABB solution determines the optimized schedule and set points for the pumping stations and groundwater wells. Deviations from

timization project is a good example of a pilot project in terms of a new operational concept introduced by the customer.



Operating personnel is informed by SMS or alarmed by pager in case their action is required.

the schedule are continuously monitored and schedules are adapted where necessary. The system runs in closed loop and automatically pages service personnel in case they temporarily need to intervene. Solution concepts were jointly developed with the customer. The main customer benefit is the reduction of operation and maintenance costs while maintaining the water quality and supply guarantee.

The successful cooperation between IWB and ABB in the water supply op-

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- [2] Gallestey, E, et al., Using Model Predictive Control and Hybrid Systems for Optimal Scheduling of Industrial Processes, *Automatisierungstechnik*, vol. 51, No. 6, 2003.

See also

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