Breathing new life

Water supply technology is used to tackle the critical global problem of decreasing fresh water supplies

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It covers two thirds of the Earth's surface, comprises 75 percent of the human body and is one of the prime elements responsible for life on earth. Even though the percentage of the world's water usable to humans is very small, there is actually enough water on the planet to satisfy the demands of a growing global population. However, an estimated one-third of the population currently lives in water-stressed countries, and by 2025 this estimate is expected to rise to two-thirds! One of the reasons for this is water quality. In many populated areas, exploitation and contamination have transformed usable water into a chemical cocktail unsuitable for human consumption or use. Another is the inefficiency in the way much of the water is used. Ineffective transportation and distribution systems also contribute to poor water access and increased water loss.

Using new and improved technology, ABB is supporting water utilities as they work to increase access to more usable water as well as reusing treated wastewater.

Water is a valuable resource but unfortunately the supply of fresh water is on the decrease while demand is on the increase. Lack of fresh water reduces economic development – as water is needed for industrial growth – and lowers living standards. Agriculture uses a large percentage of the available fresh water, and inefficiency and wastage, especially through irrigation, is on a prodigal scale. Pollution is making more of the available water unfit for use. Governments realize that there is a critical need to better manage this valuable resource and are constantly seeking ways of solving their water problems.

1 The reverse osmosis (RO) desalination plant number R.O.-1 in Saudi Arabia has increased its installed desalination capacity by 50,400 m^3 per day!

Exploitation and contamination have transformed usable water in many areas into a chemical cocktail unsuitable for human consumption or use.

With many years experience combined with its vast product and service portfolio, ABB is helping water utilities to improve water quality and distribution in areas that need it most. By focusing on the electrical and automation processes, ABB can help develop, optimize and maintain vast water networks around the globe. These improvements have or are currently taking place in:

- Upgrading desalination plants
- Upgrading Water Transmission Systems (WTS)
- Pump Efficiency Metering System (PEMS)
- Water Distribution Systems (WDS)
- Water Leakage Management Systems (WLMS)

Desalination

There are some ways of tackling the problem of eroding fresh water supplies: effective irrigation systems; or the planting of less water-intensive plants for example. As there is an abundance of salt water covering the planet, desalination is another option. Water is desalinated in order to be converted to fresh water suitable for consumption or irrigation, and in many cases it is the only way of providing fresh water in regions where the availability of water is severely limited.

There are three main desalination processes:

- *Multi-stage flash (MSF).* Used in large applications, MSF is a multi-stage distilling method whereby the seawater is heated and the ambient pressure lowered so the water "flashes" into steam. Each stage is held at a lower pressure to the previous one.
- *Multiple-effect distillation(MED).* MED gets its name from the fact that more than one boiling chamber or "effect" is used to produce distilled water. Used in medium-sized applications, seawater is boiled in a sequence of effects, each held at a lower pressure than the one before. Vapor from one series is subsequently used to heat the next. Only the first vessel (at the highest pressure) requires an external heat source.
- *Reverse osmosis (RO):* Brackish water[1)] or seawater is pumped at high pressure through a permeable membrane in a closed vessel. Concentrated brine remains on one side of the membrane and portable water on the other side. Historically RO technology has been used in small- and medium-sized plants. Because it is considered the most cost-effective desalination solution, RO methodology is used in large applications today.

Desalination typically requires large amounts of energy and is often cited as an expensive solution, especially when compared with water production in treatment plants. Depending on the desalination process used, the energy required consumes between twenty and sixty percent of the total production cost – RO being the least expensive process in terms of energy requirements and MSF the most expensive. However, production costs in desalination plants during the last few decades have fallen by more than a factor of four. ABB has been working to reduce these costs even further by developing highly efficient electrical equipment.

It is not surprising that a large percentage of global desalination plants are located in the Middle East as rapid growth has increased the need for power and water services.

More than 13,000 desalination plants are in operation worldwide [1]. The rapid growth of recent years witnessed in the Middle East has brought with it the need for basic infrastructure like power and water services, therefore it is no surprise to learn that a large percentage of global desalination plants are located in the Middle East[2)]. ABB has been closely associated with the upgrading of one of these plants, the Yanbu RO desalination plant in Saudi Arabia.

Yanbu desalination plant

The RO desalination plant (Number R.O.-1) in Yanbu, in the Kingdom of Saudi Arabia, consists of six trains with high pressure pumps 1. The installed desalination capacity in this area has been increased by 50,400 m^3

per day to a total capacity of approximately 146,000 m³ per day. The complete desalination plant was contracted to the SBG-PCM division by the Royal Commission of Jubail and Yanbu. SBG-PCM then subcontracted the main electrical parts, such as medium-voltage switchgear systems, transformers, low-voltage switchgear systems, motor control centers, the plant control system and the plant operation training simulator, to ABB. The project was completed in March 2007.

Water Transmission Systems

Getting the water to where it is needed is the job of a Water Transmission System (WTS). A WTS consists of multi-point to multi-point connections over several hundreds of kilometers, stretching from the supply side to the demand side. The water is collected from natural resources such as well fields, rivers or lakes, or from man-made resources, for example dams, water treatment or desalination plants.

Footnotes

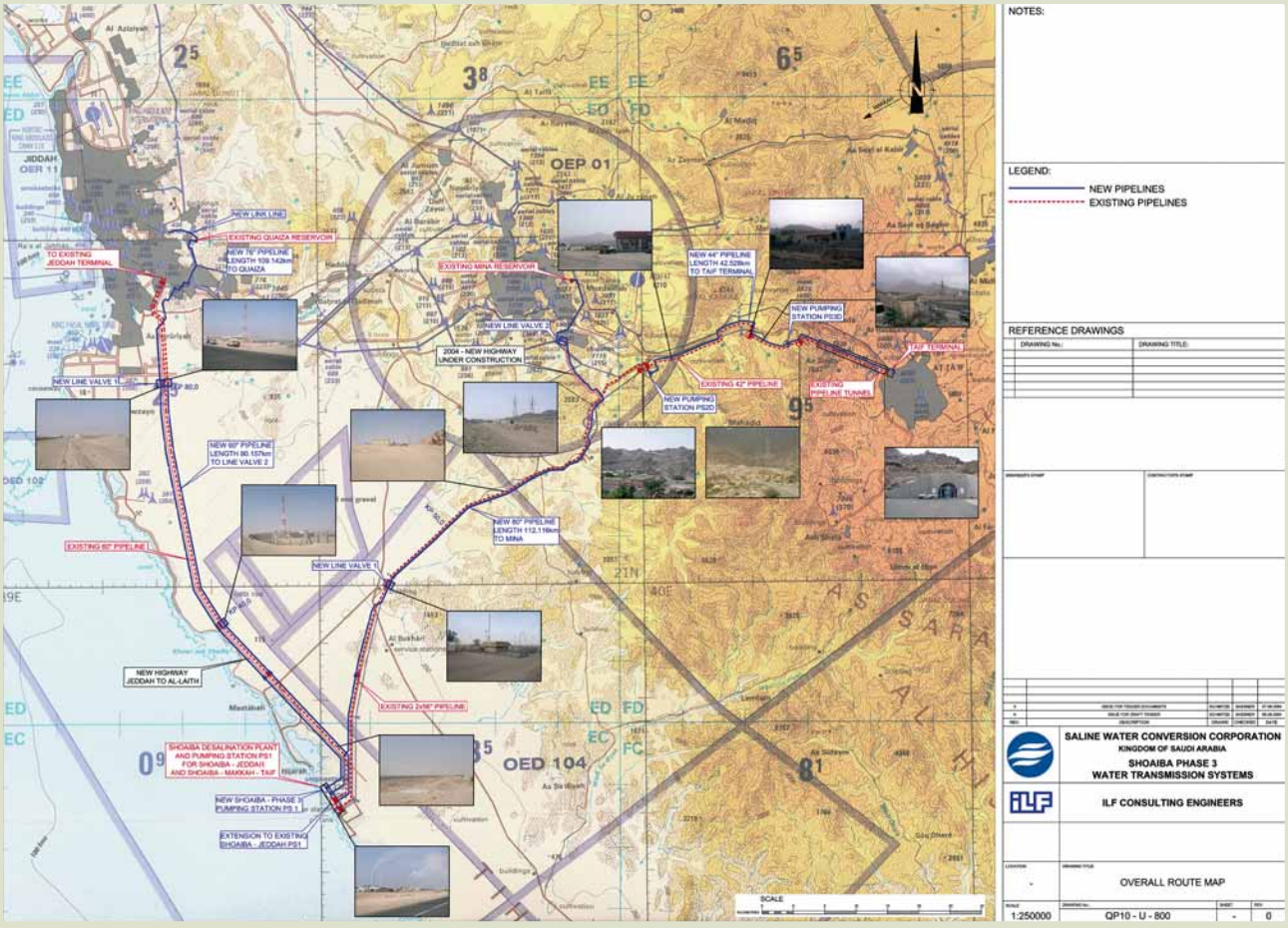
[1] Because it has a lower salt concentration, the cost of desalting brackish water is generally less than that of desalting seawater.

[2] According to the 19th IDA worldwide desalting plant inventory, a combined capacity of 47 million cubic meters were contracted up to December 31, 2005. A comparison between the average annual capacity contracted between 2001 and 2005 and the average annual capacity contracted over the previous five years suggests the market for new capacity is growing at the rate of 25 percent per year. Thirty-three percent of the new capacity contracted in the past two years has been for customers in the Arabian Gulf.

Factbox 1 Increasing pipeline capacity through the Shoaiba WTS project

Pipeline	Shoaiba Jeddah	Shoaiba Quaiza	Shoaiba Mina	Makkah Taif PS 2D	Makkah Taif PS 3D
Initial design capacity	60 MIGD	65 MIGD	100 MIGD	40 MIGD	40 MIGD
Ultimate design capacity	60 MIGD	130 MIGD	127 MIGD	40 MIGD	40 MIGD
Booster pumps initial	3 + 1 × 900 kW	2 + 1 × 1,500 kW	4 + 1 × 1,400 kW	N.A.	N.A.
Booster pumps ultimate	3 + 1 × 900 kW	4 + 1 × 1,500 kW	5 + 1 × 1,400 kW	N.A.	N.A.
Main pumps initial	3 + 1 × 3,100 kW	2 + 1 × 2,800 kW	4 + 1 × 10,300 kW	3 + 1 × 7,800 kW	3 + 1 × 7,800 kW
Main pumps ultimate	3 + 1 × 3,100 kW	4 + 1 × 7,300 kW	5 + 1 × 10,300 kW	3 + 1 × 7,800 kW	3 + 1 × 7,800 kW

2 The Shoaiba WTS P3 project, currently in progress in the western region of Saudi Arabia, consists of a 344 km pipeline system that will transport desalinated water to the cities of Jeddah, Taif and the Holy City of Makkah.



3 The Sarir/Sirt and Tazerbo/Benghazi pipeline system is part of the Great Man-Made River Project (GMR), which aims to transport enough water to the northern Libyan coastline where the majority of the population lives.

At the end of a transmission system, the water is distributed into reservoirs close to the cities. A WTS can create a bottleneck in the water supply and this must be resolved before the reservoirs can be emptied.

ABB's Pump Efficiency Metering System (PEMS) calculates efficiency by processing water temperatures, water pressures and the motor power associated with each pump.

Availability has a higher priority than cost efficiency, and using the Shoaiba WTS project in the western region of Saudi Arabia as an example 2, ABB has shown it can help increase system availability in a redundant design by delivering reliable electrical and control equipment.

Shoaiba WTS

In the Shoaiba WTS (phase three) project, a 344 km long pipeline system will transport desalinated water to the cities of Jeddah, Taif and Makkah. The client is the Saline Water Conversion Corporation (SWCC). The pumping stations and the construction of the water pipeline has been contracted to a consortium composed of Saudi Services for Electro Mechanic Works Co., Ltd. (SSEM), Al-Rashid Trading and Contracting Company (RTCC), and HAK. SSEM has subcontracted the major electrical parts, such as the extension of high-voltage switchgear systems, medium-voltage switchgear systems, medium-voltage motors, transformers, low-voltage switchgear systems, motor control centers, and the pipeline control system and a pipeline leakage detection system, to ABB. The project is currently in progress but when it is completed pipeline capacity will have increased significantly Factbox 1.

Sarir/Sirt and Tazerbo/Benghazi WTS

The Sarir/Sirt and Tazerbo/Benghazi pipeline system is part of the Great Man-Made River project (GMR) 3. Under the desert in southern Libya significant fresh water reserves are available, most of which were collected between 15,000 and 35,000 years ago in four major underground basins. Within the GMR project this water is transported to the northern coastline, where the majority of the Libyan population lives.

The Great Man-Made River Authority (GMRA) contracted the automation system, a pipeline simulator and the instrumentation work to ABB. The pipeline simulation system will model the water hydraulics up to 14 days into the future and will help GMRA to run the entire complex water supply system from the well fields to the reservoirs at the coastal area in a demand driven way. The project is currently under execution.

Pump Efficiency Metering System

The advanced Pump Efficiency Metering System (PEMS) 4, which uses ABB patented technology, continuously monitors and records the flow and efficiency of each pump. Based on a thermodynamic measuring method (in accordance with the British Standard EN ISO 5198[3]), PEMS calculates pump efficiency by processing water temperatures, water pressures and the motor power associated with each pump. Extremely sensitive temperature sensors – precisely calibrated – measure the pump's suction and delivery water temperature.

One of the key components of PEMS is the high accuracy delta-T transmitter (HADTT), which was developed and patented especially for this application. HADTT enables extremely accurate (in the mK range) temperature difference measurements, and it guarantees long-term stability because of pre-aging during manufacture. Additionally, intelligent pressure transducers from ABB, with typical accuracies of 0.075 percent, provide a high degree of flexibility with regard to metering ranges.

Continuous pump efficiency and flow measurements save energy and costs by enabling the operator to choose the most efficient pump or combinations of pumps. More than 95 percent of a pump's life-cycle costs are energy costs. By analyzing the recorded

Footnote

[3] BS EN ISO 5198 refers to centrifugal, mixed flow and axial pumps. Code for hydraulic performance tests, precision class.

pump efficiency, PEMS software proposes specific maintenance activity within a planned predicative and proactive maintenance program.

As fresh water supplies dwindle, new methods are needed to make use of the water that is available without the added burden of higher costs.

Water Distribution Systems

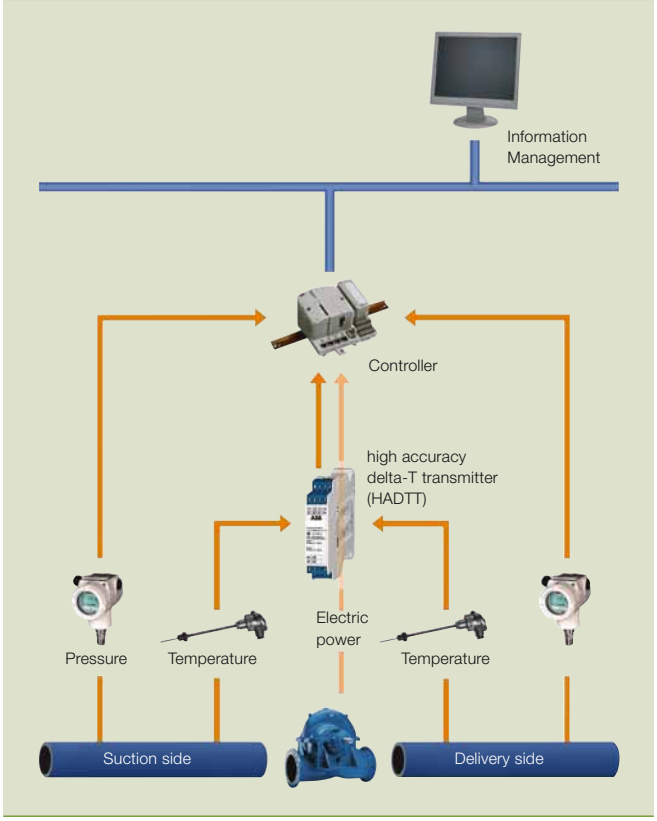
Water Distribution Systems (WDS) are meshed networks with possibly thousands of kilometers of pipes. The water is collected from resources, water treatment or desalination plants. The end-point of a WDS is the service pipes that feed industrial and residential buildings, farmlands or private households. In some areas two systems are installed: one serves agricultural industries and green lands with reused or fresh water, while the other distributes potable water for human consumption.

The target of an operational company is to continuously supply water in a defined quality at the lowest cost. To help companies – such as the Water and Sanitary Authority Makkah al Mukarramah in Saudi Arabia – met this target, ABB can increase pumping station availability through its design of a proper electrical and control system and by delivering reliable electrical and control equipment. ABB SCADA systems support operators by optimally running their water distribution and irrigation, and service managers by keeping water leakages as low as is economically justifiable.

The Makkah Al Mukarramah pumping station

The Makkah al Mukarramah pumping station 5, completed in 2004, supplies drinking water to several reservoirs and water networks connected to the Holy City of Makkah. Using pumps or gravity, water is delivered from one DN 1600 suction line – with a pipe branch to the Arafat reservoir – into four possible discharge lines ranging in size from DN 800 to DN 1100. As the subcontractor, ABB was responsible for the complete mechanical work, installation of electrical systems such as medium-voltage switchgears, medium-voltage motors, transformers, emergency power supply, low-voltage switchgears, instrumentation and an automation system, as well as the SCADA system for the pipeline network.

4 ABB's Pump Efficiency Metering System (PEMS) calculates pump efficiency by processing water temperatures, water pressures and the motor power associated with each pump.



Water Leakage Management System

One of the major issues affecting water utilities in many developing countries is "non-revenue water" (NRW), ie, the difference between the amount of water put into the distribution system and the amount of water billed to customers. High levels of NRW result from losses that are real (though leaks) or apparent (through theft or metering inaccuracies).[4)]

The Bangkok metropolitan water system is one of the largest in the world. It supplies some 13 million people in Bangkok, Nontaburi and Samutprakarn with 1,628 million m^3 of potable water a year via 24,328 kilometers of pipeline over an area of 1,855 square kilometers. However, the NRW level of the Metropolitan Water Authority (MWA) was greater than 40 percent. This value needed to be reduced to a maximum of 30 percent and MWA called in ABB to help. ABB installed its water leakage management software (WLMS) which calculates water losses at 1,000 measuring points across Greater Bangkok, allowing leaks to be isolated and quickly corrected.

Neptune

As fresh water supplies dwindle, new methods are needed to make use of the water that is available without the added burden of higher costs. In the spring of 2007, 11 companies and uni-

Factbox 2 The companies and universities involved in the NEPTUNE project

- Imperial College of Science, Technology and Medicine
- University of Sheffield
- University of Exeter
- The Chancellor, Masters and Scholars of the University of Cambridge
- Lancaster University
- De Montfort University, Leicester
- University of Leicester
- Yorkshire Water Services Ltd
- Engineering and Physical Sciences Research Council (EPSRC)
- United Utilities PLC
- ABB

Footnote

4) As well as real and apparent losses, NRW also consists of unbilled authorized consumption which can include water used for fire fighting or that provided to religious institutions. NRW is a key indicator for the quality of a water distribution system.

Factbox 3 The three main research priority areas (RPAs) associated with the NEPTUNE project.

RPA1: Sensors, data and knowledge
The aim of RPA1 is to develop pragmatic, robust and novel methods and technologies (eg, sensors and communications, and artificial intelligence and mathematical simulation technologies) to understand system performance in real time.

RPA2: Pressure management
The overall aim of RPA2 is to develop a novel approach and practical tools for pressure management to improve customer service, efficiency and the sustainability of water distribution systems, and to test implementation concurrently with energy management and leakage reduction.

RPA3: Risk-based decision support
The aim of RPA3 is to develop an integrated, risk-based decision support system to evaluate intervention strategies (both tactical and strategic), which in turn aid decision making for sustainable water system operation.

versities Factbox 2 joined forces to work on a research project[5] whose aim is to reduce the cost of water distribution and to improve water supply quality. Known as the NEPTUNE project, it covers:

- Pressure and energy management
- Information management
- Decision support tools

The project has three main research priority areas (RPAs) Factbox 3, each of which has individual work packages (WP).

With a growth rate of nine percent per annum expected in the global water market, water utilities will need to modernize and optimize their operation and maintenance activities.

A growing market

The global water market is expected to grow at a rate of nine percent per annum. Like any other plant facility, water utilities need to modernize and optimize their operation and maintenance activities. Effective automation systems and processes help reduce operation and maintenance costs and simplify cooperation between water supply installations over larger areas.

With its strong technology base and expertise, in particular in the areas of electrical systems and automation processes, ABB has an opportunity to achieve significant profitable growth in this market area. To support this aim, a strategical initiative was founded in the middle of 2007 to focus specifically on technology implementation, marketing and sales for the water market.

Water is effectively the source of life. Breathing new life into water plants helps to give and sustain this life.

5 The Makkah al Mukarramah pumping station supplies drinking water to several reservoirs and water networks of the Holy City of Makkah.

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Footnote

[5] The project is formally titled, "Delivering sustainable water systems by optimizing existing infrastructures via improved knowledge, understanding and technology – Project NEPTUNE."

Reference

[1] **Kranhold, K**. (January 17, 2008). Water, Water, Everywhere . . . , Seeking fresh sources, California turns to the salty pacific, The Wall Street Journal.