Downloading the cloud

The Spanish experience of smart irrigation with Neptuno

ENRIQUE MONSALVE, LUIS LLORENTE – Despite being one of the most abundant substances on Earth, only a tiny percent of water is directly usable by humans [1]. In less than 50 years water has gone from being considered inexhaustible and cheap to being seen as a scarce resource that must be husbanded and carefully distributed. The United Nations has proclaimed 2005–2015 as the International Decade of actions in "Water for life" [2] and have included in their Millennium Development Goals [3] halving the number of people without regular access to drinking water by 2015 and developing sustainable sources. At the same time, more than 70 percent of the fresh water consumed worldwide is dedicated to agriculture (up to 95 percent in some developing countries), followed by industry (22 percent) and domestic (8 percent) [4]. Therefore, policies linked to agriculture's use and modernization have a large, direct impact on the development and optimization of the use of water. The Neptune system provides support in achieving this goal while increasing the crop yield and improving the standard of living of the farmer.

1 Field installation of an irrigation Neptuno RTU

World population has increased from 2,500 million people in 1950 to 7,000 million today and projections expect a further increase of 2,000 million by the year 2030 [5]. This means that mankind will need to produce more food, 80 percent of the production which will require irrigation. Although each person consumes from two to five liters of water per day, an average of 3,000 liters are required to produce the food a person eats daily [6]. And this figure increases every year as the consumption of meat and vegetables increases while that of cereals decreases. However, the availability of water for agriculture is limited by the increasing demand in other sectors where the price is higher (industry and households), the degradation and distribution of water resources and the need to achieve environmental sustainability. All these issues force a production increase which must be achieved through infrastructure policies, the increase of irrigated areas (that multiplies production by two or four [1]), the modernization of agriculture and the technification of farmers. This is where automation and irrigation play a major role.

Title picture
Increased food production requires a modernization of agriculture and a technification of farms.

Specific aspects of irrigation automation

The automation of irrigation in the agricultural sector faces some very particular challenges since the control elements are usually outdoors, in extreme weather conditions, located in areas with ground and heavy machinery movement, highly distributed geographically and without access to a continuous power supply. Thus, solutions used in other sectors are not usable here (eg, communication cable or locally configurable and programmable equipment).

Irrigators, or their associations, seldom have enough knowledge or resources to maintain an automation system. Often their facilities do not have the minimum conditions to support a control system with 24 hour availability. This makes the local SCADA a problematic issue in these projects.

On the other hand, to achieve the best results with the control system, the need to have specific infrastructures owned and maintained by the end user must be avoided; a narrow-band or private radio communication is usually not an ideal solution. Similarly, a classic SCADA solution, where the operation of the system depends on local servers, does not seem the most appropriate or the most maintainable solution in such environments. With this in mind, ABB developed a specific solution for irrigation.

First approach, Neptuno irrigation solution

The basic Neptuno solution for irrigation is made up of remote terminal units (RTUs), the SCADA and communications.

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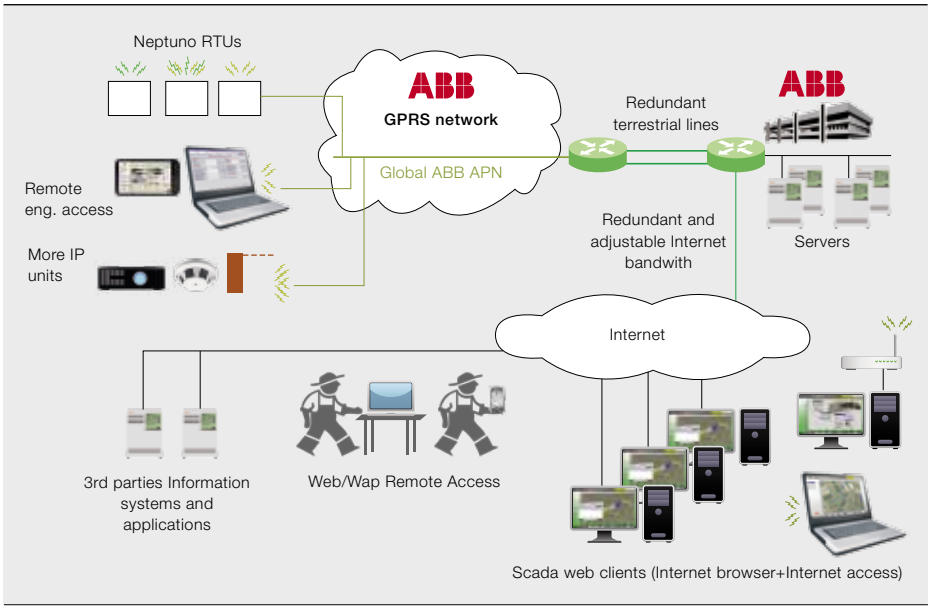
Neptuno RTUs are designed to manage irrigation information and control signals in environments without electricity and so are powered with rechargeable batteries (recharged by a small solar panel, hydro turbines or other means) or with special lithium ion batteries. The hardware is designed to minimize energy needs. The irrigation valves are activated

2 Neptuno solution scheme, including ABB GPRS network and remote access



The SCADA Neptuno not only displays RTU status, alarms, events, reports and historical data, but it also communicates via SMS and email and allows users remote internet access.

through pulses and with intelligent management of water meter and other existing signals, be they digital (intrusion . . .), or analog (pressure, humidity, etc) readings. Communication using GPRS modems (data on mobile phone) allows the installer to place the RTUs anywhere and change their location or quantity without having to create, modify or maintain a proprietary communication infrastructure ➔ 1. The only requirement is to have adequate mobile operator coverage. The unit can be controlled, configured and reprogrammed (firmware upgrade) remotely.

The Neptuno protocol minimizes network traffic (bytes) and allows adjustment of communications energy consumption to be the minimum necessary in each case. The RTU can be configured to have its communications normally off, activating them only when one of the preselected events or alarms occurs, such as at a given time (eg, pre-specified minutes, hours or days), at a pulse from the meter, the beginning or end of an irrigation program, when the analog input reaches a given value, etc. Thus the RTUs control the irrigation autonomously (up to four irrigation programs, delimited by time and/or volume, per day of the week) dating and recording all events or alarms. When any of the preselected events occur, the unit instantly activates the modem, communicates all the stored information to the SCADA, receives the SCADA information and/or instructions and shuts down communications. This way energy needs and communications are reduced to the minimum. The unit can be configured to be permanently connected, or in a mixed mode (asleep for a certain time and online for the rest), and the mode of operation can be modified at any time, individually, for each unit.

ABB's GPRS network use a private APN (access point network), secured by IPSec, that can't be accessed from the outside and with a configuration that allows users to assign a fixed IP address to each remote within the network ➔ 2. This way the information is secured and, at the same time, the amount of communications and the transmission time is reduced.

The use of GPRS provides flexibility and immediate availability while maintenance of the network and security are the responsibility of the mobile operators and the cost has been reduced in recent years. Although the client can contract the communications themselves (Neptuno system is open) ABB has reached agreements with global mobile operators to offer lower prices and a level of support that would normally be beyond the reach of customers. Thanks to these agreements ABB can offer complete maintenance support of the project, from the field to the central system.

3 Mobile phone SCADA interface for customers

4 CSIS system interface

The Neptuno system has evolved into CSIS that enables access to the SCADA interface through standard web technologies, using the SaaS concept. The customer does not need to have or maintain any specific infrastructure.

The Neptuno SCADA is able to manage the reception of signals, events and alarms and to control the transmission of communications and orders to and from the RTU asynchronously. In addition to displaying the status of the RTU, managing orders, alarms, events, reports and historical data the SCADA Neptuno can send alerts via email or SMS warning when certain events occur. SCADA Neptuno also has mobile engineering stations that can connect to the remote units from any location.

Second approach, the farmer in charge

All of the RTUs can be controlled and monitored from the SCADA, but in some irrigation communities this is not enough because the farmer wants to personally determine irrigation for his crop. To accomplish this, the Neptuno system has integrated a secure web and wap access allowing the farmer to monitor and modify irrigation from anywhere with internet access, including PCs, smartphones or even mobile phones which only have wap facilities → 3 and 8. Each user has a name and password that grants access to a series of RTUs with a certain level of authorization, eg, visualize, actuate, etc. This way the farmers are no longer forced to go to their plots to open and close valves, adjust the irrigation to changing climatic conditions or when the water is cheaper (usually the cost of water depends of the time of day it's used). Instead, they can manage all of these choices in a comfortable way and from a distance. This not only optimizes the use and cost of water, but increases the crop yield and improves farmers' quality of life.

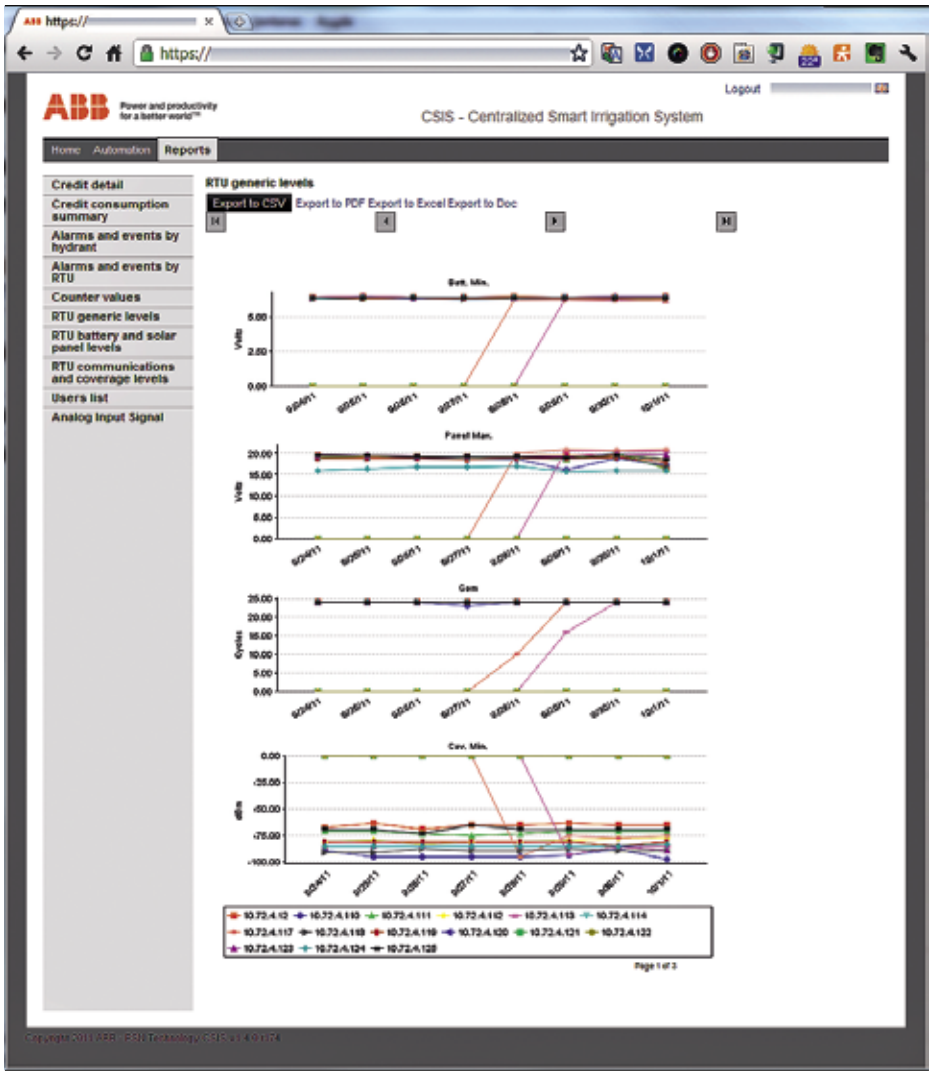
The RTUs can also be used for the control of water distribution networks or even pumping stations. For this reason the remote access is also very useful for irrigation communities' maintenance personnel, since they can control everything from anywhere with a mobile phone without needing to carry engineering stations. Cameras and any other IP elements can be integrated into the user interfaces.

Third approach, evolution of Neptuno to CSIS

Unfortunately, irrigation communities often do not have the appropriate facilities and maintenance personnel for a control system to work properly. Additionally, the initial investment needed for such systems prevent many communities from accessing its advantages and consequently improving their competitiveness.

To address these problems the Neptuno system has evolved into the centralized smart irrigation system (CSIS) that enables access to the SCADA interface through standard web technologies, using the SaaS (software as a service) concept. This way, ABB has all the necessary core elements such as software, servers, communications, power systems, cooling etc. Equally ABB takes care of operation and permanent upgrades and maintenance, offering services both to integrators such as engineering companies, and to farmers.

5 CSIS system user reports



The user can see his system from any internet browser and, thanks to the technology employed, his view will be the same as if the system was installed locally ➔ 4 and ➔ 5.

This approach achieves many of the user's objectives:

– Dramatic reduction of the initial investment (only the RTUs), so it is affordable for communities of any size and even for individual users.
– Increased availability of the system through using better equipment, redundancy and facilities that would not be economically viable in the traditional solution.
– Secure access from anywhere. Internet access, even at low-bandwidth, and an internet browser are enough to use the system.
– Access to fixes and new features of the system from the moment they are published.
– The client does not require computer specialists or maintenance personnel.
– There are no specific infrastructures or facilities required for the project.
– It minimizes the resources needed by the customer.
– Costs are distributed over time and are adjustable according to needs.

CSIS and sustainability

Each CSIS project in an irrigation community uses equipment in the 'Cloud' which replaces the on-site need for servers, communications equipment and auxiliary equipment, such as UPS and air conditioning, etc. This implies savings in energy expenditure and, therefore, reduced emissions of greenhouse gases. In this way, the CSIS approach can achieve major improvements in sustainability. This saving can be seen by comparing the annual energy consumption of a SCADA and a CSIS system with the same number of remote units. The consumption figures for a system with 1,000 remote units can be seen in table ➔ 6.

The consumption of CSIS is lower because the auxiliary systems and even the servers are shared with other users or applications. Savings are even more evident if the total consumption of several SCADA projects are compared with the equivalent in CSIS. Taking an existing installed base of 15,000 Neptuno RTUs and dividing it into projects each comprised of 1,000 RTUs, the figures shown in ➔ 7 are obtained.

While the consumption of a classic system increases proportionally with the number of projects, the CSIS consumption remains almost unchanged.

Since the system can be monitored and controlled from anywhere at any time, the farmer has to travel to his crop less frequently, thus reducing his carbon footprint.

Spanish experience, the customer's opinion

ABB started implementation of Neptuno systems in Spain, where there are now many and varied references, with projects ranging from the few dozens to thousands of RTUs. Though insufficient time has elapsed to realize all of Neptuno's advantages, some communities of irrigators have drawn interesting preliminary conclusions: water savings of between 15 and 40 percent; 10 to 25 percent saving in electrical consumption; and 20 percent higher crop productivity. Further, because in Spain peak

> Since the system is controlled and monitored from anywhere at any time, the number of times a farmer has to go to his crop is reduced, so another decrease in greenhouse gas emissions is achieved.

6 Consumption figures for a system with 1000 RTUs

	Energy consumption/yr	Equivalent CO_2 emissions saved/yr
1× SCADA system (1000 Neptuno RTUs)	21 MWh	3 Tn
1× CSIS system (1000 Neptuno RTUs)	10 MWh	1,5 Tn

7 Results from an installed base of 15,000 RTUs

	Energy consumption/yr	Equivalent CO_2 emissions saved/yr
15× SCADA system (1000 RTUs per SCADA)	315 MWh	45 Tn
1× CSIS system (15000 RTUs)	10 MWh	1,5 Tn

8 24/7 access saves water, power and emissions

Communities of irrigators and farmers value very much the ability to control their crop irrigation from anywhere and at any time.

rate electricity is four times more expensive than off-peak, moving irrigation to off-peak hours can reduce the electricity bill more than the actual reduction in consumption does.

In the irrigators' community of Canal del Zújar, with 11,122 plots in a vast 210 km^2 belt of prime agricultural land, the cost of electricity was around 2.6 million Euros annually and they used more than 100,000,000 m^3 of water a year. While not all the farmers have started to take advantage of the system, the irrigators' community is saving around 300,000 Euros annually in electricity and over 20 percent in water. These savings are expected to increase as more farmers start to use the system. At the same time, their maintenance personnel are driving 20,000 km less per year.

The irrigator community of Lorca, in the Murcia area, with 8,500 irrigators distributed across 125 km^2, has so far benefitted from a saving of around 700,000 Euros just from reducing the quantity of water used.

In addition, the communities of irrigators and farmers value very much the ability to control their crop irrigation from anywhere and at any time. This allows them to reduce the number of trips to their fields, thereby also saving on fuel and the depreciation of their vehicles → 8. Though it depends on the size and physical structure, users estimate a saving of around 100 km a year per square kilometer of land just for the maintenance personnel, on top of which must be added that of their own irrigators.

In summary, ABB systems have allowed irrigators to reduce the costs of production, minimize the use of water, get the most from cultivation without having to worry about the remote control system and achieve a better quality of life. The SaaS approach of the Neptuno system puts this solution in the hands of more irrigators, has reduced maintenance and operating costs as well as the need for local infrastructure and technical people, and at the same time, continues to contribute to the sustainability of irrigation.

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References

[1] Food and Agriculture Organization of the United Nations (FAO). Water at a Glance. 2003
[2] United Nations International decade for action. Water for life. 2005–2015. http://www.un.org/waterforlifedecade/
[3] United Nations Summit on the Millennium Development Goals. http://www.un.org/millenniumgoals/
[4] The 3rd United Nations World Water Development Report: Water in a Changing World (WWDR-3) 2009
[5] United Nations Press Release POP/952, 13 March 2007
[6] The 2nd United Nations World Water Development Report: Water, a shared responsibility (WWDR-2) 2006