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ICT for Water Efficiency

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1. Intoruction

Global change poses unprecedented threats to society through impacts on both the natural environment and engineered infrastructure. Specifically, growing global population requires urban and infrastructure development at the same time as global warming demands massive investment in measures for both adaptation to future climate and mitigation through reduced emissions. The water sector is at the heart of this 21st century challenge, and the need of the hour is to have a major revision of our approaches and implementation of technology for the management of water resources, flood risk and pollution.

As mentioned recently by the Water Supply and Sanitation Technology Platform (2005) – WSSTP - representing all the European water sector actors, "water supply, storm-water drainage, wastewater collection and treatment, as well as quality and quantity management of natural water resources need to be efficiently secured or, where necessary, improved. Only through a paradigm shift from fragmented towards integrated urban water management economic development, social balance and ecological integrity can be secured. [...] During the last three decades the European water industry has built up a great competitive strength based on innovative supply and sanitation concepts, technology, knowledge and skills; availability of financial resources; wide experience in many industrial sectors; close cooperation with European R&D organisations and universities, including active involvement in R&D projects in the various European Union R&D Framework Programmes; expanding markets in the European Union and outside; European Union policy on sustainability, environment and energy; a broad spectrum of efficient governmental structures, tailored to specific local needs. The three largest companies providing water supply and sanitation services in the world are European. In addition, a large number of European Small & Medium Enterprise's (SME's) export their expertise and equipment across the world. Several European firms and institutes have prominent positions in the open market for major water and sanitation studies and implementations. The European water sector is a major economic player - 1% of GDP - with a turnover in the European Union of about 80 billion Euro and an average growth rate of 5% per year, compared to 2.5% per year average growth rate for the European Union economy."

The diagnostic provided by the profession at the European level and with the support of the WSSTP mentions that sustainable approaches for the development of water projects are needed to deliver social, economic and environmental benefits. These demands are pressing issues in the new European Member States, and in developed and developing countries outside Europe. Technologies need to be properly integrated with social, economic and organisational measures. Until now a sectoral approach in water resources management has been dominating and is still prevailing. Many actors are not fully integrated, and many stakeholders remain uninvolved. This has led to fragmented and un-coordinated implementation of policies and technologies, and often leads to inefficient or even unsustainable solutions. To achieve sustainability, Europe, as all countries, has to apply an integrated and participatory approach for water resource management. The water industry is too slow in studying and eventually adopting new technologies. The World Water Council (2009) states: "Without major technological innovations there is little hope of bringing the water equation into balance. There is no doubt that many technological changes can help improve services for millions and reduce the stress on water systems around the world."

To remain in the forefront of this competitive business, innovative skills are essential. The knowledge and experience in water supply and sanitation that is available for example in Europe is dispersed across a large number of small utilities and enterprises. Although not directly visible to the outside world, a considerable body of knowledge has been developed in designing and optimising water infrastructure and management systems over the past 150 years. This diversity of solutions adapted to local conditions in Europe is quite valuable assets in the world market. The energies of all actors in the sector must be combined to merge the dispersed knowledge and expertise and use it to enhance the competitiveness of the water sector.

The challenges faced by the water sector in Europe and worldwide are serious and well-documented. Future water shortages require immediate action on development of resources, reduction of demand and higher efficiency in treatment and transmission. Future flood risk management requires immediate action in risk assessment, defence and alleviation systems, forecasting and warning systems and institutional and governance measures. Such development requires considerable investment in research from governments and large corporations and this is now becoming apparent in many countries. The challenge is made even more difficult, however, by the requirement for solutions to be sustainable and moving towards a "low carbon economy" which are also increasingly being stipulated by government and European Union Directives. For example, the drive for higher reliability in water resource is therefore accompanied by a drive for reductions in cost, emissions, ecological and environmental impacts.

Technology has been revolutionised over recent years and now, matured with mass production allowing wider uptake of methods and devices (Gourbesville, 2009). After the development phase, technology is now entering an application and implementation phase which is targeting several fields including environment. A relevant example is given by the European Union who has defined a major priority for the next 20 years on "ICT for sustainable growth" with the ambition to lead innovation at the worldwide scale. In such context, ICT refers to technologies that provide access to information through telecommunications. It is similar to Information Technology (IT), but focuses primarily on communication technologies. This includes the Internet, wireless networks, cell phones, and other communication mediums. As defined by the European Commission, improving the quality of life should not damage the environment for future generations. Achieving sustainable growth requires better management of all natural resources, from energy to water and ICT - Information and Communication Technologies - can enable this far more efficiently (Holz, 2004), so improving environmental protection without holding back economic development.

Key concerns are the impact of climate change and the inefficient use (or over-use) of natural resources, such as drinking water and energy supplies. However, in order to achieve these objectives, the European Commission focuses its efforts on several specific areas such as Energy Efficient Buildings, Smart Electricity Grids and Smart Metering, Freight, Logistic and Transport, Greener ICT, Water Management. In this last domain, the European Union wishes to recognize the added value of ICT solutions and to support their implementation in the water domain by elaborating, validating and disseminating recommendations, guidelines and specifications on specific technologies and uses. This strategy is duplicated at the international level with the priorities of the National Science Foundation (NSF) in USA and the Green Growth project developed in South Korea.

If the diagnostic is now shared globally, it request coordinated efforts in order to implement the various ICT solution into the water sector. This sector is complex and requires a careful analysis able to underline needs and to identify the added value provided by ICT solutions according to a realistic roadmap for implementation.

2. Methodology for assessing priorities

Obviously, in the coming years the new technologies from the IT sector will affect the full water cycle and the management of the water related services. This process represents a major challenge for the 21st century. However, the impact of these new technologies – from sensors to Decision Support Systems - could be stronger and really significant if priorities are properly defined and implemented within the R&D strategies. The main driver of the strategy has to be to achieve a comprehensive architecture of an Information System (IS) dedicated to water uses and connected to others systems involved in human activities.

By definition, Information systems are implemented within an organization for the purpose of improving the effectiveness and efficiency of that organization (Silver, 1995). Capabilities of the IS and characteristics of the organization, its work systems, its people, and its development and implementation methodologies together determine the extent to which that purpose is achieved. The IS is associated to an architecture which provides a formal definition of the business processes and rules, systems structure, technical framework, and product technologies for a business or organizational information system.

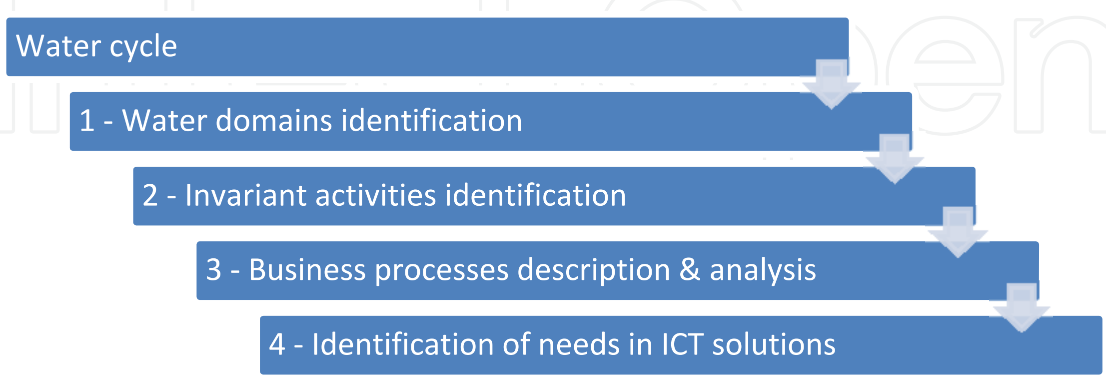

Fig. 1. General methodology for development of ICT solutions in the water sector.

In order to elaborate a specific IS for the management of the water cycle, a methodology is needed for identifying priorities and strategic investments to do in the ICT domain. The

requested approach has to investigate all domains and provide a map of the various process taking places in the different domains of the water uses cycle. This formalization exercise, using mainly concepts and processes, is now requested in order to ensure the coherence of technical choices in a holistic approach.
The methodology has to start from the water cycle, to identify the various water domains and the associated activities. The activities can be then defined with business processes which can be analysed regarding the need of ICT solutions. The proposed methodology is summarized on the Figure 1.

2.1 Domains of the water cycle

The water cycle is frequently defined as the hydrologic cycle which describes the continuous movement of water on, above and below the surface of the Earth. The hydrologic cycle involves the exchange of heat energy, which leads to temperature changes and drives states of water. The water cycle figures significantly in the maintenance of life and ecosystems.

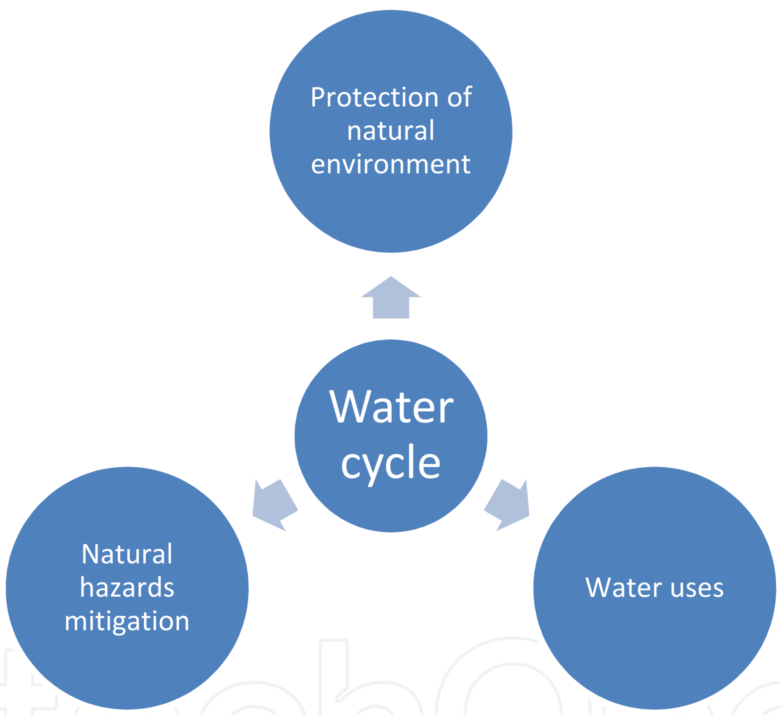

Fig. 2. Domains of water cycle.

In order to preserve this essential resource, the concept of Integrated Water Resources Management (IWRM) has been developed (Jønch-Clausen T. & Global Water Partnership (GWP), 2004). The purpose of the approach is to "promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems." Operationally, IWRM approaches involve applying knowledge from various disciplines as well as the insights from diverse stakeholders to devise and implement efficient, equitable and sustainable solutions to water and development problems. As such, IWRM is a comprehensive, participatory planning and implementation tool for managing and developing water resources in a way that balances social and economic needs, and that ensures the protection of ecosystems for future

generations. In such approach, ICT solutions can play a key role but focus has to be given to the most demanding and relevant domains of the water cycle.
In order to identify which and how ICT solutions can be implemented, it is necessary to look at the water cycle through an approach based on functional domains and business processes. This methodology allows considering each action involved into the resource management and identifying the potential needs of ICT.
The water cycle can be divided in three domains which are associated to specific activities and business processes:

- Protection of natural environment and ecosystems;
- Natural hazards mitigation and disaster prevention;
- Water uses.

The first domain considers all actions needed to assess and advice on the environmental impacts of development proposals and projects related to specific water uses. Results are used by regulatory services. The domain covers also all conservation actions of water related ecosystems.
The second domain is focused on water related natural hazards mitigation actions. Floods, water-borne and vector disease outbreaks, droughts, landslide and avalanche events and famine are the processes covered by this domain. Every year, disasters related to meteorological, hydrological and climate hazards cause significant loss of life, and set back economic and social development by years. The disaster is defined as a serious disruption of the functioning of a community or a society causing widespread human, material, economic and/or environmental losses.
The last domain covers the added influence of human activity on the water cycle. Generally, the water uses refer to use of water by agriculture, industry, energy production and households, including in—stream uses such as fishing, recreation, transportation and waste disposal. All of those uses are directly linked to specific activities and processes which are potential targets for deployment of ICT solutions. In order to stick to the reality oft he water management operated by entities in charge of water services, the traditional classification can be reviewed. The main water uses appear then as: agriculture, aquaculture, industry, recreation, transport/navigation, and urban.

2.2 Water uses, activities and business processes

According to the defined water domains, the water uses represent the largest field where ICT solutions can be developed and implemented. The various uses may be classified and defined as follow.

- Agriculture: Irrigation water use is water artificially applied to farm, orchard, pasture, and horticultural crops, as well as water used to irrigate pastures, for frost and freeze protection, chemical application, crop cooling, harvesting, and for the leaching of salts from the crop root zone. In fact, irrigation is the largest category of water use worldwide.
- Aquaculture: Aquaculture is the farming of aquatic organisms including fish, molluscs, crustaceans and aquatic plants. Farming implies some sort of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators and so forth. It also implies individual or corporate ownership of the stock being cultivated. This activity uses part of the water bodies in order to develop activities.

- Industry: This water use is a valuable resource for such purposes as processing, cleaning, transportation, dilution, and cooling in manufacturing facilities. Major water-using industries include steel, chemical, paper, and petroleum refining. Industries often reuse the same water over and over for more than one purpose.
- Recreation: It often involves some degree of exercise as well as visiting areas that contain bodies of water such as parks, wildlife refuges, wilderness areas, public fishing areas, and water parks. Some of the activities that imply the uses of water for this purpose are: fishing, boating, sailing, canoeing, rafting, and swimming, as well as many other recreational activities that depend on water. Recreational usage is usually non-consumptive; however recreational irrigation such as gardening or irrigation of golf courses belongs to this category of water use. Besides, recreation and tourism represent a growing sector for industry at the worldwide scale.
- Energy: Derived from the force or energy of moving water, which may be harnessed for useful purposes, such as Energy production. There are several forms of water power currently in use or development. Some are purely mechanical but many primarily generate electricity. Broad categories include: conventional hydroelectric (hydroelectric dams), run-of-the-river hydroelectricity, pumped-storage hydro- electricity and tidal power.
- Transport/navigation: It refers to the transport of goods or people using water as a means of transportation. This water use refers only to commercial transport, since recreational transports such as sailing is considered above in Recreation water use.
- Urban: Urban water use is generally determined by population, its geographic location, and the percentage of water used in a community by residences, government, and commercial enterprises. It also includes water that cannot be accounted for because of distribution system losses, fire protection, or unauthorized uses. For the past two decades, urban per capita water use has levelled off, or has been increasing. The implementation of local water conservation programs and current housing development trends, have actually lowered per capita water use. However, gross urban water demands continue to grow because of significant population increases and the establishment of urban centres. Even with the implementation of aggressive water conservation programs, urban water demand is expected to grow in conjunction with increases in population. The urban environment is associated to a high dynamic which implies a growing complexity related to number of inhabitants and management of water resources in order to fulfil the needs of population.

The water uses are associated to business processes and are linked to economical and social values. In most of the cases, five major activities are taking place within each water use and appear as invariants. These key activities are: Investigating /surveying, observing / monitoring, designing, building and decommissioning, operating. Each activity could be defined.

- Investigating/surveying: Consists in the gathering of information of the previous and actual state and/or working of the domain in study. This assembly of information can be done either by a systematic collection of field data (survey) or a collection of information or data from a methodical research of available documents and/or the production of new ones in order to understand or to improve the actual state of the domain.

- Observing/monitoring: From a general point of view, this activity refers to be aware of the state of a system. It describes the processes and activities that need to take place to characterise and monitor the quality and/or state of the domain in study. All monitoring strategies and programmes have reasons and justifications which are often designed to establish the current status of the domain or to establish trends in its parameters. In all cases the results of monitoring will be reviewed and analysed. The design of a monitoring programme must therefore have regard to the final use of the data before monitoring starts.
- Designing (including risk assessment): Refers to the process of devising a system, component, or process to meet desired needs. It is a decision making process (often iterative) in which the basic sciences, risk assessment and engineering sciences are applied to convert resources optimally to meet a stated objective. Among the fundamental elements of the design process are the establishment of objectives and criteria, synthesis, analysis, construction, testing and evaluation. In order to obtain a design that achieves the desired needs for the domain in study, the two previous steps should have been accomplished and taken into account.
- Building & decommissioning: Consists in carrying out the proposed solution (design) for the domain. In order to execute this design, construction and/or decommission activities may be executed. It is essential a minimal environmental impact when accomplishing these activities. The tolerable environmental impact will be obtained from the risk assessment of the designing step.
- Operating: It refers to the action of manoeuvring a system. It may include the combination of all technical and corresponding administrative, managerial, and supervision actions. Operation may also include performing routine actions which keep the system in working order. This latest actions might turn out as response of problems detected during monitoring.

Fig. 3. Invariant activities taking place in the various domains and water uses.

The final step of the approach is dedicated to the identification of the various business processes which are taking place in each activity. A business process is defined as a collection of related, structured activities or tasks that produce a specific service or product (serve a particular goal) for a particular customer or customers. It implies a strong emphasis on how the work is done within an organization, in contrast to a product's focus on what. A process is thus a specific ordering of work activities across time and place, with a beginning, an end, and clearly defined inputs and outputs: a structure for action. Some processes result in a product or service that is received by an organization's external customer. These are called primary processes. Other processes produce products that are invisible to the external customer but essential to the effective management of the business. These ones are called support processes. In keywords, a business process has a goal, has specific inputs and specific outputs, uses resources, has a number of activities that are performed in some order, may affect more than one organizational unit - horizontal organizational impact - and creates value of some kind for the customer. An example of a business process for a water utility can be meter reading. It has to be done in concordance of the billing period. The goal of this process is to give inputs to the billing department, and see the progress of the customer’s consumption. Depending on the technology used for the metering (smart or manual metering), different resources (technology, personnel) are used.
The uses in urban environment, carried out by water utilities, can be defined with a limited number of business processes – 29 in total - summarized into the table 1 and which are covering drinking water, waste water and storm water management. The final step of the approach is then to identify for each business process how ICT solutions can be implemented and provide added value. This diagnostic has to be shared by professionals and operators in order to ensure a coherent deployment. This validation process can be made through an associative body gathering representatives from all involved sectors.

1 - Asset management	16 - Water primary network management and water balance
2 - Crisis management	17 - Water secondary network management
3 - Field intervention management	18 - Leak detection
4 - Field works	19 - Meter reading (AMR & MMR)
5 - Use of GIS	20 - AMR & MMR management
6 - Maintenance of GIS	21 - Public service contract management
7 - Management of plant maintenance	22 - Waste water network management
8 - Electro mechanical maintenance	23 - Storm water network management
9 - Laboratory activity and quality control	24 - Waste water treatment plant management
10 - Automation & sensors	25 - Sewer inspection and sewer cleaning
11 - Real time network management	26 - Billing
12 - Planning and design of new assets and plants	27 - Customer care & communication
13 - Water resources management	28 - Innovation & pilots
14 - Environment management	29 - Supports
15 - Drinking water treatment plant management	

Table 1. Business processes for urban uses.

3. The @qua approach

The European Union has defined a key objective for his industrial development on interoperability of systems. This approach is dedicated to various domain including environment and water. In order to support this vision, the European Commission has launched a Thematic Network called @qua under the CIP-ICT PSP Programme. The ICT Policy Support Programme (ICT PSP) under the Competitiveness and Innovation Programme (CIP) aims at stimulating innovation and competitiveness through the wider uptake and best use of ICT by citizens, governments and businesses, particularly Small and Medium-sized Enterprises (SMEs). The approach is based on leveraging innovation in response to growing societal demands.

In his programme frame of ICT Policy Support Programme (ICT PSP) 2011, the General Direction Information Society (DG INFSO) of the European Commission has launched a new theme network dedicated to Innovation Communication Technologies for water management. This domain represents a sector which the European Union wishes to develop during the next 10 years and it's contemplated in different initiatives of the Digital Agenda for Europe 2020 which will allow at the same time improving the user's services quality and developing a sustainable management of resources. These objectives will be achieved with the improvement of already available technologies, adaptation of the existing solutions and the identification of R&D axes to work on the next years.

@qua Innovation Network (http://www.a-qua.eu), founded by 17 partners and managed by Nice Sophia Antipolis University gathers thus ICT and water services leading actors from SME to majors, research entities developing competences in both sectors, local and regional authorities directly responsible for water policy and water management. Partners have developed significant expertise about the interface of ICT and water and at the same time, covering the full spectrum of the water related domain. @qua provides a forum to exchange and to share expertise in deploying innovative ICT solutions for water management, studies feasibility of standardized ICT solutions and interoperability in the field of water management across the EU and develops specifications and guidelines according to a jointly defined "level of sharing" among representatives of professional sectors. Focus of @qua is on gathering and sharing experiences on how to overcome barriers to the introduction of ICT solutions for innovative water management and on how to ensure their wider uptake and best use. Partners have the ambition to develop and to promote the interoperability principle and the use of common standards in the water industry. In a holistic and consistent approach, @qua addresses all the issues of the water management from resources to societal changes, using a wide range of ICT solutions: data acquisition, numerical modelling, real-time monitoring and field operation management.

3.1 The @qua methodology

The @qua thematic network members have developed a general methodology based around few steps which can be summarized as follow:

Step 1. Water business processes and ICT solutions: identification of gaps and expectations of the water domain professionals on ICT solutions;

Step 2. Identification and validation of innovative ICT solutions by the ICT professionals with the objective to bridge the identified gaps during the Step 1;

Step 3. Develop the "level of sharing" of each ICT solution in order to address interoperability, standards, architecture and roadmap for implementation issues;

Step 4. Produce guidelines, standards and specifications on specific ICT solutions needed by the water domain in order to achieve a more efficient water management.

The two main characteristics of the defined approach are:

- the global analysis based on “business processes” and associated added value;
- the definition and the use of concept of "level of sharing" to decide which ICT innovations could be widely disseminated throughout the water profession.

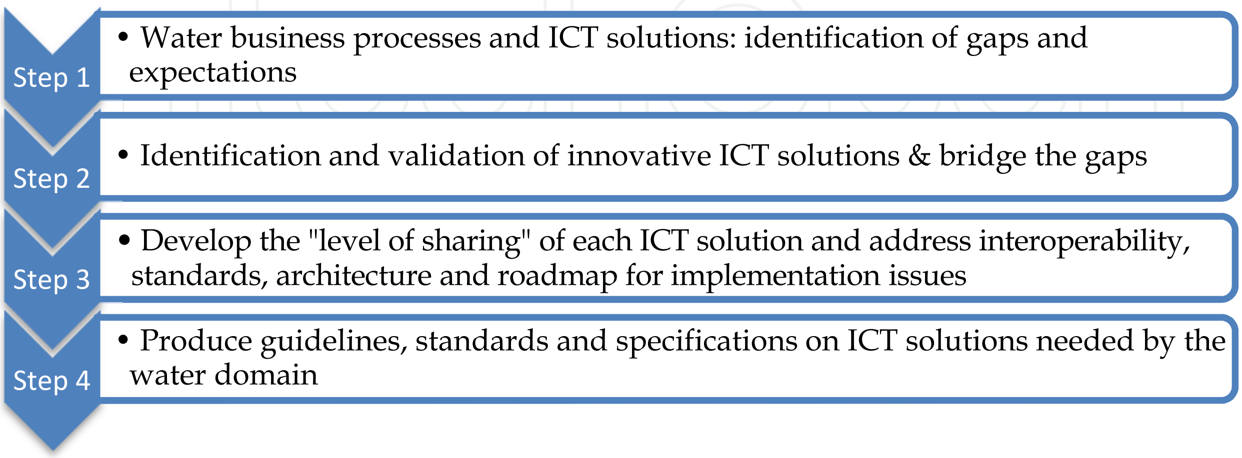

Fig. 4. The @qua methodology.

The initial step, led by water utilities and water engineering companies, is dedicated to the analysis of the business processes, both for the artificial cycle and the natural cycle of water, and both for design and for operations. The business processes are described at a macro scale, where the tiny differences between entities are not seen and where just the common "backbone" is visible. These business models are used as "base maps" in order to show the unequipped - or poorly equipped - steps in terms of ICT. A special attention is turned to the analysis of added value of these unequipped steps. The diagnostic characterizes the added value not only on the economic point of view, but also on sociological and ecological dimensions. In addition to the common map of the water business processes itself, the result of this step is the list of the steps / processes that "deserve" to be equipped with new ICT tools. This effort of analysis according to the business processes vision represents an essential input in the water domain. Until now this diagnostic was not established for several reasons and especially due to the low maturity of water industrial domain regarding ICT solutions and uses.

The second step is led by the ICT sector representatives and consists in a technologic analysis of the needs and requests written by the water companies’ representatives. The step includes not only the assessment of the feasibility, the potential availability and the cost of the requests, but it will also propose other tracks, unimagined or not foreseen during the previous step. The water companies have a partial vision of ICT solutions and they need a better knowledge of the current trends of the ICT industry / market. Alternating the leadership of the steps between the "water people" - water companies and other stakeholders - and the "ICT people" brings an efficient synergy.

The third step is focused on the determination of the "level of sharing". This concept is a central element which is developed and used by the @qua network. For the time being, the use and the implementation of existing ICT solutions in the water domain is made case by case, with a quite variable customization which is covering a simple technical adaptation like wavelength, to in depth R&D development like the use of alternative energy sources for power supply in waste water monitoring actions. The partners of the @qua network have significant experience of implementation and development actions. The spectrum of their expertise is covering most the business processes involved in the water domain. From this experience and according to their identified needs in innovative ICT solutions, they define, for each technology identified as a priority, the requested level for developing an efficient interface between the different components involved into the business process. Such work represents a major output for the @qua network and constitutes clearly an added value provision by the network to various professional communities. It is clear that in a wide community as the European water profession, the status of the various Information Systems has a very high variety. This step will analyse the "IS/IT context" parameters in the profession: maturity of the IS, level of integration (integration of the IS itself as well as integration in the business processes), level of alignment with the strategy, and the local parameters (ERP/ software already installed, other relevant IT projects, trends of the local IS/IT market, etc.). This step proposes the ideal "level of sharing", i.e. the level which will maximize the effectiveness and efficiency of the new ICT tools by taking into account the actual current IT/IS situation. This output defines the outcomes of the @qua network, which could go from the very theoretical - methodologies, data models, architectures, principles of standardization, etc. - to the very concrete elements such as list of devices compliant with the selected telecom standards, deployment of a common software and instructions of customization, etc.

In a final step, the production of the guidelines and specifications whose needs are identified in the previous steps. According to the results of the previous step, these results can go from very generic guidelines to more precise technical specifications such as hardware requirement for sensors, software architecture, strategy for implementation and deployment in water services, metadata architecture, business process description and standards. A similar approach has been partly applied with HarmonIT project (http://www.harmonit.org) on the specific field of the hydroinformatic systems interoperability and the development of the OpenMI standards (http://www.openmi.org). In the case of the @qua approach, the spectrum is much more wider because it's addressing most of the business processes involved in all water uses and domains.

3.2 The expected results and impacts

The water domain - and water stakeholders - is very wide and covers a huge number of business processes especially if all domains and activities are considered. This situation legitimates the mapping process and the prioritization of gaps that need to be bridged. Clearly the efforts have to be focused on five major areas directly linked to the urban water use which where both expectations and possibilities are the highest:

a. Real time monitoring
    - Specially real time networks monitoring including Automated Meter Reading(AMR);
    - Installation of leak detectors in the network;
    - Real time quality management (disinfectant, turbidity, pH, temperature, conductivity, RedOx, etc.);
    - Sensors at all Points Of Use (POU);
    - Real time information of customers and stakeholders;
    - Related technologies such as Supervisory Control And Data Acquisition (SCADA), GIS, telecommunications, sensors (especially low cost sensors), inverse models, decision support systems.

b. Cities of Tomorrow
   - In the current vision , there is an absolute need of generalized ICT in the operation of the cities of the future, or sustainable cities, or water-sensitive cities;
   - Cascading usages of water (incl. re-use and recycling), rainwater harvesting, storm water management, desalination, managed aquifer recharge, micro treatment plants, etc. are the core techniques of the cities of the future These techniques need a very high level of monitoring and thus, a sophisticated density of ICT;
   - Leakage reduction in distribution networks;
   - Improving water efficiency in cities.

c. Asset Management and Field Work Management
   - In-pipe and "through road" condition assessment sensing technologies;
   - Continuous performance, condition and risk assessment sensors and prediction models;
   - Optimised network operation and "just in time" repairs and investment programmes;
   - GIS/GPS information;
   - Buried asset electronic identification and tagging devices, wireless communication through road materials;
   - "Wearable computers" for field workers, giving access in real time to all data bases of the company, with interfaces consistent with field conditions.

d. Energy Efficiency
   - Smart grid in water distribution systems (real time management of pumping strategy, refined demand forecast, optimization of network management and of operating costs);
   - Tools for energy saving in treatment plants;
   - Real time status monitoring (open/closed) of manual valves (cf. above : equipment of field operators);
   - Monitoring and control of heat recovery in wastewater;
   - Tools for Smart Metering / Smart Pricing (e.g. condition-based tariffs).

e. Water efficiency
   - Improving water efficiency in cities;
   - Improving water efficiency in agriculture, including detection of illegal abstraction;
   - Ecosystems and land-use management in perspective of project scope and available resources.

4. Some ICT solutions for water efficiency

The analysis of the domains and the business processes demonstrates the relevance and the key position of the data acquisition process through sensors located in the various sectors of the water cycle. This need is recurrent and could be seen in the three domains and takes a central position in surveying, monitoring and operating activities.

4.1 The sensor revolution

The analysis of the domains and the business processes demonstrates the relevance and the Following the PC revolution in the 1980s and the Internet revolution in the 1990s, the on-going revolution is connecting the Internet back to the physical world, creating that world its first electronic nervous system or Information System. The sensor revolution is based on devices that monitor environment - natural & built - in ways that could barely imagine a few years ago.

A sensor is any device that can take a stimulus, such as heat, light, magnetism, or exposure to a particular chemical, and convert it to a signal. Sensors have certainly been around for a very long time with scales (weight sensors), thermometers (temperature sensors) and barometers(pressure sensors). More recently, scientists and engineers have come up with devices to sense light (photocells), sound (microphones), ground vibrations (seismometers), and force (accelerometers), as well as sensors for magnetic and electric fields, radiation, strain, acidity, and many other phenomena.

While the concept of sensors is nothing new, the technology of sensors is undergoing a rapid transformation. Indeed, the forces that have already revolutionized the computer, electronics, and biotech industries are converging on the world of sensors from at least three different directions:

Smaller. Rapid advances in fields such as nanotechnology and (micro electro-mechanical systems (MEMS)) have not only led to ultra-compact versions of traditional sensors, but have inspired the creation of sensors based on entirely new principles. The reduced size fits perfectly with the constraints of the water supply and open possibilities into the monitoring and operating activities.

Smarter. The exponentially increasing power of microelectronics has made it possible to create sensors with built-in "intelligence." In principle, at least, sensors today can store and process data on the spot, selecting only the most relevant and critical items to report. One of the emerging concepts in this domain is the ubiquitous computing paradigm. This approach is highly relevant for the water domain especially for all warning and monitoring systems which may avoid the centralized design.

More Mobile. The rapid proliferation of wireless networking technologies has cut the tether. Today, many sensors send back their data from remote locations, or even while they're in motion.

In the urban water domain, the new sensors are already deeply impacting several business processes with Automated Meter Readers (AMR), water quality control devices and operating supervision. Such trend is following the recent evolution observed in energy distribution sector. An emblematic evolution is the one taking place with the introduction of the smart metering concept for water consumption monitoring.

4.2 From mechanical meters to smart metering

Water meters reading remains one of the core business process of water utilities or public services in charge of drinking water supply. This activity requests a good level of organization and a good management of the devices. To date, water meters have been accumulation meters, pulse meters or interval meters which are all mechanical devices. The data are collected directly regularly on the field. This process can report about consumption and can detect some leakages into the network. However, reactivity is low due to the limited visits on the field. The past decade has seen an evolution of conceptual design of advanced or smart metering and its terminology. Driven by electricity investment, metering has evolved from accumulation meters to interval meters with simple communications, to advanced or smart metering with an increased range of metering functionality. This increase in electricity meter functionality and complexity has started to be mirrored in the water industry.

Interval metering is comparatively more expensive than pulse metering, as the interval meter is required to constantly monitor the water flows through the meter and record this volume at the expiration of the metering interval. By using a fine pulse quantum and analysing the time stamps of these pulses, pulse metering data can be used to approximate

interval water metering data and hence deliver similar benefits. Use of pulse metering where a time stamp is made when a certain quantum of water is consumed, is more common in the water industry and these pulse meters are available at reasonable cost.
Smart water metering for the water industry will extend beyond the capability of Automated Meter Reading (AMR). Smart water metering is expected to, as a minimum, establish more granular - within a day - water usage data, two-way communications between the water utility and the water meter, and potentially include communications to the customer. With respect to a customer's household, smart water metering could enable:

- Recording of water consumption within a day;
- Remote meter reading on a scheduled and on-demand basis;
- Notification of abnormal usage to the customer and/or the water utility;
- Control of water consumption devices within a customer's premise;
- Messaging to the customer;
- Customised targeting of segments.

The options to be considered for smart water metering are:

- Choice of communication to the water authority/water utility and the home;
- Choice of consumption data measurement (pulse or interval metering).

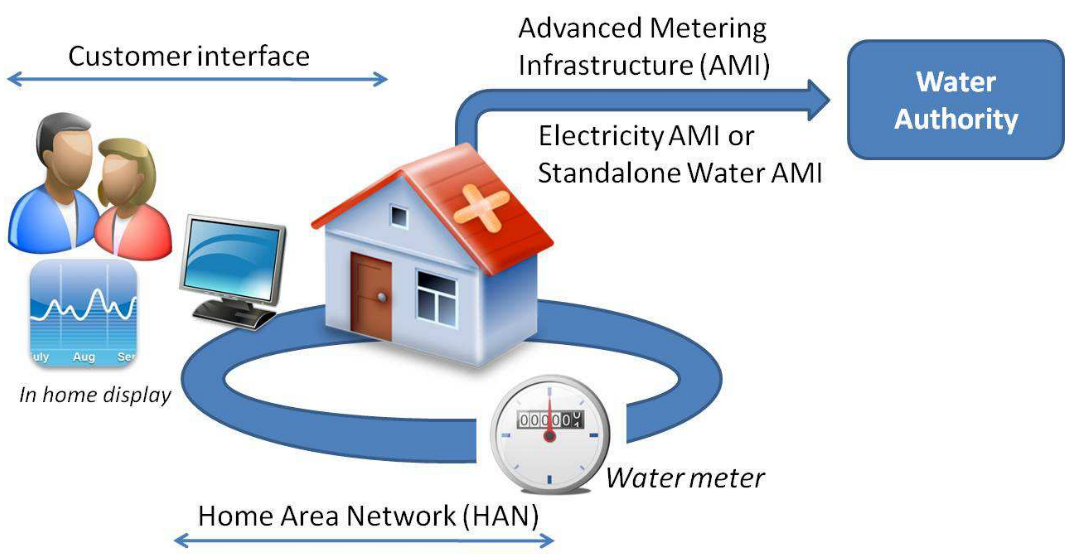

Fig. 5. Smart water metering logical architecture.

Options for the implementation of smart water metering communications arise through choices on:

- Water authority/water utility communications: The method and frequency of data collection through either drive-by collection, leveraging electricity Advanced Metering Infrastructure (AMI) communication networks or standalone water AMI communications networks;
- Customer communications: The method of communicating consumption information to customers: either in real-time across a Home-Area-Network (HAN), or in a historical manner through bills.

Since 2006, various pilot projects - from 100 to 500 smart meters – have been implement worlwide and espacially in Europe within France, Italy, Spain and Malta. The projects are carried out by the water utilities who are supporting development and implementation in various municipalities and for different situations (type of building, type of cities, ...). Most of the projects are based on wireless devices and very few are deployed on the wire networks. Following the first experiments, the main water utilities have already initiated the implementation of smart meters at a large scale with for example more than 350 000 units for France.

The pilot studies and experiments carried out since several years by the water utilities have demonstrated the savings in water consumption due to the use of the smart metering. The savings are taking place at various levels such as:

- Reduction of individual consumption. The details of the consumption are accessible through various media such as a specific website or a small electronic terminal. The information provided to the consumer immediately generates a reduction up to 15%;
- Reduction of water consumption at the macro scale (city to block). The smart metering allows to identified non conform water consumption and consequently help to reduce leakages after and before the smart meter itself. Text messages could be sent to consumers when the consumption is initiating a non coherent pattern with the previous consumption. The water utilities can also detect major leakages on the networks.
- The knowledge in real time of the water consumption allows to identify seasonal needs of the population and to anticipate the volumes of resources to mobilize. This approach allows a more functional use of resources and contributes globally to reduce the consumption.
- The knowledge in real time of the water consumption opens the doors to a new approach about pricing, based on seasonal and even hourly values.

Today, according to various publications and sources (Oracle, 2011), about a third of water utility managers in USA say they are in the early stages of adopting smart meters, despite the fact that 71 percent of water users say that having more detailed information on their water consumption would promote better water conservation. This figure is representative of the worldwide situation. From the water utilities point of view, the following benefits to adopting smart meters could be identified:

- enabling early leak detection ;
- supplying customers with tools to monitor/reduce water use;
- providing more accurate water rates;
- curbing overall water demand;
- improving the ability to conduct preventative maintenance.

The financial efficiency of the smart metering has been already demonstrated through various study cases and pilots (Marshment Hill Consulting, 2010) In developing countries where development of infrastructures and management of water resources represent a great challenge, the opportunity to invest in the smart metering concept is clearly a key issue which request an integrated effort in the global urban management.

5. Conclusion

The water sector represents a major challenge for the 21st century. The climate evolution combined with the growing of pressure of populations will generate new stresses on a limited resource which has to be carefully managed and protected. The fast development of ICT solutions allows today to enter a new area which may be characterized by the idea to move from a scarcity of data to a continuous flow of data - "data rich world" - about natural and built environment. This new situation will become a reality in the coming two decades

and will allow potentially improving, globally, the water management. However, if this perspective represents a clear benefit both for natural and manmade environments, it request the development of a coherent vision based on a process allowing to integrate the fragmented activities developed until now in the water sector. The ICT solutions will allow this integration process but they have to be coordinated under guidelines and standards which have to be jointly defined by the various actors of the water sectors. Regulating bodies, public services, water utilities and IT producers are invited through organisations like @qua, to engage an active dialog in order to develop a coherent strategy. The suggested approach, based on business processes, represents a solution which has to be extended to all activities and domains of the water sector. It implies a real mobilization of all actors from who have to formalize their processes. Of course this effort requests a maturity in the process itself in order to be able to characterize the tasks and their dynamic.
The water sector represents a vast area where ICT solutions can be implemented and provide a real improvement. In order to benefit of these solutions, the water sector has to be pro active and structured in order to express needs. This challenging and exciting task will mobilize many professionals from both sectors and will request debates within the society on choices regarding water and its management.

6. Acknowledgment

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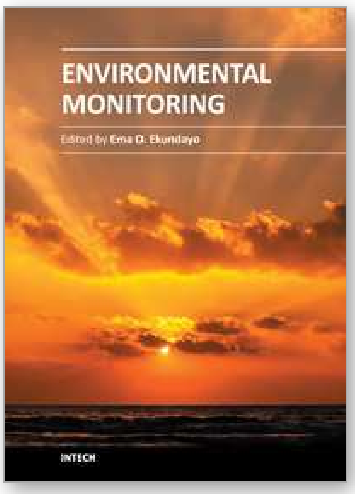

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"Environmental Monitoring" is a book designed by InTech - Open Access Publisher in collaboration with scientists and researchers from all over the world. The book is designed to present recent research advances and developments in the field of environmental monitoring to a global audience of scientists, researchers, environmental educators, administrators, managers, technicians, students, environmental enthusiasts and the general public. The book consists of a series of sections and chapters addressing topics like the monitoring of heavy metal contaminants in varied environments, biolgical monitoring/ecotoxicological studies; and the use of wireless sensor networks/Geosensor webs in environmental monitoring.

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