


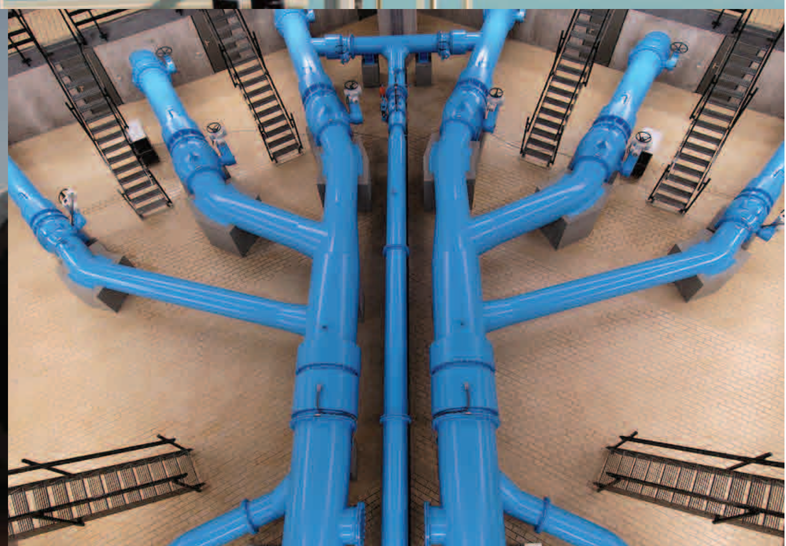

ACQUEAU

A Eureka initiative
for

GROWTH AND INNOVATION IN WATER

Blue Book 2: Technology Road Mapping

ACQUEAU
is the EUREKA Cluster
for Water

ACQUEAU is the first
industry driven initiative
to fund innovation and RTD
in the water sector.

ACQUEAU is an industry driven EUREKA initiative dedicated to water related technologies and innovation. It aims at promoting innovation and market driven solutions to develop new technologies in the European water sector.

The major goal is to facilitate the generation of market driven, pan-European collaborative water research and technological development projects for the benefit of the European Water Industry.

ACQUEAU is a non-profit association under Belgian law, it was founded by industrial companies. It counts 12 funding members from 6 European countries.

ACQUEAU adresses industries that develop and sell their products or services dedicated to water catchment, production, distribution, collection and treatment, that use water in manufacturing processes and that have interest in developing technologies related to the water cycle.

www.acqueau.eu

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ACQUEAU, the EUREKA cluster for water

Summary

ACQUEAU is the first cluster entirely dedicated to a natural resource.

The main goal is to promote and to ensure the future competitiveness of water technologies and services in Europe and in the world market.

The other key mission of ACQUEAU is to develop the first industry driven programme for the water sector and to meet the need to foster a bottom-up approach and market driven initiatives for the stakeholders involved in the water sector and all industries interacting with water services and technologies. This part of the Blue Book describes the different technological areas identified by ACQUEAU. The technological areas have been identified from nine water components of the water cycle. The goal is to set out the major challenges and potential technological breakthroughs that could be expected from ACQUEAU within the short term (2015) and the long term (2030).

On the basis of those nine water components and technological areas, ACQUEAU selected five initial major challenges that will drive the major programmes of ACQUEAU at least for the first five years. This section describes the various targets of ACQUEAU in order to develop new markets in Europe.

The technological areas and major programmes of ACQUEAU have been selected from the societal, economic and technological needs. Experts selected the projects from such key drivers for the water sector as public health, the environment, cost reduction, regulation and technological breakthroughs. Based on this work and expertise, ACQUEAU will support projects that contribute to the implementation of its strategy and the development of new market solutions for water applications.

Water, a vital good, a specific sector

Water is a vital resource with particular benefits. It has an economic value once the services have been provided to deliver drinking water to the public.
Starting from the Strategic Research Agenda of the WssTP, the experts of ACQUEAU decided to set up the technological areas of ACQUEAU based on the water cycle.
Traditionally, the water cycle is divided into the natural water cycle and the domestic water cycle.

The natural water cycle includes the traditional stages of the water movement between the land, the ocean and the atmosphere. It includes evaporation, condensation, precipitation, infiltration, run-off and transpiration.

The domestic water cycle includes the different stages and processes from extraction from ground or surface water to the return of treated wastewater to the environment. Overall, the water sector is organised following the water cycle. The experts of ACQUEAU decided to follow the water cycle and to identify the technology developments and breakthroughs that could be expected from a Eureka initiative. They identified nine technological areas also called “water components”.

Nine Technological Areas for water innovation

The strategy of ACQUEAU is based on water components & technological areas that combine to indicate technological needs and future project development requirements.

These key water components are:

1. Water resources
2. Water treatment
3. Water distribution
4. Customer
5. Agriculture
6. Industry
7. Urban drainage and Wastewater collection
8. Wastewater treatment
9. Bio solids and other sludge

The ultimate goal of a Eureka cluster is to ensure the competitiveness of the European industries worldwide. It aims to develop technologies and innovation that will drive the future standards of the water sector worldwide.

For this purpose, ACQUEAU emphasises the need to augment technologies within the water sector considering both the current state of technological development and the vision for RTD. It intends to consider the peculiarity of water, a vital resource within a highly fragmented sector throughout Europe and worldwide.

For each water component, the experts developed a definition, a scope of technological areas and the RTD needs. The goal was to establish a relevant strategy based on the peculiarities of the water sector. The Technology Road Map (TRM) further complements the needs and potential technological breakthroughs foreseen in each technological area.

Technology Road Mapping

The aim of the Technological Road Map (TRM) process is to map out specific technology needs and gaps for the water sector, in order to identify, prioritise and develop innovative market driven technological breakthroughs. The completed Technology Road Map targets the definition of the standards for the world of tomorrow. The TRM aims at designing, manufacturing and implementing the future water sector technologies.

The European water sector is highly fragmented: water resources, water supply and sanitation/wastewater and agricultural needs have often been managed individually without integration. It is acknowledged that this fragmentation has been an obstacle to developing a research strategy for a competitive water sector.

Overcoming this obstacle has been a major challenge, but in 2004 the EU established the European Environmental Technology Action Plan (ETAP) whose goal was to remove obstacles and to release the full potential of environmental technologies for environmental protection, whilst contributing to competitiveness and economic growth.

The TRM is therefore a complementary approach bringing together the state of current research and existing technologies with the needs of the water sector. It includes a short and long term vision for 2015 and 2030. It also takes into consideration different drivers for each working area and need.

The TRM is shown in a table for each area and technological need in order to set the necessary innovation dependant timescale and the key challenges (drivers). The classification of the working areas and the state of the existing technologies in the water sector drove the five major programmes that ACQUEAU identified as priorities in the short term. Those five key programmes have been chosen considering not only what could sensibly be proposed today by the water industries but also considering the key factor of creating new , innovation-led markets and services in Europe.

Five major programmes for innovation

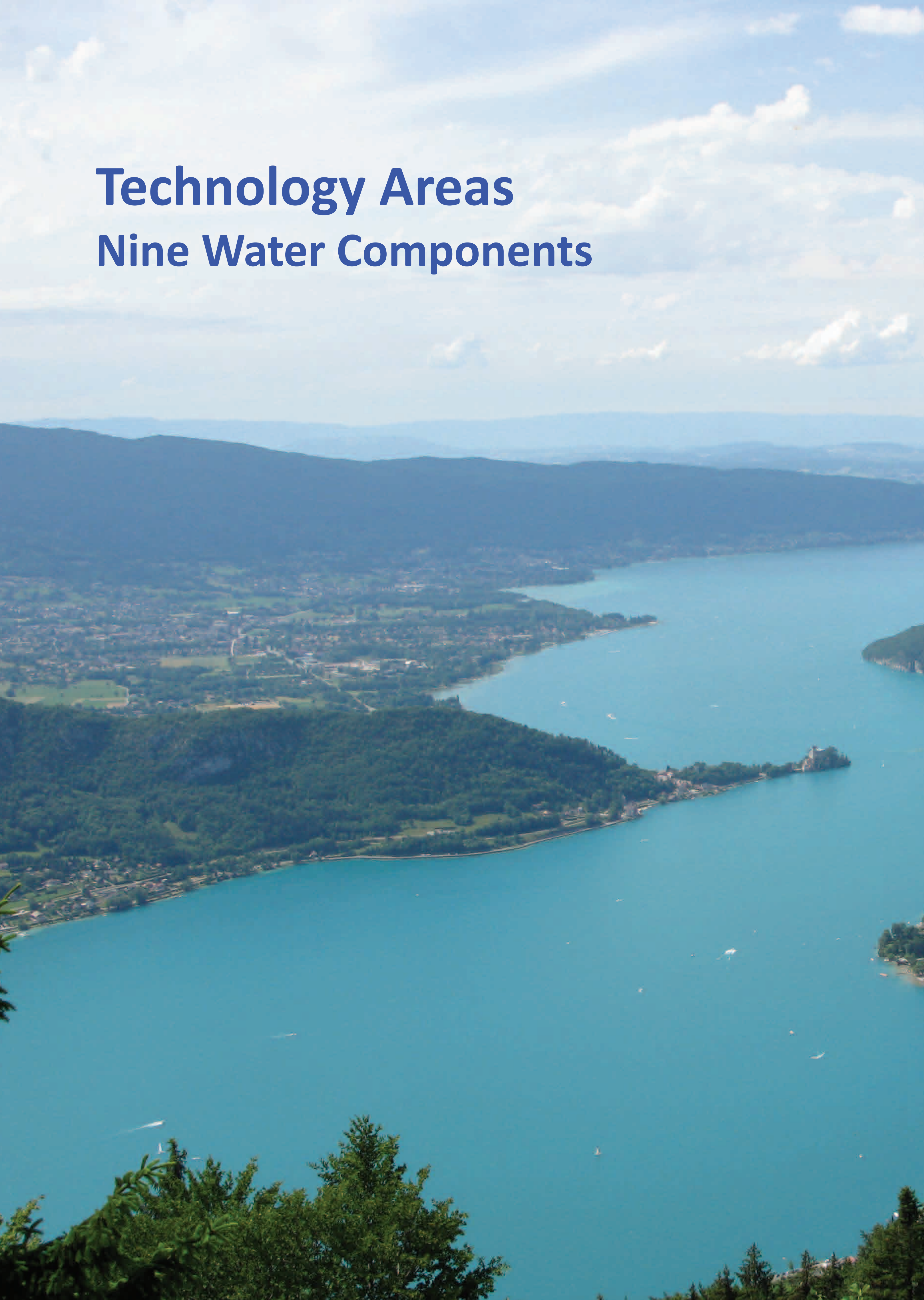
The first phase of activity of ACQUEAU is based on five major programmes that will contribute to create new markets and technologies for the water sector. It will influence directly the standards of tomorrow and develop key know-how for the European water sector.

These key major programmes are:

1. Membranes technologies
2. Real-Time System Management
3. Low energy waste water treatment
4. Material for pipes and coating
5. Low environmental impacts for disinfection and oxidation

This section describes briefly the scope of each programme, the objectives of such a programme, the technical targets and the market. It also includes the potential companies that could be interested in submitting an application to build new projects within the framework of a EUREKA initiative.

Technology Areas
Nine Water Components



Water component 1

Water Resources

Protect water resources and prevent damages to the environment

Water Resources are seen by the stakeholders from different perspectives. To water undertakings they are both the "raw material" for the production of drinking water and the receiving bodies for treated effluent discharges. Consumers, however wish to live in an ecologically sound environment and demand the protection of water sources. Resources are more and more under threat and efforts have been allocated to managing demand and quality and to improving the efficiency of water use.

More generally speaking, we are now heading towards a better fit between the supply and the demand (relating to both quality and quantity). "Alternative resources", i.e. resources other than the traditional underground and surface water, are gaining acceptance in regions with water stress. These alternative resources can include rainwater (harvested before reaching rivers or aquifers), sea water, brackish water, and wastewater re-use or grey water.

Measures for environmental protection applied in recent decades in industrialized countries have improved the quality of water sources considerably. This has required the cooperation of all parties involved, particularly, industry, agriculture, waste water treatment and water supply as well as stringent performance control.

Treatment technologies for sea (or brackish) water have improved a lot in recent years and are now widely used. With the expected decrease of energy consumption of these technologies, sea water will become a real alternative in many coastal areas throughout the world.

For industry, reuse and recycling will probably be the larger source of "alternative resources", not only in a closed-loop inside a given factory but also on a broader perimeter, one industry's discharge becoming another's resource.

3Other alternatives such as ice from glaciers or snow (before melting and reaching rivers or aquifers), dew condensation have not been considered as they are not at present economic.

Vision and Challenges

Climate change will increase water stress especially in areas already short of water and may influence the water quality. In addition, population growth is leading to an increase of consumption and pollution. At the same time, regulations are growing more stringent on environmental issues and on the quality of drinking water, thereby raising the cost of water services.

The EU Water Framework Directive (WFD) requires water quality issues to be addressed at the river basin level with the ultimate aim of achieving "good status" for all water bodies and "good ecological status" for surface water bodies. Efforts to reach these objectives will require specific measures including decrease of diffuse pollution, enhanced control of priority substances and improvement and restoration of aquatic ecosystems.

Efforts devoted to protecting or restoring the quality of the resource will retain their importance in the future with changed drivers, but might not be sufficient in areas suffering from water stress and population growth. Additional interest will focus on managing the demand and this will work in favour of reuse, recycling and producing a better fit between demand and supply by using water of the right quality and quantity for a given use.

In areas of water stress, more efforts will be devoted to looking for non-conventional resources. Public health, consumer requirements and the environment will be the main issues to address when looking at alternative resources and specific water treatment will have to be developed in accordance with the regulations for any particular water use.

Benefits and Expected Technologies Breakthrough

Balancing the growing water demand (domestic, industries and agriculture) and availability of the resources will be a major challenge of the coming decades in regions with water stress and increasing prosperity. Measures will be taken to build up a natural and socially harmonious environment in which water sources will play a major role. Areas of former industrial activity will be restored and natural wetlands will be conserved.
Water efficiency and more intense water management (both quality and quantity) in each sector will be the objectives. Our capacity to respond to this request will be dependent on the development of faster and more reliable analytical tools and on-line quality monitoring sensors, improvements in IWRM and DSS, the capacity to process a large amount of data coming from different sources and finally modelling for both forecasting and control purposes.

With the development of reliable and cheap sensors, real-time monitoring and control will become possible, opening the door to real-time management of the quality and quantity, as long as infrastructures are modified to do so.

The use of less expensive and more natural treatment technologies for water supply will be applied to well protected water sources. This will require the control of pollution and the maintenance or restoration of the quality of ecosystems. Non-conventional resources may be treated to an increasing degree by dedicated technologies.

Work Areas

Sustainable use of water resources

In quantity:

- DSS and demand management systems to allocate water resources
- Advanced methods and tools to set environmentally sustainable river flows
- Abstraction of groundwater from karstic systems
- Reliable identification of quality and quantity of underground water before drilling

In quality:

- Comprehensive water quality and nutrient monitoring tools, including early warning systems for pollution and pathogen detection
- Protection of catchment areas
- Mitigation of salt-water intrusion
- Better technologies for modelling, controlling & removing diffuse and point source pollution
- Integrated eco-technological solutions for remediation and mitigation of degraded water zones
- Real-time management of different resources according to the needs

Alternative resources

In quantity:

- Rainwater harvesting
- Reuse of wastewater, grey water, etc. (Cf. water treatment)
- Sea water and brackish water (Cf. water treatment)
- Aquifer recharge

Alternative resources

- Risk management
- Impact of climate change on water sources and remediation measures

Membranes (Cf. water treatment)

- Reuse of wastewater, grey water, etc.
- Sea water and brackish water

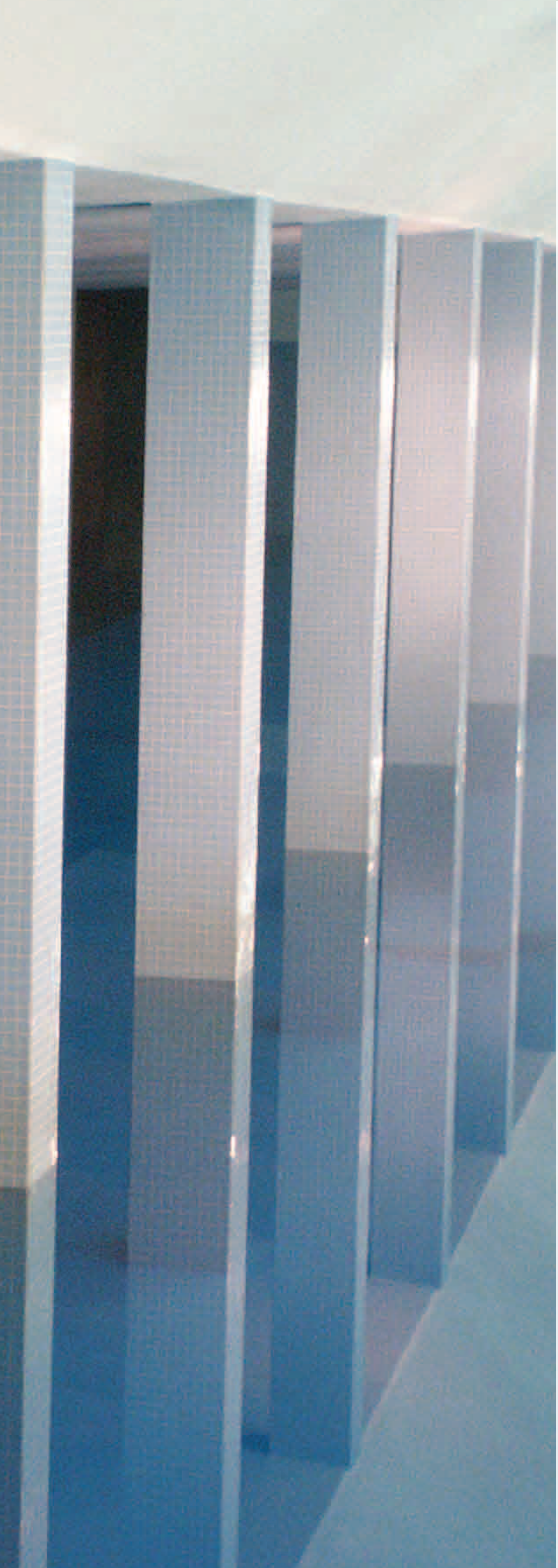
Real Time System Management

- IWRM/DSS: quality assessment to highlight benefits of advanced approach such as hydro-economical models
- Methodologies to map and to format the collected data, GIS-based tools to assess risks in groundwater catchments
- Economic models (e.g.: how to value water savings, tool to facilitate transactions with reservoir managers or farmer associations...)
- Development of interpretation tools, algorithms (trends, reference data, prediction, compliance)
- Technologies to support data collection, sampling, surveys
- Improvement of spatial and temporal measurement with new sensors /data loggers and multilevel permanent monitoring
- Real time data loading from monitoring network and soft data sources, data transfer from sensors to data base and modellers

Time Frame and Drivers for Technologies Needs

Technology Need Drivers scored 1: Very High, 2: High, 3: Average, 4: Low, 5: Very low

Technology Area	Technology Need	2015	2030	Public Health	Environment	Cost Reduction	Business opportunities	Regulatory Compliance	Technologies Breakthrough
Sustainable use : quantity	DSS and demand management systems to allocate water resources	X		3	2	2	2	5	3
	Advanced methods and tools to set environmentally sustainable river flows	X		3	1	1	5	3	5
	Abstraction of groundwater from karstic systems	X		1	3	2	2	3	3
	Reliable identification of quality and quality of underground water before drilling		X	3	3	1	2	5	1
Sustainable use : quality	Comprehensive water quality and nutrient monitoring tools, including early warning systems for pollution and pathogen detection	X		1	1	2	1	1	3
	Protection of catchment areas	X		3	1	2	3	1	3
	Mitigation of salt-water intrusion	X		3	3	1	3	3	3
	Better technologies for modeling, controlling and removing diffuse and point source pollution		X	2	1	2	2	2	3
	Integrated eco-technological solutions for remediation and mitigation of degraded water zones		X	2	1	1	1	2	2
	Real-time management of different resources according to the needs		X	2	2	1	1	1	1
Alternative resources	Rainwater harvesting	X		1	1	5	3	2	5
	Reuse of wastewater, grey water, etc. (Cf. water treatment)								
	Sea water and brackish water (Cf. water treatment)								
	Aquifer recharge	X	X	1	1	3	2	2	2
Climate change	Risk management	X		1	1	3	2	2	3
	Impact of climate change on water sources and remediation measures		X	1	1	3	3	3	3
Membranes	Reuse of wastewater, grey water, etc. (Cf. water treatment)	X		1	1	3	2	1	3
	Sea water and brackish water (Cf. water treatment)	X		1	1	2	1	2	2
Real Time System Management	IWRM/DSS : quality assessment to highlight benefits of advanced approach such as hydro-economical models	X		3	1	5	3	2	5
	Methodologies to map and format the collected data, GIS-based tools to assess risks in groundwater catchments	X		3	1	5	3	2	5
	Economic models (e.g.: how to value water savings, tool to facilitate transactions with reservoir managers or farmer associations…)	X		5	2	5	4	2	5
	Development of interpretation tools, algorithms (trends, reference data, prediction, compliance)	X		3	1	5	3	2	5
	Technologies to support data collection, sampling, surveys	X		3	1	5	3	2	5
	Improvement of spatial and temporal		X	3	1	3	3	2	3



Water component 2

Water Treatment

Anticipate emerging quality issues and protect the public health

Water treatment plants (WTP) are producing drinking water from different sources of varying quality such as surface water, groundwater or seawater using various technologies including filtration, flocculation, precipitation, oxidation and adsorption.
Suitable technologies for drinking water treatment depend on feed water quality and quantity (from Point-of-Use systems up to plants serving large conurbations) Depending on the treatment scheme they produce liquid and solid wastes (e.g. brines and sludges) which need to be handled and reused.
Moreover, treatment technologies should manage the risks arising from the catchment area or the water source (e.g. trace compounds, microorganisms, including temporal variations or consequences of pollution accidents) in order to reliably produce water at least of a quality as defined in the European drinking water directive and water framework directive. In this regard, WTPs are often equipped with on-line technologies to monitor the treatment quality and also to control the process operation and optimise the operating conditions. The technologies implemented to produce safe drinking water have also to consider the effects of water treatment on the distribution system (e.g. corrosion or particle load) and the potential for recontamination in the distribution system. The latter may require additional process steps for pH adjustment, remineralisation or final disinfection.
Recent industrial developments have widened the range of drinking water technologies. The most rapid advances in recent years were witnessed in the areas of membrane and nano technologies, with applications such as reverse osmosis (RO) for seawater desalination, low pressure reverse osmosis membranes (LPRO) or nanofiltration (NF) for softening or removal of trace compounds and micro- and ultrafiltration (MF/UF) for the removal of particles and microorganisms. Full scale installations of membrane plants in public water supply are showing exponential growth, following the increased competitiveness of these technologies.
Beyond the need for infrastructure that can be costly for a community and occupy vast and valuable spaces, treatment steps require carefully selected additives and consumables to minimize the whole life cost and the environmental footprint of a system.

Vision

Raw water availability will be affected by catchment protection and climate change. From current understanding a multiple barrier concept inside and outside the treatment process guarantees safe drinking water. However the primary focus will be the improvement of the quality of surface and ground water sources as supported by the European Water Framework Directive.
In high income countries, public awareness is expected to increase and to remain at a high level. Issues such as pharmaceutical and endocrine disrupting compounds will be

increasingly emphasized. This will influence the choice of treatment technologies in accordance with new drinking water guidelines.

Technological breakthroughs will occur and new technologies will be developed and will become competitive to address the European needs for safe drinking water treatment. The European industry will take the lead in developing these new technologies and systems. This industrial know-how will be exported to other regions of the world. In developed countries similar issues to those in Europe will be addressed whilst low income countries will be in urgent need of solutions to provide safe drinking water for their populations.

Water works usually prefer proven technologies due to their strict responsibility to deliver high quality water at any time to the population. Therefore, full-scale demonstration of any innovative processes will be required. In order to reduce the industrial and economical risk taken by the water utilities, the demonstration projects in Europe will need to be financially supported by regional, national or European instruments. The introduction and demonstration of new technologies in waterworks within the European Community will not only help refine the developed process, but will also act as reference for sustainable and cost-effective water treatment in Europe.

Challenges

Public Health and Drinking Water Quality

Among all products for direct consumption, drinking water has to cope with the most regulatory constraints (as specified in the European Drinking Water Directive and also in the Water Framework Directive) and is therefore the most monitored and controlled "food"product.

The introduction of advanced treatment systems improves the finished water quality and enhances the reliability of the whole treatment process. Systems of any size must produce the required quality for safe drinking water. This concerns not only very large plants serving an entire conurbation of up to several million inhabitants but also domestic systems (Point-of-Use devices). In the context of increased urbanisation, decentralised local structures are often presented as an option to supply drinking water. Robust, reliable and cost effective systems will be needed to serve small communities. In order to monitor the water quality and adjust the treatment conditions, specific on-line monitoring instruments and strategies are required.

Climate Change

Climate change may create extreme weather conditions, influencing quality, quantity and temperature of raw water and thus the choice and operation of water treatment steps. Future treatment plants will need to be resilient and to cope with larger fluctuations of raw water quality while still guaranteeing the drinking water quality of the treated water. Given the increased competition with other water users (industry, agriculture, environment), and the concentration of populations along coastal areas, seawater is expected to gain increased relevance as a source for drinking water production. Seawater desalination will experience huge growth if the cost competiveness can be further increased against other processes and if the environmental impact can be reduced.

Water and Energy

Current preoccupations relate to the impact of the energy crisis and "energy package" directive (aimed at the reduction of carbon emissions) on the water sector. In drinking water plants, better integration and synergies with (renewable) energy sources will be under examination as well as energy savings and the reduction of the total system carbon footprint, including construction materials and consumables. In particular, sustainable approaches may be considered to lower the carbon footprint of the whole water treatment process, such as long term protection of catchments and the application of natural treatment steps including bank filtration.

Benefits and Expected Technologies Breakthrough

Fields of innovation are expected in the following technological areas:

- Nanomaterials for water treatment
- Membrane hybrid processes
- Membrane desalination
- Membrane technologies for softening and micropollutants & organics removal
- Disinfection / advanced oxidation
- Treatment or beneficial use of brines, residues and concentrates
- Water treatment plants with low environmental footprint
- Online sensors

Nanomaterials for water treatment

Nanotechnology has huge potential for improvements in water treatment technology. Developments in nanotechnology include the development of new materials with improved performance (yield, recovery, selectivity, productivity, kinetics, etc) such as:

- New membranes (functionalised organic or inorganic membranes, composite or hybrid membranes, biocide membranes, etc.)
- New adsorbents (materials with enhanced active surface, capacity, selectivity and reactivity)
- New oxidants and catalysts (greater active surface)

Membrane technologies

Since the introduction of reverse osmosis in the 1960s and MF/UF technologies in the 1980s, membrane processes for drinking water treatment have undergone a rapid development with a steady > 10% annual growth. Today, references of large sizes (> 100 millions of litres per day, MLD) are available for all key technologies MF, UF, NF and RO. Also great expertise is available in Europe on the process integration, construction and operation of such plants' The European industry produces only a small share of the membrane modules installed worldwide. In particular, the European champions such as Norit, Inge or Aquasource remain relatively small players against world leaders such as Dow, Toray or Hydranautic. Increasing competition is now coming from emerging countries (China, Singapore, and the Middle East) which have improved their knowledge and offer membrane technologies at attractive prices. Membranes made from organic or inorganic materials and appropriate technologies, are in constant evolution (for example, prices for polymeric UF membranes have dropped by more than 90% over the last twenty years), and have short product cycles. Massive R&D efforts are witnessed in other regions of the world such as North America, Japan, Singapore, China and Australia. Industrial commitment together with public support is required in Europe in order to seize the industrial and commercial opportunity of the future market represented by membrane technologies for water applications.

Membrane technologies for softening and micropollutants & organics removal

Further progress is expected in the fields of NF or LPRO membrane technologies for softening and micropollutant and organics removal. In particular, appropriate technologies will be optimised for sustainable operation and reduced total life costs. The two following directions are considered

- Environmentally friendly operation: e.g. less use of recalcitrant antiscalants, low pressure systems, ion selective membranes, energy recovery (today there is no efficient energy recovery system for membrane systems requiring 5 to 20 bars)
- Improved 'electro-membrane' technologies (electrodialysis, electrodeionisation…) for brackish water with low salt concentration

Membrane hybrid processes

The potential of hybrid processes (type '1+1 > 2'), a combination of membrane with other processes such as adsorption, precipitation or oxidation, have not been fully exploited. This will unleash the economic potential of membrane applications, while improving the performance of a membrane plant and extending the field of application. There is a need to develop and demonstrate synergetic advanced process combinations adapted to the characteristics of the feed water. Such hybrid processes may include the combination of two membrane processes (eg NF + RO, ED + RO, Forward Osmosis, etc.…), or other processes as pre-treatment followed by a membrane technology (eg oxidation / catalyser / adsorbant + membrane, possibly using nanomaterials developed above).

In parallel adapted membrane operation concepts including advanced and environmentally friendly flushing and cleaning processes will be developed.

Disinfection / advanced oxidation

Current chemical based disinfection technologies may produce potentially harmful by-products such as halogenated compounds or bromates. In comparison, physical disinfection options such as UV-irradiation or membrane technologies remain costly and energy consuming. Environmentally friendly disinfection or advanced oxidation techniques are still needed. This could be based on catalytic disinfection (UV/TiO_2 etc, possibly using new nanomaterials). The technique of UV-LED represents a promising alternative to the current low pressure mercury lamps, as much higher energy efficiency could be achieved if the energy yield and stability / life span of the LED constructed today in visible / blue domains could be matched.

Treatment of brines, residuals and concentrates

Residuals of RO and LPRO membrane processes are often discharged directly into the sea or into surface water. Due to their environmental impact in some cases, this will be a hindrance to the broader application of these technologies.
Solutions are required to handle these waste streams, i.e. to remove the harmful pollutants, and possibly to concentrate / crystallise the valuable substances to achieve recovery ("zero liquid discharge" concept). One main focus is to develop reuse technologies for discharge flows.

Water treatment plants with low environmental footprint

Progress and breakthroughs in processes and concepts are expected to tackle the issue of reducing the overall environmental and carbon footprint of water treatment plants.
In particular, improvements are expected in the following fields:

- Low energy processes: Increasing efficiency of pumps (no improvement on pump efficiency for many years)
- Optimum integration of treatment process versus energy consumption and supply: better integration / synergetic coupling with (renewable) energy sources
- Low carbon footprint of the full treatment stream (including embedded energy in civil work and consumables, optimising design and operation, identifying alternative additives or practices)
- Optimal integration of natural processes such as bank filtration and aquifer recharge for increasing resilience and sustainability of the whole water treatment system

Online sensors

New on-line monitoring technologies will be required to monitor the treatment quality but also to control the process and optimise the operating conditions.
Technical breakthroughs for online monitoring systems will follow the current demand of water utilities in these three domains:

- Viruses and bacteriological indicators including disinfection performance control and membrane integrity tests
- Membrane fouling or water fouling propensity for low and high pressure membrane systems
- Micropollutant detection and toxicity tests

Work Areas

Nanomaterials for water treatment

(Refer to FP7 cluster “Nano4Water’)

- Make use of advances in nanoscience to develop new materials for water treatment with improved performances (yield, recovery, selectivity, productivity, etc)
- New membranes (functionalised organic or inorganic membranes, composite or hybrid membranes, biocide membranes etc)
- New adsorbents (resins, powdered activated carbon with enhanced active surface, capacity and reactivity)
- New oxidants and catalysts (greater active surface)

Membrane hybrid processes

- Develop and demonstrate synergetic advanced process combinations (type ‘1 + 1 > 2’) membrane + membrane (Ex NF + RO, ED + RO, Forward Osmosis, etc….)
- Other process + membrane (Ex oxydation / catalyser / adsorbant + membrane, possibly using nanomaterials developed above)

Membrane desalination

- Develop and demonstrate low energy membrane desalination technologies for seawater and brackish water. (current performance: 3-4 kWh/m3 for large plants with energy recovery, theoretical limit for seawater: 0.6 kWh/m3)
- Goal by 2015: 2 kWh/m3
- Optimisation of RO technology: energy recovery, pre-treatment, low pressure operation, ‘backwashable RO’ etc
- Goal by 2030: 1 kWh/m3
- Radical breakthrough technologies: membrane distillation, carbon nanotubes, biomimetic membranes such as aquaporines, etc

Membrane technologies for softening and micropollutants & organics removal

- Optimise appropriate technologies for sustainable operation and reduced total life costs:
- Environmentally friendly operation (e.g. abdication of recalcitrant antiscalants, energy recovery)
- Improve ‘electro-membrane’ technologies (electrodialysis, electrodeionisation …)

Disinfection / advanced oxidation

- Develop and demonstrate competitive strategies of disinfection and advanced oxidation
- Alternatives to chlorine and ozone to avoid by-products
- Catalytic disinfection (UV TiO2 etc, possibly using nanomaterials above)
- Develop and demonstrate UV-LED technologies (low energy and cheap if technological goals can be tackled: reach energy yield and stability of LED as in visible / blue domains)

Treatment of brines, residuals and concentrates

- New methods for managing and or valorisation of residuals of water treatment plants
- Development of techniques for beneficial use of brine
- Zero discharge softening or desalination (for in-land applications with brackish water)

Water treatment plants with low environmental footprint

(“Water & Energy”)

- Reduce environmental / carbon footprint of water treatment
- Low energy processes: High efficiency new techno pump (no improvement on pump efficiency since years)
- Optimum integration of treatment process versus energy supply: better integration / synergetic coupling with (renewable) energy sources
- Low carbon footprint of full treatment lane (including embedded energy in civil work and consumables, optimising design and operation, identifying alternative additives or practices)
- Optimal integration of natural processes such as bank filtration and aquifer recharge for increasing resilience and sustainability of system

Online sensors

- Develop relevant and economical sensors for online monitoring of:
- Viruses and bacteriological indicators incl. membrane integrity tests and UV performance control
- Membrane fouling or water fouling propensity (for low and high pressure membrane systems)
- Micropollutants / toxicity

Time Frame and Drivers for Technologies Needs

Technology Need Drivers scored 1: Very High, 2: High, 3: Average, 4: Low, 5: Very low

Technology Area	Technology Need	2015	2030	Public Health	Environment	Cost Reduction	Business opportunities	Regulatory Compliance	Technologies Breakthrough
Nanomaterials for water treatment (refer to FP7 cluster "Nano4Water')	Make use of advances in nanoscience to develop new materials for water treatment with improved performances (yield, recovery, selectivity, productivity, etc) - new membranes (functionalised organic or inorganic membranes, composite or hybrid membranes, biocide membranes etc)	X		1	3	2	2	2	2
	- new adsorbents (resins, powdered activated carbon with enhanced active surface, capacity and reactivity)	X		1	3	3	3	2	2
	- new oxidants and catalysts (greater active surface)	X		1	3	3	3	2	2
Membrane hybrid processes	Develop and demonstrate synergetic advanced process combinations (type '1 + 1 > 2') - membrane + membrane (Ex NF + RO, ED + RO, Forward Osmosis, etc….)	X		2	3	2	2	2	3
	- other process + membrane (Ex oxydation / catalyser / adsorbant + membrane, possibly using nanomaterials developed above)		X	1	3	2	2	2	1
Membrane desalination	Develop and demonstrate low energy membrane desalination technologies for seawater and brackish water. (current performance : 3-4 kWh/m^3 for large plants with energy recovery, theoretical limit for seawater : 0.6 kWh/m^3) - Goal by 2015 : 2 kWh/m^3 Optimisation of RO technology : energy recovery, pre-treatment, low pressure operation, 'backwashable RO' etc	X		3	2	3	2	3	3
	- Goal by 2030 : 1 kWh/m^3 Radical breakthrough technologies : membrane distillation, carbon nanotubes, biomimetic membranes such as aquaporines, etc		X	3	2	1	1	3	1
Membrane technologies for softening and micropollutants & organics removal	Optimise appropriate technologies for sustainable operation and reduced total life costs: - environmentally friendly operation (e.g. abdication of recalcitrant antiscalants, energy recovery)	X		1	2	3	2	2	2
	- Improve 'electro-membrane' technologies (electrodialysis, electrodeionisation …)	X		1	4	3	2	2	2
Disinfection / advanced oxidation	Develop and demonstrate competitive strategies of disinfection and advanced oxidation - Alternatives to chlorine and ozone to avoid by-products Catalytic disinfection (UV TiO2 etc, possibly	X		1	3	3	3	2	2

Time Frame and Drivers for Technologies Needs

Technology Need Drivers scored 1: Very High, 2: High, 3: Average, 4: Low, 5: Very low

Technology Area	Technology Need	2015	2030	Public Health	Environment	Cost Reduction	Business opportunities	Regulatory Compliance	Technologies Breakthrough
Treatment of brines, residuals and concentrates	New methods for managing and or valorisation of residuals of water treatment plants Development of techniques for beneficial use of brine	X		4	1	4	4	2	2
	Zero discharge softening or desalination (for in-land applications with brackish water)	X		4	2	4	4	2	2
Water treatment plants with low environmental footprint ("Water & Energy")	Reduce environmental / carbon footprint of water treatment Low energy processes: High efficiency new techno pump (no improvement on pump efficiency since years)	X		4	4	2	2	4	2
	Optimum integration of treatment process versus energy supply: better integration / synergetic coupling with (renewable) energy sources	X		4	4	3	3	4	3
	Low carbon footprint of full treatment lane (including embedded energy in civil work and consumables, optimising design and operation, identifying alternative additives or practices)	X		4	3	3	3	4	4
	Optimal integration of natural processes such as bank filtration and aquifer recharge for increasing resilience and sustainability of system	X		2	2	2	3	2	3
Online sensors	Develop relevant and economical sensors for online monitoring of: Viruses and bacteriological indicators incl. membrane integrity tests and UV performance control	X		1	4	3	2	1	2
	Membrane fouling or water fouling propensity (for low and high pressure membrane systems)	X		3	4	2	4	3	3
	Micropollutants / toxicity	X		2	3	3	3	2	2

Water component 3

Water Distribution

Optimise the cost of the management of water

Water distribution systems are essential infrastructures for any modern society and key elements for public health, growth and human development. However, a large proportion of the world's population does not have access to safe drinking water.

The water distribution component worldwide has two contrasting realities and associated challenges:

1. In developing areas of the world, improving access to water by providing appropriate infrastructure is a key role of the water authorities and the water industry.
2. In developed regions, existing water distribution systems must be operated and maintained efficiently in order to manage cost, risk and quality of service to consumers.

Where available, water distribution systems in urban areas are usually comprised of complex pressurized pipeline networks which carry treated water from production plants (water treatment plants, desalination, etc.) to consumers. In order to meet consumer demands with adequate quality and pressure levels, these systems contain storage tanks, flow/pressure control elements such as pumping stations and valves and quality control and/or disinfectant injection stations. In most cases, the system may be operated remotely from a central location through telemetry and remote control systems. These provide monitoring, supervision and control capabilities, based on real-time measurement and decision support tools.

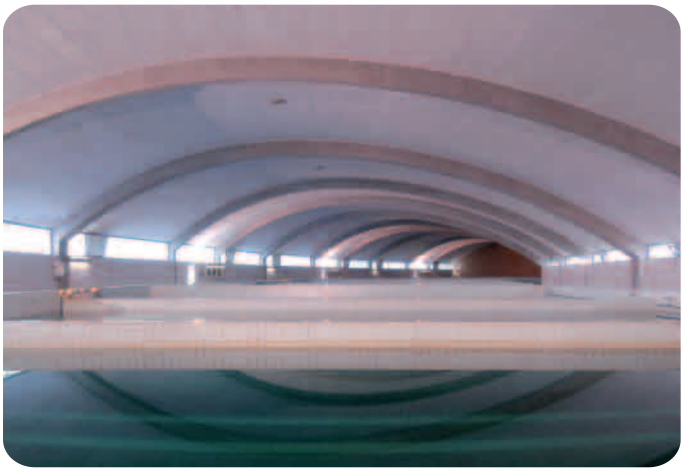
Water distribution systems are increasingly challenged by several factors, namely:

- A growing demand: As the world's population increases, so does the proportion of people living in urban areas, putting extra strain on infrastructure
- Climate change: Water supplies may be increasingly scarce due to environmental factors and changes in water usage
- Energy demand: Supplying water with appropriate pressure and quality levels is an energy-consuming process. Rising energy costs and the need for carbon footprint reduction will require maximum energy efficiency
- High CAPEX: networks represent the largest part of the investment in water infrastructure
- An ageing infrastructure: Poor infrastructure condition is the main cause for water loss, a crucial problem for water utilities, due to its economic, environmental and service disruption impacts
- Increasingly stringent regulation: Higher standards of service quality are required by consumers and regulators

Advances in technology and specific research can provide answers to these challenges, as follows:

- Developing strategic investment planning for infrastructure over the short, medium and long term, based on an accurate knowledge of the infrastructure condition and performance
- Incorporating advances in new materials for water network building, rehabilitation and monitoring

• Incorporating advances in sensor and actuator technology, telecommunications and computer control to improve monitoring and control of quantity and quality in water systems, in order to minimize energy consumption, operational costs and water loss.



Vision and Challenges

Water distribution systems may face the challenges imposed by a growing demand, climate change, energy efficiency, ageing infrastructure and increasingly stringent service standards by developing research and incorporating technological advances in several areas.

In the next 5-10 years, strategic infrastructure-planning programmes will aim towards:

• Characterizing infrastructure location and condition, using advanced intrusive and non-intrusive detection and inspection techniques

• Understanding mechanisms of infrastructure deterioration and failure by comprehensive studies of material-water interactions

• Developing appropriate tools to forecast performance for a given level of investment and to provide decision support for rehabilitation

Similarly, in order to improve the energy efficiency of operation, and to reduce overall costs, water loss and the risk of service failure or quality degradation, research must be focused on:

• Taking advantage of new sensor technology to improve monitoring at moderate cost

• Incorporating advances in wireless telecommunication systems and more autonomous power supply to achieve greater coverage of monitoring

• Furthering the development and implementation of decision support tools for predictive control of water networks, in order to operate pumps and valves, according to specific operational goals, such as reducing energy use and electricity cost.

• Use of mathematical models and enhanced sensing to detect and locate water leaks and/or water quality degradation.

Over the next 20 years, the research agenda will presumably also be focused on:

• The need to develop techniques and materials to improve access to safe drinking water to an increasingly large number of regions

• The need to incorporate advances in new materials to improve infrastructure performance

• Climate change and global change which will influence the amount and quality of water sources, prompting the need for integrated water resources management at a watershed level

• New water regulations driven by an enhanced level of awareness and detection capabilities for emerging contaminants, which will in turn require investment in treatment and distribution.

Benefits and Expected Technologies Breakthrough

Strategic Asset management in water distribution systems will benefit from:
• Detection techniques for buried pipes
• Inspection techniques based on remotely controlled vehicles and robotic tools
• Advanced materials testing and analysis techniques
• Capital investment planning tools
• Database and information integration techniques

Efficient operation, monitoring and control will benefit from:
• Advances in sensors and micro-sensors to achieve low-consumption, low-cost devices
• Wireless telecoms
• Alternative energy supply systems for increased autonomy
• More extensive use of modelling and decision-support tools

During this period, important contributions may derive from the field of materials research:
• New materials to improve water systems performance
• New pipe coatings with sensing capabilities for continuous monitoring at specific strategic locations
• Advanced composite materials to prevent corrosion in valves
• Low-cost materials

Work areas

Non-intrusive detection techniques

• Characterizing infrastructure location
• Characterizing infrastructure condition

Inspection, Robotics, Data management

• Characterizing infrastructure condition (tethered or externally-operated devices)
• Characterizing infrastructure condition (autonomous devices)

Materials, corrosion

• Understanding mechanisms of infrastructure deterioration and failure

Maintenance and rehabilitation planning

• Understanding pump & valve life-span and deterioration

mechanisms; developing pre-emptive maintenance plans
- Develop new techniques for rehabilitation to minimize disturbance
- Develop new techniques for rehabilitation works, without disturbance and respectful of the environment

Software development

- Applying knowledge mechanisms of infrastructure deterioration and failure in decision support tools Investment planning, software development
- Strategic investment planning tools

Sensors

- Advanced monitoring capabilities (study and test of new sensors)
- Advanced monitoring capabilities (extensive implementation of low-cost micro sensors)

Telecommunications

- Efficient telecommunications for water network monitoring and control (study and prototype testing)
- Efficient telecommunications for water network monitoring and control (extensive implementation)

Energy efficiency

- Advances in autonomy of power supply for water network monitoring and control (study and prototype testing)
- Advances in autonomy of power supply for water network monitoring and control (extensive implementation)

Operational Efficiency, Systems Engineering, Software development

- Predictive control and decision support tools for efficient real-time network operation, including cost minimization in pumping operations, as well as quality and safety optimization (development, 1 real-time implementation)
- Predictive control and decision support tools for efficient real-time network operation, including cost minimization in pumping operations, as well as quality and safety optimization (extensive implementation)
- Modelling and decision support for leak detection and location/ efficiency monitoring (development, single real-time prototype)
- Modelling and decision support for leak detection and location/ efficiency monitoring (extensive implementation)
- Modelling and decision support tools for real-time quality monitoring (prototype)
- Modelling and decision support tools for real-time quality monitoring (complete implementation at a few sites)
- Data integration and sharing between operations, investment planning, billing, etc. for efficient use of information
- Data integration and sharing between operations with new operational software (rehab, monitoring, decision support, etc.)

Materials

- New materials for building water networks in areas with no access to safe drinking water (analysis, testing)
- New materials for building water networks in areas with no access to safe drinking water (deployment)
- New materials for enhanced pipe performance and durability (analysis, testing)
- New materials for enhanced pipe performance and

durability (deployment)

- New materials for infrastructure with lower carbon footprint
- New materials for enhanced monitoring of water infrastructure (intelligent pipes with embedded sensors to detect leaks) (analysis, testing)
- New materials for enhanced monitoring of water infrastructure (intelligent pipes with embedded sensors to detect leaks) (deployment)

Knowledge acquisition and transfer

- Best practice manuals for constructing water networks in areas with no access to safe drinking water

Integrated resources management, Systems engineering, software development

- Decision support tools for Integrated water resources management at watershed level (development, testing)
- Decision support tools for Integrated water resources management at watershed level (extensive implementation)
- Data management for leak control and performance monitoring using intelligent pipes at strategic locations (development, prototype implementation)
- Data management for leak control using intelligent pipes at strategic locations (real-time extended implementation)

Time Frame and Drivers for Technologies Needs

Technology Need Drivers scored 1: Very High, 2: High, 3: Average, 4: Low, 5: Very low

Technology Area	Technology Need	2015	2030	Public Health	Environment	Cost Reduction	Business opportunities	Regulatory Compliance	Technologies Breakthrough
Non-intrusive detection techniques	Characterizing infrastructure location	X		3	4	2	2	2	1
	Characterizing infrastructure condition		X	3	4	2	2	2	1
Inspection, Robotics, Data management	Characterizing infrastructure condition (tethered or externally-operated devices)	X		2	3	2	2	2	1
	Characterizing infrastructure condition (autonomous devices)		X	2	3	2	2	2	1
Materials, corrosion	Understanding mechanisms of infrastructure deterioration and failure	X		2	3	2	2	2	2
Maintenance and rehabilitation planning	Understanding pump and valve life-span and deterioration mechanisms; developing preemptive maintenance plans	X		3	2	1	3	2	4
	Develop new techniques for rehabilitation to minimize disturbance	X		2	3	3	2	2	2
	Develop new techniques for rehabilitation works, without disturbance and respectful of the environment		X	2	1	3	2	2	2
Software development,	Applying knowledge mechanisms of infrastructure deterioration and failure in decision support tools		X	2	3	2	2	2	2
Investment planning, software development	Strategic investment planning tools	X		5	5	1	2	2	5
Sensors	Advanced monitoring capabilities (study and test of new sensors)	X		1	2	2	2	2	1
	Advanced monitoring capabilities (extensive implementation of low-cost micro sensors)		X	1	2	2	2	2	1
Telecommunications	Efficient telecommunications for water network monitoring and control (study and prototype testing)	X		2	5	2	2	4	1
	Efficient telecommunications for water network monitoring and control (extensive implementation)		X	2	5	2	2	4	1
Energy efficiency	Advances in autonomy of power supply for water network monitoring and control (study and prototype testing)	X		2	1	1	1	4	1
	Advances in autonomy of power supply for water network monitoring and control (extensive implementation)		X	2	1	1	1	4	1
Operational Efficiency, Systems Engineering, Software development	Predictive control and decision support tools for efficient real-time network operation, including cost minimization in pumping operations, as well as quality and safety optimization (development, 1 real-time implementation)	X		3	2	1	1	2	2
	Predictive control and decision support tools for efficient real-time network operation, including cost minimization in pumping operations, as well as quality and safety optimization (extensive implementation)		X	3	2	1	1	2	2
	Modelling and decision support for leak detection and location/ efficiency monitoring (development, 1 real-time prototype)	X		2	2	1	1	4	2

Time Frame and Drivers for Technologies Needs

Technology Need Drivers scored 1: Very High, 2: High, 3: Average, 4: Low, 5: Very low

Technology Area	Technology Need	2015	2030	Public Health	Environment	Cost Reduction	Business opportunities	Regulatory Compliance	Technologies Breakthrough
Operational Efficiency, Systems Engineering, Software development	Modelling and decision support for leak detection and location/ efficiency monitoring (extensive implementation)		X	2	2	1	1	4	2
	Modelling and decision support tools for real-time quality monitoring (prototype)	X		1	2	5	1	1	1
	Modelling and decision support tools for real-time quality monitoring (complete implementation at 1 or few sites)		X	1	2	5	1	1	1
	Data integration and sharing between operations, investment planning, billing, etc. for efficient use of information	X		5	5	1	1	2	3
	Data integration and sharing between operations with new operational software (rehab, monitoring, decision support, etc.)		X	5	5	1	1	2	3
Materials	New materials for building water networks in areas with no access to safe drinking water (analysis, testing)	X		1	1	2	1	3	3
	New materials for building water networks in areas with no access to safe drinking water (deployment)		X	1	1	2	1	3	3
	New materials to enhanced pipe performance and durability (analysis, testing)	X		1	1	1	1	3	1
	New materials to enhanced pipe performance and durability (deployment)		X	1	1	1	1	3	1
	New materials for infrastructure with lower carbon footprint		X	3	1	4	1	2	2
	New materials for enhanced monitoring of water infrastructure (intelligent pipes with embedded sensors to detect leaks) (analysis, testing)	X		1	2	1	1	1	1
	New materials for enhanced monitoring of water infrastructure (intelligent pipes with embedded sensors to detect leaks) (deployment)		X	1	2	1	1	1	1
Knowledge acquisition and transfer	Best practice manuals for building water networks in areas with no access to safe drinking water	X		1	1	1	1	2	5
Integrated resources management, Systems engineering, software development	Decision support tools for Integrated water resources management at watershed level (development, testing)		X	3	3	1	1	2	3
	Decision support tools for Integrated water resources management at watershed level (extensive implementation)		X	3	3	1	1	2	3
	Data management for leak control and performance monitoring using intelligent pipes at strategic locations (development, prototype implementation)	X		3	1	1	1	2	1
	Data management for leak control using intelligent pipes at strategic locations (real-time extended implementation)		X	3	1	1	1	2	1

Water component 4

Customers

Enforce the trust and confidence of consumers towards water

In recent decades, the public interest in the Environment and more specifically in water (and wastewater) issues has been growing. More recently, with the impact of Climate Change, this interest has turned into a real concern about the threat to the availability of freshwater and the impact of pollution. Also in some European countries the situation relating to drought and to water stress provides an urgent need to develop a management system that includes the use of water for water ecosystems needs. The competition for water uses has increased.

However the regulations have become more stringent: the higher quality of the drinking water and the advanced treatment of wastewater have led to an increase in the cost of the service. Even if they are more interested, the price increase is not always well understood by the customers. In terms of the infrastructure, in some major cities there is an increasing need for rehabilitation and extension that incurs increasing costs for delivering water.

The expectations of the customers are linked with their specific situation and are very different depending of the level of service that is proposed. In countries where the service is not delivered 24h/24, the first requirement is for a constant supply. Then, once the quantity is sufficient to meet the needs, the quality of water and the price become important.

Customers of Western countries are used to high quality standards but remain concerned by the possible impact on health. From the service point of view, they request ease of contact and a quick response when there is a problem. In the coming years, they might be asking for a better control and knowledge of their individual consumption, individual treatments for water or wastewater, recycling systems and rainwater harvesting but all within a safe risk-free operating regime.

Vision and Challenges

The “customer” is at the same time a citizen, a user, a consumer and a taxpayer.

As a citizen, he might be concerned about the availability and the quality of the water resources. He is thinking in terms of sustainable development, “the natural environment” and the protection of eco-systems in order to maintain biodiversity of species. As a water consumer, it is different. In some regions of the world, water is a question of survival. But in European countries, people are used to having it available at the tap at any time and do not think about it anymore. The “green citizen” does not always act as a well-informed consumer and does not always make the link between his own way of living and the impacts on the environment. The costs related to the protection of the environment are not on his mind, and he regards it as a “public administration issue”. The expectations are very high, but not the willingness to pay. Introducing the

idea of "monetarizing" environmental impacts can help to change the perception.
The customer is the one who pays for water provision (directly or indirectly). Some decades ago, this customer – probably because he was captive – was not really identified as a "customer" but more as a "user" and the "customer service" element was more related to billing and responding to complaints. He is now perceived as a customer with full rights.
The first step taken in this direction was about understanding his expectations. The second step is to fulfil them, and thanks to in-house ICT tools, it opens the door to a full range of services to be provided. Using AMR would be the key for providing new and advanced services linked to the use of water, such as real-time information about leakage, and this will impact on the behaviour of the customers.
One of the issues for the customer is about the price of water. People used to think that water was free, and it is. But the water service cannot be free. The costs have increased in the past years, mainly because of new regulations on wastewater imposing an upgrading of the installations. People have to understand that either they pay for the protection of the environment on their water bill, or they pay for it in their tax. To find an equable sharing of costs between the customers and the taxpayers is an important matter and the split point is not always obvious. As additional costs arise linked to protection of the water resources, flood protection (linked to Storm water management) and new regulations, understanding the position of the customers related to the price will become an important issue. Continuous improvements have to be made to invoices, with a clear explanation of the various elements of the price of water, thus improving the relationship between the customers and the service provider by developing easy access to such information.

Benefits and Expected Technologies Breakthrough

The fast-growing development of ICT tools and the advances in domestic communications (such as the internet) has started to change profoundly the way service providers communicate with their customers. Nowadays, it is already a two-way communication allowing on one side (the supplier) to gather information on the expectations of the customers, their satisfaction, etc. and on the other side (the customer) to get easy access to information about the systems, tariffs, etc.
However this might also create different categories of customers: those with and those without access to ICT. It is therefore important to develop, whilst ICT tools are expanding, a service for customers without access to these tools, in order to guarantee the same level of service and information for all customers.
As Automatic Meter Reading systems are becoming widespread, they will allow not only access to real-time consumption data, but also to any type of data regarding such items as consumption patterns, network status, leak detection and any other information useful for the supplier and the customers. The challenge is to be able to handle this flow of information and to be able to analyze and share it. In fact, it could allow a water consumption audit for every customer in the future. The need to investigate ways of maximising battery life and provide the support to send information (radio, optical fibres etc) is one of the central technological issues linked to AMR.

Work areas

Social Engineering

- Tolls for analysis of psychological barriers for water reuse and use of alternative resources
- Tools for acceptance of water pricing: cultural and institutional barriers, willingness to pay
- Tools to monitor customers expectations and satisfaction
- Tools to monitor customers behaviour patterns

Automatic Meters Reading (AMR) systems

- Data transportation directly from the customers to integrators (w/o concentrators)
- Universal access to information (for customers w/o their own ICP systems
- Battery-free AMR systems
- On-line detailed household consumption patterns

Pricing

- Individual economical and reliable metering systems, linked to tariff structures and billing procedures allowing both demand management and social access to water
- Pricing systems which are affordable and efficient and match the income profile of water users
- Demands for smart and stable tariff structures, able to combine cost coverage (fixed and variable), economic value of natural water resources and demand management (ad-hoc pricing systems)

Quality monitoring

- Replacement of chlorine for disinfection (with the same advantages as chlorine but w/o the disadvantages – Cf. water treatment)

Real Time System Management

- Real-time monitoring of the quality at the tap
- New sensors for bacteriology, taste and smell for on-line monitoring of water quality and treatment processes at individual level (domestic, "small" commercial premises)
- Sensors/systems for internal leak detection

Materials

- "Self-repairing" domestic piping system

Time Frame and Drivers for Technologies Needs

Technology Need Drivers scored 1: Very High, 2: High, 3: Average, 4: Low, 5: Very low

Technology Area	Technology Need	2015	2030	Public Health	Environment	Cost Reduction	Business opportunities	Regulatory Compliance	Technologies Breakthrough
Social Engineering	Tolls for analysis of psychological barriers for water reuse and use of alternative resources	X		**1**	**1**	**5**	**3**	**2**	**5**
	Tools for acceptance of water pricing : cultural and institutional barriers, willingness to pay.	X		**5**	**5**	**3**	**5**	**3**	**5**
	Tools to monitor customers expectations and satisfaction	X		**3**	**3**	**5**	**2**	**5**	**5**
	Tools to monitor customers behaviour patterns	X		**4**	**3**	**3**	**2**	**5**	**4**
Automatic Meters Reading (AMR) systems	Data transportation directly from the customers to integrators (w/o concentrators)	X		**5**	**2**	**1**	**1**	**5**	**1**
	Universal access to information (for customers w/o in-house ICP systems	X		**5**	**5**	**3**	**3**	**1**	**3**
	Battery-free AMR systems		X	**4**	**1**	**1**	**1**	**5**	**1**
	On-line detailed in-house consumption pattern		X	**5**	**3**	**2**	**2**	**5**	**2**
Pricing	Individual economical and reliable metering systems, linked to tariff structures and billing procedures allowing both demand management and social access to water	X		**5**	**5**	**5**	**1**	**1**	**3**
	Pricing systems which are affordable and efficient and complying with income timing of water users	X		**5**	**5**	**5**	**1**	**1**	**3**
	Demands for smart and stable tariff structures, able to combine cost coverage (fixed and variable), economic value of natural water resources and demand management (ad-hoc pricing systems)	X		**5**	**5**	**5**	**1**	**1**	**3**
Quality monitoring	Replacement of chlorine for disinfection (with the same advantages than chlorine but w/o the disadvantages – Cf. water treatment)		X	**1**	**3**	**3**	**1**	**1**	**1**
Real Time System Management	Real-time monitoring of the quality at the tap	X		**1**	**5**	**3**	**1**	**1**	**1**
	New sensors for bacteriology, taste, smell … for on-line monitoring of water quality and treatment processes at individual level (domestic, "small" professionals)		X	**1**	**5**	**3**	**1**	**1**	**1**
	Sensors/systems for internal leak detection		X	**1**	**5**	**3**	**1**	**1**	**1**
Materials	"Self-repairing" domestic piping system		X	**3**	**3**	**2**	**1**	**5**	**1**

Water component 5

Agriculture

Achieve a sustainable production while protecting water resources

This component of the Strategic Research Assessment (SRA) covers the need to adopt a system of sustainable water management for agriculture within the European Union.
Within Europe agriculture uses 30% of water abstracted, compared with the 17% used for the public water supply. In Southern Europe this figure rises to 73%. Much of the remainder is water used for cooling purposes in power stations. Frequently the use of water for irrigation is very inefficient – it has been estimated that at least 40% of the water abstracted is wasted. Agricultural and drinking water abstractions are often in competition, particularly when complete river basins are considered.
Much of the land irrigated (82%) is within the southern EU countries where there is extensive seasonal water stress resulting from low rainfall and high demand for competing uses. It is vital to adopt sustainable water management as the unavailability of water for irrigation would have severe effects on the economy of the regions concerned. This will lead to a better degree of water balance between availability and demand at local levels.
There are several types of irrigation: surface (or flood) irrigation distributes water by gravity across the surface of the land, as for example in rice paddies. Localised (drip or trickle) irrigation supplies water at low pressure to each plant and finally sprinkler systems use sprays or rain-guns to supply water to cropped areas.
The agricultural use of water is difficult to regulate. Much of the activity is currently unmonitored so it is difficult to obtain an accurate picture. However the Water Framework Directive (WFD) will require abstraction from watercourses and aquifers to be on a sustainable basis and will also require that diffuse pollution from agricultural land will be controlled to avoid the run-off of nutrients and other pollutants from farmland.

Vision and Challenges

The general vision on the use of water for agriculture is that:

- Agriculture will produce safe food economically and sustainably
- Water will be used more efficiently and more use will be made of new or “non-conventional” resources
- Environmental protection will become a key factor in agricultural water use

Because many water-users are small-scale farmers and horticulturalists there will be need to address the number and heterogeneity of the customers and issues faced. A key enabler will be the development of a strategy to reach all water users.

Public Health and Drinking Water Quality

As with all water components public health considerations are paramount. Three issues must be addressed whilst developing sustainable agricultural water use: quality standards will have to be developed and monitored to ensure that food safety is maintained, suitable treatment systems will have to be developed for alternative water sources and finally, irrigation run-off will need to be monitored to ensure that water sources used for drinking water abstraction are not put at risk.

Climate Change –Drought and Flood

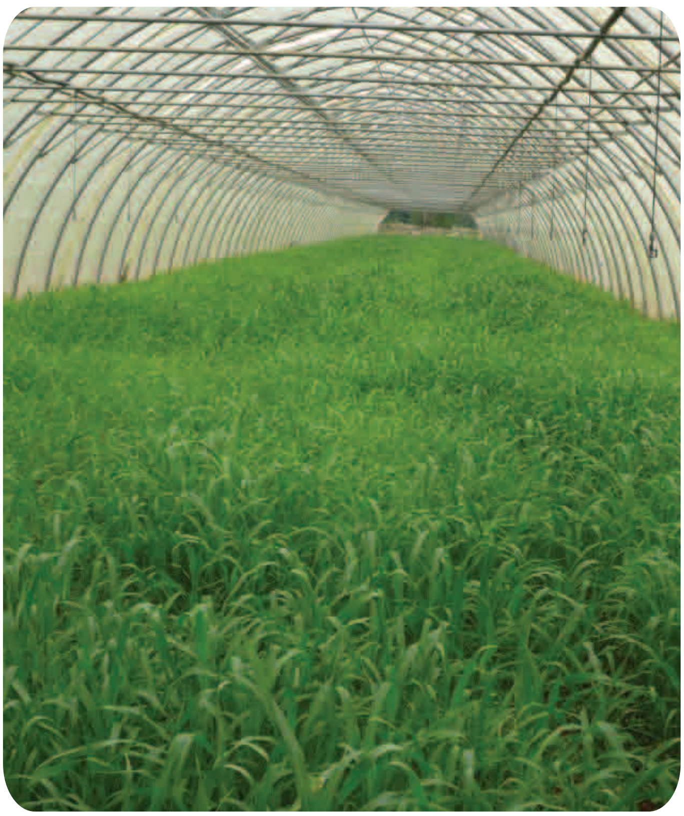
Greater use must be made of water from non-conventional sources. This will mean using water that is not currently exploited for human use. This will call for “cascading” irrigation systems (rather than “once through”) and for the development of technologies and controls for the re-use of waste water that has been treated to an appropriate standard- already in some areas 20% of irrigation uses recycled waste water. Solutions will need to be adapted for local circumstances. Increasing water stress will call for improved efficiency of use throughout the EU. This will require the development of new management tools at river basin level, the development of sustainable production methods and improvements in the efficiency of agricultural water use.

Water and Energy

On the macro-scale water abstraction for irrigation does not use vast quantities of energy. However as pressure to reduce energy consumption increases more efficient pumps and less wasteful irrigation systems will be developed. In addition over-abstraction of potential drinking water for irrigation can drive an unnecessary reliance on energy-intensive water treatment processes such as desalination.

Regulation

The Water Framework Directive will require the reduction of diffuse pollution caused by agrochemicals, nutrient supplements and manures. A comprehensive regime of monitoring and analysis will be needed together with the development of cost effective usable methods for the precise dosing and application of water, agrochemicals, nutrients and manures.



Benefits

- More water will be available for use in the public supply
- Agricultural activities will produce less diffuse pollution
- River quality will improve
- Farmers pumping costs will reduce
- Irrigation will use water of an agreed quality standard
- Irrigation will become less labour intensive
- Food safety will improve
- Cultivation techniques and crop varieties will become better suited to the area
- Farmers will be better informed on sustainable water use

Expected Technologies Breakthrough

- Improved irrigation technologies
- Improved irrigation management systems
- Rugged, tamper proof control systems for irrigation
- Optimised cropping practices
- Development of drought resistant varieties
- On line methods of water quality measurement
- Simple effective methods of irrigation water treatment
- Nutrient and pesticide management
- Regulated drainage
- Precision application of nutrients and pesticides, cost effective easy to access, adaptive technologies for precise dosing
- Drainage recycling

Work areas

Alternative Water Sources (AWS)

- Strategy for identification of AWS
- Develop quality standards for different uses
- On-line water quality measurement
- Simple irrigation water pre-treatment

Environmental Protection

- Integrated catchment modelling
- Abstraction measurement and control
- Drainage interception and treatment
- Accurate application methods for fertilisers and pesticides

Irrigation

- Robust control systems
- Improved efficiency devices
- Systems for drainage re-use
- Low attendance irrigation systems

Agronomic Practice

- Identification and promotion of locally suitable crops
- Optimisation of cropping practices
- Farmer education programme
- Development of drought resisting varieties

Time Frame and Drivers for Technologies Needs

Technology Need Drivers scored 1: Very High, 2: High, 3: Average, 4: Low, 5: Very low

Technology Area	Technology Need	2015	2030	Public Health	Environment	Cost Reduction	Business opportunities	Regulatory Compliance	Technologies Breakthrough
Alternative Water Sources (AWS)	Strategy for identification of AWS	X		4	1	5	4	4	3
	Develop quality standards for different uses	X		2	4	5	3	1	3
	On-line water quality measurement		X	2	5	3	2	1	1
	Simple irrigation water pre-treatment		X	3	5	3	2	4	2
Environmental Protection	Integrated catchment modeling		X	4	2	5	3	2	4
	Abstraction measurement and control	X		5	1	5	2	1	2
	Drainage interception and treatment	X	X	4	1	3	2	1	2
	Accurate application methods for fertilizers and pesticides		X	4	2	2	2	3	2
Irrigation	Robust control systems	X		5	3	2	2	2	2
	Improved efficiency devices		X	5	2	3	2	4	3
	Systems for drainage re-use	X	X	5	1	3	2	3	2
	Low attendance irrigation systems		X	4	3	2	2	4	3
Agronomic Practice	Identification and promotion of locally suitable crops		X	5	2	3	4	4	2
	Optimisation of cropping practices	X		5	4	1	2	4	4
	Farmer education programme	X	X	3	2	4	4	1	5
	Development of drought resisting varieties		X	5	3	1	2	5	1

Water component 6

Industry

Ensure a sustainable use of water in industrial processes

Industrial activities use roughly 20% of the European water consumption. Produced wastewaters are very different in quality and quantity according to their industrial sources. However, this wastewater has to be in compliance with regulations before any release into the environment (free of toxic contaminants, approved levels of organic matter, salts and suspended solids).

The main characteristics of this activity are:

- High variability of the effluents to be treated. Indeed, in addition to the variety of industries, the same industrial site may frequently switch production according to its business plan (food industry, textile industry, chemical industry, etc.), or the same production can produce effluents of different qualities (organic load, nature of the pollutants)
- High variability in the volume of produced effluents according to the industry type
- Possible high environmental impact: Industrial wastewater can contain high loads of toxic materials
- Complexity is one of the main characteristics of industrial wastewaters, with possible mixtures of organic and salts at high concentrations.

Vision and Challenges

The goal of industrial wastewater treatment is first of all to produce an effluent that can be safely released into the environment and if possible to reuse the treated water. The challenges are:

- to produce an effluent of stable quality from a highly variable (in load and composition) influent
- to decrease the environmental impact and cost of these processes by:
    - o valorising as much as possible the components of this effluent , hence the need for more selective processes
    - o decreasing the energy consumption of the overall process by process optimisation and/or the development of new, less energy consuming processes
    - o recycling this effluent and thus dealing with the concentration of pollutants

In the short/medium term, research will focus on the combination of new treatment modules to further improve existing plants. In the long term, there is a need to rethink the overall treatment by quantifying the energy and matter fluxes.
Among the technologies to be developed or improved for industrial wastewater treatment are the following:

- Membranes: production of improved membranes for decreased energy consumption, nanotechnology based modifications of membrane surfaces for specific reactions or flux increase, compatibility with several type of compounds (e.g. acids, bases, and operating conditions (high temperature, high concentrations

- Biological processes: these processes are usually more environmentally friendly than their physico-chemical counterparts, and less costly. However, their application in industry has been hindered by toxicity problems on the one hand, and by the high variability of effluents on the other hand. Overcoming these limitations would broaden the application of these processes to the field of industry.

One particularly important field in industrial wastewater treatment is the treatment of brines, where technological breakthroughs are needed. Although there are few regulations on salt at the present time, chloride discharge through brines by European industry is more than 12 million tonnes per year.

Benefits and Expected Technologies Breakthrough

Technological breakthroughs are needed in the following processes or applications:

1. New/optimised technologies for the treatment of brines, with a focus on low energy consumption, such as: membrane concentrate treatment, distillation, low fouling membrane electro-dialysis, crystallisation (precipitation or thermal) with control of by-products

2. Biological treatments: today, biological treatments, when applied in industry, are usually far from optimal. There is a need for a breakthrough combining the fields of biology and engineering in order to produce an operate a biomass adapted to extreme and variable conditions and apply it to treatment in an optimal process

3. Process intensification, in particular
   a. the development of catalytic processes (e.g. organic compound removal, ...)
   b. the application of nano-engineered materials.

In the field of membranes, surface modification may allow specific reactions to occur; membrane nano-engineering may also reach higher fluxes with lower energy requirement (as an example, for reverse osmosis to reach less than 5 kwh/m^3 instead of 7 today). In the field of adsorption, new materials are needed to enhance the specificity and efficiency of processes

4. Membrane processes: low scaling/low fouling membrane treatment

5. By-product valorisation: selective separation of valuable mineral compounds (e.g. metals), or valuable organics. Recovery of organic matter to produce energy or use of this organic matter as a resource in other applications.

6. Treatment of refractory COD by sustainable processes: today, treatments such as ozonation are commonly applied. The development of processes such as electrochemical processes should achieve a reduction in energy consumption chemical use. Catalytic combined processes for adsorption and/or oxidation can also be considered.

Work areas

Biological treatment

- Reliable treatment to cope with the high variability of influents (load and composition) in each industrial sector

Membrane

- Low scaling membrane treatment
- Modification of membrane surface to limit scaling and fouling issues
- Ceramic membranes with catalytic properties
- Increase of membrane capacity by nanotechnologies

Selective separation

- Functionalized membrane
- Highly Selective adsorbent easy to regenerate

By-product valorization

- Selective separation of valuable mineral compound (e.g. metals)
- Selective separation of organic compounds

Salt removal

- Salt separative treatment integrated into an industrial re-use strategy in order to limit corrosion (Chloride) and scaling

Brines treatment

- Energy saving membrane concentrative treatment
- Energy saving distillation processes
- Low fouling Selective membrane for electro-dialysis treatment
- Crystallization (precipitation or thermal) processes with by-product control

Refractory COD treatment

- Cost effective oxidative or electro-oxidative treatments with control of by-products
- Catalytic combined processes for adsorption and/or oxidation (nanomaterials)

Process intensification

- Improvement of kinetics, reduction in size of units

Time Frame and Drivers for Technologies Needs

Technology Need Drivers scored 1: Very High, 2: High, 3: Average, 4: Low, 5: Very low

Technology Area	Technology Need	2015	2030	Public Health	Environment	Cost Reduction	Business opportunities	Regulatory Compliance	Technologies Breakthrough
Biological treatment	Reliable treatment regarding the high variability of influents (load and composition) on each industrial sector	X	X	4	2	2	2	1	2
Membrane	Low scaling membrane treatment	X	X	5	3	2	2	4	2
	Modification of membrane surface to limit scaling and fouling issues	X	X	5	4	3	2	4	1
	Ceramic membranes with catalytic properties	X	X	5	4	3	3	4	1
	Increase of membranes capacity by nanotechnologies		X	5	3	1	3	4	1
Selective separation	Functionalized membrane	X	X	5	4	3	2	3	1
	Highly Selective adsorbent easy to regenerate	X	X	4	4	2	1	4	1
By-product valorization	Selective separation of valuable mineral compound (e.g. metals)	X		3	3	1	2	2	3
	Selective separation of organics compounds	X		3	3	1	2	2	3
Salt removal	Salt separative treatment integrated in industrial re-use strategy in order to limit corrosion (Chloride) and scaling.	X	X	5	4	2	1	3	2
Brines treatment	Energy saving membrane concentrative treatment	X		5	3	1	2	4*	2
	Energy saving distillation processes		X	5	3	1	3	4*	2
	Low fouling Selective membrane for electro-dialysis treatment		X	5	3	1	3	4*	2
	Crystallization (precipitation or thermal) processes with by-product control	X		5	3	1	2	4*	3
Refractory COD treatment	Cost effective oxidative or electro-oxidative treatments with control of by-products	X		2	2	2	2	1	2
	Catalytic combined processes for adsorption and/or oxidation (nanomaterials)		X	2	2	3	3	1	1
Process intensification	Improvement of kinetics, reduction of size units	X	X	4	3	2	4	4	1

Water component 7

Urban drainage and waste water collection

Prevent foul water flooding and avoid inconvenience to the population

Urban drainage refers to the provision and operation of infrastructure to carry away rainfall and waste water without causing flooding. This topic also includes storm water and waste water collection, transport and discharge to a Waste Water Treatment Plant (WWTP) or to the receiving body of water.

Rainfall runoff and sewage may be transported together in the same pipes, the so-called combined sewers, or can be kept separate, conveying waste water to the treatment plant and storm water to the receiving body. Both situations have advantages and disadvantages.

In combined sewers problems may arise at WWTPs because of the wide variations in flow. Any overflows from the sewer will contain sewage as well as run-off and because the WWTP cannot handle very high flows, diluted but only partially treated sewage can be discharged to the receiving body of water.

However, when separate systems are used, other problems can arise. Difficulties are experienced keeping the networks separated; there will be an increase in capital and running costs as two systems will need maintenance. The direct run-off of storm water can damage water quality because it will contain floatable and suspended solids and heavy metals.

The historical trend has been to build combined sewer systems, especially in the Mediterranean areas. Nevertheless, in northern European regions, it is more frequent to find separated systems, which also imply a series of problems (pollution loads, hygiene risks) that should be taken into serious consideration.

Additionally, in recent years, several modifications to both systems have been developed in order to keep lightly polluted water out of the separate and combined sewers through best management practices (BMPs). One example is the use of sustainable urban drainage systems (SUDS) to manage storm water close to its origin (where the rain falls), reducing surface runoff quantities and protecting or enhancing storm water quality.

On the other hand, it has to be noted that there are significant differences in the level of sophistication of waste water collection and urban drainage systems all around Europe. The legal framework, the size of the population served and the annual investment determine the main characteristics and complexity of the systems, as well as their degree of conservation.

The problems associated with waste water collection and transports are mainly related to blockages, odours and restoration. However, in recent years knowledge on the behaviour of pollution and sediments in sewers and the source control of emerging contaminants that can be detected in the waste water are also becoming important.

For urban drainage, the main issues concern flood risk and

uncontrolled wet weather overflows to receiving bodies, especially when they come from combined sewer systems, including waste water pollution.

Vision and Challenges

Urban drainage in Europe will evolve from a static to a dynamic system that will be able to cope with such climate change effects as extreme rainfall and with the new regulations relating to flood control and pollution prevention. The key issue will be the development and implementation of technologies for the advanced management of waste water collection and urban drainage systems.

Waste water collection and urban drainage will have to face several problems in the future, and technological development will be a key component to successfully dealing with these challenges.

Infrastructures deterioration

In the next 5 – 10 years, in countries with ageing sanitation systems, the main challenge will be the deterioration of infrastructures. As a result, it is very important to develop technologies and tools that improve, optimise and reduce the costs associated with the rehabilitation of infrastructures for the collection and transport of waste water and storm water. There is also need for technologies that help to correctly maintain these infrastructures, to improve their performance and extend their life. A combination of measures for the prevention of deterioration and conservation of these infrastructures will reduce the costs associated with rehabilitation and renewal.

Development of new infrastructures

In contrast, developing countries will have to face the consequences of lacking infrastructure, such as flood risk, diseases and environmental damage. To solve this situation, sometimes technologies and methodologies that have been applied in developed countries can be useful, although they will have to be adapted to different socio-economic and cultural situations in other regions. This technology transference may help the optimisation of the large investments that will be required to meet the Millennium Development Goals (MDG).

Pollution control

Another important challenge is the implementation of the Another important challenge is the implementation of the Water Framework Directive (WFD) and the impact of pollution from wastewater and storm water on the receiving bodies. On one hand, there is a need for improved technologies for the minimization of overflows during rain events (optimum management of existing infrastructures, real-time control, and the development of decentralized technologies to pre-treat most of the overflows) and, on the other hand, there is also a need for the at source control of pollution as waste water and surface runoff. The development of technologies that help to increase the knowledge of the behaviour and degradation of emerging contaminants in waste water and rain water, and their interaction with sediments are also important.

Finally, related to the issue of at source control technologies to reduce impacts of storm water, the development of technologies capable of treating storm water up to reuse requirements (rainwater harvesting) will both produce an alternative source of water and reduce the quantity of storm water entering the sewer system. A starting point in this research will be the use of SUDS to validate technologies for reducing storm water runoff and for storing and treating storm water for uses such as street cleaning, fire fighting and irrigation.

Flood control

In the medium term (next 20 years), climate change and, more broadly speaking, global change will be the main challenge that urban drainage will have to face, due to the expected changes in flood hazard and vulnerability of urban areas. Technologies to reduce the impact of extreme events must be developed and applied to the areas where flood risk is a relevant issue and also in areas that are currently not affected by these kinds of problems, but in the future they will have to face them. These technologies will have to improve all the steps related to flood risk management: preparedness, prevention, management of event and recovery after it.

The combination between technologies and management must be focused in increasing the resilience or preparedness to global changes. That is, sustainable and flexible technologies and practices have to be incorporated into planning and operation. They have to cover different scales of application, that may range from very local solutions (few km2) to more extended areas (metropolitan areas), and different degrees of sophistication, to cover the different needs and socio-economic conditions.

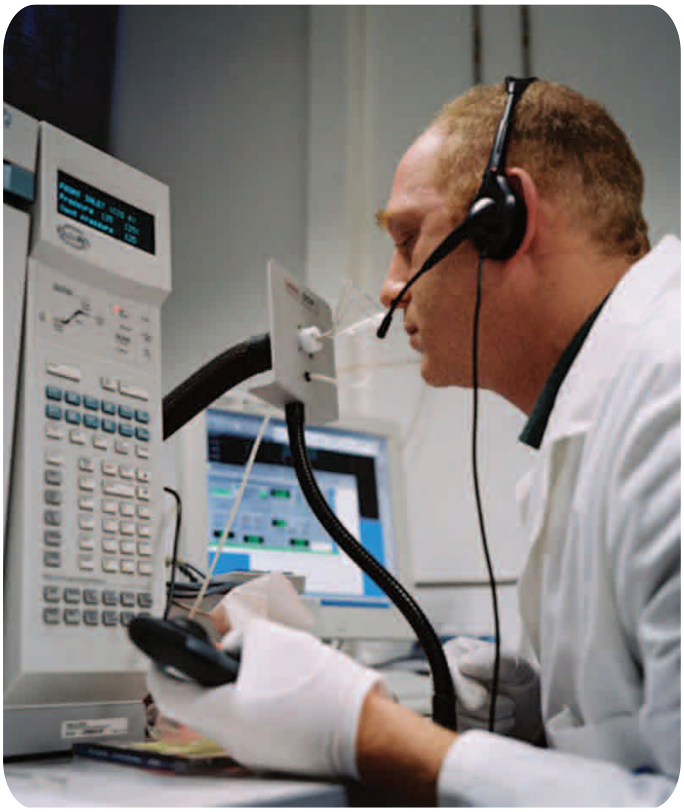
Technology transfer

Finally, another important challenge that affects technology research in different fields is the difficulty of technology transfer, from the development and validation phase to the real application. Efforts may be put on promoting this transference, because it is a critical point that determines the success of a given technology.

Benefits and Expected Technologies Breakthrough

The main benefits that can be achieved and the associated technologies to be developed and improved are listed below:

- Prevention of blockages: monitoring, modelling, better technologies for construction (e.g. to avoid sag points), better control of unauthorised discharges into the network
- Early detection of blockages: inspection with TV cameras, optimization of the manual inspection from surface through video-periscope techniques, teledetection
- Better control of discharges or spills into the network: quality monitoring, quality modelling, portable sensors combined with GIS information to detect the origin of the discharge, database and tools for the management and control of discharges
- Control and removal of odours: automatic noses, passive sensors, modelling, mitigation and removal technologies
- Real time monitoring and control: decision support systems for the optimum control of sewer networks; sensors embedded into the pipes; reverse models for real time monitoring and management
- Technologies to increase the sustainability of sewer systems and their resilience: alternative technologies for storm water collection (Sustainable Urban Drainage Systems: retention ponds, infiltration trenches, soakaways, sand filters, etc.), technologies to store and treat storm water for urban uses (Rain Water Harvesting, RWH)
- Real time rainfall forecasting: improved NWP models, more accurate and affordable meteorological radar, monitoring of rainfall (rain gauges), doppler radar, satellite
- Improved management and prediction of flooding: modelling of flood hazards through 1D/2D models (runoff-sewers), prediction and modelling of the effects of local events and impacts on small urban areas, use of simple models (rolling-ball, sag points)



- Coordinated management of hydraulic infrastructures, taking into account the effects on the receiving water bodies: integrated modelling of urban drainage systems, Waste Water Treatment Plants (WWTP) and receiving bodies (including quality parameters)
- Prediction of problems and optimisation of planning procedures: GIS-based technologies for the estimation of land use changes in urban areas, technologies for the estimation of changes in extreme weather distribution based on global change scenarios
- Asset mapping: inspection and condition assessment through the use of innovative robots and new sensors; surface pipe location technologies; surface condition assessment technologies of underground pipes
- Optimising existing infrastructures and prevention of future problems: ageing models in sewers, GIS-based technologies for vulnerability estimation
- Optimum management and maintenance of infrastructures: no-dig or trenchless technologies for rehabilitation and other purposes; technologies for the assessment of the structural condition, non-destructive methods; databases, GIS and DSS for the management of rehabilitation tasks; technologies for better modelling of networks, avoiding critical maintenance points
- Planning technologies: technologies for better sewer construction, improving their quality, technologies for modelling sediment behaviour in sewer systems

Work areas

Blockages

- Inspection devices: TV cameras
- Video-periscope technologies to make easier the manual inspection of sewers from surface
- Monitoring of blockages
- Modelling of areas sensitive to blockages
- Technologies for teledetection of blockages
- Technologies for construction to avoid sag points

Contaminant unauthorised discharges

- Technologies for quality monitoring
- Technologies for quality modelling in sewers
- Technologies based on portable sensors combined with GIS information to detect the origin of the spill
- Database and tools for the management and control of unauthorised discharges

Odours

- Odours mitigation and removal technologies
- Technologies for the detection and monitoring of odours: automatic noses, passive sensors
- Technologies for the modelling of sewers in order to prevent odour risk

Real time monitoring and control

- Decision support system for the optimum control of sewer networks

Real time rainfall forecasting

- Improved Numerical Weather Prediction (NWP) models

- Technologies of rainfall measurement: more accurate and affordable meteorological radar, monitoring of rainfall (rain gauges), Doppler radar, satellite
- Technologies for the combination of different rainfall forecasts (i.e. radar & rain gauges)
- Sensors embedded into the pipes
- Reverse models for real time monitoring and management

Management and prediction of floods

- Technologies for the detailed modelling of flood hazard through coupled 1D/2D models (runoff-sewers and river-runoff-sewers),
- Technologies based on the use of simple models (rolling-ball, sag points…)
- Technologies for the prediction and modelling of the effects of local events and impacts on small urban areas

Management of flows

- Sustainable Urban Drainage Systems (SUDS)
- Rain Water Harvesting (RWH)

Coordinated management

Taking into account the effects on the receiving water bodies

- Technologies for the integrated modelling of urban drainage system, Waste Water Treatment Plants (WWTP) and receiving bodies (including quality parameters)

Medium – Long term planning

- Technologies for the estimation of changes in extremes distribution based on global change scenarios
- Technologies for the prediction and modelling of the effects of local events and impacts on small urban areas

GIS-based technologies for the estimation of land use evolution in urban areas

Asset mapping

- Inspection and condition assessment through the use of innovative robots and new sensors
- Surface pipe location technologies
- Surface condition assessment technologies of buried pipes

Optimum maintenance of infrastructures

- Technologies of rehabilitation: No-dig or trenchless and others
- Technologies for the assessment of structural condition. Non-destructive methods
- Databases, GIS and DSS for the management of rehabilitation tasks
- GIS-based technologies for vulnerability estimation
- Technologies based on ageing models in sewers
- Databases, GIS and DSS for the management of rehabilitation tasks
- Technologies for the better modelling of the networks and avoiding critical maintenance points

Short-term Planning

- Technologies for the better construction of sewers, improving the quality of them
- Technologies for the modelling of sediments behaviour in sewer systems

Time Frame and Drivers for Technologies Needs

Technology Need Drivers scored 1: Very High, 2: High, 3: Average, 4: Low, 5: Very low

Technology Area	Technology Need	2015	2030	Public Health	Environment	Cost Reduction	Business opportunities	Regulatory Compliance	Technologies Breakthrough
Blockages	Inspection devices: TV cameras	X		2	2	3	4	4	3
	Video-periscope technologies to make easier the manual inspection of sewers from surface	X		2	2	3	4	4	3
	Monitoring of blockages		X	2	2	3	4	4	3
	Modelling of areas sensitive to blockages		X	2	2	3	4	4	3
	Technologies for teledetection of blockages		X	2	2	3	4	4	3
	Technologies for construction to avoid sag points		X	3	3	4	4	4	2
Contaminant unauthorised discharges	Technologies for quality monitoring	X		2	1	3	3	2	3
	Technologies for quality modeling in sewers	X		2	1	3	3	2	3
	Technologies based on portable sensors combined with GIS information to detect the origin of the spill		X	2	1	3	3	2	3
	Database and tools for the management and control of unauthorised discharges		X	2	1	3	3	2	3
Odours	Odours mitigation and removal technologies	X		3	2	4	3	3	3
	Technologies for the detection and monitoring of odours: automatic noses, passive sensors		X	3	2	4	3	3	3
	Technologies for the modelling of sewers in order to prevent odour risk		X	4	3	4	4	4	3
Real time monitoring and control	Decision support system for the optimum control of sewer networks	X		2	3	2	4	3	3
Real time rainfall forecasting	Improved Numerical Weather Prediction (NWP) models	X	X	3	2	2	4	3	3
	Technologies of rainfall measurement: more accurate and affordable meteorological radar, monitoring of rainfall (rain gauges), Doppler radar, satellite	X	X	3	2	2	4	3	3
	Technologies for the combination of different rainfall forecasts (i.e. radar & rain gauges)	X	X	3	2	2	4	3	3
	Sensors embedded into the pipes		X	4	4	3	3	4	1
	Reverse models for real time monitoring and management		X	4	3	2	1	4	1
Management and prediction of floods	Technologies for the detailed modeling of flood hazard through coupled 1D/2D models (runoff-sewers and river-runoff-sewers),	X		3	3	4	4	3	3
	Technologies based on the use of simple models (rolling-ball, sag points…)	X	X	3	3	2	3	3	3
	Technologies for the prediction and modeling of the effects of local events and impacts on small urban areas	3	3	4	4	3	3		
Management of flows	Sustainable Urban Drainage Systems (SUDS)	X		2	2	4	4	3	3
	Rain Water Harvesting (RWH)	X		5	1	4	2	4	2

Time Frame and Drivers for Technologies Needs

Technology Need Drivers scored 1: Very High, 2: High, 3: Average, 4: Low, 5: Very low

Technology Area	Technology Need	2015	2030	Public Health	Environment	Cost Reduction	Business opportunities	Regulatory Compliance	Technologies Breakthrough
Coordinated management taking into account the effects on the receiving water bodies	Technologies for the integrated modeling of urban drainage system, Waste Water Treatment Plants (WWTP) and receiving bodies (including quality parameters)	X		2	2	4	4	3	3
Medium – Long term planning	Technologies for the estimation of changes in extremes distribution based on global change scenarios	X	X	3	3	4	4	3	3
	Technologies for the prediction and modeling of the effects of local events and impacts on small urban areas		X	3	3	4	4	3	3
	GIS-based technologies for the estimation of land use evolution in urban areas		X	4	3	2	3	3	4
Asset mapping	Inspection and condition assessment through the use of innovative robots and new sensors	X		3	3	2	4	3	2
	Surface pipe location technologies	X		4	2	2	2	5	2
	Surface condition assessment technologies of buried pipes	X		4	2	2	2	5	2
Optimum maintenance of infrastructures	Technologies of rehabilitation: No-dig or trenchless and others	X	X	3	2	2	3	4	2
	Technologies for the assessment of structural condition. Non-destructive methods	X		4	2	2	2	5	2
	Databases, GIS and DSS for the management of rehabilitation tasks	X		3	3	1	2	4	3
	GIS-based technologies for vulnerability Estimation								
	Technologies based on ageing models in sewers								
	Databases, GIS and DSS for the management of rehabilitation tasks								
	Technologies for the better modeling of the networks and avoiding critical maintenance points								
Short-term planning	Technologies for the better construction of sewers, improving the quality of them								
	Technologies for the modeling of sediments behavior in sewer systems								

Water component 8

Waste water treatment

Changing from a consuming industry to one producing resources

Waste water treatment works (WWTWs) are constructed at the end of waste water collection systems (sewerage systems) to remove contaminants before effluent is returned to a water course or re-used. They range in size from units serving single properties to those serving major cities.

A variety of waste water treatment processes are needed to deal with the contaminants that may be encountered. These contaminants may include floating or large suspended solids, small suspended and colloidal solids, dissolved solids, dissolved gases and immiscible liquids.

There are three main classes of treatment processes:

- Physical treatment (eg screening, sedimentation and filtration)
- Chemical processes (eg coagulation, precipitation and ion exchange)
- Biological processes (eg biological filtration and activated sludge)

Typically a modern municipal waste water treatment plant will have a minimum of three stages. The first (physical) stage removes rags, grit and other gross debris, the second (biological) stage oxidises the organic matter contained in the waste water (almost certainly together with the ammonia) and the final stage separates inorganic solids and biomass from the treated effluent which can then be returned to the water-course.

Plant serving smaller populations can be package units brought to the site ready assembled. Larger plants are usually constructed of concrete (though other materials can be used) with separate treatment processes linked by pipes or channels.

Some plants, discharging into sensitive water courses require additional treatment stages to further remove certain pollutants or safeguard sensitive downstream processes.

Examples include:

- Fine screening (if membrane treatment is used)
- Chemical coagulation (if phosphorus removal is required)
- Additional gravity settlement, or “primary tanks” before oxidation processes (to save power)
- Separate biological nitrogen removal
- Additional filtration or disinfection stages before discharge

Wastewater treatment works produce solid wastes (screenings, grit/sand, primary and secondary sludges) and incorporate appropriate handling systems. These include screening and grit washing and compaction and sludge thickening, digestion, drying and incineration. (See Water component 9: “Biosolids”)

Vision

The European water sector will develop affordable, effective, environmentally sound waste water treatment processes to meet existing and future effluent quality requirements.

It will become the leading international centre of expertise and be capable of servicing the global demand for the supply and operation of waste water treatment plants.

Challenges

Regulation

The Urban Waste Water Treatment Directive is likely to designate increasing numbers of receiving courses as sensitive.

Total nitrogen limits on estuarine discharges and rivers discharging to certain marine areas are likely to provide a particular challenge.

The effect of the Water Framework Directive will be to reduce levels of ammonia and BOD5 permitted in WWTW discharges.

Pressure on this has relaxed (at least in the UK) but will return beyond 2015. It will be difficult to achieve further effluent improvements whilst reducing energy and chemical use.

Environmental regulation and public pressure are beginning to demand the removal of « priority substances », compounds such as endocrine disrupting chemicals, pharmaceuticals and metals from sewage effluents.

Public Health and Drinking Water Quality

As water stress increases it will become more difficult to separate the effects of waste water discharges from drinking water and irrigation water quality. Cost effective methods of treating waste water will become vital together with agreed water standards for various water uses.

Climate Change – Drought and Flood

The impact on collection networks will probably be greater but effects on treatment works will include the following

- Stronger (higher organic and ammonia levels) waste water during dry periods
- Higher temperature sewage leading to settlement and odour issues
- Regulatory pressure to maintain flows in small water courses
- Commercial/social pressure to provide effluent for recycling
- The need to accommodate widely fluctuating flows in extreme rainfall events
- Increased duration of high rainfall periods leading to storm water treatment and biomass retention problems.

Water and Energy

There is a worldwide movement to address climate change by reducing the carbon footprint of all countries. In the EU the Emissions Trading System will apply to power intensive industries.

As an example of the « knock-on » effect on the Water Industry, in 2010 many UK water undertakings will become subject to the « Carbon Reduction Commitment » targeting a reduction in energy used and its associated carbon emission.

This pressure will affect waste water treatment in several ways:

- There will be pressure to recover as much energy as possible from the waste water at all stages of the process
- Processes will have to operate in a more energy efficient manner
- There will be a need to develop less energy intensive processes still capable of meeting advanced standards.

The chemicals used in waste water treatment will also come under increasing scrutiny because of their carbon footprint.

Benefits

- Energy Saving or even energy production (both environmental and financial benefits)
- Reduced chemical use
- Use of recycled substances in place of “pure” chemicals
- Nutrient and water recycling
- Reduced maintenance and labour requirement
- Improved river flows and improved water quality under all conditions
- Optimisation of total environmental benefits (water pollution control versus carbon footprint)

Expected Technologies Breakthrough

- Non invasive monitoring for organics (Safeguarding biological processes and river quality)
- “Simple” treatment for high flows in storm conditions
- Low head loss processes to reduce pumping costs
- Anaerobic processes for temperate climates
- High quality effluent/small works packages
- “Black box” processes to polish effluents at small (decentralized) WWTWs.
- Catalytic/absorption processes for organics and metals removal

- Effective screening for processes producing high quality effluent
- Improved biological processes for nitrogen and phosphorus removal
- Improved filtration or other processes for solids removal
- Low flux/low maintenance membrane processes
- Recycling processes for phosphorus, metals and other materials removed in WWTWs
- Simple, forgiving processes requiring low manual input (eg reed beds and lagoons)
- Robust wireless monitoring and control (cell phone technology?)
- Appropriately engineered systems for producing high quality effluents (chemicals for pH correction or oxygen provision)

Work areas

Instrumentation, control and telemetry

- Reliable non-invasive methods for detecting and measuring organics in waste water for WWTW protection
- Wireless systems for monitoring, control and data acquisition.

Physical separation processes

- Better or more reliable screening, grit and fat removal processes for small works or prior to membrane processes
- Develop enhanced systems for primary sedimentation to maximise yield of sludge gas generation systems and minimise power required for oxidation
- High flow, quick start-up methods for treating storm flow
- Low head loss filtration process for tertiary treatment
- Develop long life, high flux, performance graded membrane systems suitable for municipal waste water treatment

Biological processes

- Develop anaerobic waste water treatment systems applicable to cooler climates and weaker waste water. Including ways to avoid methane release
- Develop polishing step to follow such anaerobic systems, if possible incorporating algae systems for carbon sink and biomass production
- Improve biological filtration units to give consistent performance producing low ammonia effluents
- Develop biological processes for nutrient removal to minimise chemical and power use (eg biofilm or algal reactor)

Energy

- Low head intermittent turbines for recovering energy from waste water
- Heat pump (or other) methods to exploit temperature differences for energy recovery

Producing high quality effluent

- Develop absorption and/or catalytic systems for removal of refractory organics
- Improved low energy, robust processes to produce high quality effluens (integral or bolt-on) for smaller WWTWs

Disinfection

- Develop low energy, low chemical use systems for effluent disinfection before discharge or for water re-use (eg UV-LED)

Sustainability

- Develop process schemes to produce various grades of recycled water for re-use across the range- grassland irrigation to drinking water
- Develop process schemes to optimise the recovery of carbon(energy) and nutrients
- Optimisation of “natural” systems (eg reed-beds and lagoons)
- Develop process schemes to recycle pollutants removed from sewage – eg phosphorus, nitrogen, FOG, polymers etc
- Identify waste chemicals that may be used in place of “new” chemicals and develop processes with safeguards to enable their use

Process Liquor Treatment

- Develop methods to treat existing and new process liquors without hazarding the main WWTW processes

Time Frame and Drivers for Technologies Needs

Technology Need Drivers scored 1: Very High, 2: High, 3: Average, 4: Low, 5: Very low

Technology Area	Technology Need	2015	2030	Public Health	Environment	Cost Reduction	Business opportunities	Regulatory Compliance	Technologies Breakthrough
Instrumentation, control + telemetry	Reliable non-invasive methods for detecting/measuring organics in waste water for WWTW protection	X		4	2	5	3	1	1
	Wireless systems for monitoring, control and data acquisition.	X		4	3	2	3	4	3
Physical separation processes	Better or more reliable screening, grit and fat removal processes for small works or prior to membrane processes	X		3	3	2	4	4	3
	Develop enhanced systems for primary sedimentation to maximise yield of sludge gas generation systems and minimise power required for oxidation		X	5	2	1	3	3	2
	High flow, quick start-up methods for treating storm flow.		X	4	2	4	3	2	2
	Low head loss filtration process for tertiary treatment	X		5	3	3	2	2	3
	Develop long life, high flux, performance graded membrane systems suitable for municipal waste water treatment		X	4	3	2	2	2	1
Biological processes	Develop anaerobic waste water treatment systems applicable to cooler climates and weaker waste water. Including ways to avoid methane release		X	4	2	2	1	3	1
	Develop polishing step to follow such anaerobic systems, if possible incorporating algae systems for carbon sink and biomass production		X	4	2	2	1	3	1
	Improve biological filtration units to give consistent performance producing low ammonia effluents	X		4	1	4	4	3	3
	Develop biological processes for nutrient removal to minimise chemical and power use (eg biofilm or algal reactor)		X	5	2	3	4	3	2
Energy	Low head intermittent turbines for recovering energy from waste water	X		5	3	3	3	5	2
	Heat pump (or other) methods to exploit temperature differences for energy recovery		X	5	3	3	2	5	1
Producing high quality	Develop absorption and/or catalytic systems		X	5	2	5	3	2	1

Time Frame and Drivers for Technologies Needs

Technology Need Drivers scored 1: Very High, 2: High, 3: Average, 4: Low, 5: Very low

Technology Area	Technology Need	2015	2030	Public Health	Environment	Cost Reduction	Business opportunities	Regulatory Compliance	Technologies Breakthrough
Sustainability	Develop process schemes to produce various grades of recycled water for re-use across the range- grassland irrigation to drinking water		X	2	2	2	2	3	3
	Develop process schemes to optimise the recovery of carbon(energy) and nutrients		X	4	2	2	1	3	1
	Optimisation of "natural" systems (eg reed-beds and lagoons)	X		4	1	4	3	4	2
	Develop process schemes to recycle pollutants removed from sewage – eg phosphorus, nitrogen, FOG, polymers etc		X	5	2	3	3	5	2
	Identify waste chemicals that may be used in place of "new" chemicals and deveop processes with safeguards to enable their use		X	5	2	3	3	5	3
Process Liquor Treatment	Develop methods to treat existing and new process liquors without hazarding the main WWTW processes	X		5	3	3	4	3	2

Water component 9

Biosolids

Maximise energy and resource recovery

Wastewater biosolid is an unavoidable residue derived from Wastewater biosolids are an unavoidable residue derived from wastewater treatment. The biosolids volume amounts to only a few percent of the processed wastewater volume, but its handling accounts for up to 50 percent of the total wastewater treatment plant operating costs. Biosolids management has become one of the most critical issues for the wastewater industry worldwide, due to the very fast increase in biosolids production resulting from increasing numbers of new wastewater treatment plants, more inhabitants connected to existing sewerage systems and upgrading of existing facilities to meet stricter discharge criteria.

Biosolids are a complex mixture of organic carbon (proteins, lipids, carbohydrates etc) readily or slightly biodegradable with a large mineral fraction, but also contains some molecules dangerous for the environment (micro-pollutants, endocrine disrupters, heavy metals etc) and a large number of micro-organisms with some affecting human health (pathogens, virus etc).

The term biosolids covers different products (primary, secondary and mixed) generated by the various phases of wastewater treatment. The biosolids treatment stream must be adapted to the characteristics of each product (biodegradability, rheological behaviour, dewaterability etc).

So treatment of biosolids needs a large range of technologies in order to have a safe final product for re-use or disposal.

Biosolids management covers a broad range of challenges, including material reuse or disposal, environmental and health impacts, regulations, and public perception. The development of responses to these challenges has the last few years led to better raw material characterization, development of new technologies and improvement of energy recovery.

Creating sustainable biosolids management solutions producing valuable materials and energy is the major challenge for the future.

Vision and Challenges

Current preoccupations related to the impact of the energy crisis and "energy package" directive (aiming to reduce carbon emissions) on the water sector. In wastewater treatment plants energy consumption for pollution removal and biosolids treatment will be under focus in order to promote energy savings and reduction of the total system carbon footprint, including construction materials and consumables.
The major challenge for the next years is to solve the disposal of biosolids in another way by changing the paradigm. Instead of consuming energy and chemicals to eliminate biosolids, we have to consider biosolids as a source of green energy and reusable materials meaning that biosolid is no longer a waste to

be destroyed but a product generating value.

Biosolids are recognized not only as containing valuable sources of energy, plant nutrients and organic matter, but also containing potential contaminants. Sustainable management will economically recover the value whilst protecting the environment from harmful impacts. Biosolids can be a significant source of renewable energy, making biosolids treatment processes energy self-sufficient and wastewater processes partially self-sufficient. Biosolids are also a significant source of fertiliser nutrients, especially phosphorus which is in limited supply from mineral sources.

The non exhaustive routes for giving value to biosolid are as follows:

- Biosolid as a solid fuel
- Biosolid as a substrate for biogas "biomethane" production
- Biosolid as a primary matter for compost production
- Biosolid as a resource for nitrogen & phosphorus recovery
- Biosolid as a component for building materials

In order to meet these challenges, the introduction of new technologies in wastewater treatment within the European Community will act as reference for sustainable and cost-effective biosolids disposal in Europe.

Benefits and Expected Technologies Breakthrough

Development of technologies allowing energy recovery and production of valuable materials plays a key role for improvements in biosolid disposal.

New technologies to improve the energy recovery from biosolid

- Increase the availability of organic matter for anaerobic digestion in order to enhance biogas production
- Improve conditioning of dried sludge in order t produce a valuable solid fuel
- nvestigate new technologies for producing by-products with high energy potential (i.e. biohydrogen)

New technologies to avoid environmental and health risks

- No GHG emissions
- Removal of micro-pollutants
- Removal of pathogens and viruses

Green technologies for biosolid treatment

- Zero fossil energy consumption
- Development of green chemicals

Work areas

Enhancement of biogas production

- Pretreatment of biosolids by physical and chemical means
- Selection of new microorganism for degrading refractory compounds
- Develop wastewater treatment processes that increase the organic carbon levels in the biosolids

Improving conditioning of dried sludge

- Minimize energy consumption for biosolids treatment processes
- Technologies to reduce or remove heavy metals content

Production of by-products with high energetic potential

- New anaerobic concepts for producing biohydrogen
- Production of liquid fuel from biosolids

No GHG emissions

- Development of technologies avoiding GHG emissions
- Development of software for estimating N2O emissions

Removal of micro-pollutants

- Development of specific treatment for micro-pollutants removal (thermal and/or chemical)
- Technologies for leaching and recovering heavy metals

Removal of pathogens and viruses

- New technologies with no energy or chemical requirements

Zero fossil energy consumption

- Energy self-sufficient biosolids treatment processes

Development of green chemicals

- Develop new generation of green polymers for dewatering and drying stages

Time Frame and Drivers for Technologies Needs

Technology Need Drivers scored 1: Very High, 2: High, 3: Average, 4: Low, 5: Very low

Technology Area	Technology Need	2015	2030	Public Health	Environment	Cost Reduction	Business opportunities	Regulatory Compliance	Technologies Breakthrough
Enhancement of biogas production	Pretreatment of biosolids by physical and chemical ways	X		3	1	2	2	2	2
	Selection of new microorganism for degrading refractory compounds		X	2	1	2	2	2	1
	Develop wastewater treatment processes allowing to keep organic carbon into the biosolids	X		3	1	2	2	2	2
Improving conditioning of dried sludge	Minimize energy consumption for biosolid treatment processes	X		3	1	1	2	2	2
	Technologies to reduce or remove heavy metals content.	X		1	1	3	2	1	2
Production of by-products with high energetic potential	New anaerobic concepts for producing biohydrogen		X	3	2	1	1	2	1
	Production of liquid fuel from biosolid	X		3	1	2	1	3	2
No GHG emissions	Development of technologies avoiding GHG emissions	X		1	1	3	2	1	1
	Development of software for estimating N2O emissions	X		3	1	2	2	1	3
Removal of micro-pollutants	Development of specific treatment for micro-pollutants removal (thermal and/or chemical)	X		1	1	3	2	1	2
	Technologies for leaching and recovering heavy metals	X		1	1	3	2	1	2
Removal of pathogens and viruses	New technologies with no energy or chemicals needs		X	1	2	3	2	2	1
Zero fossil energy consumption	Energy self-sufficient biosolid treatment trains	X		3	2	1	1	3	2
Development of green chemicals	Develop new generation of green polymers for dewatering and drying steps	X		2	1	3	2	2	1

Five major programmes for innovation

Membrane Technologies

Membrane technologies include any process for water or wastewater treatment achieving filtration through a porous or permeable media made of polymeric, mineral or composite material. Depending on the pore size and the rejected pollutants membrane processes as referred to as microfiltration (MF, for turbidity and bacteria removal), ultrafiltration (UF, for removal of viruses and colloidal substances), nanofiltration (NF, for removal or organic substances and divalent ions) and reverse osmosis (RO, for removal of monovalent salts). Hybrid membrane systems may combine membrane filtration with another technology, such as membrane activated sludge, or membrane bioreactor (MBR), for advanced treatment of wastewater.

Objective

- Foster the emergence of European champions with new technologies to secure a market essentially dominated today by US and Japanese equipment suppliers.

- Develop European know-how and equipment in order to propose competitive European technologies for the following applications:

– Seawater desalination

– Brackish water desalination

– Water softening or removal of organic substances

– Disinfection for drinking water production

– Wastewater treatment and reuse

Market

The global membrane market for water applications will grow by 8.6% to over €10,5 billion in 2012. New technological breakthroughs will increase the competitiveness and open up large new markets.

The current size and development of membrane technologies for water application is as follows:

– Desalination (RO): about 50% of total sales with strongest growth, essentially for seawater and brackish water desalination, but also for softening and organic substance removal (LPRO, low pressure RO). If economically viable, desalination could in the long term supply drinking water to 80% of the world population.

– Drinking water treatment with MF or UF: about 30% of total sales

– Tertiary wastewater treatment with MF or UF: about 10% of total sales

– Wastewater treatment with MBR: about 4% of total sales

– Other applications (RO pre-treatment, ultrapure water etc): 6% of total sales

Technical targets

The main economic hindrance to all membrane technologies for water application today is membrane life span (durability of membrane systems) and the specific energy requirement. Commercial competiveness will be secured by developing durable and low cost membrane systems with the following energy demands:

– Advanced reverse osmosis treatment for desalination (by 2015): specific energy < 2 kWh/m^3 for seawater. Today in large units with energy recovery: 3-4 kWh/m^3, theoretical 0.6 kWh/m3. To be used also for brackish water desalination and softening.

– Alternative non-RO membrane process for desalination (by 2030 with carbon nanotube, membrane distillation, bio mimetic membranes, forward osmosis, electrodionisation, etc): specific energy ratio < 1.5 kWh/m^3 for seawater. To be used also for brackish water desalination and softening.

– Low-pressure MF or UF systems for drinking water, tertiary filtration or MBR filtration systems (by 2015): for large units < 0.05 kWh/m^3 for drinking water, < 0.1 kWh/m^3 for tertiary filtration and < 0.2 kWh/m^3 for MBR filtration system (membrane scouring + filtration/backwash system).

Companies involved

Polymer suppliers (petro-chemical industry), start-up companies new processes), equipment suppliers (extrusion and moulding industry), engineering companies, end users (water companies)

Real Time System Management

Real time system management (RTSM) includes online sensors networks, data management systems, representation (map, link with GIS, etc.) and modelling, wireless communication systems.

Objective

Develop European know-how and equipment in order to:
– Protect the quality of the water resources
– Secure the management of water and wastewater works (including the networks)
– Secure the quality of the product delivered to end-users
– Improve the operation of networks and reduce the cost of construction
– Develop new services

Market and Technical Targets

All technical components of the water cycle are relevant to RTSM:

Water resources management

o Improvement of spatial and temporal measurement with new sensors/data loggers and multilevel permanent monitoring
o Real time data transfer from sensors to data bases and modellers; technologies to support data collection, sampling, surveys
o Integrated Water Resources Management and Decision Support Systems at watershed level; development of interpretation tools, algorithms
o Methodologies to map and format the collected data, GIS-based tools to assess the risks
o Economic models

Water treatment

New on-line sensors will be required to monitor the treatment quality but also to control the process and optimize the operating conditions. Technical breakthroughs for online monitoring systems are expected in these three areas:
o Viruses and bacteriological indicators including disinfection performance control and membrane integrity tests
o Membrane fouling or water fouling propensity for low and high pressure membrane systems
o Micro pollutant detection and toxicity tests

Water distribution

Incorporating advances in sensor and actuator technology, telecommunications and computer control to improve monitoring and control of in water systems (quality and quantity), in order to minimize energy consumption, operational costs and water loss. Efficient operation, monitoring and control will benefit from:

o Advances in sensors and micro-sensors to achieve low-consumption, low-cost devices
o Wireless telecoms; Efficient telecommunications for water network monitoring and control
o Predictive control and decision support tools for efficient real-time network operation, including cost minimization in pumping operations, as well as quality and safety optimization
o Modelling and decision support for leak detection and location, efficiency monitoring, real-time quality monitoring
o Data integration and sharing between operations, investment planning, billing, etc. and data sharing with new operational software (rehab, monitoring, decision support, etc.)

Customers

The fast-growing development of ICT tools and domestic tools of communication (eg. internet) have started to change profoundly the way service providers communicate with the customers. It is already a two-way communication through:

o Automatic Meter Reading (AMR) systems to access data: consumption patterns, status of networks, leaks detection, etc.
o Data transportation directly from the customers to integrators (w/o concentrators)
o Universal access to information
o Battery-free AMR systems
o New sensors for real-time monitoring of the quality at the tap: bacteriology, taste, smell, domestic leak detection etco For industrial and agriculture: on line methods of water quality measurement

Wastewater treatment

Besides on-line sensors required to control the process and optimize the operation conditions, specific needs are identified for:

o Non invasive monitoring for organics
o Robust wireless monitoring and control

Wastewater collection and urban drainage

Efficient operation, monitoring and control equipment are needed for:

o Blockages: monitoring and modelling and early detection
o Quality: monitoring and modelling, portable sensors combined with GIS information, for a better control of discharges or spills into the network; modelling of sediment behaviour in sewer systems

o Odours in sewer: Automatic noses, passive sensors, modelling

o Management: sensors embedded into the pipes; reverse models for real time monitoring and management, decision support systems for the optimum control of sewer networks;

o Rainfall forecasts: improved models, accurate and affordable meteorological radar, monitoring of rainfall, use of satellite data

o Flooding forecasts: modelling of flood hazard, effects of local events and impacts

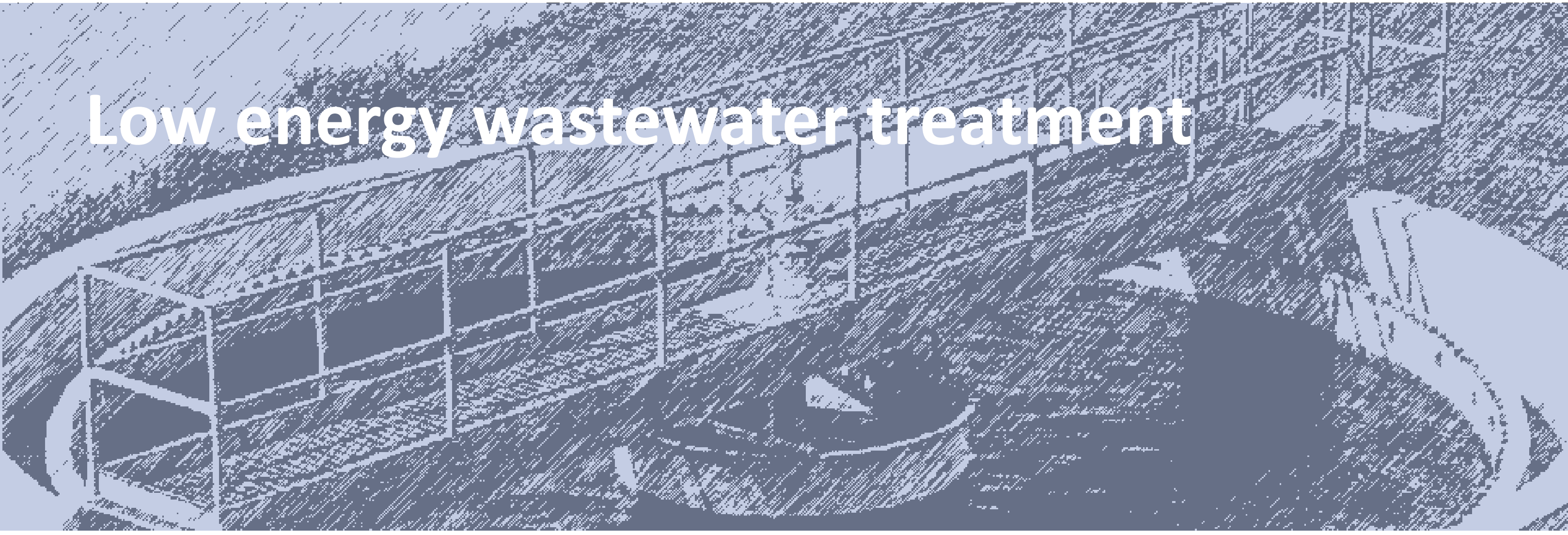
o Coordinated management of hydraulic infrastructures, taking into account the effects on the receiving water bodies: integrated modelling of urban drainage systems, Waste Water Treatment Plants (WWTP) and receiving bodies (including quality parameters)

o GIS-based technologies for estimation of land use changes in urban areas and estimation of changes in the frequency of extreme events based on global change scenarios

Companies involved

Sensor companies, telecommunication network operators, software architects and data systems, pipe manufacturers, IT companies, water companies, engineering companies (modelling), water companies

Low energy wastewater treatment



Municipal wastewater treatment is using large energy inputs to achieve the removal of pollutants from the wastewater stream before disposal into natural water bodies or recycling.

Direct energy inputs include electricity for air supply, pumping, mixing, centrifuging and UV disinfection, and also fuel for sludge transportation, while indirect energy is involved in the production of the large amounts of chemicals utilised for biosolids dewatering, phosphorus removal, ozonation or adsorption processes.

In the past 3 decades, the main attempt to balance the huge energy needs for proper wastewater treatment has been the anaerobic digestion of sludges in order to recover biogas, but the yield is still limited, i.e. 16% +/- 2 % of the inlet carbon is converted into methane.

Objective

A major part of the development of the municipal waste water plant of the future (2020) is to achieve a neutral or positive energy balance, that can be easily combined with a very low carbon footprint, although obtaining at the same time better wastewater treatment performances (removal of emerging pollutants, disinfection and wider recycling). Europe has a clear lead and deep experience in anaerobic processes (NL, D, DK, CZ, HUN, and others) and in all technologies dedicated to new energy production or management; this can be advantageous for new wastewater treatment energy management in four main areas:

– Energy savings (20% of the overall energy improvement)

– On site renewable energy production (solar, wind, 10% of the overall energy improvement)

– On site energy recovery (gravity flow, heat ; 10% of the overall energy improvement)

– On site energy production from input organic matter (wastewater, greases, human wastes, etc ; more than 60% of the overall energy improvement)

Market

Although the worldwide municipal waste water treatment market has not yet been well studied and segmented, some estimates based on demographic trends and on wastewater assets and operations audits can be used to indicate an order of magnitude for:

- The need for new WWTP: more than 4,000 large WWTP (> 500,000 PE) are required to address urban populations' demands for sanitation in emerging countries (> 20% in China)

- In developed areas, more than 50% of the large WWTP are to be upgraded or reconstructed in the next decade, and energy saving should be the major design criterion. It's a clear paradigm shift in the way wastewater is treated and managed, leading to a total market potential exceeding €250 Bn for the next 10-15 years.

Technical targets

The main economic hindrance of all wastewater treatment systems today is the use of aerobic biological processes for carbon and nitrogen removal. Commercial competiveness will be secured by developing new advanced anaerobic based systems and their associated co-treatments:

– Advanced anaerobic treatments for sludges (by 2015): increase mean methane yield from 26% to 50% (over municipal sludges and others municipal organic matters received on WWTP).

– Advanced anaerobic treatments for wastewater treatment (by 2020): decrease anaerobic treatment applicability constraints from 37°C to 20°C and from 4 kgCOD/m^3 to 1 kgCOD/m^3.

– Develop all required side stream treatments for total depollution of effluent (COD / BOD / SS / Nitrogen / Phosphorus) and total valorisation of by-products or outputs, with a focus on P recovery (> 50% of input P recovered by low energy processes) and on low energy N treatment or recovery (50% less energy for N treatment).

Companies involved

Biochemical companies, mechanical engineering companies (turbines, methanisers, etc), renewable energy companies, other engineering companies, end users (water companies)

Material for pipes and coating

Drinking water is usually in contact with man-made materials during distribution and storage. Water distribution and storage is based on a comprehensive infrastructure for water delivery to private or industrial consumers, which is responsible for about two third of the total costs for water supply in developed regions. Main components are long distance transport mains, local distribution pipes including storage tanks as well as indoor installations. Waste water systems and urban drainage require similar expenditures to fulfil basic demands of every developed society to discharge wastewater and stormwater from urban areas.

Objective

Strengthening European competitiveness in the area of nano-based materials in contact with water. Development of nano-engineered products to ensure:

- Unchanged water quality and adequate pressure from purification facilities to place of use during distribution and storage of drinking water including materials resistant to disinfectants
- Reduced energy demand for pumping during transport and distribution of drinking water due to smart material surfaces
- Maintenance free and durable drinking and waste water systems
- Innovative rehabilitation techniques for water mains and pipes
- Well balanced cost-benefit-ratios for all water transport systems

Market

On the worldwide scale water distribution systems are divided into two different markets: Developing regions aspire to an appropriate infrastructure for water supply and developed regions have existing, but ageing distribution systems.

Distribution systems are faced with different water demand trends: growing demand in emerging markets due to increase of industrial water use and population growth and declining demand in some developed regions due to improved water-saving. Apart from that, climate change may boost water scarcity and demand in all regions of the world, which could require an increasing capacity of infrastructure for water distribution. Similar conclusions are valid for waste water and surface drainage systems.

Technical Targets

Pipes and coatings based on new materials are desired in the following sectors:

Drinking or clean water systems

- o For infrastructure with reduced carbon footprint (e.g. plain and low fouling surfaces to minimize friction at the pipe wall resulting in a decrease of energy demand for pumping)
- o Resistance to internal and external corrosion (e.g. prevention of coloured water, usage in soils with corrosive characteristics)
- o For integrated monitoring of current state of water infrastructure (e.g. intelligent pipes with embedded sensors to detect leaks)
- o For rehabilitation of existing networks
- o With new composite materials (e.g. to prevent corrosion in valves)
- o For construction of water networks in areas with no access to safe drinking water
- o Innovative coatings (e.g. durable, self cleaning surfaces) for newly made storage tanks
- o rehabilitation of storage tanks

Waste water systems and drainage

- o For rehabilitation of waste water and drainage mains by innovative coatings

All water transport systems

- o For improved pipe performance and durability (e.g. maintenance free surfaces and extended product life span)
- o Low cost materials

Long-distance transportation (water conveyance)

- o Materials and new construction techniques

Companies involved

Chemical industry, nano industry, pipe producing industry, start-ups, water companies

Low energy processes for disinfection and oxidation

Disinfection is widely used to reduce or eliminate microbiological activity in water. Its primary use is in drinking water treatment, where typically it is used as a final stage of treatment and within the distribution system to ensure drinking water safety at point of use. Disinfection processes are also applied to waste water effluents to ensure the safety of bathing waters. Advanced oxidation processes, with or without catalyst involvement, may also be used for disinfection in addition to their application in removing refractory organic compounds and are included in this Master Programme.

For historical, technical and economic reasons most drinking water processes rely on chlorine for disinfection. It is a hazardous material to store or produce onsite however and in some circumstances it can combine with other compounds in the water to produce harmful "disinfection by-products". A major advantage of chlorine is that it has a residual effect so can eliminate micro-biological contamination occurring in the distribution system.

In Europe ultra-violet (uV) light is generally used in waste water applications, although membrane systems are sometimes used where there are footprint or effluent quality constraints.

Objective

This programme is intended to develop new disinfection or other oxidation processes for the removal of microbiological activity or other harmful compounds. It should:

o Produce drinking water or wastewater compliant with EU regulations

o Yield water having acceptable taste and odour

o Avoid generation of harmful or unpleasant by-products

o Reduce the environmental footprint of the process

o Have an acceptable cost

o Use chemicals and materials that can be safely employed

Market

o All drinking water undertakings

o Waste water undertakings with disinfection requirements (bathing waters)

o Industrial users of water

o Municipal and amenity water facilities (swimming pools etc)

Technical targets

o Develop and demonstrate competitive flow-sheets for disinfection and advanced oxidation by 2020.

o Discover alternatives to existing chlorine and ozone flowsheets that avoid hazardous by-products

o Explore and optimise catalytic oxidation combinations possibly using nano-materials.

o Develop low-energy alternatives to existing uV lamps for waste water disinfection, possibly using uVLED (light emitting diode) technology.

Companies involved

Chemical companies, catalyst producers (eg titanium dioxide), lamp manufacturers (uV), disinfection equipment manufacturers.

Technology Road Mapping
Methodology of the Writing Committee

The Writing Committee of ACQUEAU is composed of experts from major European water industries and research centres (AGBAR, ANJOU Recherche, CETAQUA, CIRSEE, KWB, R+I Alliance, SUEZ Environnement, TZW, Veolia Environnement, UKWIR). They set up the Blue Book and the Technology Road Mapping following the water cycle. The aim was to identify technology needs and potential breakthroughs to ensure the development of a leading market position in Europe.

This section describes the methodology adopted by the Writing Committee and how to understand the strategy developed by ACQUEAU. It should be helpful to read the table for each water component and the sections describing the five priority programmes for the next five years.

Understand the tables

To establish the future technological priorities of ACQUEAU, the key drivers for each "water component" were considered. From this work, tables of work areas and technological needs were drafted for each "water component". The writing committee worked on two key elements:

1/ The time-line provided that ACQUEAU has to propose a short term and long term vision for technology development. Each table therefore includes a double entry for 2015 and 2030. It particularly shows that some technological needs will require a continuous effort to accomplish major technological achievements from 2010 to 2030. It also shows that some technological breakthroughs can be expected by 2015 to allow ensure a leading position for the European market in the short term.

2/ The group of ACQUEAU established a list of key drivers that influence the water sector and activities. In order to support the inclusion of a 'technology need' in the road map and assist with its prioritisation, six drivers have been selected that may or may not apply to the technology need. The group noted the appropriate driver(s) that apply and scored them from 1 to 5 as follow: 1: Very High, 2: High, 3: Average, 4: Low, 5: Very low. The six drivers and the grade for each work area and technological need helped to target technologies where research and technology development is needed to secure the future of the water sector.

Target technologies development through key drivers of the water sector

The group of experts of ACQUEAU chose six major drivers influencing the water sector and particularly, the development of new technologies and innovation for the market and the industries.

Public health

One major driver of the water sector is ensuring the quality of drinking water. Water is vital for human beings; it should be of good quality in order to avoid illness and diseases. The major priority of water distributors is to guarantee that the water delivered to households is drinkable and without danger to human health. Related to this mandatory mission, water is one of the most controlled substances in most European countries (strict regulations and controls). All technology developments should include the guarantee of delivering good quality safe water to the public.

Environment

The environment includes all the natural resources and also the overall quality of life.. The environment is rarely included as a major factor in evaluation criteria.

Technology should increasingly be evaluated on environmental grounds, and more specifically, on reduced environmental risks. In this framework, RTD in ACQUEAU should take into account development of eco-technologies preserving natural resources.

Cost reduction

Water costs have long been a subject of debate in terms of water pricing. The costs in the water industry particularly rely on management of water systems and distribution, forecasting, and on managing risks and extreme events. The main goal for companies is to reduce and control the cost of managing water infrastructures. It involves developing technologies that will help to reduce and limit ageing, breakdown, pollution, etc.

Business opportunities

Eureka cluster are industry driven initiatives that are aimed at developing a market lead to ensure the economic growth of Europe and to boost the competitiveness of its companies. It clearly means to encourage initiatives that will create new products or services to sustain the economic activities.

ACQUEAU is strongly managed to support activities that will create new activities for industries and create business opportunities in Europe and worldwide to drive the standards of tomorrow.

Regulatory compliance

The local, regional, national or European frameworks are a set of constraints for the water sector. They can also stimulate the creation of new solutions and support the development of new activities to ensure the implementation of laws and regulations. In 2000, the European Commission endorsed a directive which set a framework prescribing steps to reach the common goal to achieve good qualitative and quantitative status of all water bodies (cf. Blue Book Part 1). As it is, it urges member states to implement the Water Framework Directive. The WFD encourages the development of technologies that support the monitoring and control of water quality applying to various areas of the different water components.

Technologies Breakthrough

Each technology area has been evaluated considering its potential to develop new original, relevant, valued new products, processes, or services. It aims at including major innovation and technology developments that could augment existing research and technology development.

Vision on the short and long term

Eureka clusters are long term initiatives that aim at promoting competitiveness and market driven solutions for RTD. They are usually set up for five years providing a vision for technology development on a scale of 20 years. Based on the vision of the SRA of the WssTP, ACQUEAU proposed a complementary vision to support technologies and innovation development for industries. It clearly involves both work on short term solutions and following a longer term vision to drive the homogeneous and continuous progress and growth of the water sector.

Setting the priorities for calls and ensuring implementation of new technologies

The experts of ACQUEAU decided to focus on five major programmes that were set up as priorities based on two major criteria:

1/ The results of the graduation of technology areas and needs from the key drivers and the potential break-throughs in the water sector

2/ The most feasible and potentially valuable technology developments within the five next years. ACQUEAU will administer two calls a year starting in July 2010. To involve companies with developed close to market solutions that can be adapted to the urgent needs of the water sector. It also intends to support activities that are mature enough to produce results and open to new markets during the first years of the running of Acqueau

Index, Credits and Contact

Index

Bn	Billion
EC	European Commission
EEA	European Environmental Agency
ETP	European Technology Platform
EU	European Union
FP	Framework Programme
GDP	Gross Domestic Product
GIS	Geogrraphical Information System
ICT	Information and Communication Technologies
IWA	International Water Association
IWRM	Integrated Water Resources Management
LCA	Life Cycle Assessment
RTD	Research and Technology Development
SME	Small and Medium Entreprise
SRA	Strategic Research Agenda
WFD	Water Framework Directive
WssTP	Water supply and sanitation Technology Platform
WTP	Water Treatment Plant
WWTW	Waste Water Treatment Works

Credits

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