WssTP

The European Water Platform

Water and Energy

Strategic vision and research needs

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WssTP

The European Water Platform

Table of contents

1. Introduction

1.1 Introductory letter from Mike Farrimond and Steve Kaye

Dear members of WssTP,

Dear readers,

As Chair of WssTP, I am very pleased to present our sixth scientific publication based on the work of our Pilot Programmes and Task Forces. We are very proud to have published a set of publications targeting key water challenges such as urban areas, irrigation, climate change, manage aquifer recharge and coastal zones. The actions of these working groups have been instrumental in stimulating communication between the different parties involved in water management across all levels in the European water sector in order to identify research needs.

After the successful update of our SRA in 2010, the year 2011 represents a challenging year with many opportunities to grow and step forward.

The European Commission (EC) is currently in the process of establishing the future EU funding schemes and a Common Strategic Framework (CSF); implementing the objectives of the Innovation Union and shaping the European Innovation Partnership (EIP) for "Water Efficient Europe". To ensure the creation of an efficient, coordinated and strong European water research area, WssTP is continuing to provide key inputs on the important challenges related water innovation. This report on Water and Energy represents a key milestone towards the improvement of water efficiency and a better understanding of research and innovation challenges to better use water resources.

At the political level, WssTP is providing key recommendations on the coordination of EU policies in the water cycle for improving water efficiency and integration of research results to boost the innovation cycle.

Looking forward, these initiatives represent key opportunities for WssTP to demonstrate our role as the leading platform and network of experts in Europe. WssTP will seize ongoing initiatives to strengthen efforts towards more research and technology developments from the various European water stakeholders:

- close collaboration with the JPI on water,
- success of ACQUEAU, EUREKA Cluster on Water,
- launch of the Innovation Union and European Innovation Partnership by the European Commission,
- design of the coordinated fund for water.

This report confirms WssTP´s commitment to guarantee the transparency of our work; by sharing the recommendations of our pilot programmes and task forces, and we look forward to receiving your opinions on our plans.

On behalf of the European Technology Platform for Water, the Water and Energy Task Force, is pleased to give its proposals and recommendations for the Commission's FP7 Cooperation Work Programme for 2012.

We hope that you enjoy reading this report.

Yours sincerely,

Dr Mike Farrimond
Chair of WssTP

Steve Kaye
Task Force Leader of Water and Energy
Manager of Innovation, Anglian Water

1.2 WssTP, a Common Vision for Water Innovation

The European Water supply and sanitation Technology Platform (WssTP) is one of the technology platforms (ETPs) set up within the European Environmental Technology Action Plan (ETAP) adopted by the European Commission in 2004. The platform aims to federate water stakeholders across sectors and disciplines to improve coordination and collaboration around the development of joined technological solutions, for sustainable and integrated water resources management (IWRM).

WssTP is lead by industry to enhance the transfer of research outcomes to engineering and to market, promoting competitive innovation and financial opportunities (Lisbon Strategy) and supporting initiatives relevant to the Millennium Development Goals (MDG)2.

The Vision and Strategic Research Agenda (SRA) initially published in 2006 were updated in 2009 and published in 2010; as activities progress, the SRA becomes more informative and up-to-date.

To date the WssTP counts 61 official members from industry, research institutions, policy institutions and water utilities and will continue to welcome new members. The network includes many non-member participants with a wide variety of expertise, significantly contributing to the identification of future research and technology development needs.

WssTP works with European Member States' national representatives through the Mirror State Member Group (MSMG), representing 27 countries.

Currently the WssTP operates through six permanent Pilot Programmes:

- Mitigation of water stress in coastal zones
- Sustainable water management inside and outside large urban areas
- Sustainable water management for agriculture
- Sustainable water management for industry
- Rehabilitation of degraded water zones (surface and groundwater)
- Adaptation to hydro-climatic extremes (droughts and floods)

A Pilot Programme is an organisational structure that addresses a major European water problem and covers the pre-competitive phase of generic research and the enabling of technology development, as well as the competitive phase of practical application through a number of Implementation Cases (IC's) executed by commercial consortia. Each Pilot Programme has been working with the stakeholders from representative Implementation Cases to define the needs and identify the matching research, development and technology demonstrations.

A number of temporary Task Forces have been initiated since 2009 to better handle cross-cutting issues identified by the Pilot Programmes' coordination committee.

A Task Force (TF) is a working group handling cross-cutting issues of several Pilot Programmes. Task Forces are called by the Board of Directors on a specific topic for a limited amount of time.

In 2009, the Board created three strategic task forces on:

- Climate Change
- Managed Aquifer Recharge
- Sensors and Monitoring

In 2010, the Board created three more task forces on:

- Membrane technologies for water application
- Water and Energy
- Millennium Development Goals

As representatives of the Task-Force Water and Energy, we are pleased to share our results and recommendations.

1.3 Introduction to our recommendations

The recommendations for Research and Technology Development (RTD) presented in this document are in agreement with the Strategic Research Agenda released by WssTP in May 2010 after intensive consultation of the European water sector. The WssTP Strategic Research Agenda presents the R&D Roadmap for water issues for the next 20 years. Through the operational bodies of WssTP (Pilot Programmes and Task Forces), the corporate members of WssTP and other participating stakeholders identified the priority RTD needs to be addressed at short term in the FP7 ENV Work Programme 2012. When available, full "Call Texts" are presented, otherwise a short summary of the R&D needs is proposed. The criteria of prioritisation were:

- RTD outcomes with short term impact (supporting 2nd cycle of WFD or other pending directive)
- Significant expected impact (environmental, social, industrial, commercial etc.)
- No current or recent EU project or call on this topic

The proposed RTD needs will address acute challenges of the water sector in Europe and elsewhere. Most of these environmental or industrial challenges also represent market opportunities, and are therefore considered as most relevant to support the European industry in developing and financing projects and demonstration cases that will ensure the growth of the European water sector. These recommendations focus on generic research that will also further encourage RTD activities based on the cooperation with other ETPs or FP7 Work Programmes, but also with other pan-European initiatives addressing water management such as Euraqua, EuroGeoSurvey, various ERANET initiatives. Eureka or Joint Programming Initiatives, and are proposed for co-ordination with national research programmes.

This report highlights research opportunities that will support Europe in terms of how Water and Energy are utilised more sustainably, and will contribute towards industry minimising significant predicted increases in energy consumption, as a consequence of societal, environmental and regulatory challenges. This will also help the EU achieve its targets of 80% reduction in carbon emissions by 2050. It is clear that existing systems and processes will not achieve global targets for the environment; therefore a paradigm shift is required across society and industry towards a more integrated approach.

A more holistic approach is needed with regard to water, waste treatment and energy efficiency across all industrial and commercial sectors. Waste water and energy are considered as resources to be recovered, and new treatment and recovery options should be explored as part of the strategy.

The report highlights research opportunities to both the water sector, and wider industry, that will ultimately enhance the capability of the supply chain in provision of energy efficient technologies for water & wastewater usage & treatment, both in the EU and abroad, thereby increasing the global competitiveness of European water & wastewater solution providers, and also enhance public perception in terms of corporate and social responsibility of the water and energy service providers/users towards the environment.

The business and public sectors generate over one third of the EU CO2 emissions. Significant carbon abatement could be achieved in these sectors while at the same time delivering bottom line financial benefits using existing and new energy efficiency technologies. Investment in new technology at its current rate is unlikely to meet the demands for change in the required timeframe. Innovation and integration between the water industry, wider industry and society; plus the adoption of commercial synergies offers the potential of additional savings if R&D or demonstration funding could be better targeted.

2. The Interaction between Water & Energy

2.1 Key Considerations

As Europe develops a more integrated approach to Water and Energy the following drivers and opportunities should be considered:

- Reduce our reliance on fossil fuels and water, particularly imports, by reducing demand.
- Quantify domestic and industrial energy and water usage, in order to identify where the greatest benefits can be targeted. Focus on water & energy consuming industries.
- Aim for holistic management of water and energy industry.
- Identify the priorities, usage statistics, and synergies associated with energy and water use, between industry and municipal use.
- Focus on water & energy (water bound) consuming industries. So providing knowledge to inform policy and develop business drivers to influence industrial usage.
- Identify opportunities to integrate public and private (e.g. district heating) for optimisation of water chain.
- Identify industrial and water synergies in terms of technology opportunities such as IT, metering and so encourage major players to collaborate.
- Identify where existing beneficial technologies are not exploited such that they can be re-examined and repackaged as "innovative use of existing technology".
- Identify the most energy efficient technological innovations for industrial and domestic water and wastewater treatment.
- Identify how are where innovative technologies can best be deployed, by demonstrating the benefits of short term retrofit solutions, (maximising the use of existing assets).
- Identify the longer term paradigm shift, which could involve greatly different decentralised infrastructure models, and the provision of water of varying quality but fit for purpose.

Energy and water are used in different forms and their use cuts across most development functions in society. With growing populations and economies, the demand for water for food production and energy production (bio-energy and hydropower), and water for industry and domestic use is steeply increasing at the local, national and regional levels.

2.2 Water needs Energy

Energy is required in all the steps along the water value chain, from providing water services such as pumping water for water supply and sanitation systems, to the delivery of irrigation water, for food and bio energy production, to the construction of large scale water storage for flood protection. The energy and carbon requirements to produce water, is significant (586 kWh of electricity is required to treat 1 M liters of water). Despite water companies largely achieving leakage targets within Europe the energy wasted through leakage is still significant. As water resources become scarce, water may end up being pumped long distances, or be produced through energy consuming alternative means, such as desalination processes. E.g. Water Companies in the UK report increases of over 60% in electricity usage since 1990 due to advanced treatment and increased connection rates, and conservative estimates predict increases of a further 60%-100% over 15 years in order to meet new EU Directives (Urban Wastewater Treatment Directive, Bathing Waters Directive, Freshwater Fish Directive, The Habitats Directive, The EU Sludge Directive, and Water Framework Directive).

Type of water supply	Approximate total energy footprint of water supply and treatment (kWh/m³)
Surface water (rivers & reservoirs)	0.5 - 4
Recycled water	1 - 6
Desalination	4 - 8
Bottled water	1000 - 4000

Table 2.1 - Sources: Henrik Larsen, DHI Water Policy, 2008

To be noted in addition that 89% of carbon emissions in the municipal water cycle are related to domestic water heating in households (excluding space/central heating, briefing note of UK Environment Agency). For example, in regions with hard water, water softening may have an overall positive energy balance, improving the energy transfer for heating in household appliances.

2.3 Energy needs Water

In return, water is a crucial component in the production of power (cooling towers, hydropower[1]), and renewable energies are often related to water and or the presence of water bodies with embedded energies (geothermal power, heating pumps, tidal and wave power, osmotic power, bio-ethanol, etc). In industries the optimisation of the water cycle is very often associated with energy reduction when reusing water with low or high temperatures.

The very high water footprint of 1st generation biodiesels is an item of concern. The production of biodiesels from crops as intensive agriculture for the production of biofuels will increase the pressure on the water sector through higher agricultural water demand and aggravated phenomena of eutrophication, erosion and sedimentation. Biodiesels of 2nd or 3rd generation (with waste biomass or with algae) will be very useful in decoupling the energy production from the water demand, and may as well provide interesting complementarities to sanitation schemes.

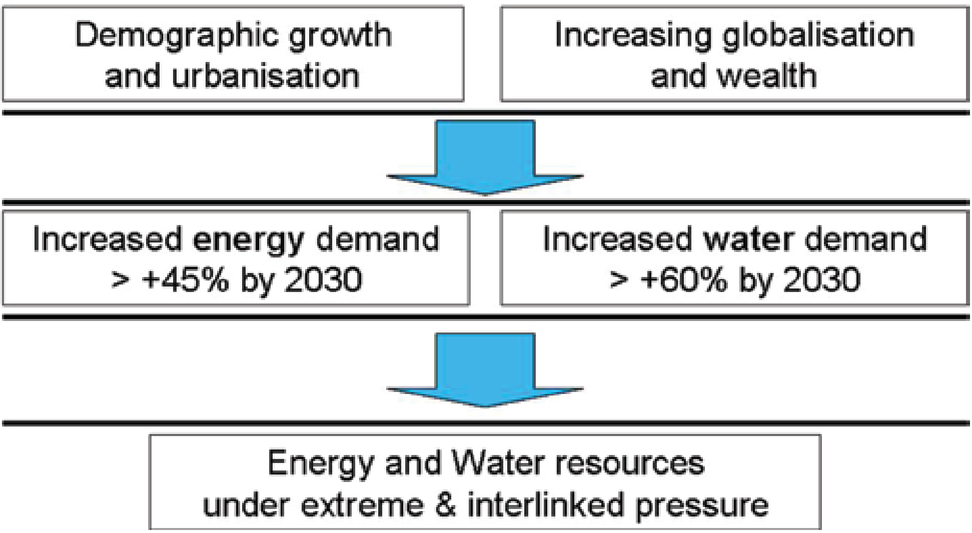
[1] Energy production: 44% of water abstraction in Europe! (EEA, 2009)

Energy type	Water consumed (m3/MWh)
Wind	0.001
Gas	1
Coal	2
Nuclear	2.5
Oil/Petrol	4
Hydropower	68
Bio-fuel, 1st gen. (corn, US)	184
Bio-fuel, 1st gen. (sugar, Brazil)	293

Table 2.2 - Sources: Henrik Larsen, DHI Water Policy, 2008

2.4 Water and Energy scarcity will further grow together and will fuel each other

As response to the 2 drivers "demographic growth and urbanisation" and "increasing globalisation and wealth", an increase of > +45% and > +60% for respectively energy demand and water demand are expected by 2030 in Europe.



2.5 Energy crisis will boost energy prices

Primary energy is a significant share of operation costs in drinking water supply and sanitation systems, which often represent the greatest energy bill of municipalities (and about 3% of total energy demand of western countries). With the looming energy crisis driven by the unbalance between the demand and production of crude oil, increasing energy prices are expected. In May 2010, EC forecasts moved from $66 to $88 per oil barrel by 2020 (as hypothesis for future Energy-Climate politics). According to Bourgas, 2008, and taking into account that the prognosis has always been lower than the actual crude oil price and that inaccuracy of prediction gets higher with the course of time, the oil price could even far above the record of $110 per barrel reached in March 2008. This will have strong impacts on the economics of water supply systems and will foster an industry shift towards energy efficiency and energy recovery.

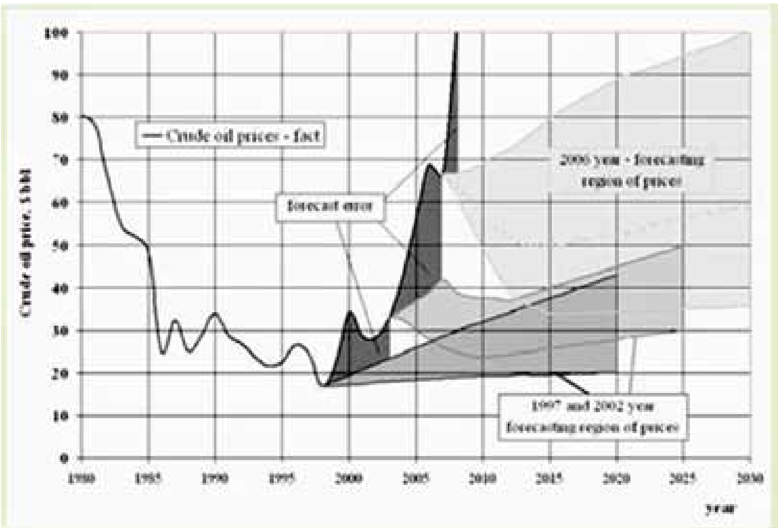


Table 2.3 - Source: Burgas, 2008

2.6 Two conflicting EU directives? WFD and Energy Climate Package

As mitigation measure to Climate Change, the European Energy Climate Package commits to 20-30% reduction of CO2 emission by 2020 (reference 1990), with negotiations of up to 50% reduction by 2030 and 80% reduction by 2050. These objectives should be matched by all sectors including the water industry. In opposition, the implementation of the Water Framework Directive will require additional treatment measures and existing solutions all require additional energy. In the UK, energy consumption in the water sector has doubled since 1990 as a result of the Urban Waste Water Treatment Directive and Drinking Water Directive due to the required additional treatment. Further increases are likely, resulting in a “pollution displacement” from water bodies to the atmosphere. Therefore there is an urgent need to conciliate the Water Framework Directive and the European “Energy Package” and to find optimum and low energy measures which will best protect water bodies while minimising the impact on global warming.

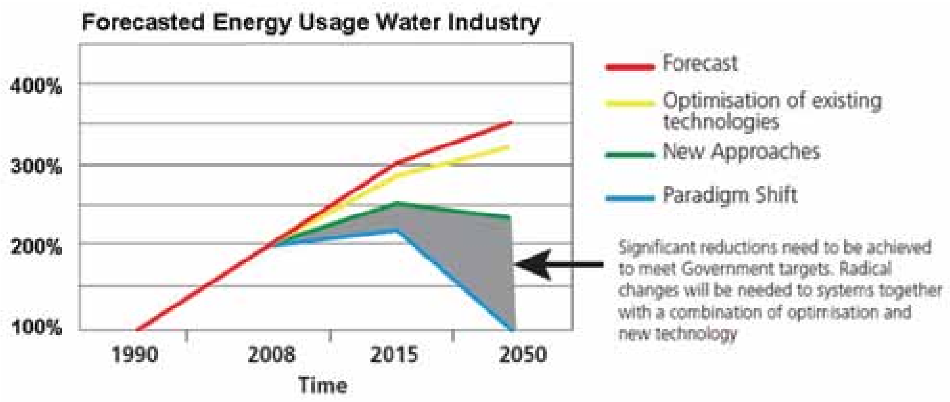


Table 2.4 - Sources: UK Council for Science and Technology (adapted)
‘Improving innovation in the water industry’, 2009

2.7 Benefits to Europe

In the developed world legacy infrastructure often constrains the widespread adoption of novel approaches, due to cost and practicality of retrofit. In the developing world there is more opportunity for short term solutions not constrained by existing infrastructure. Given this there is great opportunity for European innovation to be widely adopted in both the developed and developing world, enabling us to better compete with Asia, Russia, US in export markets. Ultimately this will enhance wealth creation in Europe and create many jobs in the environmental sector.

There will be reduced pressures on carbon, energy, water targets, and there will be reduced reliance on oil and gas imports from the Middle East and Russia.

These approaches will reduce the impact of climate change and other drivers, reduce the costs of service provision and provide financial benefits to society.

3. Strategic Vision and Research Needs

3.1 Strategic Vision and Specific Targets

It is clear that existing systems and processes will not comply with the challenges described above; therefore a paradigm shift is required across society and industry. This will require quick innovations and change of mind set instead of “business as usual” compliance within the water industry and other industries; plus end user and public behavioural changes.

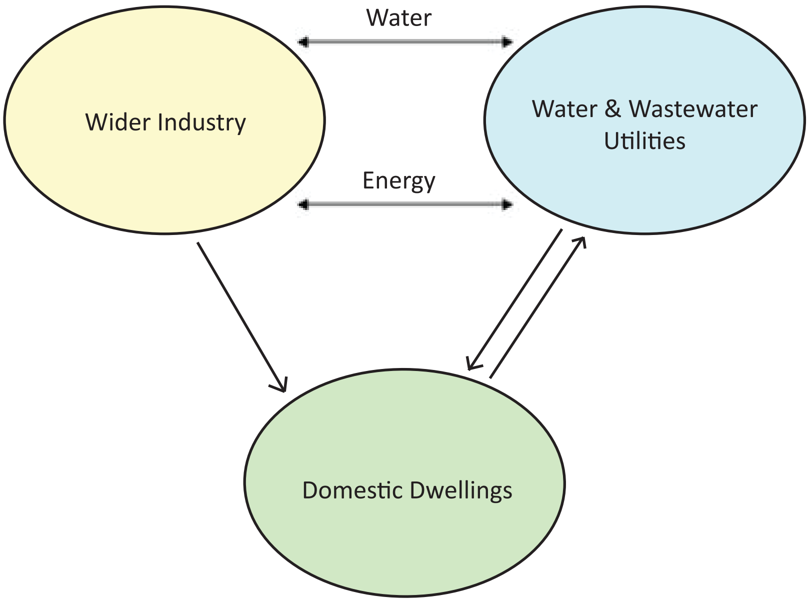


Figure 3.1
High Level - Water and Energy Nexus

In particular, this will require the sector to:

- systematically detect energy efficiency measures (incl. leakage reduction);
- develop economically viable energy efficient processes and systems;
- exploit any untapped energy potential in water systems (chemical, hydrostatic, osmotic or thermal energy potential, included embedded energy through resource recovery);
- plan water and energy supply systems in an integrated and optimised way (integrated water/energy nexus in planning);
- define methods to assess environmental footprints of concepts and enable selection based on environmental performances together with economical performances.

Within this strategy a number of specific targets could be aimed for:

- reduce energy demand and carbon emission of water industry of 20% by 2020 and 80% by 2050 (reference 1990);
- all large WwTW (> 100,000 PE) to be energy neutral by 2015;
- all large WwTW (> 100,000 PE) to be energy positive by 2030;
- small WwTW (<100,000 PE) to be energy neutral by 2030;
- beneficial use of all wastewater constituents e.g., nutrients going to agriculture, living roofs etc; and beneficial use of all the other constituents eg. H_2; O_2; heat; electricity; water; organic acids; biopolymers; embodied energy;
- detect and exploit untapped energy sources in water systems;
- minimise water related energy usage in households and industries;
- develop low water footprint biodiesels.

The development of reliable evaluation methods is crucial in order to be able to sort out between good and bad ideas. For example, there are many examples of costly enhancements to wastewater treatment that deliver questionable environmental benefits, inter alia: a spot compliance regime, effluent disinfection, odour control, nitrogen removal and sludge pasteurisation. Current common practices will need to be reviewed under the new perspective of energy efficiency. The materials and chemicals used in water and wastewater treatment but also water network managements will also come under increasing scrutiny because of their carbon footprint. Synergies between water utilities and wider industry (e.g., power industry) should also be explored in further details.

4. Approach of the Water and Energy Task Force

Core group of individuals representing the Water and Energy Task Force are:

- Steve Kaye (Anglian Water Services – UK) – Task Force Leader
- David Smith (CTM – Spain) – Lead Writer – Water
- Elise Cartmell (Cranfield University) – Lead Writer – Wastewater
- Albert Jansen (TNO – Netherlands) – Advisor – Industry
- Alex Collins (Imperial College - UK) – Lead Writer – Industry
- Claire Hunt – (Imperial College, Yorkshire Water Associate – UK) – Lead Writer – Industry
- Henrik Larsen – (DHI – Denmark) – Lead Writer – Tools and Systems

The task force met three times since February 2010 and has produced a detailed discussion document including a long term roadmap. The general areas covered were as follows:

- Water and Energy Tools and Systems
- Water and Energy in Industry
- Energy Positive Wastewater Treatment and Supply
- Low Energy Water Treatment and Supply
- Water and Energy Efficient Homes

The High level roadmap agreed by task force can be found in appendix 1 and the outputs from the task force workshops are summarised in appendix 2.

5. Short List of R&D Priorities

Considering the water and energy dependencies illustrated by figure 3.1 (water & energy nexus), the conclusions of our own workshops and also the various other reports/roadmaps on water and energy (e.g. GWRC, Stowa, WERF, UKWIR), the following areas highlight the RTD themes considered as having most potential.

5.1 Water and Energy Tools and Systems

5.1.1 Integrated Water and Energy Planning Models/Approaches

Water plays an important role in a sustainable energy production, and vice versa, but the current technologies and management approaches are poorly coordinated across sectoral boundaries. Driven by criteria such as security of supply and economic feasibility, the energy and water sectors have undergone rapid reform in recent years. The introduction of extensive water reforms, such as the Water Framework Directive, has reinforced the need for watershed management, full cost recovery and the primacy of ecological health. However, in existing policy frameworks, energy and water policies are developed largely in isolation from one another – a fragmentation that is resulting in unsustainable developments in both sectors, and sometimes with conflicting objectives (e.g. additional water treatment requirements may have negative impacts on energy consumption). Some countries are beginning to realize the advantages of a more coordinated and integrated policy approach and have started research into the water-energy nexus. Examples are the US (which uses vast amounts of scarce water for energy production purposes) and Singapore (which depends on import of both water and energy and therefore wants to optimize the use of both.

The challenge for policymakers and industry alike is to develop effective policies, processes and analytical tools that allow an integration of the energy-water nexus into policy and investment decisions. Research is needed on identification and evaluation of existing integrated policy-assessment measures and development of new or adapted ones, that would enable identification, specification and analysis of the water implications of energy proposals, and vice versa. Research must help answer questions like: What is the impact of water policies and regulations on energy supplies and demands? What is the impact of energy policies and regulations on water demands and availability? How do policies aimed at climate mitigation and adaption affect policies developed in the energy and water sectors, and, specifically, the energy-water nexus? What kind of regulatory framework is necessary and feasible to minimize the negative trade-offs in the energy-water nexus in both public-sector planning and private enterprise?

Funding scheme: Collaborative project, such as a large-scale integrating project, with possible involvement of non-EU partners (e.g. US research laboratories) to add value where relevant.

Expected impact: Benefits to society include more efficient and coherent policies in the water and energy sectors which leads to lower costs and more optimal use of natural resources.

5.1.2 Benchmarking Tools (linking water, energy and carbon)

Little has been done so far by way of developing benchmarking tools for water, energy and climate impact of products and services. There are tools like Life Cycle Analysis available but these are difficult to communicate. Efforts have recently been made to develop the "footprint" concept for impact on water resources but concepts and methodologies are still being debated.

In order to get policy-makers and end-users more engaged and involved in water- and energy-saving practices there is a need for more appropriate information on "eco-friendliness" of products and services. Hence, there might be a scope for labelling water and energy footprints. Only if the consumer knows, at the moment of purchasing, what the energy and water footprints of the potential purchase are, she can make an informed choice of whether or not to make that purchase. Such labelling would in turn provide a clear incentive for private producers to develop greener and more water-efficient products and services. Water footprints, and the related concept of virtual water, are key tools for addressing challenges and facilitating transparent decision-making processes on water and energy. The availability of easily accessible data on energy and water consumption allows policymakers and industry to make informed decisions about what infrastructure to support or invest in, or which technologies or strategies are so energy or water intensive as to outweigh any benefits.

Hence, research is needed in order to develop appropriate benchmarking tools for water consumption, energy consumption and carbon emissions for services and products, and methodologies for how to convey the results to policy-makers and end-users.

Funding scheme: Collaborative projects, such as small or medium-scaled focused research actions.

Expected impact: More transparent and sustainable investment decisions based on actual information on combined effects on water, energy and climate change.

5.2 Water and Energy in Industry

5.2.1 Recovery of heat from industrial cooling waters

Recovery of heat from industrial cooling waters using a heat exchanger can offer significant energy savings. This heat can either be used onsite for industrial processes and heating buildings or else exchanged and taken off site. Some European cities already have district heating networks (DHN) that provide both energy and carbon emissions savings. In Copenhagen, for instance, DHN supplies 98% of the city's heat needs, with 80% of this heat recovered from electricity generating stations. This saves 655,000 tonnes of CO2 annually (Thorton, 2009). Since water and wastewater industries are energy and heat intensive, considerable carbon emissions could be avoided through the transfer of heat from industry to water utilities. Currently this is rare and its development requires the integration of different industries, changes in infra-structure, best practices and, in some cases, legislation. Research into how to make heat exchange between industrial processes and the water industry feasible is strongly recommended.

Funding scheme: collaborative project (such as large scale focused research actions) with close collaboration between utilities and industry recommended.

Project support: Directive 2001/77/EC of the European Parliament and of the Council of 27 September 2001 on the promotion of electricity from renewable energy sources in the internal electricity market and future policies for GHG reduction and renewable energy production; WERF task force 4: Technology Roadmap to Optimize WWTPs in a Carbon-Constrained World.

Society benefits: The re-use of heat will allow for reduced GHG production and also avoid thermal heat pollution when waters are discharged. Re-use of heat from industry could allow lower operating costs for utilities, reducing costs to customers.

5.2.2 Reducing the amount of water used in cooling

It is estimated that energy generation accounts for 44% of all water abstracted in the EU. This is used primarily for the production of fuel and cooling purposes in the thermoelectric power plants. Conventional cooling methods are highly water intensive, especially in thermoelectric power generation. Therefore, reducing the amount of water used in cooling can result in significant water savings. The introduction of closed loop cooling, reusing the cooling water, can make water savings of up to 30% compared with once through cooling (Environwise, 2007). The introduction of cooling water recycling at a thermal power plant in Latvia led to a ten-fold reduction of water use from 30 Million to 3.1 Million m^3 per year (Dworak et al., 2007). Other advanced cooling technologies include dry cooling, evaporative cooling and hybrid cooling. These either reduce water consumption or completely eliminate the need for water all together. The Pacific Gas &Electricity company submitted plans to install dry cooling at its Contra Costa power plant in the US. The introduction of dry cooling here is expected to reduce the plants water consumption by 97%. However, examples of such technologies in the energy sector in the EU are limited and not well documented (Dworak et al., 2007). Research into the combined water and energy savings of these technologies is needed to understand how they can be best developed and also to prevent pollution displacement.

Funding scheme: collaborative project (such as large scale focused research actions) with close collaboration with energy companies recommended. Study of existing plants recommended. A number of such plants can be found in the US

Project support: The Water Framework Directive; WHITE PAPER Adapting to climate change: Towards a European framework for action. It is also likely that the 2012 Water Scarcity & Droughts Policy Review will support the project.

Society benefits: Reduce amounts of water abstracted allowing less stress on aquifers and reducing the risk of saline intrusion. Restoring of rivers to natural flows provides many benefits for habitats and fisheries improving ecological status. Investigating low carbon water saving cooling will also ensure that there is not a tradeoff between the protection of aquatic environments and climate change mitigation.

5.3 Energy Positive Wastewater Treatment and Supply

Achieving energy positive wastewater treatment at all treatment scales as well as resource (e.g. nutrient, water) recovery whilst minimising green house gas (GHG) emissions is a hugely challenging but potentially highly valuable ambition for the Water Sector. As such the WssTP concurs with priorities outlined in reports from the Global Water Research Coalition, GWRC (2010), STOWA Foundation for Applied Water Research (2010), Public Utilities Board PUB, Singapore (2010) which urge development of wastewater treatment plants for 2030 and beyond based on the concept of water, energy and nutrient factories. This will require, as a priority, continued progress towards anaerobic treatment process flow sheets replacing aerobic processes (proposal call 2.3.1), increased application of adsorptive treatment processes (proposal call 2.3.2) and further energy reduction approaches for existing technologies (proposal call 2.3.3).

However, unless these wastewater treatment developments are coupled to increasing integration with industry (Section 2.2) and the home (Section 2.5), the impact of the water sector on EU carbon reduction and renewable energy production targets and future resource security will be significantly reduced. Increasingly, integrated approaches involving the wider energy industry and other sectors such as domestic dwellings and manufacturing industries are required to ensure the effective use of heat and water resources.

5.3.1 Anaerobic treatment of municipal wastewater

ENV. 2012.x.x.x-x Next Generation anaerobic treatment of municipal wastewater

A large proportion of wastewater treatment works across Europe utilise the activated sludge process as the main treatment stage. Energy requirements to operate this process vary from 0.15 to 0.7 kWh/m^3 often representing over 50% of the total site energy demand. Recent research has demonstrated the practicality of treating the influent wastewater flow anaerobically for energy production (1.7 kWh/m^3 wastewater treated). Further advances in this field can be achieved through research on anaerobic technologies, liquid methane recovery and greater integration of resources between industrial sectors.

Proposals should consider developments in innovative wastewater anaerobic treatment for municipal wastewater which can be utilised in a process flow sheet of 2030 and beyond such as (but not exclusively) as outlined below (GWRC, 2010).

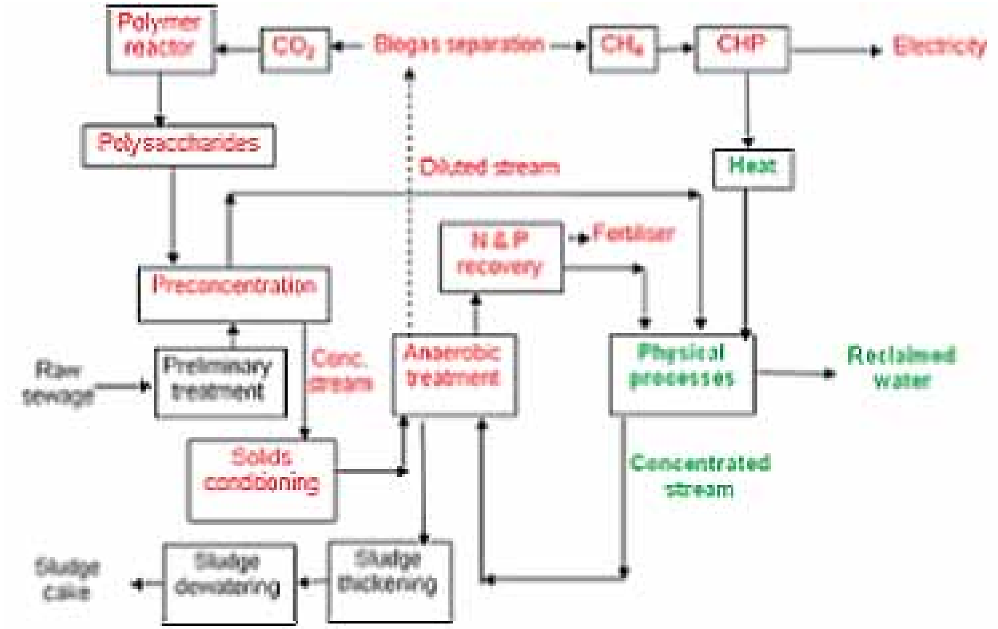


Figure Schematic diagram of a possible 2030 wastewater treatment anaerobic flow sheet (GWRC, 2010)

In addition to anaerobic treatment technology developments in the medium to large scale treatment plant flow sheets as outlined above the following should also be considered.

- Small scale decentralised treatment processes without methane release or with methane capture, linked to small scale electricity production and/or heat use and/or gas use.
- Low energy odour technology (increased use of anaerobic treatment could lead to more odour treatment being required, therefore to keep overall energy demand low, lower energy odour treatment or odour treatment integrated or prevented within the processes would be preferred).
- Liquid methane – techniques to abstract and utilise liquid methane which is particularly relevant when operating under lower temperature conditions (<15ºC) in order not to create CO2e emission problems with greater application of anaerobic technologies.
- Develop more plug and play flexible modular wastewater treatment units for anaerobic processes and improve the understanding of their robustness and reliance.
- Technologies such as enhanced primary sedimentation or low energy filtration technologies to increase the organic content – could improve anaerobic treatment efficiencies by pre-concentration.

Finally, cascading resources and greater integration of the anaerobic municipal wastewater flow sheet with wider industry should be emphasised.

Funding scheme: collaborative project (such as small to medium-scale focused research actions) with close collaboration with the energy sector recommended. Technology development at laboratory/pilot scale with full-scale application where appropriate. In addition project(s) integrating isolated areas of European expertise to deliver more unified approaches to anaerobic wastewater treatment are encouraged with possible collaboration with East Asian partners to facilitate added project value.

Expected impact: More effective and efficient anaerobic treatment processes and control mechanisms as well as better integrated anaerobic treatment at regional scale. Reduced costs to consumers and climate change mitigation. Industrial benefits include improved overall resource recovery and lower energy or manufacturing production costs.

Outputs will also support implementation of Directive 2001/77/EC of the European Parliament on the promotion of electricity from renewable energy sources in the internal electricity market, the EU Emissions Trading Scheme and the Kyoto protocol. Commission policies on Energy ("An energy policy for Europe"), and climate change ("Limiting Global Climate Change to 2 degrees Celsius - The way ahead for 2020 and beyond" will also benefit.)

5.3.2 Adsorptive treatment processes

ENV. 2012.x.x.x-x Adsorptive and wastewater treatment processes

EU surface water quality legislation is expected to require greater nutrient removal in the future. However, nutrient removal in wastewater treatment works is currently achieved through aerobic processes requiring the largest proportion of works energy inputs >50%. If aerobic processes for nutrient removal can be reduced or avoided then energy consumption during wastewater treatment can potentially be substantially reduced. For example, nitrogen removal using adsorbents such as zeolites potentially removes the need for nitrification and dentrification at treatment works. However, even greater benefit could be achieved by recovering nitrogen and phosphorus together perhaps with potassium. This approach would provide a nutrient source suitable for agriculture and wider industry application. Proposals should advance methods and technologies for adsorptive nutrient or struvite recovery which could be applied, for example, at the post anaerobic wastewater treatment stage. In addition adsorption technology performance for priority hazardous substance removal could be assessed to improve overall wastewater effluent quality. Understanding and optimisation of removal mechanisms need to be combined with operational developments to ensure economic effectiveness.

Funding scheme: collaborative project (such as large scale focused research actions) with close collaboration with SMEs for technology development recommended. Technology development at laboratory/pilot scale with full-scale application where appropriate.

Expected impact: More effective and efficient nutrient recovery from wastewater treatment processes. Novel adsorbents and technologies for nutrient recovery. Supports implementation of the Water Framework Directive and future policies for GHG reduction. Society benefits include more efficient wastewater processes reducing costs to consumers and climate change mitigation. Industrial benefits include EU technology development within SMEs to deliver increased export potential and EU job creation.

5.3.3 Enhancement of existing processes

ENV. 2012.x.x.x-x Reduction of energy use in wastewater treatment by 50% of 2010 levels through enhancement of existing processes.

A focus for 2030 and beyond is to reduce the proportion of wastewater treated through aerobic processes and improve nutrient and water recovery. However, there are a number of approaches to optimise existing assets which can be utilised to achieve mid term targets of halving wastewater energy demands. Proposals should consider all scales of current wastewater treatment works operation in relation to energy reduction whilst minimising GHG emissions. Technologies highlighted with potential for alteration/optimisation for energy reduction include processes associated with activated sludge such as fine bubble air diffusion, dissolved oxygen control, variable frequency drives (VFDs), appropriate plant sizing, utilization level versus design capacity and biotechnology – enzyme additions, enzyme optimisation reactors. Candidate technology optimisation solutions should also be considered within the context of the operation of wastewater treatment works under a variable consent framework to achieve additional energy and GHG reduction.

Funding scheme: collaborative project (such as a large scale integrating project) with participation of National Environmental Regulators recommended. Identified technology solutions should be demonstrated as far as possible across a range of regulatory regimes. Demonstration at full-scale facilities with underpinning laboratory/pilot studies where required.

Expected impact: Suite of process and control / optimisation improvements to deliver ambitious reductions in wastewater treatment energy demand. Project supports the Water Framework Directive and greenhouse gas reduction targets. Value to society includes improved wastewater treatment efficiencies and reduced costs to consumers.

5.4 Low Energy Water Treatment and Supply

5.4.1 Development of low energy desalination processes (potentially linking up with heat from industrial applications)

Apart from water transportation pumping, membrane desalination is the highest user of energy in treating potable water. Current methods of desalination cannot produce water sustainably if the energy required for these processes is provided by fossil fuels. Neither

can it be said that by building wind and solar power plants to desalinate water has no climate change impact, when limited renewable resources might otherwise be used to reduce existing fossil fuel consumption.
Reverse Osmosis (RO) membranes and processes have improved significantly in recent years, however there remains the theoretical minimum energy value that will always be required to desalinate sea water using RO. Apart from the need to reduce energy usage in desalinisation there is also a significant need to reduce the ecological impact of brine waste.
Promising low energy alternatives to membrane RO desalination have very recently been discovered in a bid to make desalination of sea and brackish water sustainable in terms of energy use and brine waste. Low grade waste heat from Industry can effectively and efficiently be utilised in conjunction with research into new or existing technologies to utilise the waste heat and reduce brine waste. Alternative low pressure large scale desalination innovation and research should also be considered that uses little to no energy. The active participation of industrial partners that require a solution to their waste heat represents an added value to the activities of this topic and will greatly influence the Implementation, exploitation and Impact of this project.

Funding Scheme: Small-Medium Scale focussed research project. Potential topic for Joint Call with the NMP and Energy Programmes

Expected impact: A change from current desalination methods is expected to have an overall, positive impact for a drastic reduction in energy usage for the desalination of sea or brackish water as well as the potential for a waste from one industry to become a resource for another. The European Union (EU) have pledged to cut its annual consumption of primary energy by 20% by 2020. Add to this energy usage within the water utilities is likely to increase within Europe as water industries have been forced to employ increasingly more energy intensive processes as a consequence of expanding water quality legislation. Therefore the introduction of an alternative desalination method either through low grade waste heat or other low energy alternatives would provide a sustainable solution that can also eliminate or drastically reduce the ecological impact of brine waste.

5.5 Water and Energy in Homes

5.5.1 Smart Houses – Self Sufficient in Water and Energy

EU-Funded research shows (in the UK) that around 90% of householders don't make the link between the water they use and their energy bills, while other studies show relatively low levels of awareness around water-saving devices like efficient shower heads.
However over 60% of people polled in a recent Energy Saving Trust survey said they were interested in fitting water saving devices, while over 64% would prefer to have energy saving devices installed at the same time.
In light of this evidence the future research opportunities are more likely to be around the education and behavior of household residents, coupled with aligned communication

strategies from electricity and water utility companies.
The development of incentive mechanisms and appropriate taxes will also drive the outcome of more energy efficient homes.

Funding Scheme: A medium scale research project to assess the opportunities across Europe to change household residents behavior, focusing on developing combined energy and water incentives and pro-active communication strategies from the utility sector.

Expected Impact: Greater understanding of water and energy saving opportunities (residents, utilities and government).

Changed habits and alternative infrastructures to support water and energy saving.

6. Summary

The implementation of the strategic vision and research agenda described above will lead to an integrated approach to water and energy use between industry, home and water and wastewater treatment.

Key priorities identified are as follows:

5.1 Water & Energy tools and systems

- 5.1.1 Integrated Water & Energy planning models/Appro
- 5.1.2 Benchmarking Tools

5.2 Water & Energy in Industry

- 5.2.1 Mission: Innovative heat exchange between industry & water/wastewater utilities.
  Gains: Major energy saving

- 5.2.2 Mission: High efficiency cooling techniques
  Gains: Saving high volumes of supplied water

5.3 Energy Positive Wastewater Treatment and Supply

- 5.3.1 Anaerobic treatment of municipal wastewater
- 5.3.2 Adsorptive treatment processes
- 5.3.3 Enhancement of existing processes

5.4 Low Energy Water Treatment and Supply

- 5.4.1 Development of low energy desalination processes

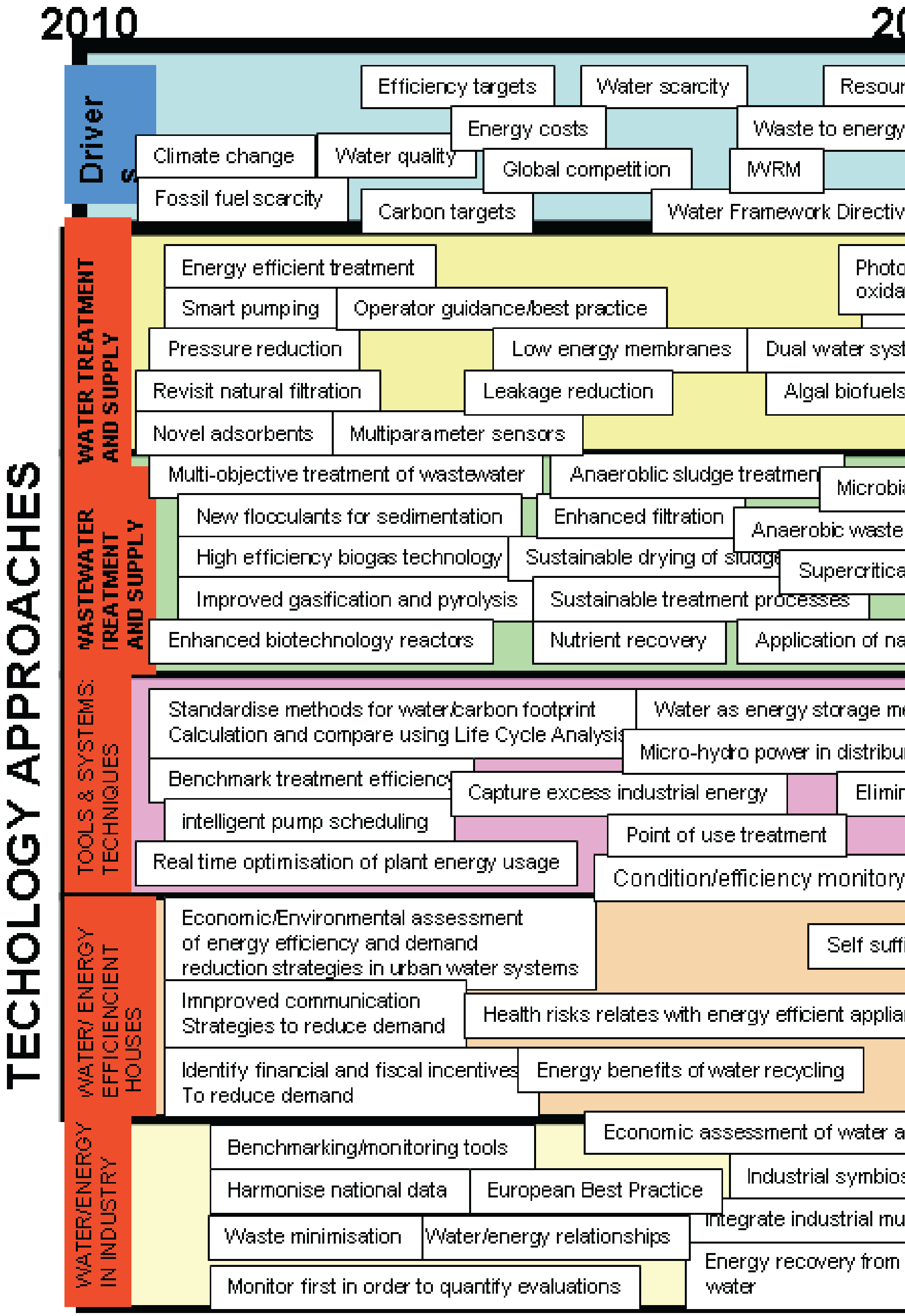
5.5 Water & Energy in Homes

- 5.5.1 Smart Houses – Self Sufficient in Water & Energy

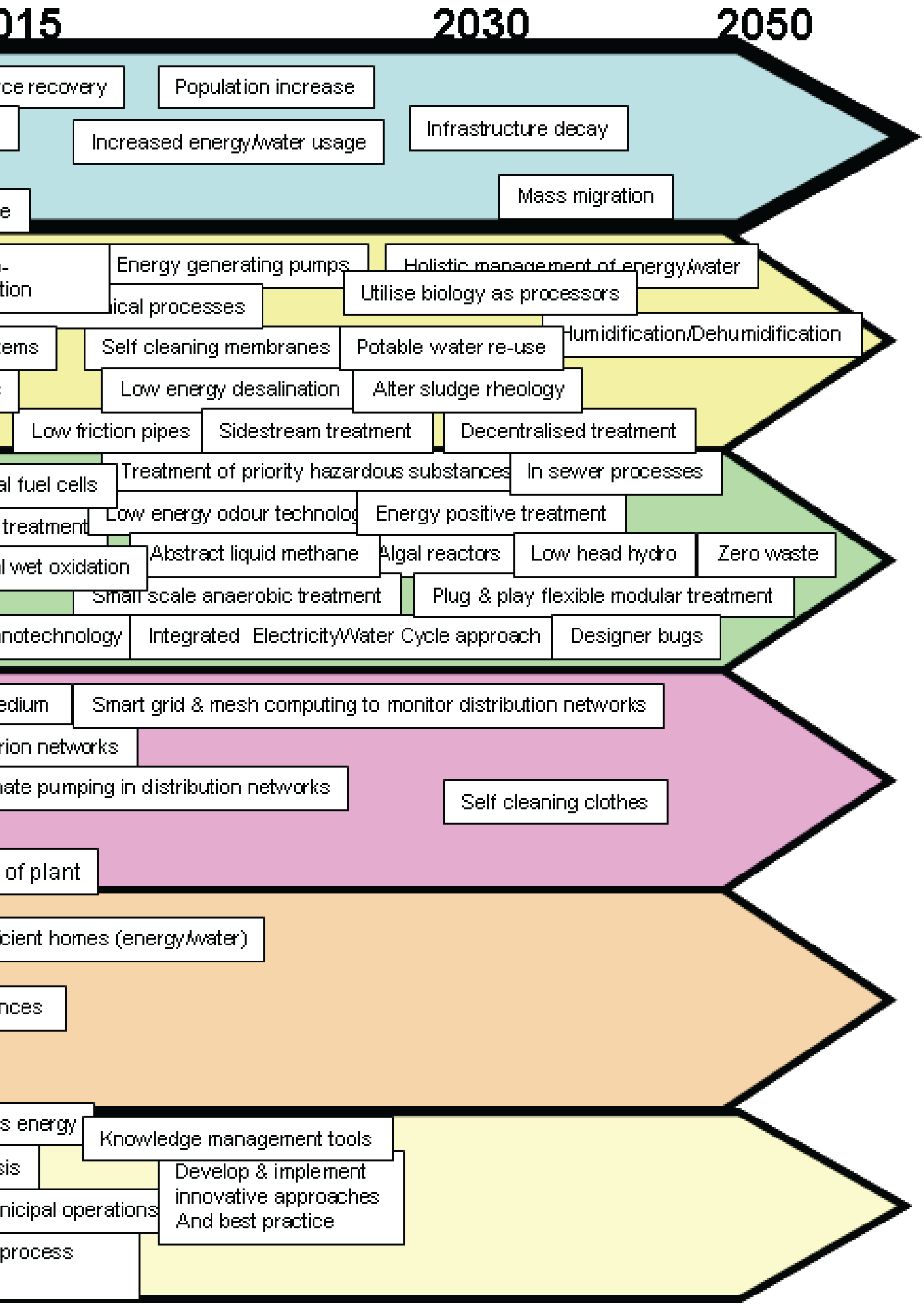
These priorities should be presented to the European Committee as options in the FP7 co-operation work programme.

Appendix 1 Roadmap

WssTP Energy/Water Task Force – Tec



hnology Roadmap



Appendix 2 Outputs from Workshops

A workshop was held in Brussels on the 11th February 2010 exploring R&D opportunities in the area of Water and Energy from a European perspective. Five research themes have been identified as priorities in the area:

1. **Water & Energy tools and systems**
2. **Energy efficient water treatment & supply (inc. networks & renewables)**
3. **Energy neutral/positive wastewater treatment (inc. collection, bio-solids and renewables)**
4. **Water & Energy efficiency in home**
5. **Water & Energy in Industry**

The specific research needs for each of these themes are summarised in a Technology roadmap, Appendix 1.

The detailed strategic vision and research priorities for each theme are presented below:

1. Water & Energy Systems Analysis

Notes from Feb 2010 workshop

2015

- Develop harmonised methods to assess footprints of concepts
- Develop benchmarking tools (pinch, LCA, water footprint, carbon footprint) and ways to monitor where (and how much) water & energy are used
- Harmonise current national figures (UK, NL, & Singapore) to be appropriate for a European report and obtain additional information where necessary
- Integrated electricity/water cycle approach; methods for integrated catchment source management
- Smart grid & mesh computing, monitoring grid distribution, providing warning devices to protect drinking water
- Maintenance planning of power infrastructure: motor monitoring for efficiency & pre-emptive maintenance

2030

- None. Normalised methods should be defined in early stage to enable assessment of concepts.

Notes from 4th Oct 2010 Workshop

Should try and promote development of tools and methodologies to make water and energy decisions. For example, what is needed by planners and regulators, industry and scientists to analyse energy planning taking into account impacts on water resources and energy.

Set of steps/sequence

- Common approach to units re water and energy
- What energy is used in water systems and visa versa?
- Develop a tool which links the two together
- Then utilise the tool re planning/stakeholder engagement

Less on basic research more on integrated assessment and planning of water and energy schemes

- Pollution displacement needs to be considered
- Tools help to design infrastructure and systems and bring stakeholders together. Making people more aware
- Inclusion of carbon and energy into WFD.
- Scope for development of decision support tools to optimise different aspects of planning.
- Smart urban planning models/ approaches that will allow planners to plan infrastructure re optimisation of water and energy. Multiple criteria models.
- Basic planning tools – e.g. WFD how to factor in water / energy. Water footprint analysis. BUT make sure you are actually looking at water and energy
- Concept of water and energy footprint – harmonising data/methodologies 2015 work.
- Create new third currency between water and carbon footprints to examine water and energy.
- But also need to examine how carbon and water footprints are measured.
- Need to compare figures between countries etc
- What does this lead us to? Tools for optimisation trade offs
- Two sides of this hardware for smart meters etc and how you use this info
- Smart grid thinking at regional/household level. Smart meter needs to display both energy and water – need a new currency. Important to say what the benefits are. Cuts across all areas.
- Introduce energy-water links into existing planning mechanisms – for instance, consider vetoing a new housing or industrial development if its water supply will need to be pumped long distances.
- Planning Procedures – integrating knowledge on planning procedures - how can water and energy stakeholders work better together?
- Develop methods for benchmarking treatment efficiency to identify systematic shortcomings and characterise efficient systems.

2. Water & Energy in Industry (also see appendix 3)

Notes from Feb 2010 workshop

- The Virtual Power Station: capture excess industrial energy capacity and sell it to power producers, use of water as an energy storage medium (e.g. a way of storing wind energy), Micro hydro power (using excess pressure in network for power generation)

- Monitor first in order to quantify evaluations
- Develop water and water bound energy relationship
- Express water in energy terms to make it economic/strategic
- Investigate ways to recover energy (heat) from used process water (no CH4 and H2)
- Integrate grey area between industry and municipal operations e.g. Hospitals water & energy, medicines)
- An (EU) study of industrial sectors that provides an evaluation of new innovative concepts and technologies, and calculates potential achievements for important regions
- Develop inventory of good ideas/technologies

Notes from 4th October 2010 Workshop

- Waste heat from Industry use – change some systems to get higher heat
- Drinking water company Netherlands – recovery of methane from groundwater 1 million m^3 methane gas/year. Similar in Denmark.
- Technology platforms – discussions for water re-use, concentration of company waste is increasing as water consumption goes down. These wastes are often incinerated – high cost. Further step needed by completely dewatering these wastes so that the waste can be more concentrated and incinerated more efficiently. Recovery products from this material
- Technology for water increasingly needed for more marginal water e.g. industry wastewater.
- How to set up co-operation between urban and business areas
- Evaluation tool – what to do with heat
- Need more heat mapping perhaps!
- Water is used for cooling – look for more efficient water cooling systems. Use of latent heat perhaps evaporate a smaller quantity of water instead? But here loose control of water. From a water management perspective need to keep control over this water evaporated water has a lower value than water which is under your control.
- Water based cooling systems dangerous re legionnaires problems so perhaps get rid of these systems. What are we gaining from this – reduced water used? But here we also need to use low quality water. Need to optimise both energy and water quality use together not separately.
- Can you get the same amount of energy into half the amount of water? Yes by increasing the temperature – does this need a policy change? Does this give an overall environmental benefit?
- Groundwater scarcity / brackish water are meaning that more surface water is used for cooling. This causes clogging / scaling problems.
- Keep more heat in the water, transport and use.
- Use of nanotechnology in industry – e.g. membranes, target specific compounds for treatment and recovery
- NEW TECHNOLOGIES SHOULD BE DEALT WITH IN A BROAD SENSE – ACROSS THE FIVE AREAS; SAME GOES FOR TOOLS.
- Harmonise current national figures – do we need any key data for this?
- Take a step back and examine problems/benefits before implementing projects.

- Water from community to industry. Not just products from industry going out.
- ENERGY FACTORIES PROJECTS (8 districts included). Results so far state of art for energy recovery – energy neutral due to more energy needed for water re-use, mineral recovery e.g. P recovery. Other strategic issues in society e.g. hazardous substances causing energy demands.
- Cannot loose energy can change it.
- Here you are not necessarily saving energy but using it more efficiently - energy efficient processes
- Total amount of power production is equalled by waste heat (higher than wastewater
- Future research must include multi utilities e.g. power and water utilities
- Moving heat around sewers co-operation between private and public organisations
- More efficient concepts incorporated into design for Industry
- Singapore example – reclaimed land for an industrial area. Looking at tools to understand the appropriate industrial linkages
- Need to minimise the losses of heat/power/water. Optimise the mix of industrial activities. How to design an area
- Encourage energy re-use from waste, waste heat (e.g., incinerators, power stations), carbon sources (co-digestion of food waste), energy (e.g., renewables), to both reduce demand and generate significant amounts of energy.

3 Energy neutral/positive wastewater treatment (inc. collection, bio-solids and renewables)

Notes from Feb 2010 workshop

2015

- Enhanced primary sedimentation or low energy filtration technologies to increase the organic content – could improve anaerobic treatment efficiencies – enhance efficiency by using different flocculants but need to avoid additional chemical/salts use
- Upgrading biogas technology – technology solutions which can be used in smaller facilities / more flexible, reduce chemical use
- Gasification / pyrolysis optimisation to reduce tar problems
- Biotechnology – enzyme additions, enzyme optimisation reactors, H2 production
- Sludge drying – using waste heat, sun, plants (eco drying)
- Nutrients adsorbents and Struvite / nutrient recovery processes
- Eco sanitation -greater use and optimisation of extensive processes when positive triple bottom line
- Low energy secondary and tertiary treatment (WFD)Multi-objective treatment of wastewater (e.g. thermal harvesting)
- Anaerobic technology improvement – high rate process development for high solids applications (biomass retention)

- Concentration technologies for priority hazardous substance removal
- Encourage algae for energy production/fuel
- Small scale decentralised treatment processes without methane release or with methane capture, linked to small scale electricity production and/or heat use and/or gas use
- Low energy odour technology (concern that increased use of anaerobic treatment could lead to more odour treatment being required, therefore to keep overall energy demand low, lower energy odour treatment or odour treatment integrated or prevented within the processes was preferred)
- Liquid methane – techniques to abstract and utilise it in order not to create CO2e emission problems with greater application of anaerobic technologies
- Nanotechnology – greater application but linked with assessments as to overall environmental impact
- Microbial fuel cells; Super Critical Wet oxidation
- Develop more plug and play flexible modular wastewater treatment units. Improve understanding of their robustness and reliance – in conjunction with policy developments for variable consents etc
- Use of anaerobic technologies to full flow wastewater treatment applications

Notes from 4th Oct 2010 Workshop

- Where should the emphasis be / influence – where do the research suggestions fit re research levels
- Define research gaps including close to markets
- Prioritise areas for development in the report emphasis on need/integration/wealth/jobs
- Algae
- Activated sludge – Gravitox (UU) enhancing existing aeration processes, load reduction, multi use of activated sludge (e.g. use as cooling processes for industry) e.g. costs? billion pounds and if we could get it 10% more efficient can save?
- Heat exchanger at the bottom of a pipe of sewers
- Not just transporting water and wastewater – actually transporting heat/energy
- DECENTRALISATION – important to reduce pumping costs but for energy production centralised. Report needs to acknowledge decentralisation is a future scenario not necessarily help decide if that's the right approach or not.
- CO2 sequestration, energy storage, CO2 use.

Three- Four research areas identified provisionally as move to anaerobic flow sheets, improved thermal processes, nutrients, existing processes optimisation.

Blue Sky Energy positive at <100PE; Different end uses for wastewater products; No waste to treat; Collection of gas in sewers and in sewer treatment and power generation (harvest flow and heat energy); Low head (1 m) symphonic hydro with wastewater treatment

4 Energy efficient water treatment & supply (inc. networks & renewables)

Notes from Feb 2010 workshop

2015

- Energy Efficient Treatment Processes – e.g. bubbleless DAF – (Currently 90% inefficient)
- Pumping (pumps and systems) - pumps : smart pumping, real time control, systems: peak tariff demand etc
- Pressure reducing devices
- Revisit natural / filtration processes with lower CO_2 footprint. Investigate sand filters, Slow Sand Filters's, biofilters
- New medias – adsorption medias (links with wastewater treatment)
- Low energy membranes
- Reliable multi-parameter sensors (inc energy data based sensor devices)Introduce intelligent pump scheduling (real-time, dynamic optimisation of pump efficiency)
- Realtime optimisation of plant energy usage

2030

- Energy creating pumps
- Low chemical membranes e.g. self cleaning membrane
- Low friction pipe material for leakage and energy reduction – timescale 2015 but widespread implementation in 2030.
- Low CO_2 and low chemical processes
- Low energy desalination use of mechanisms employed by animals (fish) and plants (mangroves) which allow them to survive in brackish water etc
- Humidification / dehumidification (step change approach)but applied in nature e.g. cactuses and desert animals
- Use of mussels (zebra mussels) – 2015/2030 timescale
- Sidestream / reject water treatment – requires greater focus in the future
- Sludge rheology – alter to reduce energy demands
- Potable water re-use – technology improvements needed

Blue Sky

- Low friction water an option to reduce energy pumping demands
- In pipe water treatment

Notes from 4th Oct 2010 Workshop

For the 2015 – put into themes e.g.

- Existing energy efficient treatment processes (inc. low energy membranes, low energy pumping) existing processes being made more efficient. Include nanotechnologies to recover materials from water (e.g. pharmaceuticals) – targeted removal and possible recovery (e.g. iron)
- New energy efficient processes/technologies (bubbleless DAF, new membranes)

- Pumping - automatic real time control, pump turbines.
- Energy recovery – PRV, turbines , algae in digesters.
- Some of the biggest challenges are pesticide removal e.g. metaldehyde (UV and hydrogen peroxide). Groundwater quality an issue in Denmark.
- Carbon cost of pollutant removal – drive this by forcing research proposals to link with policy/legislation. Don't allow technology developments to be limited by waiting for policy changes.
- Wastewater and industrial water re-use for water supply – need policy angle.
- Real time control for water networks. Need to link our work with ICT, sensors very important especially if going for a catchment management approach – link with Water and Energy tools area. Pre-emptive maintenance does this reduce energy? Make sure there's a strong link.
- Algae problems with surface water – catchment management and use algae.
- Zebra mussels.
- Disinfection – check whether this should be a problem / opportunity or not. Maybe it's more relevant to use of lower grade water to industry in the future. What about in pipe treatment /disinfection.
- MUST BROADEN APPROACH TO OTHER INDUSTRIES/HOME.

5 Water & energy efficiency in homes

Notes from Feb 2010 workshop

- Comparative global cost and environmental assessment of all strategies that can be used reduce energy demand of urban water systems (compare strategies set at households level including behaviour change with strategies impacting central infrastructure)
- Social science to improve communication impact of demand reduction, and identifying appropriate incentives / taxes measures to encourage efficiency.
- Health risks relates with energy efficient appliances? (low T° washing machine, recirculation shower etc)
- Identify synergies which could be established with water saving concepts (rain water harvesting, grey water treatment etc)
- Smart houses, self-sufficient in water & energy
- Tanker delivery of drinking water, eliminating pumping
- Point of use drinking water treatment

Bluesky: Self-cleaning clothes – technologies requiring development to minimise water use in the home, but also need to examine impact of these technologies in wastewater treatment and environment (e.g. use of silver)

Notes from 4th Oct 2010 Workshop

- Action - Adriana Hulsmann (KWR, Netherlands) to potentially provide some data
- What products/innovations can be developed to save water?
- How do you influence people?

- Where should utilities stop involvement - should include KPI for utilities to do the right thing? Utilities are encouraged to bring about water / energy savings in the home though
- Should water and energy be separated? NO needs to be linked
- Self sufficient homes in terms of water and energy? Bring this forward – link with developers and existing houses OR should you? Will houses be doing the same with water as they are with power e.g. decentralised power producers.
- Split into themes
- Technology development – water re-use
- Water saving – promoting why this is needed (economic)
- Linking with industry to use low grade heat
- Water utilities being used as energy suppliers in the water and wastewater networks
- RISK based analysis – how to apply re-circulation
- Reduce household hot water demand (through encouraging the use of water saving devices, targeted communication on best behaviours etc)
- Improve energy efficiency of household "hot water systems" by: encouraging the installation of energy efficient heating appliances (low T° washing machine, dish washer, heating units); Encouraging the installation of heat recovery systems (such as heat-exchangers in showers or grey-water systems); improving the performance of heat exchangers e.g. in regions with hard water, soften the water in order to avoid the deposition and increase energy transfer.

Appendix 3 Water and Energy in Industry Summary Notes

Industry is a major user of water throughout the European Union, with 20% of all the water abstracted estimated to be used by industry (ACQUEAU, 2010). However, water use varies considerably between different industries, with high variability in quantity and composition of effluent produced. As a result it is difficult to obtain good data and generalise patterns of water use throughout the industrial sector.

The European Environment Agency (2009) has estimated that manufacturing accounts for 11% of water abstracted across Europe. Water in manufacturing can have a number of different purposes, including: cleaning, heating, cooling, the generation of steam, transport of dissolved substances, as a raw material, as a solvent or as a constituent of the product itself. Data from Eurostat shows that the production of chemicals and petrochemicals accounts for half of all the water used by the manufacturing sector (EEA, 2009; Eurostat 2009). Other industries that use large amounts of water include the paper and pulp, textile, leather, food, metal and mining sub-sectors (EEA, 2009).

Water used in the energy sector is typically calculated separately to other industries. It is estimated that energy generation accounts for 44% of all water abstracted in the EU. This is used for the production of fuel and cooling purposes in the thermoelectric power plants (EAA, 2009). The International Energy Association predicts that energy demand will double between 2004 and 2030, which could lead to increased water consumption. A rise in temperatures may increase the amount of water required for energy production as cooling becomes less efficient. This along with reduced water availability may also have adverse effects on energy production across Europe, as power stations must be closed when intake water rises above certain temperatures and when river levels are low (EEA, 2008). This has already led to reduction in energy production in some member states during warm summers (Lehner et al., 2005).

a) State of the art – what is currently happening

In general water use by industry has been decreasing in long-industrialised countries due to the decrease in water intensive industries such as mining and steel. There has also been a 70% decrease in water use by industry in acceding countries (EEA, 2009). Across much of Europe, sector-specific reductions in water use are increasingly reported. For example, it has been estimated that water abstracted by the chemicals industry across Europe was reduced by 8% between 2003 and 2006 (CEFIC, 2007). Reductions have also occurred in the paper industry with reductions of more than a half in Austria between 1990 and 2007 (Austropapier, 2007). The use of water for cooling has been reduced by about 10% across Europe in the last 10-15 years (EEA, 2009). However, water use in the energy sector has been increasing. Global annual water use by industry is also expected to rise from 752 km^3/year in 1995 to an estimated 1,170 km^3/year in 2025.

Water use in industry is reduced in a number of ways, including: changing production processes reduction in wastage, recycling and re-use of water, changes in cooling technology. The water savings for different efficiency measures has been estimated (table 1), showing a number of measures having significant water saving potential (Dworak et al., 2007; Environwise, 2005).

Efficiency measure	Percentage of water saved
Closed loop re-use	90%
Closed loop recycling with treatment	60%
Cleaning in place	60%
Reuse of wash water	50%
Counter current rinsing	40%
Scrapers	30%
Spray/jet upgrades	20%
Pressure reduction	Variable
Cooling tower heat load reduction	Variable

Table 1: Water saving potential of different efficiency measures (Environwise, 2005)

Water re-use through closed circuits can offer significant water savings and Europe offers many examples. A LIFE funded programme demonstrated that water reuse in a diary processing factory reduced water intake by 550 Million litres per year, a 67% reduction, and a reduction in wastewater production from 800 to 545 Million liters/year (Dworak et al., 2007). However, the study stressed that this may not lead to financial gains. A metal surfacing and coin producing company installed a closed circuit water system in 2001. This has reduced water consumption from 20,000 m³ in 2000 to 2,000 m³ in 2007, resulting in reducing water abstraction charges by 27,000 Euro per year. The system cost 700,000 Euros to install, with the payback period expected to be 12-15 years (Dworak et al., 2007). In France it has been mandatory to install closed circuit water systems for all newly built plastic transformation factories since 1993. It is believed that this has been one of the main factors in the reducing France's water withdrawals from 5,107 Million m³/year to 3,942 Million m³/year between 1985 and 1995 (EAA, 1999).

Recycling of water with onsite treatment can also provide companies with significant water and monetary savings. A large transport company in Hungary fitted a waste water treatment facility that enabled water to be re-supplied for washing of vehicles. This achieves water recycling efficiency of 80% and recovered the investment in an estimated 1.3 years (Dworak et al., 2007). Similarly, a drive through car washing and valeting centre in Swansea, UK, fitted a closed loop water recycling system using reed bed treatment. It has been estimated that recycling water using membrane technology in the tanning industry can provide water savings of up to 90% (COTANCE 2002). However, it is important to also factor in the energy requirements of implementing on site treatments in order to avoid simple pollution displacement. A review of both the water and energy saving potential should be conducted and compared to current procedures before techniques of onsite treatment are recommended.

Significant water, and therefore also energy savings, can be made from the reuse of wash water, where it is used in a second application before being released. This requires a good understanding of the quality of waste water along with an understanding of water requirements elsewhere on site. Common final uses of re-used water include the makeup of raw material, such as slurries or the first wash down of floors or containers. The pay back on these measures is typically in the order of months to a year (Environwise, 2005). The Dow Chemical's site in the Netherlands re-uses 9.9 million liters of municipal household wastewater every day as feed water for several plants. This water is then treated and used as feed water for cooling towers. This process change has resulted in reducing wastewater production by 38%, energy use by 60% and CO2 emissions by 5,000 tons/year (WBCSD, 2010). Water from non-traditional sources can, due to the less restrictive water quality requirements, be more easily re-used for cooling than for other sectors such as food and agriculture sectors.

Water savings of around 40% can also be achieved from counter current rinsing. Here water a product in rinsed in progressively clearer water, whilst water moves progressively from the first rinse to the last, ensuring more efficient water use. Counter rinsing in a plating and metal finishing company saved 70% of water consumption and had a payback time of 2.4 years (Environwise, 2005).

There are also many examples of where businesses have conducted water audits to identify simple water usage efficiencies. In the UK a fish processing company produced water balances for two of its factories. This led to the implementation of a programme of leak repairs, improved cleaning procedures and the introduction of dry filleting. Significant water savings of 58% per tonne of final product were achieved, equalling an estimated £95,500/year (Envirowise, 2005). A company in the electronics manufacturing industry in the UK, proactively monitored water use to identify possible water savings. As a result, measures were put in place to reduce flow to both static rinse and counter flow rinse lines. This reduced water demand from 46,000 m^3/year to 41,000 m^3/year (or a 12.5% reduction), equalling a £3,000 per year of cost savings. At the same time, water demand reduction led to an effluent reduction from 35000 m^3/year to 32,000 m^3/year, saving an additional £2,700 per year. An electroplating company in the UK installed good housekeeping measures, flow monitors and flow restrictors, reduced water consumption by 60,000 m3/year, without any significant modifications and with a payback time of 6 months (Envirowise, 2005).

Rain water harvesting can also offers water savings. A Renault car factory in north France collects 35% of its annual water consumption from rainwater, equalling 200,000 m^3 of water. In Berlin 19 buildings of the complex are used to yield 23,000 m^3 of rainwater a year. This water is used mainly for toilet-flushing, garden water and machine washing (Rainwater tool-kit, 2010). Rainwater harvesting can also be used to compensate for water lost through evaporation in closed circuit reuse systems. This is the case in the metal surfacing and coin producing factory where 5,000 m^3 of roof surface is used (Dworak et al., 2007).

Reducing the amount of water used in cooling can result in significant water saving for industry. Conventional cooling methods are extremely water intensive, especially in thermoelectric power generation. The introduction of closed loop cooling, where water for cooling is reused, can make water savings of up to 30%, compared to once through cooling (Environwise, 2007). The introduction of recycling of cooling water at a thermal power plant in Latvia lead to a reduction of water use from 30 million m^3 per year to 3.1 million m^3 per year (Dworak et al., 2007). Other advanced cooling technologies include dry cooling, evaporative cooling and hybrid cooling. These technologies either reduce water consumption or completely eliminate the need for water all together. In 2006 The Pacific Gas & Electricity company submitted plans to install dry cooling at its Contra Costa power plant. This was done in response to declines in the Delta Smelt habitats, salmon and steelhead populations and general water quality. The introduction of dry cooling is expected to reduce the plants water consumption by 97% (Cherry, 2006). Such examples from the energy sector in the EU are limited and not well documented (Dworak et al., 2007). It is also unclear about the relative carbon emission of different cooling technologies.

A WRF report on a workshop with the purpose of discussing ways of optimising WWTPs in a carbon constrained world also identified heat recovery as a high priority for future research (WRF, 2009). This was primarily concerned with the reuse of heat from the treatment process itself or the use of heat for nearby industries. However, it is clear that across the water industry the use of heat is a seen as a priority for optimisation.

Recovering heat from cooling using a heat exchanger can offer significant energy savings. Heat can be exchanged from cooling waters and used to heat processes and buildings in other areas of plants. For example, Intel's plans for a certified green building included using heat recovery chillers to capture heat from servers and other equipment, in order to heat the building in winter and provide year round hot water to the kitchens and bathrooms (Intel, 2007). Intel estimated that savings of approximately USD 235,000 annually would be due to reduced fuel consumption, resulting in a return on investment of about 1.7 months.

Heat generated at industrial sites can also be exchanged and used off site. In 2008 IBM presented plans for a carbon neutral data centre which would utilise an innovative water cooling circuit. Here water is pumped through micro channels in computers, the water absorbs the heat from the computers and is used to heat nearby homes. It is believed a 10 mega watt data centre could heat 700 homes (IEEE, 2008). District heat networks (DHN) can offer considerable energy and carbon emissions savings. It has been estimated that a network covering 250,000 homes may save between 0.25 Mt CO2 and 1.25 Mt CO2 relative to conventional heating annually (Davis and Woods, 2008). In Copenhagen DHN supplies 98% of the city's heat needs, with 80% of the heat recovered from electricity generating stations. Recycling waste heat on this scale allows Copenhagen to save 655,000 tonnes of CO2 annually (Thornton, 2009).

Industrial waste waters from large industries can be treated anaerobically for the production of biogas. This is particularly suited for industries discharging highly concentrated (over 1,500 mg COD/l) waste waters. For example, the food and food processing industry, beer breweries, soft drink producing factories, paper producing or processing factories, and some chemical industries. However, this technology is not jet developed for waste waters with less concentrated organic loads.

Based on information from Spain, UK and France it can be assumed that approximately 30-40% of industrial plants have already implemented water saving measures. These measures have been found to save 15-90% of water use, with most measures saving in the range of 30-70% of water use (Dworak et al., 2007). This shows the potential of water saving measures in the industrial sector. However, the majority of businesses have not implemented any water saving measures and it is unclear whether those who have already implemented measures have captured all the possible water savings.

b) What new R&D opportunities are there, the 2015 perspective

It is clear that there are a number of water and energy efficiency measures already in place throughout the industry sector. These have the potential to save considerable amounts of water and in the process also save energy. Therefore, by 2015 the priority should be to maximise the use of already proven measures. With an estimated 60-70% of business not having any water saving measures in place this may be quite a challenge. However, typically industry welcomes efficiency savings where financial benefits can be demonstrated. It is estimated that in the UK maximising water saving potential in industry could save up to £10 million per day (Environwise, 2009). Progress will be able to be made when such savings are successfully demonstrated.

The most effective water saving measure detailed above is the use of dry cooling. This reduces water consumption by 97% and in some cases completely removes the need for abstraction for cooling purposes. However, due to the capital costs there are few examples of use in non arid environments or areas without specific environmental considerations. Research is clearly needed into whether this technology can deliver both water and energy saving benefits and to ensure that a pollution displacement is not promoted. Research will then be required into how to make this technology attractive and easily implemented. Where dry cooling proves not to deliver both water and carbon savings the use of municipal waste water should be investigated for cooling. This would reduce the amounts of water abstracted and the energy required for abstraction and treatment.

The second most water efficient measure that can be implemented in industry is the use of closed water circuits. However, the adaption of plants to this system may be disruptive and require large capital investment. Research into minimisation of the adaption process and costs would help promote the adoption of this strategy, as would a sharing of information regarding costs and payback times. Financial incentives may also be required to promote this efficiency saving.

The promotion of recycling water with onsite treatment would also benefit from the above suggestions. However, research is also required into the most energy efficient and cost effective methods of treating different industrial wastes. Some sectors which produce highly concentrated and/or toxic waste waters may need to implement membrane technology. Therefore, research is required into making this technology more energy efficient so that pollution displacement doses not result in its implementation. Research into how to make biological treatment of waste waters more reliable and suitable for a wider range of industrial effluents is also required to promote low energy onsite treatment and water re-use.

Re-use of water can offer significant energy savings along cost savings for companies, as demonstrated by the Dow Company. There should be increased demonstration and sharing of best practice regarding how companies can re-use the waste water they produced. Research into novel uses for once used water will be of benefit to the promotion of this measure. There should be a review of the need for legislative banning of water re-use where these apply. The review should consider restricting the ban of water re-use to certain industries and business only, as opposed to a total ban. The re-use of water first used off site should also be promoted as offering significant water and energy savings, along with avoided abstraction costs for companies. Research into how to adapt infrastructure and increase its efficiency will be required. Consideration should be given to water re-use in the planning of new residential and industrial areas and this idea should be promoted to land use planners and public authorities.

The use of water auditing in the industrial sector is particularly important. Especially as it has been estimated that two third of businesses do not monitor water use at all (Envirowise, 2008). A water audit can highlight a number of effective water and energy saving measures that can be implemented at low cost and inconvenience to a company, such as pressure and leakage reduction. Schemes such as the Ripple Effect in England and the Big Splash in Scotland, which are a free resource demonstrating water efficiency measures to businesses, should be extended and promoted in countries without such schemes.

Rain water harvesting in the industrial sector may provide considerable water savings due to the large surface area of many plants and the ease of use for harvested water in industry. Although there are a few good examples of the benefits rainwater harvesting can bring in individual cases, there has not be an assessment of the benefits large scale implementation across Europe could bring. Investigating this would help to identify whether promoting water harvesting to industry should be a priority in Europe.

It is clear that the re-use of heat exchanged to water can offer significant carbon savings as illustrated by the use of DHNs. Due to water and wastewater industries being energy and heat intensive, considerable carbon emissions could be saved through the exchange of heat from industry to water utilities. Heat could be used, for example, for the drying of sludge and aerobic processes. Currently there are few examples of this occurring and the development of this requires the integration of different industries, changes in infra-structure, best practices and in some case legislation. Research is required into the feasibility of this.

c) What is the impact of the 2015 perspective

Few studies are available for the industrial sector concerning the impact of water saving measures in terms of volumes of water saved, energy saved and cost implications. A study carried out by ICAEN for the Catalonia region in Spain between 1992 and1997 shows potential water savings for different industrial sectors varying between 25 and 50%.

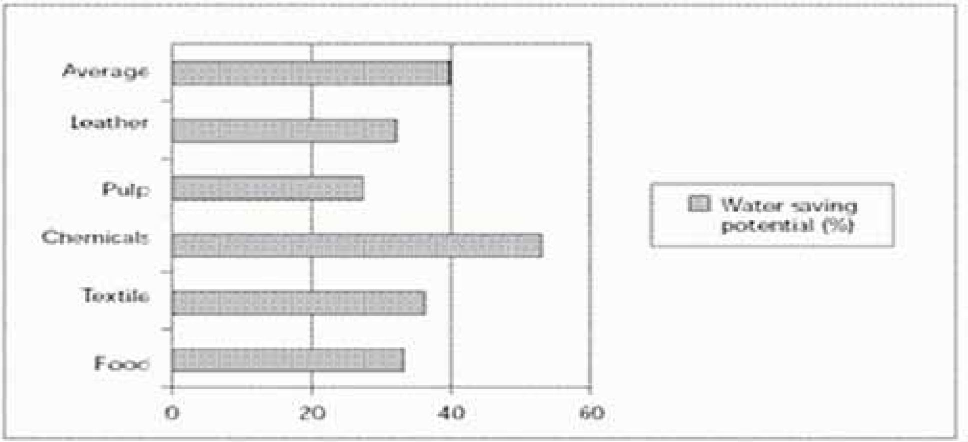


Figure1: Potential water saving in different industrial sectors in Catalonia (1999) (Dworak et al., 2007)

Dworak et al (2007) calculated today's potential water saving based on the following formula:
Savings in Million m^3 = (Is * Tr * Tiwu)/(Is + I0 * Tr)
Where:
Is =Industry without any water saving technology currently applied.
I0=Industry with currently no further water saving potential. As a result from the information collected several industrial companies have already implemented the current maximum water saving measures and there is currently no room for improvement. This has to be taken into account. This value was estimated at 25%.
Tr = the potential saving. Based on the information collected an average saving potential of 50% for each and every industry can be assumed
Tiwu=Total industrial water use. According to the latest information in Eurostat the EU 31 abstracted in 2001 around 34,194 Million m^3 of water
Using the formula above and based on a total industrial water abstraction for EU-30 of 34,194 Million m^3 per year, total water savings amount to 14,655 Million m^3 per year. Implementing all water saving measures in the industrial sector today could then lead to a reduction in industrial water abstraction by 43% (Dworak et al., 2007).

d) Long term 2030 perspective

By 2030 it is expected that there will be large advancements in the saving of water and carbon emissions form industry. The list below outlines the features that are expected to be common place by 2030 if we are to see such savings

- The use of water auditing will be common place in industry and all companies will produce reports on water consumption and objectives for saving water
- The practice of water re-use and closed circuits will be common place in industry
- The recycling of water will be used where water quality is not sufficient for immediate re-use. The technologies used for this will be low energy measures.

- The use of water in cooling will be significantly reduced. Processes such as low energy dry cooling or use of municipal waste water for cooling will be common.
- Waste heat from industry will be used much more efficiently and heat will be seen as a valuable resource not a waste product. There will be close cooperation between heat intensive industries and utilities in order to facilitate the exchange of heat. Land-use planning will take this beneficial relationship into consideration and heat intensive industries and water treatment plants will be located in close proximity.

Appendix 4
Reference List of related publications

GENERAL

- ACQUEAU (2010). Growth and innovation in water, Blue Book 2: Technology Road Mapping
- International Water Association IWA (2010) Water and Energy are linked – within Climate Change and beyond. An appeal to the world's decision makers. Messages for COP15 from IWA International Conference Water and Energy 2009.
- Environment Agency of England and Wales (2010). A Low Carbon Water Industry in 2050. Report: SC070010/R3.
- European Cooperation in Science and Technology (2009). The Energy-Water Nexus: Managing the Links between Energy and Water for a Sustainable Future. Policy recommendation and research projects.
- European Commission, Directorate General for the Environment (2010): Water for life- LIFE for water: Protecting Europe's water resources. Particularly the chapter regarding water and climate change from page 9.
- European Commission, Directorate General for the Environment: Water resources across Europe — confronting water scarcity and drought.
- European Commission (2009). White paper - Adapting to climate change: towards a European framework for action.
- European Commission (April 2009). Policy paper on Water, Coasts and Marine issues77.
- UKWIR (2007). A Road Map of Strategic R&D Needs to 2030

Theme specific road maps provide a new shared vision: a framework that can give direction to the supply chain and the research community that will deliver solutions for the water utilities medium and long term needs. The maps (underground assets, sustainable leakage, intelligent customer metering, energy efficiency, and chemical free treatment) address key issues facing the water sector. They are not the only issues but the format provides a good model for future mapping.

- UKWIR (2010). UK Water Innovation - Which Way Forward in Europe?

As part of its activities to encourage funding for research, UKWIR has been active in commissioning projects to investigate the barriers to innovation and also to simulate research funders to better understand the research needs of the water sector. This effort resulted in the Technology Strategy Board commissioning UKWIR to produce this report on the opportunities for water related research and innovation in Europe.

- UKWIR (2006). Barriers to Innovation in the UK Water Industry.

The project explores enablers and barriers to innovation within the UK water industry, focusing on the application of new technological products and processes. Ten innovation

cases are researched involving interviews, opinions and evidence from over 100 stakeholders, representing 54 unique organisations. Regulatory (systemic) and non-regulatory (market) influences upon success or failure are determined and relevant data, literature, reports and policy materials are reviewed. Within the limits of the evidence the project concludes there is misalignment of expectations between the supply-chain, the water companies, the regulators and government which is limiting the sector's ability to fully exploit its capacity for technological innovation to sustainably meet the future needs and challenges of UK and world markets. The project suggests that a collaborative innovation strategy for the industry should be developed with all key stakeholders.

- UKWIR (2008). Climate Change - A Programme of Research for the UK Water Industry: Volume 1 - Summary Report

This report provides a first climate-related snapshot looking across the UK water industry and out to 2100. It identifies where significant uncertainties in the climate science remain, the nature and extent of impact and business risks, adaptation options, and where there are critical knowledge gaps and capacity within the industry.

A long term, integrated, forward looking programme of climate change research needs is recommended that will allow the industry to put in place a sustainable response to adapting to climate change and for the industry to develop a 'one voice' approach that will underpin the development of strategies by individual companies.

WATER AND ENERGY TOOLS AND SYSTEMS

- UKWIR (2010). Better Regulation: Integrated Catchment Regulation

This project was established to identify options for the application of better regulation which should seek to improve the balance between the environmental gains in water quality through permitting and the potential economic and environmental costs. A number of themes of research were advanced including seasonal consenting, real time control and the scoping of the future requirements for modelling.

- UKWIR (2008). Carbon Accounting in the UK Water Industry: Guidelines for Dealing with 'Embodied Carbon' and Whole life Carbon Accounting

This project is one of a suite of UKWIR projects carried out to provide guidance for the UK water industry on carbon accounting.

The purpose of the project report is to provide clear guidelines for UK water companies to estimate the carbon embodied in construction and to carry out whole life carbon accounting for investment selection, including planning for PR09 and more detailed project option appraisals. The document builds on separate UKWIR guidance for operational emissions (08/CL/01/5).

The report contains: guidelines on setting boundaries for whole life carbon accounting; guidelines on estimating embodied carbon; recommended emission values for some typical construction work items; guidelines on deriving whole life carbon costs; and information on including some additional operational emissions. Application of the guidelines is illustrated by a working example and some case studies.

- GWC (2010). Water Sector Greenhouse Gas Accounting, Reporting and Management in the UK (Water Utility Management International)
- WERF (2010) Sustainable Water Resources Management Volume 3: Case Studies on a New Water Paradigm

The project, which considered the real-life challenges of two communities in Tucson/Pima County Arizona and Northern Kentucky, developed a new water management paradigm based on a composite of five integrated components:

- sustainability goals
- sustainability operating principles
- integrated technological architecture
- institutional capacity
- adaptive management

The report constructs a framework for supporting the new paradigm which includes an integrated planning structure that connects current institutional silos; a technical toolbox to use in the context of performance-based requirements at the watershed and community scale; and regulatory flexibility to encourage innovation and affect better outcomes. The framework also addresses research and demonstration to build knowledge and capacity; new partnerships and funding mechanisms; and a variety of means for engaging the community stakeholders to broaden support and affect better outcomes.

- The United Nations World Water Assessment Programme. Water Footprint Analysis (Hydrologic and Economic) of the Guadania River Basin by Maite Martinez Aldaya, Twente Water Centre, University of Twente and Manuel Ramon Llamas, Department of Geodynamics, Complutense University of Madrid, Spain

ENERGY AND INDUSTRY

- Aquafit 4 use (2010) Water quality demands in paper, chemical, food and textile companies
- AquaFit4Use (2010) Mid-Term Conference: Successful water circuit optimisation at Sappi Maastricht and Hamburger Rieger.
- AquaFit4Use. Water in industry, Mid-Term Conference: Waste water treatment evaluation of sensors and analysers
- Global Water Partnership Technical Committee (TEC) (2009). Managing the other side of the water cycle: Making wastewater an asset
- ACQUEAU, 2010. Blue Book 2, Technology Road Mapping.
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http://www.austropapier.at/uploads/media/ Umwelt_01.pdf
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- WBCSD, 2010. Responding to the Biodiversity Challenge: Business contributions to the Convention on Biological Diversity

WATER AND ENERGY

- WssTP (2005). Water safe, strong and sustainable. European vision for water supply and sanitation in 2030
- Prepared Enabling Change (2010) WssTP project

The PREPARED project is about the adaptation of the water supply and sanitation sector to cope with the impacts of climate change. PREPARED will do that through: The development of tools, approaches and decision support systems (DSS) to help water utilities to better cope with the anticipated and uncertain impacts of climate change. Guidance on how to deal with the uncertainty in the global IPCC scenarios to and the translation of such scenarios to a very local level, the level at which our targeted end-users and problem-owners have to operate. The creation of awareness amongst end-users through participatory approaches and enabling change within the local and national decision making processes, positively affecting the decision-making and policy processes at local level through the key involvement of the problem-owners: the city.

WASTEWATER AND ENERGY

- Global Water Research Coalition, GWRC (2010). Water and Energy in the Urban Water Cycle: Improving Energy Efficiency in Municipal Wastewater Treatment.

The project included a review of published scientific literature and GWRC reports, site visits, invited contributions and comments from international researchers and wastewater treatment professionals, and feedback at workshops specifically organized for the project. The findings suggest possibility of increasing energy reductions from 20 – 50% while still retaining and largely using existing assets. Changes which can be considered include fine bubble air diffusion, dissolved oxygen control, variable frequency drives (VFDs), appropriate plant sizing, utilization level versus design capacity, the type of aerobic process, and anaerobic biogas production. However, from 50 - 80% and beyond, escalating number of changes to existing assets will likely be required leading eventually to a treatment train which can be quite different from the current state-of-the-art. Such changes can include the ANAMMOX which will significantly reduce aeration needs, nutrients (N-P-K) recovery at the beginning of the treatment train instead of at the end, pre-concentration of carbon substrates, organic solids conditioning prior to anaerobic degradation, and polymer construction. Discussion at the workshops had identified solids conditioning and the anaerobic process as the most likely unit processes which can yield significant overall system energy performance improvements. These shall likely be followed by nitrogen removal.

- PUB (2010) Wastewater Treatment Plant Technology Roadmap.

PUB have provided a number of update presentations to their above GWRC report which outline wastewater treatment flow sheets of the future and the water, energy and nutrient factory approach.

- STOWA Foundation for Applied Water Research (2010). NEWs: The Dutch Roadmap for the WWTP of 2030.

This report expands on the GWRC report regarding the possible treatment technologies and treatment plant options for the water factory, energy factory and nutrient factory.

- Waterschap De Dommel (2010) Research study lists to define the energy plant of the future.

- Water Environment Research Foundation, WERF (2010). Technology Roadmap for Sustainable WWTPs in a Carbon-Constrained World WERF OWSO4R07. George V. Crawford, P.Eng. CH2M HILL Canada Limited.

- Environment Agency of England and Wales, EA (2009). Transforming wastewater treatment to reduce carbon emissions. Report: SC070010/R2.

- Water Environment Research Foundation WERF (2009). Modelling Onsite Wastewater Systems at that Watershed Scale: A User's Guide

This report gives planners and regulators guidance in developing and using models to evaluate watershed-scale water quality scenarios associated with decentralized or onsite wastewater systems. It includes resources for each step of the planning process, and explains modelling philosophy, model selection, model sensitivity analysis and calibration, and other concepts. The guide provides case studies and links to reference materials. The information will be useful to anyone who wants to understand how models are used for watershed assessments and decision making. Published by WERF. 236 pages. Soft cover and online PDF.

- Environment Agency
- Environmental Transfer Network (2008) Energy efficient water and wastewater treatment (including roadmap up to 2020)
- WERF (2007) Promoting Equitable consideration of Decentralized Wastewater Options.

This research digest identifies the principal barriers that prevent engineers from giving equitable consideration to decentralized wastewater treatment options. After identifying and prioritizing the barriers, the project team developed strategies that the engineering community can use to overcome them. They obtained input from stakeholders and evaluated the proposed strategies, which included methods, options, tools, laws, organizational designs, business models, curriculum design, financial design, and educational programming. For each strategy, one or more specific actions for resolving or removing the barrier were identified. Published by WERF. 28 pages. Soft cover and online PDF. (2007)

- UKWIR (2005). Literature Review of the Efficiency of Natural Systems in Removing Faecal Indicator Bacteria

Two wetland types have been distinguished according to the presence of a free water surface. This feature determines the extent to which key processes, including oxygen diffusion and the balance of removal mechanisms between sedimentation and sieving, will operate. Removal of faecal indicator organisms and pathogens has been represented as a two step process, where initial retention is followed by elimination. Short-term by-pass and channelled flow, which might occur during storm-events, represents a potential problem to operational efficiency. Despite this fact, almost no intensive, event-based, sampled data exist. The majority of studies rely upon infrequent (weekly or longer) paired sampling of influent and effluent flows which are likely to be biased towards more stable flow conditions. Few data quantify seasonal changes to FIO and pathogen populations within individual wetlands. Thus, the principal data gap is event-based faecal indicator flux assessment to assess impacts on 'protected areas' such as bathing waters.

- UKWIR (2002). Tightening WwTW Emission Standards - A Review of the Treatment Technologies And Their Impact On Climate Change
- www.decentralizedwater.org (2010). Development of Design Criteria for Denitrifying Treatment Wetlands

The purpose of this student-led research was to evaluate the use of subsurface wetlands constructed with an organic medium for the denitrification of domestic wastewater. Nitrate removal performance and the effects of concentration, temperature, length of operation, and aquatic plants were assessed. Six different subsurface wetlands were constructed to study the effect that media type, time of operation, and aquatic plants have on the removal of nitrate.

- www.decentralizedwater.org (2010). When to Consider Distributed Systems in an Urban and Suburban Context

Water infrastructure systems of the 21st Century will increasingly rely on an integration of centralized and decentralized treatment approaches to most effectively deliver economical, flexible, and sustainable water services to communities. Distributed water management describes integrated planning, design, and management using system infrastructure at various scales -- from decentralized to centralized -- based on an equitable approach that considers suitability and sustainability. This research presents distributed infrastructure management approaches to a variety of stakeholders, provides examples showing where and why distributed approaches are being used to advance sustainability at the community level, and provides tools that practitioners can use to make informed infrastructure decisions.

- www.decentralizedwater.org (2008). New Approaches in Decentralized Water Infrastructure

Decentralized water technologies and designs, such as water-efficient appliances, rooftop rain gardens, and onsite wastewater treatment and reuse, are the keys to enhancing the performance of the nation's aging centralized water and sewer systems and to assuring adequate water supplies and healthy ecosystems into the future. Decentralized systems also create a host of other benefits for communities, including energy savings, improvements in air quality, creation of green spaces, restoration of streams, aquifers, wetlands, and habitat, and stimulus for new green companies and jobs. This project explores the various pressures or drivers—as well as the impediments—for a change in the fundamental "paradigm" of water management. A series of workshops with experts and advocates was convened to explore the institutional issues and to tease out various new strategies for jump-starting and easing a transition.

WATER AND ENERGY EFFICIENCY IN HOMES

- Environmental Transfer Network (2008) Energy efficient water and wastewater treatment (including roadmap up to 2020)
- Environment Agency for England and Wales (EA) and the Energy Saving Trust (2009). Quantifying the energy and carbon effects of water saving full technical report
- UKWIR (2003). A Framework Methodology for Estimating the Impact of Household Metering on Consumption - Main Report

This report presents the Framework Methodology for estimating the impact of metering (both changes in the number of metered customers and the demand effects of metering) on consumption, in the form of a six stage process. For each stage a range of approaches companies might take, and the data required to do so, are also presented. An accompanying Supplementary Information Report provides useful background and inputs. Sold as a set with 03/WR/01/5

- UKWIR (2010). A Review of the Case for More Intelligent Water Metering

Water metering and communications technology have developed significantly over recent years and may offer an important option for addressing supply-demand pressures, whilst

meeting expectations for efficient and high quality customer service.
This report has been developed against a backdrop of the planned roll-out of 'smart' metering for domestic energy customers in Great Britain by the end of 2020. Without a similar national mandate for water industry smart metering, companies must develop policies appropriate to their specific situation and the expectations of customers and other stakeholders.

Extensive consultation with water companies, regulators and other stakeholders has resulted in a comprehensive review of current experience and future potential for more intelligent water metering, tariffs and related customer service technology.

- Waterwise (2010). Water efficiency in new developments- a best practice guide
- Waterwise (2010). Evidence Base for Large-scale Water Efficiency in Homes
- Waterwise (2010). Water Efficiency and the Water Companies a 2010 UK Review
- Waterwise (2009). Water Efficiency Retrofitting - A Best Practice Guide

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WssTP
List of publications

Strategy and Vision

2005 – Vision Document

"Water safe, strong and sustainable European vision for water supply and sanitation in 2030"

2006 – Strategic Research Agenda

"Water Research - A necessary investment in our common future"

2007 - Implementation Plan

2010 – Updated SRA (April 2010)

The four documents are available on our website: **www.wsstp.eu**

Pilot Programmes reports

Each pilot programme produced or will produce a number of reports on its issues and challenges.

Coastal zones

- "Research and Technology Development Needs" Report 12-10-2009

Urban areas

- "Managing rain-related events and flooding in urban areas" - Report 03-14-2008
- "Asset management for sustainable urban water" - Report 06-05-2008
- "Supply Demand Balance & Public Participation Report 01-11-2008
- Sustainable Sludge Management in Urban Areas Report 09-01-2008
- "Alternative Water Resources" Report 11-13-2008
- "Water Treatment" - to be released
- "Pollution Control" - to be released

Agriculture

- "Irrigation Techniques" – Report 12-10-1009
- "Water reuse" – to be released
- "Nutrient Management" – to be released

Task Force reports

Manage Aquifer Recharge
"State of the Arts and Research Needs"
Report 18-09-2010

Climate Change
"Incorporating Climate Challenge"
Report 01-12-2010

Sensors and Monitoring, to be released

Membrane Technologies for Water Applications, to be released

Millennium Development Goals, to be released

Brines, to be released

Leakages, to be released

Scientific Publications

1. "Sustainable water management inside and around large urban areas", September 2009.
2. "Irrigated Agriculture. Water saving options in irrigation, looking for efficient techniques, irrigation management and adapted cropping practices". September 2010.
3. "Research and Technology Development Needs for Coastal Zones", February 2011..
4. "State of the Arts and Research Needs for Managed Aquifer Recharge", February 2011.
5. "Incorporating Climate Challenge", February 2011.

Our Vision

"By 2030 the European water sector will be regarded as the global leader in the provision of sustainable water services."

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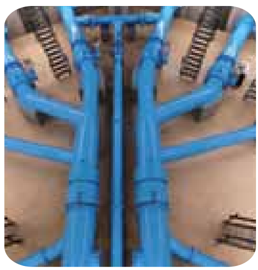

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