Adaptive Strategies

Integration in Work Area 7

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Adaptive Strategies: Integration in Work Area 7

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Summary

Work Area 1 (WA1), *Rethink the System*, has the overall objective to identify driving forces for change in drinking water supply from source-to-tap and to determine future requirements and challenges for water systems.

Work Package 1.1 (WP1.1) identified trends relevant for drinking water for different representative regions across Europe and in South Africa. Challenges to water supply systems will result from ten major trends:

- Climate change
- Urbanisation
- Emerging technologies
- Ageing infrastructure
- Globalisation
- Consumer involvement
- Emerging pollutants
- Energy use and costs
- Efficiency driven water sector
- Bottled water

In addition to these trends, a further major challenge presented by the Millenium Development Goals (MDGs) is to halve the proportion of the population without access to safe drinking water.

WP1.2 sought to identify and develop adaptive strategies that would be able to meet the future challenges posed by the trends and the MDGs. Adaptive strategies were developed that included the implementation of new technologies, new financing models and concepts for distribution systems. Some adaptive strategies provided solutions for specific cases whilst more general strategies were developed for cases with common themes.

Some of the adaptive strategies are being tested in case studies in WP1.3:

1. A decision support system for flexibility-enhancing regulatory instruments.
2. Flexibility in coping with water stress and integration of different measures.
3. Flexibility in addressing future water demand, required infrastructures and drinking water quality in the Baltic area.
4. Integration of different measures to reach MDGs in Sub-Saharan Africa.
5. Integration of stakeholders: consumers and utilities.

Other adaptive strategies are integrated in WA7 case studies, these include:

- Multi-barrier treatment
- Risk assessment
- On-line instrumentation and monitoring
- New analytical techniques
- Cost-benefit analysis (CBA)
- Supplier/customer relationships

This report reviews the development of adaptive strategies and their integration in the WA7 case studies.

Contents

1 INTRODUCTION

Work Area 1 (WA1), *Rethink the System*, has the overall objective to identify driving forces for change in drinking water supply from source-to-tap and to determine future requirements and challenges for water supply systems.

Work Package 1.1 (WP1.1) identified trends relevant to drinking water for different representative regions across Europe and in South Africa. Challenges to water supply will result from ten major trends:

- Climate change
- Urbanisation
- Emerging technologies
- Ageing infrastructure
- Globalisation
- Consumer involvement
- Emerging pollutants
- Energy use and costs
- Efficiency driven water sector
- Bottled water

In addition to these trends, a further major challenge presented by the Millenium Development Goals (MDGs) is to halve the proportion of the population without access to safe drinking water.

Whilst some of these trends can be considered as opportunities, others present threats to water supply: climate change, urbanisation, emerging pollutants, energy costs, ageing infrastructure, increased use of bottled water and consumer involvement (also an opportunity). The main impacts of these trends are summarised in Table 1.1.

Table 1.1 Trends that threaten water supply

Trend (Threat)	Impacts
Climate change	More frequent droughts and/or floods Water availability reduction Water quality deterioration Increased demand for water
Urbanisation	Distribution systems do not match demand Urban water resources are depleted Shanty towns in developing and transition countries without appropriate water infrastructure Increased sealed surfaces, less soil infiltration
Emerging pollutants	Disturbance of water resources and ecosystems High degree of uncertainty (about environmental concentrations, about effects and risks) Demand for ecological human toxicity assessment Adoption of regulatory framework (limit value) Development of new and refined analytical tools and monitoring methods Reduced acceptance of drinking water
Energy costs	Higher energy prices Increased operational cost Increase of water prices Intensified search for alternative and renewable energy sources
Ageing infrastructure	Especially severe in regions with unstable economy Leakages in distribution system results in water losses and possible intrusion (water quality compromised) Corrosion affects water quality Crusting results in increased energy demand for distribution Problems aggravated in areas of depopulation (overcapacity)
Bottled water	Little influence on tap water consumption (max. 10%) Consumption can indicate that perceived quality or taste is more important for the consumer than price (up to 1000 times more expensive than tap water) Consumption can be considered an indicator for perception of water quality or reliability of public supply

Trend (Threat)	Impacts
Consumer involvement	Consumers more demanding regards service levels A growing need for transparency and mutual trust Greater openness and transparency increases ownership, trust and acceptance of decisions but may serve to erode consumer trust (e.g. revealing scientific uncertainty regarding possible health impacts of emerging pollutants)

WP1.2 sought to identify and develop adaptive strategies[1] that would meet the trends that are seen as threats. Adaptive strategies were developed to address:

- Coping with reduced water availability
- Coping with deteriorated / poor / insufficient water quality
- Addressing the issue of micropollutants
- Bearing the costs: The efficiency-driven water sector
- Consumer involvement
- MDGs
- Privatisation / globalisation
- Risk-oriented society
- Population growth and urbanisation

Some of the adaptive strategies developed are being tested in case studies in WP1.3:

1. A decision support system for flexibility-enhancing instruments.
2. Flexibility in coping with water stress and integration of different measures.
3. Flexibility in addressing future water demand, required infrastructures and drinking water quality in the Baltic area.
4. Integration of different measures to reach MDGs in Sub-Saharan Africa.
5. Integration of stakeholders: consumers and utilities.

Adaptive strategies not addressed in the studies above will be integrated in WA7 case studies where such studies are appropriate for their evaluation.

[1] Pronk, W and Kazner, C (2008). *Adaptive Strategies: Integrated Approach and Flexibility under recognition of local Conditions*, TECHNEAU Deliverable D1.2.1.

2 OVERVIEW OF ADAPTIVE STRATEGIES

2.1 Guiding principles

There are no simple, overriding solutions for all trends that pose threats, thus adaptive strategies must be developed according to local situations. However, some common principles apply to a whole range of solutions, thus long-term strategic planning is characterised by "**integration**, **flexibility** and consideration of **local conditions**".

Adaptive strategies must allow for challenges at different levels in the water supply sector. It is suggested that development of adaptive strategies be distinguished between:

- Technology and operation
- Organisation, operation, management and finance
- Policy, economic measures and legislation

At each of these levels, strategies can be developed for three purposes:

- Adaption - change behaviour to fit to new circumstances
- Mitigation - counteract a trend by lessening its driving forces
- Resistance - protect conventional practices and technologies

2.1.1 Integrated approach

An integrated approach is required to develop optimum solutions meeting the many demands of different water functions and threats arising from different trends. For example, water stress is expected to increase due to climate change, urbanisation and population growth. The range of possible solutions is wide and includes sea water desalination, water recycling and regulation. In order to develop an optimum solution for each specific case, the problem must be assessed in an integrated way, including consideration of resources, energy, ecosystems and financial aspects.

2.1.2 Flexibility

Flexibility is required because the extent and effect of many of the trends in the water sector are uncertain. For example, the effect of climate change on local precipitation patterns remains unclear and cannot be satisfactorily predicted. Thus in many countries future water supply systems should be able to deal with periods of high and low water availability and the associated changes in water quality.

2.1.3 Local conditions

Some trends are local by definition, e.g. urbanisation. Other trends may occur globally, e.g. climate change, but may have quite specific local impacts, e.g.

flooding or drought. The most severe problems will be caused by strong population growth in developing countries, particularly where this coincides with deficient infrastructure and poor economic conditions.

Consideration of local conditions creates a huge diversity of potential adaptive strategies. Some approaches and examples are highlighted below.

2.2 Examples of adaptive strategies

2.2.1 *Coping with reduced water availability*

Driving forces: Climate change impacts; increased demand due to population or economic growth; more stringent abstraction restrictions.

Key elements of possible adaptive strategies: Matching demand and supply; reducing network losses; developing new and alternative resources.

An overview of different elements of adaptive strategies to cope with reduced water availability is given in Table 2.1.

Table 2.1 Elements of adaptive strategies to address reduced water availability

	Technological	Organisational	Economic	Legal	Political
Flexibility:					
Alternative raw water sources	X				
Modular treatment processes (capacity, level of treatment)	X	X			
Integration:					
IWRM					
Water saving campaigns		X			X
Raw water sources protection		X			X
Local conditions:					
Water use restrictions				X	X
Drought management plans		X			X

2.2.2 *Coping with deteriorated / poor / insufficient water quality*

Driving forces: Climate change impacts; increased demand due to population growth.

Key elements of possible adaptive strategies: Flexibility in wastewater treatment; ban on combined sewer overflows (CSOs) after periods of drought or during peak flush events; flexibility in resources to cope with highly polluted sources during storm events or during periods of drought; lowering the level of distribution systems in the subsoil; changes in water treatment to treat raw waters containing increased concentrations of organics (e.g. NOM) and to increase biostability of treated water.

In this case, an integrated approach will include safeguarding resources, distribution systems, wastewater treatment and discharge, industrial wastewaters, consumers and possible international/intergovernmental collaboration.

2.2.3 *Addressing the issue of micropollutants*

Driving forces: Climate change impacts; urbanisation; emerging pollutants.

Key elements of possible adaptive strategies: Mitigation of discharges; appropriate treatment concepts; substitutes for toxic materials or chemicals; multi-barrier treatment; definition of threshold values; catchment monitoring and integration of water cycle; communication with the public.

An overview of different elements of adaptive strategies to cope with water micropollutants is given in Table 2.2.

Table 2.2 Elements of adaptive strategies to address micropollutants

	Technological	Organisational	Economic	Legal	Political
Flexibility:					
Treatment technology upgrade	X				
Integration:					
Catchment monitoring	X				X
Local conditions:					
Emission register					X
Natural background concentrations			X		

2.2.4 *Bearing the costs - the efficiency driven water sector*

Driving forces: Increasing energy prices due to soaring worldwide demand for fossil fuels; application of more advanced treatment processes (more steps, more engineered).

Key elements of possible adaptive strategies: Optimised distribution networks; energy efficient treatment processes; investment (raising capital through public or public/private partnership).

An overview of different elements of adaptive strategies to cope with rising energy demand and cost implications is given in Table 2.3.

Table 2.3 Elements of adaptive strategies to address micropollutants

	Technological	Organisational	Economic	Legal	Political
Flexibility:					
Modular treatment processes (flexible capacities, level of treatment)	X	X			
Energy intensive processes (pumping to fill reservoirs) in off-peak hours		X	X		
Integration:					
Local conditions:					

2.2.5 *Consumer involvement*

In general, consumers are not well informed but involvement and knowledge about drinking water is expected to increase in the future for both individuals and consumer organisations.

Increased transparency and improved communication should promote consumer confidence and trust.

2.2.6 *Millenium Development Goals*

One MDG aims to halve the proportion of people without sustainable access to safe drinking water and sanitation by 2015 (compared to 1990). Rapidly increasing populations, urbanisation, inadequate infrastructure and increasing numbers of immuno-compromised people add to the challenge.

Solutions should involve local stakeholders and local development of appropriate technologies. Appropriate technologies should consider decentralised (e.g. point-of-use) vs. centralised treatment, low technology vs. high technology (processes and monitoring), water quantity and quality, and available manpower and skills.

2.2.7 *Privatisation/Globalisation*

A current trend towards private ownership of drinking water services can be observed in some areas; this trend may or may not continue in the future. Globalisation is expected to continue in the future, although the countertrend (nationalism, regionalism) may be observed in some areas.

Privatisation can be cost-effective in providing drinking water but may require regulation to prevent less profitable areas, e.g. rural regions, being excluded.

Globalisation can result in synergies in terms of knowledge transfer and project design/construction increasing efficiency and reducing costs for consumers.

2.2.8 Risks-oriented society

Consumers want a safe and reliable water supply at all times. However, risks can never be totally eliminated and water supply is a potential target for terrorist activity and organised crime.

Solutions include flexibility (e.g. to cope with threats from climate change), multi-barrier treatment, implementation and development of monitoring and instrumentation, and development of advanced toxicological tests to assess the risks of unknown chemicals and mixtures of chemicals.

2.2.9 Population growth and urbanisation

A global trend towards urbanisation can be observed, often associated with depopulation of rural areas. Urbanisation may cause problems of water shortage (in dry regions) and flooding, sewerage failures and increased contamination (in wet regions).

Solutions require integration of all stakeholders, including water providers, wastewater utilities, regulators, planners and consumers (people and industry).

3 OVERVIEW OF WA7 CASE STUDIES

Work Area 7, *Integrate, Validate and Demonstrate*, includes a series of six case studies that will demonstrate the technologies, tools and approaches being developed in other work areas.

3.1 Case Study 1: Windhoek, a demonstration of a multi-barrier approach to the reclamation and treatment of wastewater to produce drinking water

The objective of Case Study 1 (CS1) is to demonstrate a multi-barrier approach to direct potable reuse from wastewater treatment plant effluent at Windhoek, Namibia. This case study demonstrates a number of integrations including risk assessment (WA4) and several monitoring and analytical techniques (WA3).

A risk assessment carried out by Chalmers at the New Goerangab Water Reclamation Plant (NGWRP) using the methods developed in WA4 identified weaknesses in terms of microbiological and chemical monitoring. A third sampling campaign will address these risks and will build on two previous sampling campaigns carried out at the NGWRP in October 2006 and May 2007. Specifically, the third campaign will integrate monitoring and analytical techniques developed in WA3, as well as extending the risk assessment to include Fault Tree Analysis (FTA).

Demonstration of adaptive strategies:

- Adaptation to water scarcity
- Use of alternative water sources
- Multi-barrier treatment
- Risk assessment
- On-line instrumentation and monitoring
- New analytical techniques

3.2 Case Study 2: Implementation of a monitoring and management strategy to understand and reduce the risk of release of pathogens from biofilms

The objective of CS2 is to integrate novel water quality monitoring with the application of Fluorescent *In-Situ* Hybridisation (FISH) or similar methods (e.g. PCR) for the investigation of pathogens in biofilm and drinking water in Lisbon, Portugal. It reflects the trend of new technologies and new analytical methods. The case study will also demonstrate the Water Treatment Simulator (WTS) developed in WP5.4, the Cost-Benefit Analysis (CBA) methodology (WP5.1) and the fish biomonitor (WP3.4) (at Aguas do Algarve).

The case study will include characterization of the distribution network to identify where water quality might deteriorate and biofilm develop. The network will then be monitored using technologies developed in WA3 in conjunction with conventional methodologies and sampled for analysis of biofilm, pathogens, AOC and other water quality parameters.

In addition, water quality at treatment works will be monitored using the fish biomonitor and the UV/Vis spectrometer whilst the WTS will be used to optimize water treatment at the Asseiceira WTP.

Demonstration of adaptive strategies:

- Risk assessment
- On-line instrumentation and monitoring
- New analytical techniques
- CBA

3.3 Case Study 3: Implementation of a monitoring and management strategy to reduce the risk of water quality deterioration in distribution networks

The objective of CS3 is to demonstrate a monitoring and management strategy to reduce risks in the water supply of Riga, Latvia. Risks identified by a risk assessment (WA4) will be mitigated using technologies developed in Work Areas 3, 4 and 5. The situation is Latvia is mainly characterised by the trends “Reduced water consumption” and “Ageing infrastructure”

The case study will include a risk assessment of the water supply system focusing on risks related to water losses and water quality deterioration. Technologies used to mitigate risks will include demonstration of the Resuspension Potential Methodology (RPM) to identify high turbidity risks in the network, on-line turbidity meters, application of FISH and Hemoflow to evaluate the risk of pathogen breakthrough and intrusion, application of modern analytical techniques including the fish biomonitor for detection of emerging substances (e.g. endocrine disruptor compounds (EDCs), new algal toxins, etc.) and application of the AOC bioassay, FCM total cell count and viability analysis to assess bacterial regrowth potential.

Various strategies to reduce risk will be demonstrated including flushing (to reduce turbidity and iron problems in distribution), and application of the WTS to improve the removal of NOM in treatment, and the corrosion- and biological regrowth models to decrease corrosion and biofilm growth in distribution.

Demonstration of adaptive strategies:

- Increased efficiency through (distribution) system optimisation
- Risk assessment
- On-line instrumentation and monitoring
- New analytical techniques
- CBA

3.4 Case Study 4: Demonstration of monitoring and analysis and feasibility of the OBM process for developing and newly-industrialised countries

CS4 will demonstrate tools for monitoring and analysis (CALUX bioassays, cyanobacteria toxin analysis) in two sampling campaigns at field sites in New Delhi, India. A feasibility study of the Oxidation-Biofiltration-Membrane (OBM) filtration process will assess OBM as a cost-effective multi-barrier treatment system for developing and newly-industrialised countries to provide a sustainable and safe drinking water supply.

Demonstration of adaptive strategies:

- Upgrade of treatment technology
- Multi-barrier treatment
- New analytical techniques

3.5 Case Study 5: Demonstration of the optimisation of operation and maintenance of water treatment and distribution

CS5 will provide a full-scale demonstration of the optimisation of operation and maintenance of water treatment plants and water distribution systems in or around Bergen, Norway. Technologies and procedures to optimize water treatment (including the Ozonation-Biofiltration (OB) process) include NOM fractionation, the new BDOC six columns-in-series analysis, and demonstration of the Delta UV/Vis probe for control of the enhanced coagulation (EC) process. Optimisation of water distribution will address modelling and measurement of sedimentation and biofilm growth as criteria for operation, maintenance and rehabilitation; effective network cleaning using hydraulic modelling and RPM; and analysis and prediction of failures to prevent ingress and to minimise repair and renovation. Cost-benefit analysis (CBA) will be carried out for a selected intervention using the CBA tool developed in WP5.1.

A cost-effective adaptive strategy will be developed - building on previous investigations and risk assessments in relation to the giardiasis outbreak in Bergen in 2004 - to mitigate future disease epidemics. Supplier/customer relationships (link to WA 6) will be investigated in relation to this outbreak.

Demonstration of adaptive strategies:

- Risk assessment
- On-line instrumentation and monitoring
- New analytical techniques
- Supplier/customer relationships
- Increased transparency by improved consumer involvement

3.6 Case Study 6: Demonstration of integrated, sustainable and optimized operation of water treatment to achieve biostability in distribution

CS6 will concentrate on technologies, CBA and testing of the WTS in relation to achieving biostability in distribution.

The main focus re technologies is the relation between NOM removal, ozonation and biological activated carbon filtration (WP 5.3) to ensure biostability in distribution. Pilot trials will be carried out at the Weesperkarspel Water Treatment Plant (WWTP) to optimize ozonation and NOM removal using technologies including ion exchange, ozonation, BAC, slow sand filtration and the OBM process. Measurement of AOC and disinfection will use on-line instruments as well as techniques such as the UV/Vis spectrometer and flow cytometry developed in WA3.

CBA (WA5) will be used to assess the relationship between biostability in the network and the degree of disinfection achieved through ozonation. The result will be used in optimising the operation of the treatment plant.

The WTS (WA5) will be used to investigate different processes (ion exchange, ozonation, BAC) for treatment at the WWTP. The results - together with the CBA - will identify optimum processes and operating conditions for the treatment plant.

Demonstration of adaptive strategies:

- Increasing efficiency and treatment performance
- Multi-barrier-treatment
- On-line instrumentation and monitoring
- New analytical techniques
- CBA