

Dutch Position

**in the European Area of Water Supply
and Sanitation Technology**

Preface

The last few months a lot of effort in both Europe and the Netherlands has been put on strengthening innovation in order to support the economic development. Within the water sector this has led to a European vision on water and based on that a long-term research agenda is being developed in 2005.

The Dutch water treatment sector is an important player in Europe and has a widely recognised influence on the worldwide developments in the water treatment sector. Therefore it also recognises the importance of the European vision and research papers and the necessity that the interests of Dutch companies and research institutes are incorporated. An important first step to reach this goal is realised by underlying Position Paper, which covers the innovative challenges and required research of the Dutch water treatment cluster in the coming years.

We are looking back on a very successful process with a lot of input and effort of the high level experts in the Dutch water sector. The outcomes are expected to have a great impact on the European research agenda, the innovation within the water sector and the European and international position of the Dutch water and sanitation sector. This Position Paper already serves as a guideline for many organisations in the Dutch water treatment sector. Not only on European level but also on national level this Position Paper has encouraged the growing cooperation between the Dutch government and the private sector and contributed to a widely accepted Dutch Position Paper in the European Water Supply and Sanitation Technology.

I would like to thank the Ministry of Economic Affairs. Without the support of the Ministry this process would not have taken place to successfully. It has become a beautiful example of public-private partnership in the water sector. I am convinced that these examples can serve as a stepping-stone to realise an innovative and successful water sector.

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Chairman of the Netherlands Water Partnership

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1 | Introduction

Clean fresh water is essential for life. Throughout history it has played a unique part in the development of Europe's geography and history. Water plays a significant role in many religions and has been crucial for the founding of numerous cities. It has not only provided sustenance, protection and transportation but has also been responsible in the deprivation of life by spreading death and disease. Water and sanitation play a critical part in all aspects of modern life: at home, in manufacturing and industry and in growing the food we eat. Access to safe water supply and sanitation is an essential prerequisite for sustainable socio-economic welfare and ecosystem protection, and presents one of the main challenges for Europe and the entire world in the 21st century.

The European water sector is a major economic player (1% of the EU15 GDP), inducing many positive effects, socially, economically and environmentally. In recent years the turnover of this sector (about 80 billion in the EU) grew by an average of 5% per year, double that of the average growth of the economy. European water enterprises are world leaders in delivering water services, while European technology providers and engineering companies have to face an increasingly strong competition on a global level. Although European research on water technologies is distinct in its kind, the sector's research expenditure still remains low in comparison to the overall size of the market.

European research policy

In order to achieve the goals set out in Lisbon by 2010, the European Union has called on the Framework Programme Seven (FP7) to follow up on the its predecessor. This framework programme will be the main instrument for research and development funding and the subsidising of innovative programs. It is expected that the core of the program will be presented by the end of 2005.

The focus and prioritization of the water related research themes fall into the hands of the 'Water Supply and Sanitation Technology Platform' (WSSTP). The overall objective of this Platform is to foster effective collaboration between the

research community, industry, policy makers, the financial community and other stakeholders.

The Dutch water treatment sector is an important player in Europe and has a widely recognised influence on the worldwide development in the water treatment sector. Therefore it also wants to play an important role in the realisation of the vision and research papers of the WSSTP in order to ensure that the interests of Dutch companies and research institutes are incorporated. Finally this can create an enabling environment in which Dutch companies and institutes can take part in innovations and new developments and projects in FP7 that benefit the Netherlands, Europe and worldwide water related challenged. An important first step to reach this goal is realised by underlying position paper, which covers the knowledge, ability, innovative chances and required research of the Dutch water treatment cluster in the coming years. The representability of the position paper by all parties is ensured through the joint input of experts from governmental, research institutes, engineering companies, business community and both public and private users from the water treatment sector.

In March 2000, European leaders committed the EU to become by 2010 'the most dynamic and competitive knowledge-based economy in the world capable of sustainable economic growth with more and better jobs and greater social cohesion, and respect for the environment.' The Lisbon strategy, as it became known, was considered to be key to the political, social and economic success of Europe. The strategy is even more urgent today, as the growth gap with North America and Asia has widened, while Europe must meet the combined challenges of low population growth and ageing.

In March 2002, the Commission issued a Communication on "Environmental Technology for Sustainable Development" which argued that environmental technology could contribute to sustainable development by boosting our

economies and protecting our environment. However, at present market barriers and a number of other obstacles prevent them from realising their full potential.

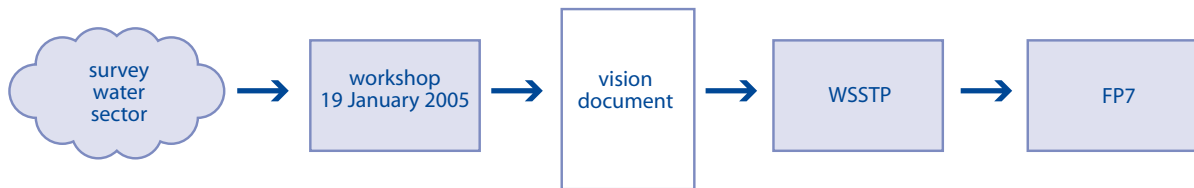
The Commission therefore proposed to the Barcelona European Council that it develop with stakeholders an action plan to remove the institutional obstacles to the development, take-up and use of environmental technologies. The Barcelona European Council approved this proposal in March 2002, confirming the political importance of environmental technology.

In March 2003, the Commission issued a Communication on "Developing an action plan for environmental technology" to follow up the commitments of the Barcelona Council and to present the process set up for consultation of stakeholders, as well as the first findings of the work. The Commission's Action Plan on Environmental Technologies includes a more comprehensive identification of promising technologies, barriers and action points. The responses of stakeholders to a number of questions in the March 2003 Communication have been taken into account in the preparation of the Action Plan.

On 28 January 2004 the Commission adopted the new European Environmental Technology Action Plan, with the aim to stimulate their development and uptake. The objectives of ETAP are the removal of obstacles so as to tap the full potential of environmental technologies for protecting the environment while contributing to competitiveness and economic growth, to ensure that over the coming years the European Union takes a leading role in developing and applying environmental technologies and to mobilise all stakeholders in support of these objectives.

The Commission will review the implementation of ETAP and report on it in 2006. It will also set up a European Panel on Environmental Technologies, where all relevant actors will exchange information, create synergies and help the Commission on ETAP.

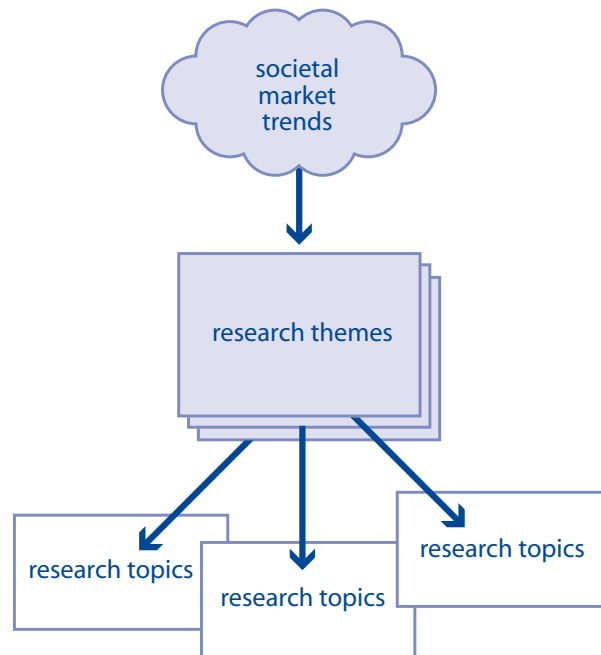
This position paper gives an overview of the identified trends, prospects that require new or improved technological solutions in order to face the expected challenges. During the identification process every aspect of the water treatment system was considered; from water supply to sanitation.



Process and procedure

The foundation and the formulation of the position paper are a joint effort and collaboration of experts within the Dutch Water Treatment Sector. Current trends in the societal and market sphere have been chosen as a focus to ensure that the final themes correspond to relevant market developments. In the preparation of this document, several high-level experts with different backgrounds were interviewed to share their visions and opinions. A workshop was organized (January 19, 2005) with the opinion leaders and the main stakeholders. During this workshop the essential part of the development of a Dutch research agenda has taken place in a two phases. In the first phase the trends prospects, challenges and possible research themes within the water treatment market were identified and analysed. The results of this phase are presented in chapter three and four. Chapter three gives an overview of the main challenges in the coming years and chapter four describes the research themes that are related to these trends. In the second

phase these 'opportunity areas/research themes' were elaborated in research topics during an interactive session. The results of this second phase are described in close cooperation with experts in the sector and presented in chapter five.





2 | Rationale

The worldwide market for water and wastewater amounted more than € 250 billion in 2002, and analysts anticipate an overall growth rate of 18% by 2005 and of 60% by 2010. Finance, technology portfolio, internationalisation and greater attention to users needs are among the major criteria for success in this highly competitive market. Quality deterioration and increasing scarcity of water resources appears as a key environmental factor influencing systems' performance and the cost of various products, services and processes. Furthermore, the cost of building, rehabilitating, operating and maintaining water/wastewater related infrastructure ranks high at investment decisions at national, regional and local level, influencing the cost of essential public services and ecosystem protection. Hence, adaptive, cost-effective and energy efficient environmental water and sanitation technologies are more and more in demand, under increasing trends of integration of environmental externalities and energy aspects in the planning of water resources management.

2.1| *Millennium Development Goals*

On September 8th 2000 the General assembly of the United Nations resolved unanimously to support the Millennium Development Goals. The 191 member states of the UN promised to take all measures to halve by the year 2015 the number of people living in deep poverty, suffering extreme hunger, lacking basic education, dieing of major, often water born diseases or without access to safe drinking water and basic sanitation.

The UN also agreed that two indicators would be used to track progress towards these goals, namely indicators 30 and 31: 30 Proportion of population with sustainable access to an improved water source, urban and rural 31 proportion of population with sustainable access to improved sanitation, urban and rural.

It is estimated that currently 1.2 billion people do not have access to safe drinking water. Halving this figure in the next 10 years means that every year 60 million people must be connected to advanced water supply systems. Assuming 300

working days per year, every day water treatment and distribution systems have to be built to serve 200,000 people. Similarly, everyday sanitation has to be provided for 900,000.

2.2| *Water Framework Directive*

Water policy and regulation are major drivers for investments in the water supply and sanitation sectors. In particular the requirements of the Drinking Water and Urban Waste Water Directives has driven major changes in approach and will continue to be a driver for the new member states, where investment in water infrastructure has been more patchy. The implementation of the Water Framework Directive will require massive investments in the water sector of the EU 25, representing a considerable percentage of the Regional Funds, to upgrade and to extend water supply and sanitation systems and to bring water ecosystems to a good ecological and chemical status. The efficiency and cost effectiveness of the implementation of relevant policies shall be heavily influenced by the availability and access to improved technological tools as well as the public acceptance of the outcome of these tools.

2.3| *The Environmental Technologies Action Plan (ETAP)*

Sustainable development – development that meets the needs of the present without compromising those of future generations – is at the core of the European Union’s (EU) objectives. In 2001, the Göteborg European Council launched the EU strategy for sustainable development. This set ambitious objectives and called for a more integrated approach to policy making in which economic, social and environmental objectives can be achieved at the same time. It therefore complemented the Lisbon strategy to make the EU “the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion”. It also underlined that “sustainable development requires global solutions”, thereby supporting the EU’s efforts to take a leading role internationally to promote global economic and social development while protecting the environment. The strategic importance of

investment in research and development (R&D) for the Lisbon Strategy and sustainable development was recognised at the 2002 Barcelona European Council, where it was agreed that overall spending on R&D in the EU should increase and approach 3 % of Gross Domestic Product (GDP) by 2010. Investing in research, from both private and public sources, is vital for the EU economy, including eco-industries.

The potential of technology to create synergies between environmental protection and economic growth was recognised by the October 2003 European Council. Environmental technologies – taken in this Action Plan to include all technologies whose use is less environmentally harmful than relevant alternatives - are key to this. They encompass technologies and processes to manage pollution (e.g. air pollution control, waste management), less polluting and less resource-intensive products and services and ways to manage resources more efficiently (e.g. water supply, energy-saving technologies). Thus defined, they pervade all economic activities and sectors, where they often cut costs and improve competitiveness by reducing energy and resource consumption, and so creating fewer emissions and less waste. These potential benefits can also be of great importance for developing countries. With sufficient technology transfer they can provide these countries with affordable solutions for reconciling their desire for strong economic growth with the need to do so without increasing the pressure on the local, or the global, environment.

This Environmental Technologies Action Plan (ETAP) aims to harness their full potential to reduce pressures on our natural resources, improve the quality of life of European citizens and stimulate economic growth. As such it is an important means to implement the EU Sustainable Development Strategy and to pursue the Lisbon Strategy, while also helping developing countries. It is based on the recognition that there is significant untapped technological potential for improving the environment while contributing to competitiveness and growth. Encouraging the choice of advanced environmental technologies in all investment

and purchasing decisions will go some way towards realising this potential, thus widening their market and reducing their cost. This Action Plan sets out a series of measures to do this; measures that will require a concerted effort by the Commission, Member States and partners in the research community, industry and civil society.

2.4| *Water Supply and Sanitation Technology Platform (WSSTP)*

The ETAP has identified the water supply and sanitation technologies as a topic to be supported through a European Technology Platform. "Technology Platforms" are being set up At the initiative of the Commission and industry, which bring together companies, research institutions, the financial world and the regulatory authorities at the European level to define a common research agenda which should mobilise a critical mass of - national and European - public and private resources. The Water Supply and Sanitation Technology Platform will play an essential role in fostering effective collaboration between the research community, industry, policy makers, the financial community and other stakeholders. The overall objective of the Technology Platform will be to face the global challenge of ensuring safe and secure water supply for different uses and sanitation services through the development of sustainable technologies within the appropriate framework conditions. Moreover, its aim will be to promote step changes in the technological capacity of the European Water industry, with the aim of supporting and strengthening its competitiveness in the world market.

The WSSTP will bring together - for the very first time - all stakeholders (especially research and science, technology industry and water industry, regulators and end-users such as industrial and domestic water consumers), to jointly set up a bottom-up R&D agenda based upon vision, needs and opportunities. Research will be focused on practical problems and elegant solutions that have the support of the target group, the water sector. European research and development will benefit from a holistic non-scattered approach in the area concerned and research will be better focused on key areas. Implementation of new and innovative technologies

will be accelerated as both end-users and regulators/inspectorates are convinced of the usefulness and the need for development of technology in specific areas. Quick implementation using demonstration projects, on-the-job training and other instruments will accelerate innovation and acceptance by suppliers and end-users. The environmental technology suppliers will benefit from this positive reception of their innovations and scientific progress. The water and sanitation industry as a whole is expected to make step-wise improvements through new and innovative technologies, introduction of promising technologies from outside the water area and optimization of existing technologies. Economic, regulatory and other barriers to implementation will not hamper the introduction of new technologies. Water Supply and Sanitation in developing countries (and in some parts of Europe as well) will leap frog by participation in this developing concept of new and innovative technologies. The WSSTP will have a number of important measurable objectives:

- The production of the three main documents, vision documents, strategic research agenda and an implementation plan, a joint effort of the platform and involvement of all stakeholders. The vision document containing the strategic research agenda will include short-, medium- and long term perspectives in a coherent dynamic strategy that will be used as input for the FP7 programme of the European Commission.
- Strengthening European industry competitiveness, by providing a forum where stakeholders work together, exchange knowledge and information on technological challenges in water supply and sanitation, on new and promising technologies, on the identification of gaps in knowledge, the assessment of the potential impact of new technology and the size of the potential market.

Contributing to the MDG's through active participation of developing countries and of organizations in the platform that work in developing countries.

2.5| *The Netherlands*

In the last decades Dutch water technology has gained a prominent worldwide reputation. Well-known innovations as PVC-pipe systems, membrane technology and sewage treatment systems, like oxidation gutters and UASB systems, have all

been developed in the Netherlands. In the field of research and development the Dutch water sector has a leading position in the world and a well-developed international network. Looking at the water facilities more than 90% of the Dutch households are connected to a high quality drinking water supply and the wastewater is collected and treated in an environmentally friendly way. The Netherlands has an outstanding home market for development and use of water technology.

Nevertheless these innovations have not yet resulted in Dutch initiatives taking a larger share in the world water and sanitation market: the world market in is worth € 300 billion, of which only 2% is provided by Dutch organisations. One of the main bottlenecks is the insufficient coordination between demand and research. In a recently published report of the Dutch government this is clearly addressed: the present research innovation is lacking tuning with the demand driven market and therefore research innovation must be demand driven. The decrease in allocation towards Research and Development has further worsened the situation. Only through joint spearheaded R&D can the Dutch initiative keep its prominent position within the world market.

Furthermore, the Netherlands should find adequate solutions to the environmental goals set out by the European Union, through the implementation of the Dutch program of the Water Framework Directive. In addition, the Netherlands should play an important role in facilitating the Millennium Development Goals for water supply and sanitation in developing countries. The FP7/ETAP/WSSTP provides a European platform on which these goals can be addressed. With a the financial support of the FP7, important research themes can be put into practice within the Netherlands, possibly in cooperation with other EU countries.

3 | Trends and challenges

The European water industry faces new challenges that mean it cannot rely on the old approaches to maintain the levels of economic growth and environmental improvement seen recently. The key trends and challenges are seen as:

- Climate change
- Demographic changes & increasing customer expectations
- Ageing and increasingly vulnerable assets
- Diminishing Resources and the need for sustainability
- Cost efficiency and Competitiveness - Making use of emerging technologies
- Integrated approach
- Partnership building

3.1| *Climate change*

There is still much debate as to the exact extent of the affect of climate change. However, recent years have seen an increased occurrence of extreme weather events including rainstorms, high winds and droughts. This leads to problems in managing flood risk, storing sufficient water for supply, an increasing need for irrigation with current crop requirements and difficulties maintaining supplies during all types of extreme weather.

3.2| *Demographic changes & increasing customer expectations*

Throughout Europe there is an increasing trend towards smaller families and longer life spans leading to an ageing population and diminishing supply of young qualified personnel. This ageing population generally leads to increased demand and changes in patterns of use and an increased vulnerability to water born pathogens. In addition there is a movement of people in to cities, leading to increased problems with urban drainage and sanitation.

People are more demanding over the level of service they expect from a utility and more concerned with water quality, although their understanding of the true issues is often limited.

3.3| *Ageing and increasingly vulnerable assets*

Many of the assets in use by water and sewerage undertakings are decades or even centuries old. The rate of replacement is well below that needed to maintain the average age of the asset base. Therefore Europe has to use older and older assets to maintain the water supply and sanitation service with the increased risk that this brings. Risk to the system has also increased due to the wider threat of terrorism and ensuring the security of supplies is now a major concern in some countries.

3.4| *Diminishing Resources & The need for sustainability*

A larger and larger percentage of the available water for treatment is being utilised but still losses from water systems can amount to up to half the water abstracted. In many areas, water is being abstracted at a faster rate than it is being replenished, leading in some cases to salt water intrusion. The realisation that a sustainable environment is essential for long term European prosperity was enshrined in the Lisbon accord.

3.5| *Cost efficiency & Competitiveness*

There have been continued price increases for water and sanitation services across Europe, with a requirement from both users and governments to reduce the unit prices. In addition, although Europe is currently a major exporter of expertise in this field, other countries are developing their own skills and it cannot be assumed that there will always be a market, unless Europe maintains its competitive edge by developing new understanding which will help meet the challenges that all countries face in the 21st century. There are opportunities to use newly emerging techniques in for example nano-technology or biotechnology to improve treatment, efficiency and monitoring and to reduce wastage

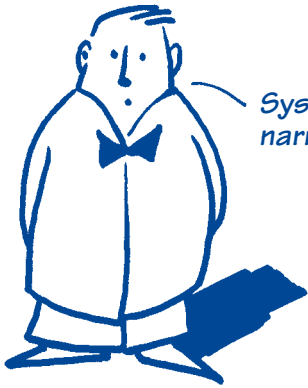
3.6| *Integrated approach*

Existing technological approaches to water supply and sanitation are reaching their limitations in the light of rapidly increasing water scarcity and deteriorating quality. At the same time demands of human welfare, well being and a better

environment call for sustainable approaches to the development of new water projects. A sectoral approach to water resources management has dominated and is still prevailing, leading to fragmented and un-coordinated implementation. An integrated approach – in which the water industry becomes part of the whole water cycle - can have important benefits. An integrated management of the water resource can provide more economic and more equitable solutions. Where a fragmented, “sectoral” approach may lead to sub-optimalisation, an approach that considers the whole water system can provide a solution that is better for all users and for nature, often already in the immediate short term, certainly in the long term.

3.7| *Partnership building*

There is a potential of capacity and expertise to benefit from the increasing world demand, but for real growth of market share specific actions are needed to overcome the structural weaknesses of the Dutch water sector. Amongst other things this implies joint efforts for creating scale and integrated solutions. This means that players should find beneficial forms of co-operation in order to become more competitive on a world scale instead of competing for each other’s modest market shares.



*System - thinking
narrows the mind...*

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narrows the mind...*



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New ways of co-operation are about to emerge.

4 | Research themes

Based on the trends and challenges mentioned in chapter three, the following research themes are selected by the Dutch Water as the most important ones. Each of the topics is described and supported by a number of key-words of possible research topics within these themes.

- Decentralised concepts
- Desalination
- Water Quality
 - Sensors and monitors
 - Endocrine disruptors
- Energy from water
- Separation technology
 - Bio fouling
 - Membrane Bioreactors
- Closing the water cycle
 - Retrieval of components
 - Re-use and recycling
- Integrated Water Resources Management
- Clustering

Effort and means should be focussed on these themes and should be addressed in the European water agenda in the coming years. Dutch organisations can play an important role in research & development and solving the challenges in these fields.

4.1| *Decentralised concepts*

Then significance of small-scale water treatment facilities is becoming ever more important. The possible locations in which these small treatment facilities could be applied is very broad, from developed to developing nations, ranging from relatively simple to very complex facilities. Decentralized solutions could positively influence the shift to a sustainable society, through the reuse of wastewater, energy savings, and a greater access to safe drinking water combined with good

sanitation (Millennium Development Goals). A specific aspect of water treatment facilities is rain water harvesting. Most of the time rainwater is collected in huge, high cost, centralised systems. A more decentralised approach, like small scale, integrated rainwater treatment will be more cost efficient and more environment friendly. Also can rainwater be used as source in water scarcity areas.

Topics

Appropriate technology, drinking water for less developed countries, decentralized systems in relation to re-use, household systems in relation to re-use, in situ solutions: low-impact during reconstruction, measurement/ inspection of the status of pipes, pipe management (replacement, rehabilitation), material research of pipes, water mining, re-use of water, low-cost point of use systems, small scale systems, decentralized process and drinking water, mobile water purification unit 'Personal recycler'. Rain water harvesting, integrated rainwater treatment.

4.2| *Desalination*

Desalination of seawater could provide a worldwide solution to lack of fresh water. A large proportion of the world population (70 percent) lives within 80 km of the coastline, while most depend on water from areas far inland. The challenge lies in the development of durable and low-cost technology. Besides desalination, other available options are: the use of membrane technology and the utilization of brackish groundwater.

Topics

Bioconversions, selective membranes, improvement of energy use, cost reduction, treatment of brackish and salt water, effects of salt concentration on bioconversion, mining specific salts, agricultural application of desalination, low cost technologies, Solar Dew, desalination, desalination (brine, fouling, recovery), removal of salt from water, salts (bio-conversions at high salt concentrations), use of UF as pre-treatment for desalination with RO.

4.3| *Water quality*

The quality, safety and security of the water supply system can be assured by protecting raw water from pollution, continuously monitoring at all critical points and assessing and addressing risks.

Sensors and monitors

Remote monitoring, sensors (chips, online), on site and on line monitoring water systems, early warning systems, online operations of water systems, consumption measuring and monitoring; leak detection.

Endocrine disruptors

Removal of organic micro pollutions including hormones, medicines and endocrine disruptors, pathogen removal.

4.4| *Energy from water*

The production of sustainable energy production is an enormous challenge. There is more energy around us than we think, in the future these sources need to be fully used. Water treatment can play an important role in this regard. Presently the desalination of salt water is still very energy-costly procedure. Turning the situation around, the addition of salt to water should provide energy. How do we approach these possibilities?

Topics

Reuse of waste to produce energy, direct hydrogen energy production, derivation of energy from the difference in charges in bacteria, energy production from sewerage water, development of low-cost membranes. Economically feasible technology.

4.5| *Separation technology*

Separation technology encompasses many technological aspects and plays a significant role in sectors that are of importance to the Dutch economy, one of

them being the water sector. Separation technology is continuously evolving with the development of new innovations, for example, membrane filters often in combination with biological treatment. These innovations lead to cost-reduction and an improvement of product quality. Technological developments in separation technology can improve the market position and lead to a more sustainable production process.

Bio fouling

Bio fouling of drinking- and process water prepared membranes, development of new treatment, development of design regulations, anti-pollution membranes by nano-particles at the surface.

Membrane Bioreactors

Reduction energy use, increase production through pollution prevention, new applications, local production, reuse, total solutions, bio fouling, small-scale application, cost efficient

4.6] *Closing the water and materials cycle*

The whole process cycle needs to be considered as a whole since the water cycle covers a wide range of inputs and outputs and needs to be considered holistically to achieve the maximum efficiency and optimum management of the environment. For example poor sewage collection and treatment can have an impact on the treatment costs of abstractions down stream.

Another example is the industry, where optimisation of the use and treatment of water to reduce costs or to meet the regulations leads to reuse or recycling of process water.

Reuse of water is an important issue in case of water scarcity or as an alternative for desalination of seawater.

Retrieval of components

Hybrid systems and processes,,: phosphate retrieval, re-use effluent, system thinking / integrated approach, re-use: accumulation of compounds, LC-approach: prevent problems EC's/ agriculture/ chemicals

Re-use and recycling

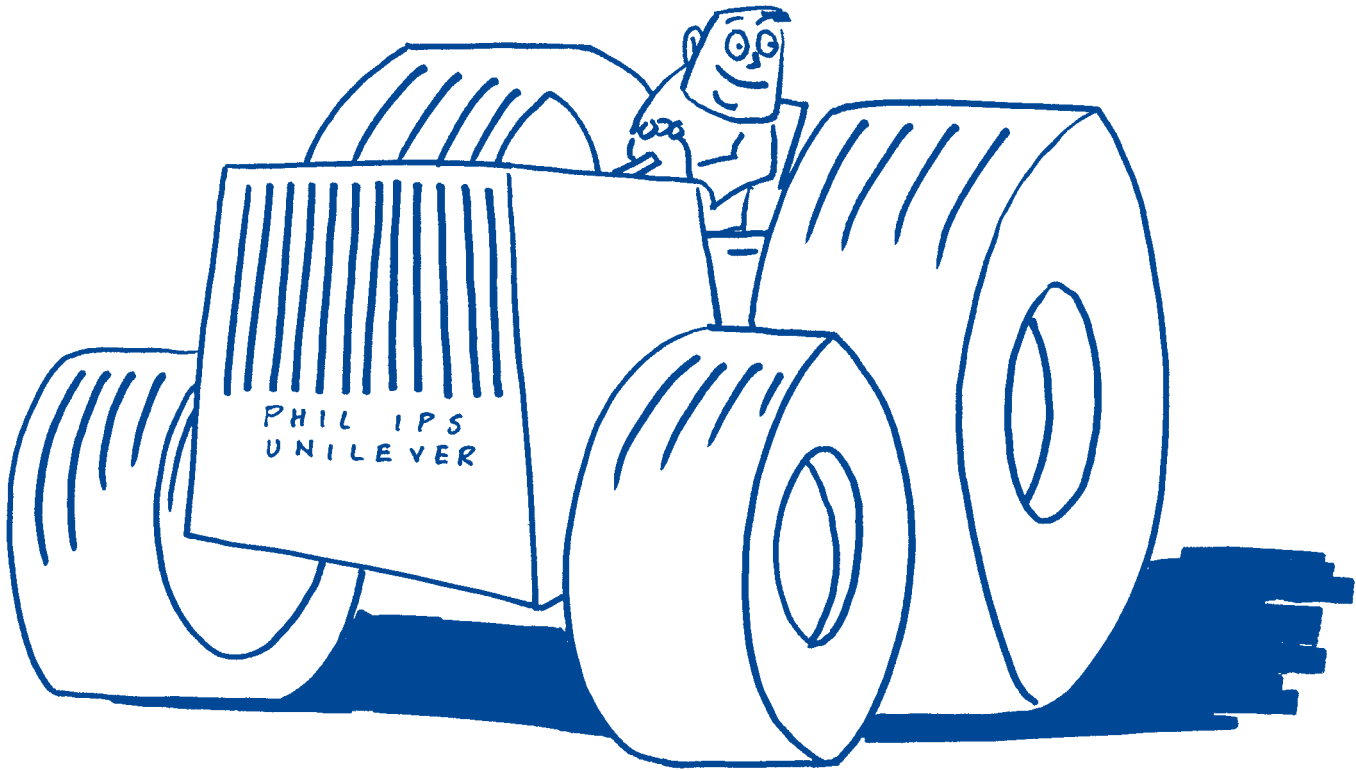
Re-use and recycling, small scale water cycle, closure of phosphate cycle, effluent valuable in re-use, cycle closure, re-use of water in industry,

4.7| *Integrated Water Resources Management*

Water is an important element in our surroundings and requires an integrated system approach. Human living, working and leisure activities directly influence water quantity and quality. Sustainable solutions are essential to maintain tolerable conditions for life on earth, of which technology alone cannot provide for. An integrated approach is needed, with awareness for the economy and ecology in combination with technology.

4.8| *Clustering*

Export clustering should be stimulated. Clusters are defined as networks of different types of companies, which create certain products or services by co-operating and exchanging knowledge with each other. The focus in innovative clustering is on the development of new products or services. The proposed integrative approach for the water sector, however, can also be considered an innovative activity that can only be realised by co-operating and by exchanging knowledge. As a result, the Dutch government could play an important role as a facilitator of clustering activities in the water sector, but cannot be expected to take the lead.



We need a big company to take the initiative.

5 | Research Topics

Based on the research themes of chapter four a large number of research topics were identified. During the workshop the most relevant topics for the Dutch water treatment sector in the area of the water supply and sanitation technology were selected, which are:

- Sensors and Monitors
- Energy from water: Blue Energy and Electric Fuel Cell
- Retrieval of components and diffuse residues
- Micro pollutants/ Endocrine disruptors
- Decentralized water system: small scale WS&S
- Decentralized concepts for waste water purification
- Desalination

Each of the topics is elaborated by experts through a short description of the topic and the expected developments in that field. Moreover the national and international business potential including funding opportunities.

5.1| *Sensors and Monitors*

Development of new sensors technologies for monitoring and quality control of drinking water from source to tap

Using current technology, real-time quality control of drinking water is not possible. Even the most advanced techniques will only give indirect indications for changes in quality, which are then further analysed using laboratory techniques. This means that contaminants, if detected at all, will only be identified after the water has been supplied. As the continuous supply of drinking water of high quality is important, and because the likeliness of water quality events is significant, techniques that are capable of on-line monitoring of this quality are needed. Especially when decentralised purification of water, envisioned as an important development in the (near) future, is to be realised, better monitoring systems are required. These systems should be capable of detecting and identifying pathogens and chemical contaminations at concentration levels below those stated in the EU Drinking Water Directive. Furthermore, they should have a very low rate of false alarms, be robust and have a low demand for maintenance. Such systems

are currently not available on the market. Various technologies would be required. The analytes with the highest priority that cannot be measured in real-time at this moment are pathogens, organic contaminants, acute toxicity measurements and chronic toxicity measurement.

Description of the (status of the) sensors and monitors

Various technologies are under development that could lead to commercial sensing and monitoring systems to fulfil the described needs. Amongst these are: optical chemical detection techniques (detection of specific chemicals), DNA arrays/micro arrays (assess toxicity), rapid identification of micro-organisms (Polymerase Chain Reaction (PCR) technology, Fluorescent in situ Hybridisation) and in-vivo cell based assays to determine chronic and acute toxicity. Techniques for rapid concentration of microorganisms from large volumes of water will also be required. Some of the above mentioned techniques, such as micro-arrays and optical chemical techniques are commercially available for use in pharmaceutical industry. Parties that are involved are e.g.: BDS, Imtek, TNO, HSG-Imit, MESA+, Lionix, Philips.

The direct research or development needs differ from system to system. As example is taken the optical chemical detector, trajectory will be different for the others systems. Required is first further proof of principle under operational conditions. To achieve this a prototype will have to be built. If successful, transfer to a commercial product is required. The receptor molecules to detect specific substances must also be developed for many target compounds. It is both a research (many new technologies and components will be required) as well as development topic (some prototype systems exist) and these must be further developed to reach a commercial application.

Description of alternative (approved) technologies

No real-time technologies that are comparable are available. All approved technologies for these parameters are laboratory technologies, which are time consuming (results will take hours or even days). Approved technologies are:

- Cell culturing
- Analysis with HPLC, GC
- In-vivo toxicity assays (however not available for all types of relevant toxicological effects)

International and national business opportunities

No systems exist that can measure specific contaminants in (drinking) online. There is a requirement for such systems in environmental monitoring, drinking water supply sector and for national security. An envisioned future market is decentralised water purification.

This research will address a global need, and is aimed at both government funded institution (environmental monitoring, national security) as well as industry (e.g. drinking water supply).

The market potential in the Netherlands is limited (limited number of drinking water companies, small market). However, international market has huge potential. Nevertheless the home market has clearly stated interest in these developments and there eventual products.

The Netherlands has a potential to become a centre of excellence in this technology, as a lot of Dutch companies are involved in the developments mentioned. Lack of funding and lack of a secure market are restricting development. Developments in this field are high cost and high risk, therefore there is hesitation to move ahead without secured customers. Yet securing customers when in a development stage is difficult due to high-risk en costs.

European and Dutch funding possibilities

Various options for the European Union and/ or European companies exist to invest in the research or development of this technology:

- FP (6 -7) projects of EU.

- IP drinking water being formulated for EU. These projects include funding for such sensor developments.
- Funding for improvement of drinking water supply in the ACP-countries to realise MDG's will be available.
- Various co funding opportunities exist with Department of Economic Affairs.
- Companies such as TNO are investing in this technology.
- Drinking water companies in the Netherlands are investing, e.g. through Benchmarking research, being executed by Kiwa.

5.2| *Energy from Water: Blue Energy*

Electricity generation from fresh and salt water by reverse electro dialysis

The problems associated with conventional electricity generation through burning of coals or gas (NO_x, SO_x, carbon dioxide, etc) can be solved. Without using these limited available fuels, sustainable electricity from water can be produced and no toxic by products are formed. The technology that is needed is called Blue Energy. The positive sodium and negative chloride ions in salt water diffuse via ion-selective membranes into fresh water. By applying alternating cat ion and anion selective membranes the membrane potential across the membrane stack (80 mV per membrane) can be harvested and used in electrode compartments to generate electricity. Laboratory installations (100 membranes) generate sufficient energy to thrive a pump or a motor.

Description of the status of blue energy

Dutch parties that are involved in this technique are Nuon, Magneto, Landustrie, Frisia, Waterlab Noord, Paques and Wetsus. The Blue Energy membrane stack is build with a large number of alternating anion and cat ion specific membranes. Commercial available membranes are very expensive and not designed to use in a blue energy process. In order to generate sufficient amount of energy new, cost-effective membranes need to be designed. Another party working in this field is Kema; they are operating a pilot plant for development of technology and developing low cost membranes.

Hydrodynamics and electrode research are necessary for efficient extraction of the released energy from mixing fresh and salt water. Bio fouling of the membranes must be prevented by either special membranes or membranes that can be efficiently (in site) cleaned. The results from this research must lead to the design of a pilot plant to gather information about up scaling the process. Wetsus is aiming for a small-scale pilot study (250 kW). Blue energy is foremost a research topic, because limited knowledge is available from previous studies.

Description of alternative (approved) technologies

Alternative approved technologies are pressure retarded osmosis, Wind energy, hydro energy and solar energy.

International and national business opportunities

Blue energy could address the sustainable energy market all over the world, especially at locations where salt and fresh water mix, for example at river deltas. Potential energy production is about 3300 MW in the Netherlands. This is based on the amount of fresh water that flows into the sea. The Netherlands is especially suited for this innovative technology due to its geographic location. Development of this technology in The Netherlands enables a strong export position.

In the Netherlands we have the potential to become a centre of excellence in this area. Reliable and cost effective membranes are essential parts of this technology. If these membranes are developed and produced in the Netherlands and build into installations a very nice export product can be created.

European and Dutch funding

Various options for the European Union and/ or European companies exist to invest in the research or development of this technology. Financing by the EU might be expected in the 7th framework were more attention is paid on water and sustainable technology and energy. Blue Energy has great potential in emission-free generation of sustainable energy, by using virtually unlimited resources. The

chances are fairly high that the Government will also invest in this technology. However, the private sector will wait until the technology is in a more mature state. The Energy sector, polymer/membrane production sector, engineering companies and Wetsus could form possible coalitions in the Netherlands.

5.3| *Energy from Water: Bacterial Fuel Cell*

Electricity generation from advanced bio-oxidation

Generation of electricity from wastewater will reduce the huge energy requirements in a wastewater purification plant. Electricity generation via methane is less efficient than direct electricity production in a bio fuel cell. In bio fuel cells an organic carbon-source is oxidized into carbon dioxide by bacteria present on a graphite or metal electrode (anode). At the same time these bacteria form protons and electrons. The bacteria to the anode donate the electrons and the protons diffuse towards the cathode through a proton permeable membrane. Via an electrical circuit the electrons are transported from the anode to the cathode. At the cathode, protons and electrons reduce oxygen into water. In this process an electrical current is generated at a certain voltage, and thus power is produced.

Description of the status of bio fuel cells

Laboratory installations using artificial wastewater generate sufficient energy from acetate to thrive a small pump or a motor. Active organizations in this field are Nuon, Magneto, Landustrie, Waterlab Noord, Paques and Wetsus. Research is needed on the microbial processes, proton specific membranes and the reactions that take place at both the anode and cathode. After successful laboratory installations using real wastewater, the process should be up scaled to pilot plants. It is a research topic, because limited knowledge is available from previous studies.

Description of alternative (approved) technologies

An alternative technology is Methane formation from biomass and subsequently burning methane in a combustion engine for electricity generation.

International and national business opportunities

The future market is the entire energy and water market, all over the world. Instead of using energy in a wastewater treatment plant electricity can now be produced while the wastewater is treated at the same time.

It is also very attractive for the market in the Netherlands. The Netherlands has the opportunity to become a centre of expertise; it acquired a lot of knowledge in anaerobic purification processes and in the design of the necessary equipment. Knowledge of proton specific membranes, electrodes and the microbial processes are required.

European and Dutch funding possibilities

Various options for the European Union and/ or European companies exist to invest in the research or development of this technology. Financing by the EU might be expected in the 7th framework were more attention is made on water and sustainable technology including energy.

The technology has great potential in reducing the energy requirements of wastewater treatment plants. The chances are fairly high that the Government will invest in this technology. However, the private sector will wait until the technology is in a more mature state. Possible coalitions in the Netherlands are those between the energy sector, wastewater treatment plants and Wetsus.

5.4| *Retrieval of components and diffuse residues*

Opportunities for recycling of valuable elements

In the world Phosphate resources are finite. There is an intensified agricultural need for phosphate removal from drainage effluent. Selective separation and recycling processes for phosphor are demonstrated viable. Lowering cost could increase widespread use of this technology. When the use of decentralized, small-scale desalination technology in Developing Countries becomes widespread, associated environmental impacts of decentralized brine disposal can be anticipated. There is an opportunity to increase widespread use of small-scale

decentralized desalination technology by added value of recycling elements with local value from brines (e.g. phosphorous, potassium).

Using a Selective adsorption technology is one way to achieve this: selective adsorption and in separate stage desorption of components from dilute or concentrated solutions (Example TNO Pertraction process). Another possibility is 'affinity separation', selective accumulation by affinity of components flowing along fixed medium. For example Mosaic Systems.

Description of the (status of the) technology

In fine chemicals, processing industry and pharmaceutical intermediates, principles, adsorbent media and methods exist. However small-scale modules and process equipment need to be designed for the specific requirements of the brine and irrigation drainage effluent sectors.

The direct research or development needs to come to approved technology include module development (target: robust in handling variability in end of pipe streams) and process miniaturization (development from existing centralized applications scale to decentralized scale).

The recycling of valuable contaminants from wastewater, drainage or brine effluents is both a Research and a Development topic. Development aspects are lower costs and increased robustness; research aspects are investigating selectivity tuning effects.

Description of alternative (approved) technologies

Alternative technologies are flocculation and sedimentation, but these technologies are not selective.

International and national business opportunities

Geographically the market for these technologies lies in the EU. It includes

phosphate recovery in areas of intensified animal husbandry (NL, D, F), anticipating environmental aspects in development of farming in Eastern Europe states and environmental impact of fast growing seawater desalination in Spain and EU Mediterranean countries and associated states such as Turkey, Israel and Lebanon.

Achieving the Millennium Development Goals also creates a market:

- Reduction of environmental burden of growing need for desalination (economic and controlled brine handling)
- By adding value to brine, desalination for drinking water and irrigation becomes economically more attractive (or has less penalty cost) It could boost the progress towards the MDG goals

European and Dutch funding

The opportunities and the chances that the European Union and/ or European companies will invest in the research or development of recycling of valuable contaminants from wastewater, drainage or brine effluents are the:

- EU water initiative
- NL Separation Roadmap initiative
- MDG development funds (UK, NL)
- Removal and recycling of certain heavy metals (e.g. Hg, Ni) from industrial brines (EET, EU etc)

Wetsus and TU Delft Applied Science already have invested in programmes on brines. Possible coalitions in the Netherlands are TNO – NORIT Carbon and NORIT MT, Thermofos, SHELL/DSM/AKZO (Wetsus), University of Twente and the university of Delft. They could include adsorption separation companies from pharma sector such as Milliken and Satorius catch maps.

5.5| *Micro-pollutants/Endocrine disruptors*

Description of the opportunity

Micro pollutants, endocrine disruptors and medicines that are either biologically degradable or adsorbed to solid particles can be removed relatively well from urban wastewater by making use of existing purification technologies. Dissolved micro-pollutants, endocrine disruptors and medicines are however far more difficult to remove during these processes. In a dissolved form these substances have the tendency to remain present in surface and ground water bodies for long periods of time. Problems are created in sources that are used for drinking water production or in the re-use of purified wastewater. These dissolved micro pollutants; medicines and endocrine disruptors potentially have a negative impact on people and their environment. It is therefore necessary to develop purification technologies that are more effective for the removal of these substances.

Description of the technology

In the current wastewater purification processes, medicines and endocrine disruptors are only partially removed. By making use of additional techniques a better removal of these substances is possible. Additional technologies that can be used for this purpose include: a) membrane technology b) adsorption to activated carbon and c) chemical oxidation technologies (UV, Ozone). These technologies are already used in The Netherlands for the preparation of drinking water and the re-use of industrial wastewater. On a pilot level some experience has also been gained by making use of membrane technology and the adsorption to activated carbon but there is no practical experience with the specific treatment of urban wastewater for the specific removal of endocrine disruptors in practice.

It is important that more experience and knowledge is gained with the different types of additional purification technologies and their subsequent removal rates for micro pollutants, medicines and endocrine disruptors. An important question that needs to be answered is whether these substances need to be removed either during wastewater treatment, or during drink water production processes. By

making use of pilots the cost and benefits for these different additional techniques can be investigated. It is imperative that the effective removal of these substances is possible for acceptable costs.

Description of alternative (approved) technology

An alternative technology for the effective removal of dissolved micro pollutants, endocrine disruptors and medicines at a central level is unknown. At a decentralised sanitation level similar problems will have to be addressed when treating urine.

International and national business opportunities

The development of purification technologies for the removal of medicines and endocrine disruptors is both a research and a development item. Little research has been executed so far on the removal of natural and synthetic hormones in wastewater and on additional purification techniques at urban wastewater treatment facilities.

Parties that have experience with the mentioned technologies are:

- a) Membrane technology: Seghers-Keppel, Zenon, Kubota, Solis, X-Flow/Norit;
- b) Activated carbon: Norit, Chemviron/Calgon
- c) Chemical oxidation: Berson, Trojan, Wedeco, Ozonia.

In the Netherlands the market potential will increase when far going removal of endocrine disruptors and medicines from water becomes obligatory by law. In the EU the development of additional techniques will be linked to the objectives and goals that are set in the EU water framework directive. Potential interesting markets outside Europe are the densely populated areas in Japan and the US.

European and Dutch funding

The financial foresights for the development of additional techniques for the removal of micro-pollutants, medicines and endocrine disruptors within the 7th research framework program are good.

5.6] *Decentralized water systems: small scale WS&S*

Development of small scale WS&S systems

Small-scale WS&S systems should fulfil a number of requirements. They should be simple, easy-to-maintain, robust, sustainable, have a low energy use and be appropriate to local conditions. They should focus on the reuse of nutrients, reuse of water and be environmentally sound: effluent pathogen-free, acceptable BOD standards. Small-scale systems could solve problems in developing countries such as the realization of MDG on habitat level (10 families) to small communities (10.000 persons). In the rest of the world it could deal with the threat of terrorism and reduce the costs for systems in low-density areas (referred to as 'IBA' in the Netherlands).

Decentralized water supply and sanitation systems for the developing world can be designed, constructed, operated and maintained on a local level, independent from centralized back up. Alternative technologies for Water supply are (hand) dug wells, borehole wells with pumps, rainwater collection, etc. For sanitation: pit latrine, septic tank, compost latrine, etc. At the moment there is a renewed interest in 'appropriate technology' systems. Parties that are active in this field are NGO's active in development co-operation, UN agencies and Bilateral Aid Agencies.

Membranes for individual drinking water systems are also an important research topic. This includes small scale Membrane technology for drinking water production from polluted ground/ surface water. In case of emergencies (e.g. terrorist attack) households could obtain drinking water (3 liters per capita per day) through individual treatment systems based on membrane technology. The source can either be through rainwater harvesting, (polluted) groundwater, or (polluted) surface water. Membrane manufacturers (Norit, Filtrix) have developed systems to be connected to the water distribution network and systems that can be used by special groups (e.g. backpackers), but there is no system yet for regular households.

A third technology that is interesting is the development of individual small-scale MBR technology for wastewater treatment at household levels (black and gray water). MBR's are currently only developed for large-scale application. Parties that could work together in this respect are membrane manufactures, consultancy firms and water authorities.

Description of the status of small scale WS&S systems

In the case of decentralized water supply and sanitation systems for the developing world we have to search for compact systems on household scale, which can be operated and maintained locally. The latest technologies (membrane, solar energy, etc.) have to be matched with the needs in the developing world. It is a development topic, as only 'proven' technologies need to be used.

Membranes for individual drinking water systems in the case of emergencies (terrorist attacks) should provide a capacity of 3 litres per capita per day; say 10 litres per system per day. The power supply should be independent from the electricity grid; be based on Membrane fouling and could focus on the Removal of dissolved pollutants. These types of membranes could be produced in the Netherlands (Norit). But firstly, the demand for this type of systems needs to be created. There is a need for pilot systems, publicity, possibly through the intermediate organizations responsible for the control of terrorism: Ministry of Interior Affairs.

Description of alternative (approved) technologies

Alternatives for decentralized water supply and sanitation systems for the developing world are (hand) dug wells, borehole wells with pumps, rainwater collection, etc. For Sanitation these are pit latrine, septic tank and compost latrine.

Alternatives for Membranes for individual drinking water systems in the case of emergencies (terrorist attacks) are the individual household filter systems.

Alternatives for MBR technology are Septic tanks, composting toilets, UASB and advanced IBA systems as small-activated sludge systems.

International and national business opportunities

The Market for decentralized water supply and sanitation systems for the developing world are the remote areas in Africa and Asia, unfit for large systems. In terms of money and business the opportunities are small. However the Netherlands NGO's and Bilateral Aid agencies are important as launching customers. We are too expensive to become a centre of expertise but it is of interest as IHE, IRC could develop and promote these systems.

In case of emergencies (e.g. terrorist attack) households could obtain drinking water through individual treatment systems that are based on membrane technology. Individual households in USA and Europe are a possible market. Say 1/20 of the households in The Netherlands. This would be around 250.000 systems. With a per unit price of 500, the size of the home market could be 125 Mln.

MBR was invented in the Netherlands. MBR technology for wastewater treatment at household levels can be interesting in Low density areas, far from centralized systems where it is important to apply high effluent standards (sensitive ecological areas) and areas that are not yet covered by IBA's, day 10.000 systems. Netherlands could be a centre of expertise, but first market research need to be done: Europe should be the target as the EU Water Directive will have a positive driving force. The home market is probably too small.

European and Dutch funding

Various options for the European Union and/ or European companies exist to invest in the research or development of small-scale WS&S systems. For the developing world it is one of the ways to realize the MDG's.

Various Dutch companies might also be interested. The Dutch government could be a launching customer.

In case of emergencies (terrorism) the opportunity is the creation of production capacity of this type of membranes. The chance that this will happen depends upon the potential market. Market research is needed. Coalitions in the Netherlands: producers of membranes (e.g. Norit) with Ministry of Internal Affairs / and Netherlands Municipalities (e.g. VNG) as launching customer.

Financial options for individual MBR technology depends on the success / failure of the large-scale MBR tests. Given the compact size and excellent effluent quality, there is a change. Municipalities are also responsible for the non-sewered areas. They could act as launching customers. Besides manufactures, large maintenance companies need to be attracted for construction and service. Possible partners are VNG, consulting firms, NGOs active in environmental protection and maintenance firms.

5.7] *Decentralized water systems: waste water purification* **Improving the conventional water chain**

The improvement of the conventional water chain could provide opportunities for re-use of valuable nutrients and energy. It could solve problems that are related to the current situation in which wastewater is collected in one pipe and transferred to a central RWZI. The negative side effects of the current situation are:

- Partial removal of nitrogen and phosphate (approximately 75%)
- Partial removal of medicines and hormones
- Relative high-energy use (due to removal of ammonium from urine residues)
- High Volume flow that makes it hard to target certain components

Description of the status of Decentralized concepts for waste water purification

Concepts such as DESAH and ECOSAN can be divided into three parts:

- Collection (separation /vacuum / compost toilets)
- Transport (local treatment, separated sewer system)
- Treatment

The technical and scientific knowledge that support these new concepts are mostly available. Pilot projects have been executed. Dutch parties that are active in this field are Wageningen University, Landuistrie, TU Delft, WASTE, LEAF, consultants, water-boards and drink water companies, but a lot more pilot projects are needed. Research results have to be tested in practice.

International and national business opportunities

What specific future market need do decentralized concepts for wastewater purification address and where is this market? In order of potential:

- Small scale in the western world where separation is relatively easy (for example sport complexes, public buildings);
- Large scale where new wastewater systems still have to be developed
- In the un-piped areas of the new world (Eastern Europe).

The possible size of the market in terms of money and business opportunities in the Netherlands is estimated to be close to 1 million euros a year till 2010 (still pilots). The Netherlands, Sweden and Germany have centres of expertise that focus on these decentralized concepts. In the Netherlands we still have to develop our home market, before we would be able to sell these concepts to foreign countries. More commitment is needed.

European and Dutch funding

Various options for the European Union and/ or European companies exist to invest in the research or development of these decentralized concepts. The new world still has a lot of work to do when it comes to waste water treatment. By introducing and developing these new concepts, it can be prevented that the unsustainable conventional system are still actively copied. The Dutch government should facilitate these new concepts with financial budgets and policy making. Coalitions with researchers, policy makers and end users are needed. In Europe coalitions can be formed with institutes in Germany and Sweden.

5.8| *Desalination*

Sea water or waste water application for sustainable production of high quality water (process or drinking water)

Scarcity of fresh water is growing by an emerging world population and unsustainable water management. Seawater desalination is now at an interesting cost level. There are environment issues including the retentive stream (concentrate):

- Scaling resulting in under water desserts
- Toxic influence of scaling inhibitors
- Waste energy (T ~50-60 °C)
- Bio fouling.

The current technology is reverse osmosis and distillation. The development aim is a hybrid technology based on membranes and distillation (Memstill®), the integration of Memstill membrane desalination with FACT (Filter assisted crystallisation technology) for the recovery of inhibitors, an integrated dewatering and crystallisation process leading to zero waste process and the prevention of bio fouling by denutritior. Another development aim is the use of ultra filtration (UF) as an alternative to conventional pre-treatment. UF can be used to improve RO feed quality by removing suspended solids, bacteria and organic matter and in that way reducing the bio fouling potential.

Description of the status of Memstil

The Memstill consortium exists of TNO, SKTN, WTH, Heineken, E.ON, EMF, Evides, UT and WBA. They could form a consortium together with RO and/or distillation technology suppliers like Norit or Landustrie/Hubert. The direct research or development needs include an increase in energy efficiency and flux by process optimization. The non-sustainability by de production of salt also has to be solved. It is both a research (Mass & Heat transfer. (Materials, T > 80°C), scaling, bio fouling) as well as development topic (production technology, experience with pilots).

Description of alternative (approved) technologies

An alternative approved technology is 'evaporation', but the disadvantage of that technology is its high-energy cost. Memstill has a higher energy-efficiency (gained output ratio > 20).

International and national business opportunities

This technology addresses future market in the Mediterranean (Spain, Morocco, Cyprus, Malta, Italy etc), the Caribbean, the Middle East (Saudi-Arabia, Oman, U.A.E) and Asia (China, Singapore). There are already large underwater deserts due to brine discharges. This technology could restore these ecosystems. There are also opportunities 'on shore.' In the south of the USA they are now introducing desalination and have no solution to the brine problem.

Desalination costs are potentially lower than for purification of surface water. This is attractive for the home market because its strength is the desalination position of Dutch suppliers. It could become a large market.

In the Netherlands we have over 20 years of experience with Membrane based desalination processes. Partners are Akzo, Estec and Hubert. RO: Norit, Promac, TNO, IHE, Hatenboer, Seghers Keppel, Christ, Lubron, WTH and others. DHV also has a specialized department. Wetsus has some new initiatives and is constructing a pilot-plant on desalination in Harlingen. For UF-technology the Dutch water sector has a strong position based on good knowledge and experience developed at the home market. This is an added value for the further development of desalination technology. There is a chance to become a centre of excellence in desalination due to our know-how and IPR. European partners could be Siemens or Spanish, Portuguese or Italian water companies.

European and Dutch funding

Various options for the European Union and/ or European companies exist to invest in the research or development of this technology. FP6, call 4 addresses the

environmental issues of desalination. The Dutch government should take up the challenge to invest in this technology. Desalination solves water scarcity during dry summers, it solves environmental issues on a global scale and it can be applied at wastewater coming from oil & gas on chemical industries. A Dutch consortium of organizations and industries is formed and can be expanded. This area will get extra attention in FP7 now Spain has decided to introduce desalination on a large scale. A European coalition is under development by TNO.



Colophon

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