Coordinating European Strategies on Sustainable Materials, Processes and Emerging Technologies Development in Chemical Process and Water Industry across Technology Platforms

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CHEMWATER: FINAL REPORT – Publishable Summary

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1. Executive Summary

ChemWater (www.chemwater.eu) was a coordination action working on "European Strategies towards Sustainable Materials, Processes and Emerging Technology Development in European Chemical Process and Water Industry across Technology Platforms". It was funded by the 7th Framework Programme of the European Union between 05/2011 – 10/2013.

ChemWater represented a jointly envisioned strategy, developed out of the cooperation between the European Technology Platforms (ETP) SusChem and WssTP, addressing a key pan-European concern: the efficient management of water in process industry. The Networks of Excellence (NoE's) EMH, ENMIX and ERIC were key partners to design this strategy.

In developing sustainable solutions for water issues the process industry, especially chemistry, can play an essential role: both as a major water user and a key innovation provider for the development of future water technologies. A core rationale behind the project was to highlight the role of the European chemical and related process industries as solution providers within the context of the complex challenges of industrial and urban water management. An essential aim of the ChemWater project was to link process industry and water industry know-how to develop sustainable water solutions.

The objectives of ChemWater were focused on four fundamental lines in direct connection with the improvement of the industrial water management cycle:

- Establishing the interdisciplinary and cross-sectoral synergies between chemical processes and the water industry.
- Creating elements and mechanisms to facilitate the rapid uptake and commercialisation of enhanced materials, technologies and production processes for an optimized industrial water management.
- Developing a common long-term 2050 vision and strategy regarding technologies directed to realize an efficient industrial water management.
- Linking the ChemWater action lines with key European activities related to water.

To achieve these aims, ChemWater followed a working strategy to come a step forward to the efficient management of water in process industry. A clear synergy potential between the chemical sector and the water sector on the way towards an integrated industrial water management was identified in the basic ChemWater analysis. The synergies were related to four priority areas: water quality, water quantity, water-energy nexus and non-technological issues. Based upon these initial results the endpoints for development routes towards a sustainable future use and treatment of water in industry were defined in the Vision 2050. The related actions needed to realize the vision are the heart of ChemWater's Joint Implementation Action Plan. This Action Plan directly addresses key European programmes and initiatives that have a relation to industrial water management. It was supported by proposals for strategies and measures to foster the implementation of new products and technologies. An effective dissemination strategy was established and implemented to ensure the communication not only of the project objectives and action plans but also best practices, methodologies and common long term strategies.

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2. Summary description of the project context and the main objectives

Europe must use water more efficiently to avoid the anticipated impacts of water shortage driven by a range of dynamics incl. climate change. On average, 12% of total water abstraction in the EU is used for industry and, of that, 20% is consumed and does not return to the original water body (EC, 2007; EEA, 2010).

In order to achieve such a complex socio-economic challenge, water needs to become part of the industrial process (integrated) and not an inexhaustible resource anymore.

Chemical industry is not only one of the major water consuming industries in Europe, but also a solution provider for materials, processes and technologies for water purification and recycling (CEFIC, 2011). Thus it is important that chemical industry plays a leading role in developing concepts for more sustainable water use as water is a critical element for increasing its competitiveness. Opportunities exist to offer innovative products and services to water providers and users who seek more efficient ways of using water. Chemical industry provides solutions not only for its own sector but also other industrial sectors: Within Europe and beyond on a global market.

The coordination action project ChemWater was a jointly envisioned strategy, developed out of the cooperation between the European Technology Platforms (ETP) SusChem and WssTP, addressing a key pan-European concern: the efficient management of water in process industry. The Networks of Excellence EMH, ENMIX and ERIC were key partners to design this strategy. The ChemWater project provided an opportunity to promote progressive science-based industry, foster a sustainable European supply industry, contributing to meet the water needs of society and having the potential to provide Europe with a leading position in the growing global NMP-Water market (NMP =Nanotechnologies, materials and process innovations).

A core rationale behind the project was to highlight the role of the European chemical and related process industries as solution providers within the context of the complex challenges of industrial and urban water management. An essential aim of the ChemWater project was to link process industry and water industry know-how to develop sustainable water solutions (Figure 1).

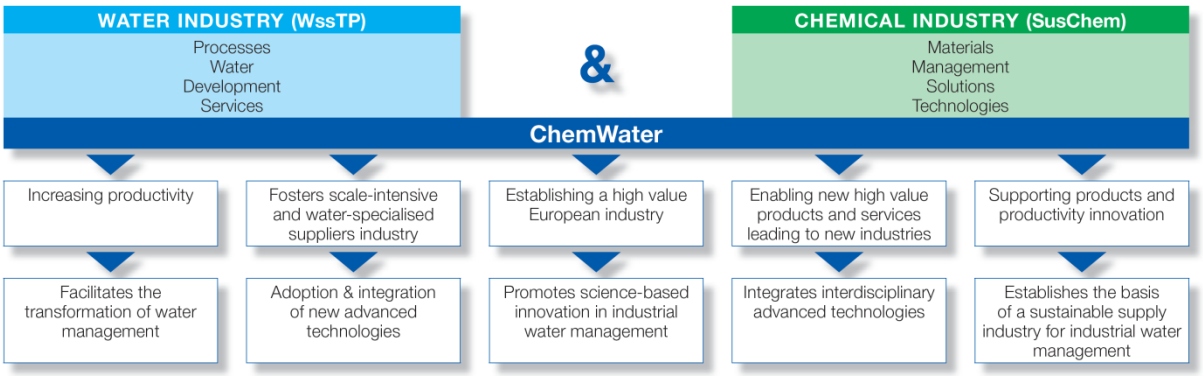

Figure 1: Contribution of the coordination action to high quality research

ChemWater's 11 European partners were drawn from research, industry and water utility communities and were working to develop a long-term strategy for sustainable industrial use of water in close coordination with existing initiatives and projects. A special focus was the exploitation of the technological potentials in the fields of nanotechnology, materials and process innovation.

OBJECTIVES

ChemWater aimed to define, coordinate and implement a joint interdisciplinary and cross-sectoral European strategy on Sustainable Materials, Processes and Emerging Technologies Development directly linked to enhance and optimize the industrial water management cycle across strategic European Technology Platforms and connecting also with existing initiatives coming from European, national and regional stakeholders.

The main objectives of the ChemWater project were focused on four fundamental lines in direct connection with the improvement of the industrial water management cycle:

- Establishing the interdisciplinary and cross-sectoral synergies between chemical processes and the water industry.
- Creating elements and mechanisms to facilitate the rapid uptake and commercialisation of enhanced materials, technologies and production processes for an optimized industrial water management.
- Developing a common long-term 2050 vision and strategy regarding technologies directed to realize an efficient industrial water management.
- Linking the ChemWater action lines with key European activities related to water.

WORKING STRATEGY

The workplan strategy of ChemWater was to base the overall aim on the following pillars:

- Cross-sectoral synergies between key stakeholders (i.e. ETPs, NoEs, ERA-NETs) drawing on knowledge from chemical processes and water technologies.
- A long term 2050 vision and strategy on technologies and process developments enabling efficient industrial water management that integrates across sectors disciplines and engages the necessary resources and relevant stakeholders.
- A Joint Implementation Action Plan addressing NMP research needs, skills needs, business development opportunities.
- Specification of those elements and mechanisms required to ensure the rapid uptake and commercialization of enhanced materials, and processes contributing to optimized industrial water management.

Establishment and implementation of an effective dissemination strategy to ensure the communication not only of the project objectives and action plans but also best practices, methodologies and common long term strategies.

3. Description of the main S&T results/foregrounds

The ChemWater working strategy led to the main results in ChemWater. A clear synergy potential between the chemical sector and the water sector on the way towards an integrated industrial water management was identified in the basic ChemWater analysis. The synergies were related to four priority areas: water quality, water quantity, water-energy nexus and non-technological issues. Based upon these initial results the endpoints for development routes towards a sustainable future use and treatment of water in industry were defined in the Vision 2050. The related actions needed to realize the vision are the heart of ChemWater's Joint Implementation Action Plan. This Action Plan directly addresses key European programmes and initiatives that have a relation to industrial water management. It was supported by proposals for strategies and measures to foster the implementation of new products and technologies. An effective dissemination strategy was established and implemented to ensure the communication not only of the project objectives and action plans but also best practices, methodologies and common long term strategies.

The main results gained in ChemWater are divided in the following subchapters:

- Identification of common and complementary elements and synergy fields of ETPs, NoEs and other initiatives– state of the art
- 2050 blueprint on materials, processes and technology challenges - Visioning 2050 on Water Sustainable Process Industry
- Programme of joint implementation activities– Joint Research and Development Roadmaps (JR&DR) and Joint Implementation Action Plan (JIAP)
- Development of strategies for measures to encourage commercialisation of products and services - Strategies and measures on enhancement of new products/technologies

3.1 Identification of common and complementary elements and synergy fields of ETPs, NoEs and other initiatives

INTODUCTION

For the emerging sector of cooperation between chemical process industry and water industry up to now innovation related activities are not coordinated. This results in overlaps and complementarities of strategies and actions.

To ensure a sustainable use and treatment of water by the chemical industry and beyond Chemwater identified and analysed potential synergies that needs to be developed between the chemical sector and the water sector. On a challenge-based approach, the contribution of sustainable materials, efficient processes and integrated/ symbiotic water management has been considered for the development of a ChemWater basis document.

A revision of the SRA's and IAP's of both, SusChem and WssTP Technology Platforms has been carried out incorporating also to the analysis the SusChem's position paper related to the EIP on Water. The SRA's of other ETP's: EuMat; Manufuture, ESTEP and SMR have been analysed. Water was not included among the priorities in the revised documents; however this situation has changed during the last years.

EMH has gathered the information related to water and sustainable chemistry from the Strategic and Business Research agenda of the Networks NanoMempro/EMH together with the contributions from ENMIX and ERIC, covering membranes, nanoporous materials and catalyst technologies related to water topics and their future improvements.

The coincidence in time with the launch of the European Innovation Partnership on Water has made reconsider the initial perspective and give a wider scope to the analysed aspects and try to align them with the main objectives of the partnership. The current situation of technologies and the described gaps together with other non-technological aspects

described in the present report should be considered as a valuable information source to the Strategic Implementation Plan of the EIP on Water.

The information was fed into the gap analysis and as basis for implementation actions and strategies.

CONCLUSIONS

- With the exception of SusChem, WssTP and SRM no other ETP among the ones included in the study, considered water as one of the priority topics in their SRA's or IAP's. This situation has dramatically changed in the recent years and sustainable water management has also become a priority for the other ETP's: Manufuture, EuMat and ESTEP.
- A 12% of the total water abstraction in Europe is used for industrial purposes, a more efficient and sustainable water management will have a positive impact, reducing the competition among the different water users through the implementation of the "Symbiotic approach".
- Waste water: a new concept. It should be considered as a source of water, valuable materials and energy.
- The integration of the Industrial, Urban and Rural water management will facilitate to exploit the synergies of the multiple efforts carried out in R&I and the dissemination of results.
- The new integrated water management approach proposed by SusChem and WssTP: recycling, reuse, more sustainable waste water treatments and alternative water resources, will be crucial in the development of a bio-based economy in Europe.
- Water-Energy resource: new solutions will allow the reduction in energy consumption for fresh water availability, distribution and waste water treatments. New ways of producing energy out of water treatments will be explored.
- The Enabling and Industrial Technologies: Advanced materials, Advanced manufacturing technologies, Nanotechnologies, Industrial biotechnology and Micro-nanoelectronic/ICT, will have a key role in supporting a more sustainable water management (e.g. nano-membranes)
- The WssTP task force on membranes for water treatment identifies the next process generation of hybrid membrane systems for water treatment and for low energy seawater desalination as key innovation areas.

3.2 2050 blueprint on materials, processes and technology challenges

INTRODUCTION

Next step in ChemWater was to sharp the focus: based on the state of the art findings, technology, methodology, and process gaps were identified and translated into demand challenges that need to be addressed by the implementation actions and strategies.

A 2050 blueprint on materials, processes and technology challenges was developed. It resulted in a long term 2050 vision and strategy on technologies and process developments enabling efficient industrial water management that integrates across sectors disciplines and engages the necessary resources and relevant stakeholders.

VISIONING 2050 ON WATER SUSTAINABLE PROCESS INDUSTRY

Three cross-sectoral workshops involving a broad range of stakeholders and experts were used to characterise the future of water use in the chemical industry. During the workshops, a vision was set and challenges and barriers to implement the vision were identified. Directions towards the solutions were given regarding **water quantity, water quality, energy and resources and non-technological challenges** such as **public awareness and education**. Over 50 participants were present in each of these events. Numerous industrial sectors were represented including the water, chemical, oil and gas, mineral resources, textiles, industrial biotechnology as well as research institutes and academia which together gave valuable contributions and outlined their vision for water in the process industry moving towards 2050.

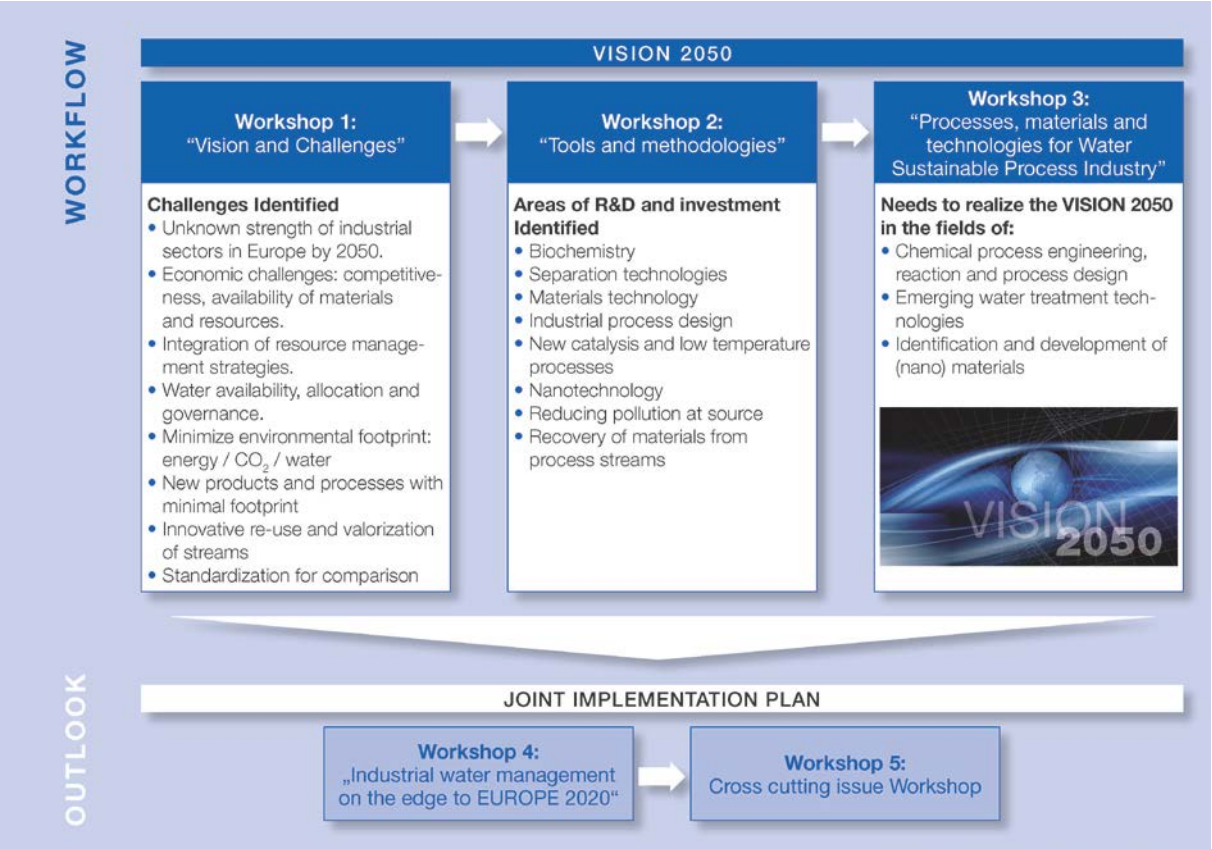

Figure 2: Overview of the workshops in ChemWater

One of the aims of the workshops was to identify regulatory, social, economic, and political drivers which are guiding the European chemical and related industries towards more sustainable water use.

The workshop debates highlighted the important role being played by regulation in setting the operating environment for water use in the chemical and related sectors. However, it was widely recognized that legislation and regulation are not capable of driving the sort of mind-set change that is required if innovative and integrated solutions are to be realized. Such fundamental change is a supra-regulatory issue with investment needed in education, solution demonstration, and innovation to achieve a permanent shift in attitudes towards water as a resource.

Main outcomes of the workshops and overall conclusions are:

- There is uncertainty about the relative strength of different industrial sectors in Europe by 2050 and thus in their water demand.
- Significant changes are likely in the availability of water as well as how it is governed and allocated.
- The water-energy nexus will be a decisive influence on process viability. There will be increasing pressure to minimize the total environmental footprint: energy / CO2 / water.
- New products and processes designed with minimal environmental impact will be preferred.
- Innovation is needed to improve re-use and valorization of water streams and materials out of them.
- Greater integration of resource management strategies - look ‘across the fence’- is necessary.
- The chemical sector could face significant economic challenges: competitiveness, availability of materials and resources at the right place and moment and many others.
- A standard approach is needed for evaluating process impacts based either on water footprint or LCA.
- Awareness and education with regard to water use and the role water plays in the wider economy will have to be raised.

OUTCOME: VISION 2050

Stakeholders in the chemical and water industry have developed a vision for the European Chemical Industry and aligned sectors regarding sustainable water management for 2050. The 10 vision points were created (shown in figure 3).

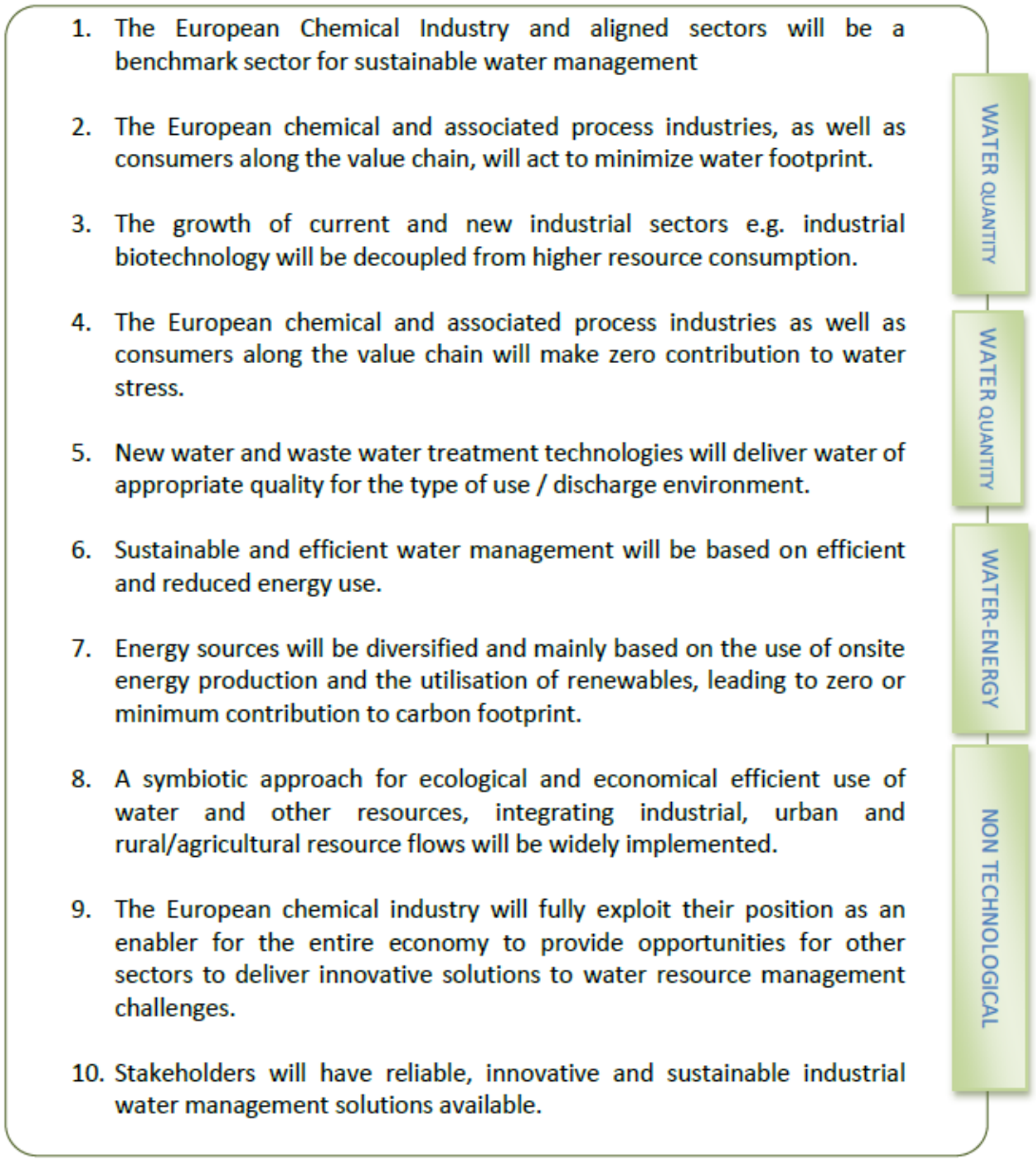

Figure 3: Vision 2050

It is important to set realistic targets for sustainable water management and the definition for 'sustainable' used here, is 'no adverse effect on the local area'. Cross -sector cooperation and Integrated Water Resources Management (IWRM) will play important roles in achieving this target. The potential benefits of IWRM relate to providing wider opportunities for water cascading between sectors and ensuring that the value of water is reflected in all its forms and qualities. The chemical industry is well positioned to not only take advantage of such catchment wide management processes but also to provide leadership. By reducing water use, resulting in a lower water footprint, making water with a quality that is fit for use, and by reducing its energy use, the chemical industry increases its competitiveness. By taking

leadership in multi stakeholder issues, the chemical industry will be able to better implement the vision and achieve cross-sector cooperation.

The principal challenges in Europe

Europe is facing a number of primary challenges; these include balancing demand with fresh water availability, ensuring the quality of all Europe's fresh water bodies, dealing with the effects of climate change, addressing the water-energy nexus, as well as ensuring the expansion of bio based industries without increased water consumption.

Drivers for change towards more sustainable water use

Members of the chemical and related industries have identified those regulatory, social, economic, and political drivers which are guiding the European chemical and related industries towards more sustainable water use. Regulation in setting the operating environment for water use in the chemical and related sectors plays an important role. However, it was widely recognised that legislation and regulation are not capable of driving the sort of mind-set change that is required if innovative and integrated solutions are to be realized. Such fundamental change is a supra-regulatory issue with investment needed in education, solution demonstration, and innovation to achieve a permanent shift in attitudes towards water as a resource. The Drivers promoting sustainable water use in the European chemical and related industries were identified (figure 4).

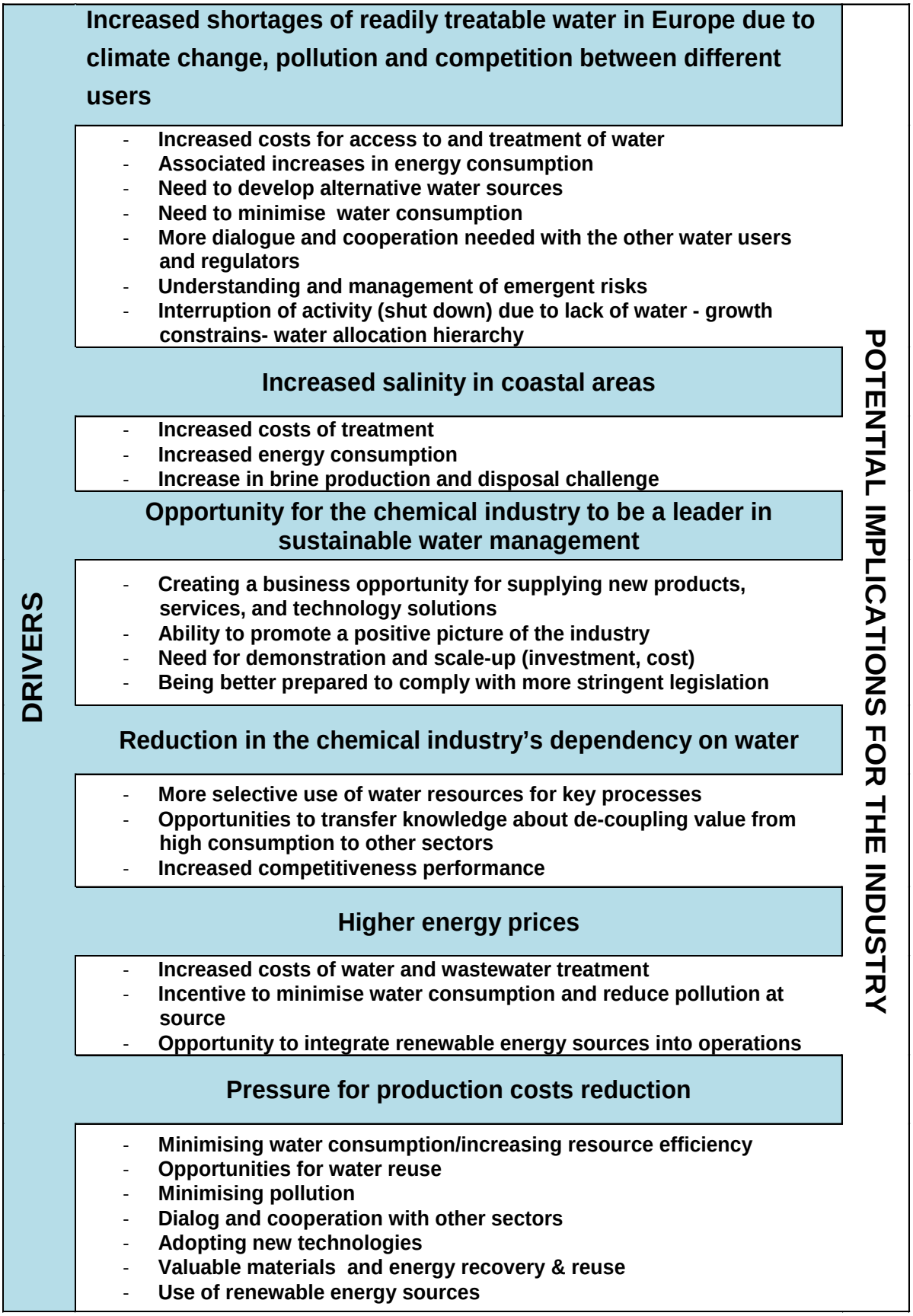

Figure 4: Drivers promoting sustainable water use in the European chemical and related industries

Directions for solutions

Directions for solutions to reach a more water sustainable chemical industry are given regarding water quantity, water quality, energy and resources and non-technological challenges.

Water quantity. Solutions regarding water quantity lie in reduce, reuse and recycle of water. A shift to (biotechnological) processes, using milder conditions with higher reaction rates is needed. The use of alternative water sources such as (treated, domestic of industrial) wastewater, rainwater or salt water is needed. This will require adaptation of current processes or equipment, being able to deal with the constituents in these waters. Also alternative cooling methods will have to be developed that use less water, such as dry cooling techniques. Reuse of water can also be reached by closer cooperation between the industrial sector and the urban and agricultural sector. The development of closed loop recycle and reuse processes and changes in processes and products will lead to reduction of water use. Gaining better insight in the processes at an industrial site will lead to a reduction in wastages and leakages of water.

Water quality. Solutions regarding water quality deal with the prevention of pollution of water and the treatment of polluted water with new or more intensified processes. This will result in the safe reuse of wastewater. Many technologies dealing with specific water quality problems have to be developed.

Energy and resources. There is a need for processes that use less energy and resources and that can use sources that are less stressful on the environment. Wastewater treatment processes have to be implemented that use less energy, or can even recover the energy that is in the wastewater. This can be both in the form of energy carriers such as methane, as well as reusing waste-heat. Wastewater treatment should also focus on the recovery of valuable resources, both organic and inorganic. Energy production is currently also a major water consuming industry, both for cooling and for the recovery of shale gas. The chemical industry can develop green chemicals in order make the use of water more sustainable, and should develop methods to treat wastewater that is released in the production of shale gas.

Non-technological challenges. To drive changes further and faster, also many non-technological challenges were identified. These involve political, legal and environmental drivers as well as drivers concerning education and public awareness. Industry can take the lead in raising public awareness about what it does to enable sustainable water use and about reuse of alternative water use. It can also take the lead in the cooperation with other sectors to implement reuse of water between sectors. There are already many regulations in Europe that focus on sustainable water use. Education is key in training qualified people in the chemical and water sector as well as in teaching the public about the way the chemical industry works.

Technologies that have to be developed can be in the field of membranes, nanomaterials and catalysis.

Both technological and non-technological challenges have to be solved to reach a more water sustainable chemical industry. Cooperation between stakeholders on a technological level as well as addressing public awareness will be key.

3.3 Programme of joint implementation activities

INTRODUCTION

For setting up the way forward in R&D a programme of joint implementation activities were developed - A Joint Implementation Action Plan addressing NMP research needs, skills needs, and business development opportunities.

The identification of cross-industry synergies was relevant for building a roadmap for technologies and process development requirements and constructing an action plan. At the same time, concepts for the rapid commercialization of innovations were formulated.

JOINT RESEARCH AND DEVELOPMENT ROADMAPS (JR&DR) ON WATER IN CHEMICAL PROCESS INDUSTRIES

Two Joint Research and Development Roadmaps (JR&DR) were developed during the ChemWater project:

1. **across ETP's:** based on the strategic documents of the ETPs (European Technology Platforms) SusChem (European Technology Platform for Sustainable Chemistry) and WssTP (European Water Platform)
2. **across NoE's:** based on the strategic documents of the NoEs (Networks of Excellence) EMH (European Membrane House), ERIC (European Research Institute of Catalysis) and ENMIX (European Nanoporous Materials Institute of Excellence)

The three ChemWater Visioning workshops ("Vision and Challenges", "Tools and Methodologies", "Processes, Materials and Technologies for Water Sustainable Process Industry") also provided a basis for the roadmaps.

The results of the two roadmaps were integrated into the Joint Implementation Action Plan (JIAP).

JOINT IMPLEMENTATION ACTION PLAN

ChemWater has brought together expertise across the European Technology Platforms SusChem and WssTP and the networks of excellence EMH, ENMIX and ERIC to elaborate this *Joint Implementation Action Plan – JIAP towards an integrated industrial water management*. It was supported by a wide range of experts from industry, research, authorities and organisations. The overall aim was to create synergies between chemical process and water industry while moving forward towards an integrated industrial water management.

The Joint Implementation Action Plan is dedicated to:

- Introduce the major action lines needed to move towards a sustainable integrated industrial water management
- Foster the link of these action lines to leading European initiatives, e.g. HORIZON2020, European Innovation Partnerships and Public Private Partnerships
- Contribute to the further programme development of these initiatives towards integrated industrial water management
- Strengthen synergies between chemical process industry and water industry in Europe
- Support Europe's leading role in driving innovation on integrated industrial water management in the global market

- Help transferring innovation into other process industry sectors, such as pharmaceutics, white biotechnology, raw materials, food and others

The ChemWater Vision 2050 for the European chemical industry and aligned process industry sectors was the basis for the JIAP framework and its action lines. The vision with its drivers and their potential implications for industry has set the objectives for integrated industrial water management in 2050 and was developed together with a wide range of stakeholders.

Further the JIAP describes cross cutting issues needed to bring innovation to the market and to foster the water – process industries interface.

The ChemWater action lines

- ***Alternative Water sources***

Alternative water sources are a key factor for reducing fresh water dependency of chemical process industry. They can be made available by cascade use, reuse, symbiotic cooperation and by storage concepts e.g. for rainwater. This includes cooperation of different water users across industries and cooperation with municipalities. Besides reliable, cost and energy efficient technologies that meet all demands of the different water providers and users, an integrated water management approach is needed to cope with the individual demands.

- ***Towards eco-efficient water loop closure***

Water loop closure, focusing on recycling and reuse of wastewater on a site is another concept to reduce fresh water consumption. Today a full water loop closure is in most cases neither ecologically nor economically viable. One of the major bottlenecks to increase the recycling and reuse rate in industry is the treatment and valorization or disposal of the concentrates. Actions have to be taken to reduce the dependency between loop closure, cost efforts and energy demand. For example novel concentrate treatment options reducing technology and energy efforts and opening up valorization options can help with this.

- ***Valorization of compounds and energy from (waste) water streams***

Industrial wastewater is source for compounds and energy. Selective separation of organic and inorganic compounds like raw materials or nutrients is a key issue. The challenge is to provide them in an appropriate, competitive quality that enables their reuse or follow-up use. Full utilization of carbon sources in wastewater for energy production still shows a significant potential for improvement. Low temperature (< 40°C) residual heat in industrial water streams is hardly used today but released in huge amounts. Here solutions for utilization have to be developed.

- ***Energy efficient industrial water management***

Energy costs and CO_2 emission are drivers to improve energy efficiency in industrial water management. To increase energy efficiency thermal aspects and energy consumption have to be considered. Linking process- and cooling water management or establishing a heat/cold management “across the fence” is an issue. Utilizing energy out of wastewater streams as indicated in the topic before can contribute to an increased efficiency as well. (Waste-) water treatment processes show a high potential to increase energy efficiency by moving stronger towards a dynamic performance management of treatment processes.

- ***Water and wastewater treatment technologies***

Improvement potentials in treatment technologies are manifold. They can contribute significantly to the action lines mentioned above. But as industrial water demands and wastewater composition are extremely heterogeneous the range of opportunities for action is

wide. Biotechnological approaches like anaerobic treatment are not fully utilized today. Separation and reaction technologies used in chemical industry have to be considered for future development of water and wastewater treatment technologies. Hybrid processes like combining photo catalysis and membrane techniques show a high potential for improving treatment performance.

- ***Advanced materials and surfaces***

Advanced materials and surfaces can significantly help to increase the performance and efficiency in industrial water treatment. Nanomaterials can play an important role here. Intelligent surfaces for example can help to reduce fouling and scaling in water systems. Advanced and multifunctional materials provide the potential to combination functions in treatment processes or enhance performance like adsorption capacity, selectivity or heat transfer. Catalytic materials can significantly reduce the energy demand for treatment processes while increasing process efficiency. Advanced materials might play an important role for increasing the efficiency in concentrate treatment. They are essential for more sensitive, faster sensors and monitoring systems.

- ***Monitoring and Control***

Improvements in monitoring and control are a basic need to increase performance of industrial water treatment systems. They are also required to move towards an eco-efficient, integrated industrial water management system. For example the range of parameters and applications for real time online sensors in water quality monitoring has to be extended. This will help to separate waste water into streams that support recycling and reuse. New sensors together with ICT tools are needed for a dynamic performance management of treatment processes. With this the performance of treatment technologies can be attuned to variations in incoming water qualities and quantities.

- ***New design of processes***

Rethinking the design of production processes in industry with regard to water use is challenging. The industry focus is on performance in production and less on water as a utility. Nevertheless reduced fresh water uptake, less wastewater to treat and fewer related energy use are ecological and economic incentives. To realize this action requires a closer cooperation between experts from reaction and process design and industrial water management. Action should be taken for example on reducing temperature levels for steam related production processes or on a more efficient water use in the production of bio-based chemicals.

- ***New and upcoming industrial developments***

Europe is moving towards a bio-based and resource efficient economy as key elements of the Europe 2020 strategy. Industrial biotechnology and biorefineries have a high demand on process water: Action has to be taken to accompany this industrial development with appropriate water treatment technologies and an eco-efficient, integrated industrial water management. Another area where resource efficiency initiates new developments is the raw materials sector. Water treatment and management is of importance for extraction, processing and recycling of raw materials. Action needs to be taken to transfer the technologies and expertise developed by the cooperation of chemical process industries and the water technology industries to new and upcoming industrial developments.

The ChemWater action lines are the heart of the JIAP. They provide specific actions and development tasks needed to strengthen the leading European initiatives and to come to a sustainable integrated industrial water management.

In the JIAP proposals for development routes were connected with related European programmes and initiatives.

3.4 Development of strategies for measures to encourage commercialisation of products and services

INTRODUCTION

ChemWater supported the realisation of innovations in the market by a set of measures. The elaboration of recommendations for market success factors provided the basis and link to the JIAP with its implementation actions. Standardisation with special care on cross sectoral cooperation to pave the way for innovation uptake was addressed. As regulation is a major driver in the ChemWater industry sector, an important way forward is tackling the uptake of innovation into BREF documents (e.g. on emerging technologies). Recommendations for policy tools linking to the Lead Market Initiative concept were arise. The results were integrated into the JIAP and fed into the dissemination activities.

STRATEGIES AND MEASURES ON ENHANCEMENT OF NEW PRODUCTS/ TECHNOLOGIES - BRINGING INNOVATION TO THE MARKET

To facilitate the transfer of innovations, in the field of Water for Chemistry and Chemistry for Water, into commercial products, technologies or concepts, well defined strategies and measures are needed.

From analysed cases (success stories and failures), common driving forces and barriers were derived that offer 'lessons learned' for future actions, strategies and measures:

- An improved awareness of the necessity for (local) action due to specific shortages in fresh water, energy, resources etc. stimulates companies towards more sustainable processes and products. Strong stimuli by means of information, legislation etc. remain important;
- Full insight into benefits of innovative cases is needed to define the real 'good business cases'. This implies that, besides the oversimplified approach of cost-benefit analysis, attention is needed for long-term benefits as e.g. a stronger market position due to improved image, LCA defined positive environmental issues etc.
- A clear view on the potential future market of a new innovative material or technology guarantees an early separation of the wheat from the chaff. An excellent network between Research and Industry provides a base in this and needs to be promoted. Such networks might define new opportunities and could facilitate the set-up of new (international) research projects. Open innovation and integrated thinking between companies and research centres needs to be stimulated.
- An early stage involvement of the future customers should orient research towards its final goal.
- Subsidies (EU or local) through research programs reduce financial risks and foster innovative developments. Access to financial support for the development of innovate techniques, especially for SME's, reduces the risk of technology uptake by multinationals and the potential risk of production transfers towards non-EU countries for their lower labour costs.
- A niche market approach can offer a step ahead of competitors. Patents may support in this and should be a feasible tool, as well for SMEs. It guarantees a certain income for a longer period when licensed to other parties.
- (Lack of) legislation sometimes stands in the way of innovation (e.g. discharge limits based on concentrations). Optimal solutions should be developed for such specific cases.

Next to that specific analyses were performed related to the role of standardization, BREF and policy aspects.

Standardisation is considered to bring forward developments and their application. But as instrument standardisation must not hinder innovation. Given the great variety of industries, technologies and processes considered in the project in which sustainable water management is consider in different ways, standardization constitutes a difficult task. First, the use of water by different sectors or industries is not comparable, what implies the need to establish reference values for the uses of water for each industrial typology. The actions to be taken in this line could be summarized as follows:

- Define the frame of application of the standards (sectors, companies, types of products, technologies, etc.)
- Define in each case what indicators most adequately represent the use of water. As stated above, the variety and complexity of the productions considered will require different assessment perspectives. In some cases, for example, it will be advisable to define use of water per unit of product produced; in others perhaps it is more relevant to assess the use of water per operation.
- Define interaction factors between indicators. This would enable to have a balance assessment of the water use.
- Establish the optimal/minimal water use in each case when possible.
- Ideally, devise, a mathematical formulation / algorithm to produce a figure that can be taken as a global water use indicator for an entity

Different standards that could be potentially linked to fiscal measures (proposed for sustainable water management) were analysed. Those fiscal measures are constituted by a programme of incentives that reward those companies committed with a sustainable use of water.

BAT documents (BREF) play an important role in setting high standards for the industry, but still feasible on a technical and economical level. The aim is as well to level these standards for the whole European Union, being a wide implementation area with industry at different levels of refinement. In conclusion, the BREF is not considered as an important innovation-stimulator. Other channels besides BREF might be more logic and efficient:

- The creation of ‘toolboxes’ that provide a path to follow and that will guide industry in the implementation of innovation.
- Stimulate national research centres in supporting local industry in their innovative developments.
- Get the introduction and description of innovative technologies into Wikipedia, known as an often first used data-source.
- Good oriented education, as a long-term approach to implement innovative new products, technologies, concepts etc.

A right **EU policy framework** is needed to support an improved cross-sector technology transfer, aiming at a more sustainable management of water by the chemical industry and beyond. Relevant policy tools could be standardisation, labelling, certification (link to European Water Stewardship (EWS) standard).

Under the wings of the European Policy Centre (EPC), being an independent, non-profit think tank committed to making European integration work, the Blue Gold Task Force was initiated. This Task Force will explore the water challenge in and outside the EU, the on-going efforts to tackle the challenge, as well as the related benefits. It will consider the role of internal and external EU policy instruments in the process as well as the challenges and benefits of developing a common EU water policy. Their key findings and recommendations

will be explained with the help of case studies and will be put into a comprehensive publication, to be distributed widely to European policy makers and key stakeholders.

Referring to the EPC Discussion Paper 'Risky Resources - Time to frame an EU approach to meeting the resource challenge'[1], with a specific focus on water, some first recommendations towards a more solid EU policy are listed:

- Change starts at home (internal actions):
  - promote eco-efficiency, which means doing more – or the same – with less. This can easily be applied on water as an important resource;
  - before putting new directives or regulations in place, ensure the implementation of existing policies on eco-efficiency (Water Framework Directive, European Innovation Partnership on Water etc.);
  - built an internal market for products and services that contribute to a greener economy. More cooperation is needed here between research, development, industry etc. in order to get products and services to markets, including innovative water treatment technologies. Via Life Cycle Analysis, the wider picture should be screened;
  - stimulate public and private investments;
  - important to build up and manage the knowledge on resource efficiency in order to grow stronger and provide a solid ground for further actions;
  - lead by example and convince non-European players of EU success story.
- Towards comprehensive, coherent and ambitious external action:
  - towards more EU inter-service cooperation, especially in policy planning on the external aspects of resource management. The involvement of the civil society, NGO's, think tanks, scientific and business sector etc. will be needed here;
  - develop a more holistic approach on European level and globally, and consider the needed instruments and financial resources;
  - aim at suggestions for policy guidelines on global resource management. Take the lead in this;
  - create a correct level playing field for eco-efficient products and services, which requires recognition and calculation of the true cost of using resources throughout their life cycle.
  - ake clear steps towards a more active role for EU in international cooperation;
  - lead by example, and demonstrate and promote the proven benefits of eco-efficiency.

A number of these recommendations are also relevant for tackling the water challenge in Europe and beyond. These recommendations, alongside the role of the EU, member states and industry, will be developed and discussed in more depth during the EPC's Task Force on Blue Gold.

[1] Annika Ahtonen and Andrea Frontini, September 2013; http://www.epc.eu/documents/uploads/pub_3740_risky_resources.pdf

4. Description of the potential impact (including the socio-economic impact and wider societal implications of the project so far) and the main dissemination activities and the exploitation of results

ChemWater linked the actions needed with EU programmes and initiatives to realize the ChemWater Vision 2050. The results are described in the Joint Implementation Action Plan (JIAP). Further actions and support for bringing innovation to the market were elaborated.

The ChemWater results were disseminated and exploited by traditional dissemination measures, and also by direct contribution to leading initiatives (e.g. EIP on Water, PPP SPIRE).

The most important results in creating the potential impact are described in this chapter.

Joint Implementation Action Plan (JIAP): Linking ChemWater Action Lines with European Programmes and Initiatives

Europe has set up a range of leading initiatives to foster innovation on water and on industrial development. In some of these initiatives the link between water and industry is well established in some the innovation potential through cooperation needs to be further developed. In the ChemWater JIAP the leading European initiatives are introduced and a matrix guides the user to the specific action lines of the JIAP relevant for the individual European initiatives and their components.

The ChemWater action lines are the heart of the JIAP. They provide specific actions and development tasks needed to strengthen the leading European initiatives and to come to a sustainable integrated industrial water management.

To approach the challenges, objectives and needs identified within the ChemWater Visioning 2050 process, a range of leading initiatives in Europe is active. They have a direct relation to the ChemWater topic “materials, processes and emerging technologies development in process industries and water industry”.

Objectives and needs identified within the Visioning 2050 process a range of ChemWater action lines were defined. In the Joint Implementation Action Plan proposals for development routes are connected with related European programmes and initiatives.

Horizon 2020

Horizon 2020 is the financial instrument implementing the Innovation Union, a Europe 2020 flagship initiative aimed at securing Europe's global competitiveness. It is the EU Framework Programme for Research and Innovation (2014-2020). Horizon 2020 supports an excellent science base, strengthens competitiveness by building industrial leadership in Europe and is tackling societal challenges for a better society. ChemWater provides input to the water related key enabling technologies for industrial leadership and for tackling societal challenges, as efficient use of resources.

EIP on Water

The European Innovation Partnership (EIP) on Water aims to boost opportunities for innovation in the water sector. It facilitates the development of innovative solutions and approaches that contribute to economic growth, solve societal challenges, create jobs and enhance Europe’s competitiveness. Within the EIP on Water eight priority areas have been chosen. For three of the eight priority areas ChemWater provides direct thematic input: Water reuse and recycling; Water and wastewater treatment, including recovery of resources; Water-energy nexus.

PPP SPIRE - Sustainable Process Industry through Resource and Energy Efficiency

SPIRE aims to develop enabling technologies and solutions for resource and energy efficiency in the process industries. The objective is to reach long term sustainability for Europe in terms of global competitiveness, ecology and employment. To achieve this SPIRE has defined two ambitions: reducing fossil energy intensity and reducing non-renewable, primary raw material intensity. ChemWater has identified development needs for a sustainable water management that fosters the SPIRE ambitions.

PPP BRIDGE - Biobased and Renewable Industries for Development and Growth in Europe

BRIDGE aims for a biobased economy by a transition towards a post-petroleum society while decoupling economic growth from resource depletion and environmental impact. In the heart of its vision BRIDGE is addressing biorefineries and an efficiency increase of industrial biotechnology. As water is essential and extensively used for biotechnological processes ChemWater has defined action fields that will help biobased industries to become more water efficient.

European Innovation Partnership on Raw Materials

The EIP has the overall target to reduce Europe's import dependency on the raw materials that are critical to Europe's industries. Besides a secure supply the EIP on Raw Materials aims to ensure and achieve efficient and sustainable management and use of non-energy materials along the entire value chain in Europe. Water plays an important role for extraction, processing and recycling of raw materials. The ChemWater action fields promote a knowledge transfer from chemical process to mining industries.

PPP Factory the Future

The Public Private Partnership aims towards an innovation-driven transformation of European manufacturing sectors. Environmental and economic sustainability of manufacturing, two of the main challenges, have a direct relation to ChemWater in terms of reduction in water use, cost efficient treatment and sustainable water management.

European Institute of Innovation and Technology (EIT) - Knowledge and Innovation Community (KIC)

A KIC is a highly integrated, creative and excellence-driven partnership which brings together the fields of education, technology, research, business and entrepreneurship. The objective is to produce new innovations and new innovation models. They will be key drivers of sustainable economic growth and competitiveness across Europe through world-leading innovation. The results of ChemWater and its partnerships provide the basis to develop a KIC on “water and chemistry”. These are two strategic domains in which Europe has today a leading position.

Table 1 shows the direct link of European Initiatives with the ChemWater Action Lines.

Table 1: Linking European Initiatives with the ChemWater Action Lines

	4.1 Alternative Water sources	4.2 Towards eco-efficient water loop closure	4.3 Valorization of compounds and energy from (waste) water streams	4.4 Energy efficient industrial water management	4.5 Water and wastewater treatment technologies	4.6 Advanced materials and surfaces	4.7 Monitoring and Control	4.8 New design of processes	4.9 New and upcoming industrial developments
Horizon 2020	✓	✓	✓	✓	✓	✓	✓	✓	✓
Industrial leadership – Key enabling technologies		✓	✓	✓	✓	✓	✓	✓	✓
ICT				✓			✓	✓	
Nanotechnologies				✓	✓	✓	✓	✓	
Advanced Materials and Technologies		✓	✓	✓	✓	✓	✓		
Biotechnology		✓	✓		✓		✓	✓	
Advanced Manufacturing and Processing					✓	✓	✓	✓	
Actions needed to address societal challenges		✓	✓	✓	✓	✓	✓	✓	✓
Sustainable and competitive bio-based industries	✓	✓	✓	✓	✓		✓		✓
Reducing energy consumption and carbon footprint through smart and sustainable use			✓	✓	✓		✓		
Unlock the potential of efficient and renewable heating-cooling systems			✓	✓					
New Knowledge and technologies		✓	✓	✓	✓			✓	
Climate action, resource efficiency and raw materials	✓	✓	✓	✓	✓	✓	✓	✓	✓
Promote the sustainable supply and use of raw materials, covering exploration, extraction, processing, recycling and recovery	✓	✓	✓	✓	✓	✓			
Strengthen eco-innovative technologies, processes, services and products and boost their market uptake		✓	✓	✓	✓	✓	✓	✓	✓
EIP on Water	✓	✓	✓	✓	✓	✓	✓	✓	✓
Water reuse and recycling		✓					✓		
Water and wastewater treatment, including recovery of resources	✓	✓	✓	✓	✓	✓	✓	✓	✓
Water-energy nexus	✓	✓	✓	✓			✓	✓	✓
Flood and drought risk management	✓	✓							
Ecosystem services	✓	✓							
Water governance	✓	✓	✓		✓				
Decision support systems and monitoring							✓		
Financing for innovation			✓						
Smart technology					✓	✓	✓	✓	✓

	4.1 Alternative Water sources	4.2 Towards eco-efficient water loop closure	4.3 Valorization of compounds and energy from (waste) water streams	4.4 Energy efficient industrial water management	4.5 Water and wastewater treatment technologies	4.6 Advanced materials and surfaces	4.7 Monitoring and Control	4.8 New design of processes	4.9 New and upcoming industrial developments
PPP SPIRE	✓	✓	✓	✓	✓	✓	✓	✓	✓
Key component Feed									
Optimal valorisation of waste, residue streams and recycled end-of-life materials as feed		✓	✓	✓	✓	✓	✓	✓	✓
Optimal and integrated (re) use of water	✓	✓	✓	✓	✓	✓	✓	✓	✓
Key Component Process									
New energy and resource management concepts (including industrial symbiosis)	✓	✓	✓	✓	✓	✓	✓	✓	✓
Key Component Applications									
New materials contributing to development of energy and resource efficient processes			✓	✓	✓	✓			
Key Component Waste2Resource									
Technologies for separation, extraction, sorting and harvesting of gaseous, liquids and solid waste streams		✓	✓		✓		✓	✓	✓
Technologies for (pre)treatment of process and waste streams (gaseous, liquids, solids) for re-use and recycling		✓	✓		✓		✓	✓	✓
Value chain collection and interaction, reuse and recycle schemes and business models		✓	✓		✓		✓		✓
Key Component HORIZONTAL									
Identification, benchmarking and crosssectorial transfer of good energy and resource efficiency solutions and practices	✓	✓	✓	✓				✓	✓
Develop skills and education programmes required for the development and deployment of novel energy and resource efficiency solutions and practices	✓	✓	✓	✓				✓	✓
Enhancing innovation and entrepreneurial skills and culture	✓							✓	✓
Key Component OUTREACH									
Analysis and establishment of efficient technology dissemination methodologies, mechanisms and frameworks	✓	✓	✓	✓				✓	✓
Develop social responsibility for the process industry	✓	✓							

	4.1 Alternative Water sources	4.2 Towards eco-efficient water loop closure	4.3 Valorization of compounds and energy from (waste) water streams	4.4 Energy efficient industrial water management	4.5 Water and wastewater treatment technologies	4.6 Advanced materials and surfaces	4.7 Monitoring and Control	4.8 New design of processes	4.9 New and upcoming industrial developments
PPP Bridge	✓	✓	✓	✓	✓	✓	✓	✓	✓
From lignocellulosic feedstock to advanced biofuels, biobased chemicals and biomaterials	✓	✓	✓	✓	✓	✓	✓	✓	✓
Emergence of new value chains from (organic) waste			✓	✓	✓			✓	✓
The integrated energy, pulp and chemicals biorefineries	✓	✓	✓	✓	✓	✓	✓	✓	✓
EIP on Raw Materials		✓	✓	✓	✓	✓	✓	✓	
Sustainable and safty supply									
Advanced pre-processing technologies		✓	✓	✓	✓	✓	✓	✓	
More efficient recycling/ recovery of mining waste		✓	✓	✓	✓	✓	✓	✓	
Reducing hazardous substances		✓	✓		✓	✓	✓	✓	
Collection, sorting and recycling			✓		✓				
PPP Factories of the Future		✓	✓	✓	✓			✓	✓
Advanced manufacturing processes			✓	✓	✓		✓	✓	
Adaptive and smart manufacturing systems			✓		✓		✓		
Digital, virtual and resource-efficient factories			✓		✓		✓		
EIT - KIC		✓	✓	✓	✓	✓	✓	✓	

Bringing innovation to the Market - Type of actions and expected impact

There is a clear importance in bringing together material, process and technology research from academia and industry. It opens new valorisation routes and enables a fast selection of promising ideas, narrowing the innovation funnel and a better targeting of the use of research money.

The demonstration of new concepts and technology trains should go hand in hand with the development of new materials, products and technologies. Currently, there seems to be a duality in the research projects and innovation routes. Projects aiming at a new material/product development usually have a 3-12 months demonstration period at the end of the project where the performance needs to be proven on a larger scale. The setting up of this demonstration phase is often based on a technology push and not linked to a technology need and actual industrial involvement. On the other hand, projects aiming at demonstration use mainly 'market ready' technologies since there is no time to start with product development and reach the longer term demonstration phase within one project.

Linked to Horizon2020, the creation of formats that support the setting up of a targeted link between projects focusing on Industrial leadership and the projects focusing on Societal challenges is considered to be crucial to enhance the uptake of new technologies to the market and create a win-win for both project types.

The launch of the Sustainable Development Flagship initiative on Water by CEFIC is considered as a good step forward to engage the private sector in the public debate. Within the chemical sector there is a general consensus that water balance needs to be the basis of sustainable water management. Assessing the water context and the impact of the operations on the water quality and quantity, as well as consulting stakeholders, are recommended next steps. The link between water and energy remains the main challenge.

Matrix presenting action plan on policy tools

Implementation of innovation is boosted, on the one hand by market needs, that is, the demand aspect and technological solutions offered, but on the other hand, there is a need of creating an atmosphere of confidence to invest in innovation in water (non-technology perspective). Bothe, technology and non-technology innovation could be fostered by policy measures.

The identified barriers for a wider implementation of innovative solutions have been grouped as: Economic; Market; Health & Safety issues; Policy/Regulatory/Governance; Socio-cultural; Others and Skills and education.

Concerning the "Policy tools" a selection of the ones considered more relevant for the scope of the ChemWater project, has been done. The proposed measures are expected to influence in a positive way the future landscape of water management in industry.

To succeed in the implementation of innovation in water, improvement of technologies is not the only solution Europe needs a new mindset and work in a coordinated way to capitalize on the synergies among different sectors and disciplines.

There is a strong competition and European industries need to look at all the resources and process if they want to be in leading positions.

A coordinated European policy will support the development of the required environment to boost investment in water technologies either at private and public levels.

Table 2: Policy tools and barriers to innovation

Barriers		PolicyTools								
		Policy/Regulation /Governance	European Standards-Quality	Public Procurement	Environmental Technology Verification Program	National/Regional policies	Financing (Prublic/Private)	EIP on Water	Eco-Innovation Action Plan	SET Plan low C economies
Economic	New technologies not competitive;									
	Prohibitive cost of new technologies									
	Potential for increased energy consumption									
	Increased operating costs (increased energy consumption, additional monitoring, etc.)									
	Prohibitive cost of removing pollutants;									
	cost of pilot lines and scale-up of new technologies									
	Insufficient investment in, poorly targeted, or poor quality R&D									
	Insufficient investment in required infrastructure									
	Prohibitive cost of the required infrastructure									
	Insufficient investment available;									
	Need for significant capital investment									
	Competition for investment with other sectors									
	Use & continuity of renewable energy supply									
	Lack of sufficient funding for R&D&I									
Market	Tailor made solutions (reduced market size)									
	Lack of effective routes to market for developed solutions									
	reuse of valuable materials									
	recovery/reuse of energy									
Health & Safety issues	Emerging health and safety issues and new risks									
	lack or water reuse application cirteria									
Policy/Regulatory/Governance	Licensing barriers to accessing new sources;									
	water reuse and recycling									
	Disposal or reuse of generated waste streams									
	Lack or harmonisation across EU									
	recovery/reuse valuable materials									
	Local or regional bureaucracy									
	Long lasting approval process for new products/technologies									
	Water as a valuable resource									
Socio-cultural	Public acceptance									
	Ineffective dialogue									
	Adoption of new practices slow									
Others	Geographical location prevents easy access									
	Competing R&D priorities within the sector;									
	Need for effective dialog with other sectors									
	Current infrastructure (pipelines)									
	Lack of trust – IP rights									
	Conflicts of interest between stakeholders;									
Skills & education	Lack of relevant skills and knowledge;									
	Competition for quality graduates with other sectors									

Expected positive impact

Dissemination and communication: Spreading excellence, exploiting results, disseminating knowledge

The aim in ChemWater was the establishment and implementation of an effective dissemination strategy to ensure the communication not only of the project objectives and action plans but also best practices, methodologies and common long term strategies.

Disseminating knowledge and communicating results

The **website** http://www.chemwater.eu has been started at the very beginning of the project. Since then it is up-dated weekly. On the public domain, everyone has access where general information about the project is given. Aim of this area is to make the community aware of the project and caught their attention and interest.

This website is an essential instrument which introduces the project in its integrative dimension particularly as regards other ETPs and NoEs. It reduces strongly duplication of information: this is one of the basis of integration. The website creates many knots, so as to be able to implement simultaneously and efficiently all the tools available with the different partner structures, at the service of the specific tasks which are tackled.

Continuation of the website after the end of the project (1 – 2 years) is given.

Three **newsletters** were produced to inform the outside scientific and professional community on the current progress and more recent advances of the project. They summarized synergy and complementarities. The newsletters were distributed by email and are available on the project website.

Two **brochures** have been prepared, one at the start of the project, one at the end. The first brochure presents the objectives, the tools and the actors. The brochure was used for communication during the workshops organised by ChemWater, during different important conferences and is furthermore available online on the project website.

The final brochure - a booklet summarizing the main finding andresults of the project – is available since the end of the project (October 2013). It will serve "as a key document" for communication with society, industrialists, institutions and various stakeholders.

In total **five workshops** have been held to integrate perspectives and needs from a wide range of stakeholders (figure 2). The workshops strongly fed into the development of the ChemWater Vision 2050 and the Joint Implementation Action Plan.

The **ChemWater final conference** was organized in combination with "ChemH_2O, ANQUE – DECHEMA Leading-edge Conference on Sustainable Water Management: Chemical Industry Setting the Pace". The conference was a platform to disseminate the ChemWater results. It brought together experts from different industry sectors - more than 100 participants were present. ChemWater was presented with 6 oral presentations.

The ChemWater results were disseminated and exploited also by direct **contribution to leading initiatives**:

- Contribution to **EIP on Water strategic Implementation Plan (2012**): Direct contribution to EIP document: "Diagnosis of Barriers and Bottlenecks for Innovation in the Water Sector" related to the eight priority areas and the one enabling factor in the Strategic Implementation Plan
- Contribution to the **PPP SPIRE Roadmap consultation (2013)**

Education and Training Actions

A successful and efficient integrated industrial water management is a strongly knowledge based challenge. The training of experts, scientists and practitioners form the water technology and process industry sector is a very important to spread knowledge and understanding on integrated industrial water management on both sides. This is especially true as they will deal in the future with the water / (chemical) production process interface.

To support the exploitation of on-going and future activities for a more efficient integrated industrial water management, three main recommendations were extracted:

1. For a paradigm shift

A key path to contribute to the penetration and consolidation of newly defined paradigms is to introduce them in training schemes from university to technical schools. The main limitation in new advances with technologies is due to a lack of education and to a poor expertise in related fields. Thus, a proper education of future professionals in the water and the (chemical) process industry sectors will be fundamental to shift the new paradigms: water for chemistry but also chemistry at the service of water; energy for water, but also water for energy; water as a highly valuable resource for the recovery of mass and energy.

To achieve this it is necessary:

- to emphasize the importance of water in achieving a sustainable production. The curricula of water and industry related studies are a general basis to promote a new philosophy all along the course of the studies. This is directly linked to the concept of “green engineering” and “process intensification”.
- to explicitly include or reinforce the water dimension into the contents of modules concerned with process engineering.

2. For a rational, holistic and multi-scale approach

A critical point in the development and adoption of technologies proposed in the Joint implementation Action Plan is to provide a multidisciplinary and holistic approach to students enrolled in chemical engineering and water related studies. Therefore a rational approach of mechanisms and processes associating water, chemicals and energy, is necessary at the expense of a simple list of objects and their respective advantages in conditions not always well defined. A efficient instruments supported by the EU are in some cases already available. For example already now a training is mandatory "to learn more about membrane technologies, what they represent today, the future challenges associated with these dominant technologies", making the best of the existing master (EM3E) and PhD (EUDIME) Erasmus Mundus supported by the EACEA agency. The same can be said in terms of catalysis, with SINCHEM the Erasmus Mundus PhD on catalysis. By practising this training, the students will be able to learn exactly the contribution of the various ingredients in the construction of intensified process, rather than being limited to the simple observation at laboratory of the alleged role of a given species. In general the final realization in industrial conditions asks much more than that.

3. For awareness rising

University degree studies on technical disciplines focus their training in already proven technologies, leaving emergent technologies for research in postgraduate schemes. In order to have the mindsets of engineers concerned with the chemical and the water industries receptive to the adoption of new technological realities, it would be advisable to start education in this field early, as soon as the graduation level. This is what is already done with the Erasmus Mundus on Membrane Engineering in the field of new membrane technologies.

The three sets of measures described above should be made concrete and proposed to the European Higher Education Area and transferred from it down to the Council of Universities at national level in order to adapt the curricula if the value of the measures is recognised.

Also in line with the objective to promote an interdisciplinary approach in educational programmes, it could be advisable to promote the creation of a new financing tool in the frame of Marie Curie actions to foster initiatives that explicitly involve the participation of several sectors.

There is a huge challenge that water and it integration in industry represent today for Europe. Following a proposal in scientific board session of the ChemWater project by representatives of industry, the creation of Knowledge and Innovation Community (KIC) around water (with the exception of Climate) and chemistry in the framework of the European Institute of Innovation and Technology (EIT) is considered as a good opportunity to move a step forward in facing this challenge.

Public website address as well as relevant contact details

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5. Use and dissemination of foreground

LIST OF SCIENTIFIC (PEER REVIEWED) PUBLICATIONS

Date of publication	Title / DOI	Main author	Title of the periodical or the series	Number, date or frequency	Publisher	Place of publication	Relevant pages	Is open access provided to this publication	Type
01.11.2011	Nanoporous materials for energy and the environment; http://dx.doi .org/10.1201/b11168	G.M.Rios, G.Centi, N. . Kanellopoulos	Materials Science	1	Springer Science and Business Media Deut schland GmbH	Singapore	300	Yes	Peer reviewed
02.05.2013	The influence of the Ti4+ location on the formation of self-assembl ed nanocomposit e systems based on TiO2 and Mg/Al LDHs with photocatalyti c properties; http://dx.doi .org/10.1016/j.apcatb.201 3.1032	E. Seftel, M. Mertens, P. Cool (partner UA, ENMIX)	Applied Catalysis B: Envi ronmental	Volumes 134–135	Elsevier		274-285	Yes	Peer reviewed
22.01.2013	Microvolume TOC analysis as useful tool in the evaluation of lab scale photocatalyti c processes; http://dx.doi .org/10.3390/catal3010074	M. Kus, S.Ribbens, V. Meynen, P. C ool (partner UA, ENMIX)	Atmosphere	3(1)	MDPI AG		74-87	Yes	Peer reviewed

LIST OF DISSEMINATION ACTIVITIES

Date	Type of activities	Main Leader	Title	Place	Type of audience	Size of audience	Countries addressed
01.03.2012	Organisation of Workshops	NEDERLANDSE ORGANISATIE V OOR TOEGEPAST NATUURWETEN SCHAPPELIJK ONDERZOEK - T NO	Water Sustainable Process industry: Vision 2050	Brussels, Belgium	Scientific comm unity (higher educat ion, Research)	50	Europe
01.03.2012	Oral presentation to a scientific event	EUROPEAN N ANOPOROUS MATERIALS INSTITUTE OF EX CELLENCE	Overview on nan otechnology and membranes for water applications?	Oberhausen, Ger many	Scientific comm unity (higher education, Research)	50	Europe
07.03.2012	Oral presentation to a scientific event	DECHEMA GE SELLSCHAFT FUER CHEM ISCHE TECHNIK UND BIOTECH NOLOGIE E.V.	Joint Research and Development Road map on Water in Chemical Process In dustries across ETP' s	Brussels, Belgium	Scientific comm unity (higher educat ion, Research) - Ind ustry	50	Europe
16.04.2012	Oral presentation to a scientific event	European Membra ne House	Diaporama on Ch emwater and Poster at the SusChem A nnual Meeting	Brussels, Belgium	Industry	150	Europe
24.04.2012	Oral presentation to a scientific event	EUROPEAN N ANOPOROUS MATERIALS INSTITUTE OF EX CELLENCE	Recent Advances in Nanotechnology-b ased Water Purifica tion Methods" (2 Diss. WS Nano 4Water Cluster)	Chalkidiki, Thessaloniki, Greece	Scientific comm unity (higher educat ion, Research)		Europe
06.05.2012	Oral presentation to a scientific event	EUROPEAN N ANOPOROUS MATERIALS INSTITUTE OF EX CELLENCE	International confer ence: Innovation for sustainable product ion 2012 (i-sup 2012)	Bruges, Belgium	Scientific comm unity (higher educat ion, Research)		European + outside Europe
06.05.2012	Oral presentation to a scientific event	EUROPEAN N ANOPOROUS MATERIALS INSTITUTE OF EX CELLENCE	Photocatalytic perfo rmance of mixed phase titanium-base d nanotubes and anatase nanosheets	Bruges, Belgium	Scientific comm unity (higher educat ion, Research) - Ind ustry		European + outside Europe
15.05.2012	Videos	European Membra ne House	Diaporama on Ch emwater, WSSTP & ACQUEAU Annual Meeting	Brussels, Belgium	Industry	150	Europa
15.05.2012	Posters	European Membrane House	Diaporama on Chemwater, WSSTP & ACQUEAU Annual Meeting	Brussels, Belgium	Industry	150	Europe
24.05.2012	Organisation of Workshops	NEDERLANDSE ORGANISATIE V OOR TOEGEPAST NATUURWETEN SCHAPPELIJK ONDERZOEK - T NO	Water Sustainable Process industry 2050: Methods and tools	Brussels, Belgium	Scientific comm unity (higher educat ion, Research) - Ind ustry	50	Europe
18.06.2012	Posters	European Membra ne House	Poster on Chem water	Aarhus, Denmark	Scientific comm unity (higher educat ion, Research)	500	Europa
18.06.2012	Oral presentation to a scientific event	European Membra ne House	Membrane techno logies in water indu stry: quo vamus?	Aarhus, Denmark	Scientific comm unity (higher educat ion, Research) - Ind ustry	500	Europe
19.06.2012	Oral presentation to a wider public	UNIVERSIDAD COMPLUTENSE D E MADRID	Chemwater Project description	Aarhus, Denmark	Scientific comm unity (higher educat ion, Research) - Ind ustry	500	Europa
27.06.2012	Oral presentation to a wider public	UNIVERSIDAD COMPLUTENSE D E MADRID	CHEMWATER, the Chemical and Water Sectors working together for a sust ainable water use	Seville, Spain	Scientific comm unity (higher educat ion, Research) - Ind ustry		World

31.07.2012	Web sites/Appli cations	European Membra ne House	http://chemwater.eu	http://chemwater.eu	Scientific comm unity (higher educat ion, Research) - Ind ustry - Civil society- Policy makers - Medias		World
31.07.2012	Flyers	DECHEMA GE SELLSCHAFT FUER CHEMISCHE TECHNIK UND BIOTECH NOLOGIE E.V.	ChemWater prese ntation to WssTp and SusChem steering group	Brussels, Belgium	Scientific comm unity (higher educat ion, Research) - Industry		Europe
05.09.2012	Organisation of Workshops	NEDERLANDSE ORGANISATIE V OOR TOEGEPAST NATUURWETEN SCHAPPELIJK ONDERZOEK - T NO	Reach the vision! Workshop on Mater ials, processes and technologies for a w ater sustainable pro	Brussels, Belgium	Scientific comm unity (higher educat ion, Research) - Ind ustry	50	Europe
05.09.2012	Oral presentation to a scientific event	European Membrane House	Membrane technol. in the perspective of ChemWater: unique and essential tools for a sustain. process	Brussels, Belgium	Scientific comm unity (higher educat ion, Research) - Ind ustry	50	Europe
05.09.2012	Oral presentation to a scientific event	UNIVERSIDAD COMPLUTENSE D E MADRID	Improved process sustainability by using solid heterogen. catalysts in water treatment technolo gies	Brussels, Belgium	Scientific comm unity (higher educat ion, Research) - Ind ustry	50	Europe
05.09.2012	Oral presentation to a scientific event	VEOLIA ENV IRONNEMENT RECHERCHE ET I NNOVATION SNC	“Water industry in 2 050: Water comp anies vision on chal lenges and tech nological needs”	Brussels, Belgium	Scientific comm unity (higher educat ion, Research) - Ind ustry	50	Europe
01.10.2012	Publication	DECHEMA GE SELLSCHAFT FUER CHEM ISCHE TECHNIK UND BIOTECH NOLOGIE E.V.	Commenting of the SPIRE Roadmap	web	Scientific community, Industry, Policy makers		World
12.11.2012	Oral presentation to a scientific event	DECHEMA GE SELLSCHAFT FUER CHEM ISCHE TECHNIK UND BIOTECH NOLOGIE E.V.	"Industrielle Wasser technik in Europa" - VDMA Congress	Frankfurt, Germany	Scientific comm unity (higher educat ion, Research)		Germany
12.11.2012	Publication	DECHEMA GE SELLSCHAFT FUER CHEM ISCHE TECHNIK UND BIOTECH NOLOGIE E.V.	"Industrielle Wasser technik in Europa" – Contribution to „VDMA Tagungsband“	Frankfurt, Germany	Scientific comm unity (higher educat ion, Research)		Germany
26.11.2012	Flyers	DECHEMA GE SELLSCHAFT FUER CHEM ISCHE TECHNIK UND BIOTECH NOLOGIE E.V.	Distribition on "EU Eco-Innovation conference"	Lissabon, Portugal	Scientific comm unity (higher educat ion, Research) - Ind ustry - Policy makers		Brussels, Belgium
20.02.2013	Flyers	DECHEMA GE SELLSCHAFT FUER CHEM ISCHE TECHNIK UND BIOTECH NOLOGIE E.V.	Distribition on "EIP on Water; WssT P/EWP SusChem m eeting"	Brussels, Belgium	Scientific comm unity (higher educat ion, Research) - Ind ustry		Europe
07.03.2013	Organisation of Workshops	EUROPEAN N ANOPOROUS MATERIALS INSTITUTE OF EX CELLENCE	Joint Research and Development Road map on Water in Chemical Process In dustries across NoEs	Brussels, Belgium	Scientific comm unity (higher education, Research)		Europe

07.03.2013	Organisation of Workshops	DECHEMA GE SELLSCHAFT FUER CHEM ISCHE TECHNIK UND BIOTECH NOLOGIE E.V.	"Industrial Water Management on the edge to HORIZON 2020"	Brussels, Belgiume	Scientific comm unity (higher educat ion, Research) - Ind ustry	50	European Countries
11.03.2013	Oral presentation to a scientific event	EUROPEAN N ANOPOROUS MATERIALS INSTITUTE OF EX CELLENCE	Chemistry of na nostructured zeolitic and titania-based materials for cataly tic and environm. ap plic.	Noordwijkerhout , the Netherlands	Scientific comm unity (higher educat ion, Research) - Ind ustry		Europe
17.04.2013	Oral presentation to a scientific event	European Membrane House	Chemwater : a partner of the cluster	Dresden, Germany	Scientific comm unity (higher educat ion, Research)	100	Europe
17.04.2013	Flyers	DECHEMA GE SELLSCHAFT FUER CHEM ISCHE TECHNIK UND BIOTECH NOLOGIE E.V.	Distribition on "Wss TP-COST confere nce - Water in the U rban Environment 2013"	Brussels, Belgium	Scientific comm unity (higher educat ion, Research) - Ind ustry		Europe
23.04.2013	Oral presentation to a wider public	DECHEMA GE SELLSCHAFT FUER CHEM ISCHE TECHNIK UND BIOTECH NOLOGIE E.V.	“Perspectives t owards eco-efficient management of water in European chemical industry”	Berlin, Germany	Scientific comm unity (higher educat ion, Research) - Ind ustry		Europe
13.05.2013	Oral presentation to a scientific event	DECHEMA GE SELLSCHAFT FUER CHEM ISCHE TECHNIK UND BIOTECH NOLOGIE E.V.	AchemAsia, CDA Satelite Symposia	Bejing, China	Scientific comm unity (higher educat ion, Research) - Ind ustry		World
15.05.2013	Oral presentation to a scientific event	DECHEMA GE SELLSCHAFT FUER CHEM ISCHE TECHNIK UND BIOTECH NOLOGIE E.V.	ChemWater - ove rview presentation S uschem Steakholder Meeting	Brussels, Belgium	Scientific comm unity (higher educat ion, Research) - Ind ustry - Policy makers	20	Europe
02.06.2013	Flyers	SUEZ ENVIR ONNEMENT SA	Chemwater Project Flyer - Distributed at the conference - 10th IWA Leading Edge Conference on Water and Wast e Water Technologies,	Bordeaux, France	Scientific comm unity (higher educat ion, Research) - Ind ustry	350	World
17.06.2013	Posters	European Membra ne House	ChemWater poster at EU meeting on I ndustrial Technologi es	Dublin, Ireand	Scientific comm unity (higher educat ion, Research) - Ind ustry	500	Europe
25.06.2013	Flyers	DECHEMA GE SELLSCHAFT FUER CHEM ISCHE TECHNIKUND BIOTECH NOLOGIE E.V.	Distribition on "Cef ic event on sustaina ble water manag ement"	Brussels, Belgium	Scientific comm unity (higher educat ion, Research) - Ind ustry - Policymakers		Europe
25.06.2013	Posters	DECHEMA GE SELLSCHAFT FUER CHEM ISCHE TECHNIK UND BIOTECH NOLOGIE E.V.	ChemWater Poster on "Cefic event on sustainable water m anagement"	Brussels, Belgium	Scientific comm unity (higher educat ion, Research) - Ind ustry - Policy makers		Europe
07.07.2013	Oral presentation to a scientific event	European Membra ne House	A session specifical ly dedicated to EU p rojects A presentati on of Chemwater	Porto, Portugal	Scientific comm unity (higher educat ion, Research)	200	world
02.09.2013	Oral presentation to a wider public	DECHEMA GE SELLSCHAFT FUER CHEM ISCHE TECHNIK UND BIOTECH NOLOGIE E.V.	Presentation Chemwater - Perspectives towards Eco-efficient Manag ement of Water in European Chemical	World Water Week, Stockholm, S weden	Scientific comm unity (higher educat ion, Research) - Ind ustry - Policy makers -	1000	World

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02.09.2013	Organisation of Workshops	DECHEMA GE SELLSCHAFT FUER CHEM ISCHE TECHNIK UND BIOTECH NOLOGIE E.V.	Cooperation to Prevent Harmful Chemicals in the Wa ter Cycle	Stockholm, Sweden	Scientific comm unity (higher educat ion, Research) - Ind ustry - Policy makers	1000	World
09.09.2013	Oral presentation to a scientific event	EUROPEAN N ANOPOROUS MATERIALS INSTITUTE OF EX CELLENCE	Synthesis and cataly tic activation of na noporous materials'	Kavala, Greece	Scientific comm unity (higher educat ion, Research)		Europe
25.09.2013	Oral presentation to a scientific event	EUROPEAN N ANOPOROUS MATERIALS INSTITUTE OF EX CELLENCE	Nanostructured assemblies of C eO2-ZnTiLDH and the derived mixed o xides as novel photo catalysts for p	Portoroz, Slovenia	Scientific comm unity (higher educat ion, Research) - Ind ustry		European + outside Europe
01.10.2013	Publication	CEFIC	Direct contribution to EIP document: "Diagnosis of Barriers and Bottlenecks for Innovation in the Water Sector" related to the eight priority areas and the one enabling factor in the Strategic Implementation Plan	web	Scientific community, Industry, Policy makers		World
01.10.2013	Organisation of Conference	VEOLIA ENV IRONNEMENT RECHERCHE ET I NNOVATION SNC	CHEMH2O 2013 Conference, Advan ced Catalysts and na no-materials for Ind ustrial Waste Water Treatment	Madrid, Spain	Scientific comm unity (higher educat ion, Research) - Ind ustry - Policy makers	100	Europe
01.10.2013	Organisation of Conference	DECHEMA GE SELLSCHAFT FUER CHEM ISCHE TECHNIK UND BIOTECH NOLOGIE E.V.	ChemWater Final Conference together with "ChemH2O 2013	Madrid, Spain	Scientific comm unity (higher educat ion, Research) - Ind ustry - Policy makers	120	Europe
01.10.2013	Oral presentation to a scientific event	European Membrane House	Advanced Catalysts and Nanomaterials for Industrial Water Treatment	Madrid, Spain	Scientific comm unity (higher educat ion, Research) - Ind ustry	100	Europe
01.10.2013	Organisation of Conference	UNIVERSIDAD COMPLUTENSE D E MADRID	Advanced Catalysts and nanomaterials for Industrial Waste Water Treatment	Madrid, Spain	Scientific comm unity (higher educat ion, Research) - Ind ustry - Policy makers	100	Europe
01.10.2013	Oral presentation to a scientific event	UNIVERSIDAD COMPLUTENSE D E MADRID	Chemical Industry Setting the Pace	Madrid, Spain	Scientific comm unity (higher educat ion, Research) - Ind ustry - Policy makers	100	Europe
01.10.2013	Oral presentation to a scientific event	European Membrane House	High tech industrial applications of mem branes	Madrid, Spain	Scientific comm unity (higher educat ion, Research) - Ind ustry - Policy makers	100	Europe
01.10.2013	Oral presentation to a scientific event	European Research Institute of Catalysis A.I.S.B.L.	The future prospects of catalysts in water treatment	Madrid, Spain	Scientific comm unity (higher educat ion, Research) - Ind ustry - Policy makers	100	Europe

01.10.2013	Oral presentation to a scientific event	DECHEMA GE SELLSCHAFT FUER CHEM ISCHE TECHNIK UND BIOTECH NOLOGIE E.V.	2050 ChemWater Scenario	Madrid, Spain	Scientific comm unity (higher educat ion, Research) - Ind ustry - Policy makers	100	Europe
01.11.13	Publication	DECHEMA GE SELLSCHAFT FUER CHEM ISCHE TECHNIK UND BIOTECH NOLOGIE E.V.	Wasserkooperationen: Bildung neuer Partnerschaften	Energie, Wasser-Praxis 11	Scientific comm unity (higher education, Research) - Industry		Germany