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and Water Industry across Technology Platforms

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VISION 2050

1. INTRODUCTION

The European's Commission's 'Roadmap to a resource efficient Europe' (EC, 2011) includes a strong vision statement describing the EU economy in 2050 as competitive, inclusive and providing a high standard of living with much fewer environmental impacts. This vision anticipates that all resources will be sustainably managed, climate change milestones will be reached and biodiversity and ecosystems protected and substantially restored. Water is a vital component of any resource efficiency initiative and the EC vision recognises this, emphasising the synergistic relationships between water and significant industrial sectors such as manufacturing, food production and the chemical industry. The chemical industry is one of the major water consuming industries in Europe as well as a solution provider for materials, processes and technologies for water purification and recycling (CEFIC, 2011). 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). It is important that the chemical industry plays a principal role in developing more sustainable water use as water is a critical element for increasing its competitiveness. Opportunities also exist for the chemical industry to offer innovative products and services to water providers and users who seek more efficient ways of using water. In both of its roles, as a user as well as solutions provider, the chemical industry should play a leading role.

This report provides a basis for the of delivery a 2050 blueprint on materials, processes and technology challenges of sustainable water management in the European chemical industry and aligned sectors where chemistry plays an important role. It is important to set a realistic vision of targets and this report is based on the information gathered during a series of workshops. The results of the workshops are used here to set up a vision of sustainable water use in the process industry by 2050.

1.1 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 bioprocess based industries without increased water consumption.

One of the main objectives was to identify main challenges which the European chemical and related industries will face in relation to sustainable water use and these are highlighted in table 1. These challenges are further detailed in Section 4.

Table 1: Summary of identified challenges (C) and opportunities (O) for EU chemical and related industries to 2050

Water quantity
Limited access to water sources of sufficient quantity (C) Minimisation of water consumption and increase of resource efficiency (C) Lowering the Water Footprint of industrial products as well as the customers' Water Footprint (C) Deliver a more water sustainable industrial biotechnology (C)
Water quality
Limited access to water sources of sufficient quality (C) Minimise pollution (C) Foster sustainable and competitive innovation Increased demand for right water quality for the right use from industry (C) Decrease of available high quality water for industrial applications (C)
Energy and resources
Develop low(er) energy water treatment processes (C) Addressing the water-energy interconnection (C) Make more effective use of industrial water effluents and water produced by the oil and gas industries and other industries (O) Recovery of valuable materials from water that can be used in other processes and industries (O) Develop water treatment processes producing energy and improve energy recovery
Non-technological
Fully exploit the opportunities arising through the industry's strategic position as an enabler for the entire economy (O) Decouple economic growth from resources, (higher) consumption and environmental impacts (C) Achieve wider sectorial integration and cooperation (O) Ensure that advances and benefits are maintained - 'Sustain the gain' (C) Foster quality innovation (C) Achieve wider sectorial integration and cooperation (C) 'Sustain the gain' Anticipate and respond to more stringent legislation (C) Develop new environmental impact assessment tools (C) Establish viable metrics for water sustainability (C) Increase social awareness of water issues (C) Respond to more specific product demand from other sectors (C) Understand the appetite for risk in the sector as well as the risk sensitivity of interventions and innovations (C) Implement solutions using existing infrastructures (C) Convince stakeholders of the feasibility of innovative and sustainable water solutions (C)

1.2 SUSTAINABLE AND EFFICIENT WATER MANAGEMENT

It is important to set realistic targets for sustainable water management and the definition for 'sustainable' adopted during the first workshop was '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 in the context of the issues being addressed by

the ChemWater project relate primarily 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.

2. DRIVERS FOR CHANGE TOWARDS MORE SUSTAINABLE WATER USE

One of the aims of the workshops was to identify those regulatory, social, economic, and political drivers which are guiding the European chemical and related industries towards more sustainable water use. Table 2 summarises those drivers that were identified during workshop discussions and subsequently refined during post-workshop analysis. 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 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.

Table 2: Drivers promoting sustainable water use in the European chemical and related industries (Workshop 1 & 2, EEA (2012), CEFIC (2011), EC (2009), WSSTP (2005))

DRIVERS	POTENTIAL IMPLICATIONS FOR THE INDUSTRY
Increased shortages of readily treatable water in Europe due to climate change, pollution and competition between different users	- Increased costs for access to and treatment of water - Associated increases in energy consumption - Need to develop alternative water sources - Need to minimise water consumption - More dialogue and cooperation needed with the other water users and regulators - Understanding and management of emergent risks - Interruption of activity (shut down) due to lack of water - growth constrains- water allocation hierarchy
Increased salinity in coastal areas	- Increased costs of treatment - Increased energy consumption - Increase in brine production and disposal challenge
Opportunity for the chemical industry to be a leader in sustainable water management	- Creating a business opportunity for supplying new products, services, and technology solutions - Ability to promote a positive picture of the industry - Need for demonstration and scale-up (investment, cost) - Being better prepared to comply with more stringent legislation
Reduction in the chemical industry's dependency on water	- More selective use of water resources for key processes - Opportunities to transfer knowledge about de-coupling value from high consumption to other sectors - Increased competitiveness performance
Higher energy prices	- Increased costs of water and wastewater treatment - Incentive to minimise water consumption and reduce pollution at source - Opportunity to integrate renewable energy sources into operations
Pressure for production costs reduction	- Minimising water consumption/increasing resource efficiency - Opportunities for water reuse - Minimising pollution - Dialog and cooperation with other sectors - Adopting new technologies - Valuable materials and energy recovery & reuse - Use of renewable energy sources

3. THE FUTURE USE OF WATER IN THE CHEMICAL AND RELATED INDUSTRIES

The European Chemical Industry is an important catalyst for economic development and wealth but in order to regain its global strategic position, the industry is facing a number of challenges including new divisions of labour between developed and emerging countries, a drive for more sustainable raw material and energy use, combating climate change, an aging population, as well as the recent financial and economic crisis (EC, 2009). The European Technology Platform for Sustainable Chemistry (SusChem) summarised its vision for the chemical industry in 2025 (and beyond) as being a sector which is eco-efficient, competitive, based on technology leadership and innovation, mastering the molecular scale (in nanotechnology and biotechnology), and with a reputation for being reliable, safe and responsible (SusChem, n.d.).

Sustainable development will evidently be a key consideration in achieving the above objectives. In the sustainable development context, efficient water use is closely linked to efficient use of other resources such as energy, chemicals, materials and land (EAA, 2012). Water is no longer a cheap easily accessible resource but is at the same time becoming a key enabler for the industry (Shell, 2011). There are varying views on this rather contentious issue as for some, water is still relatively easy and cheap to source but this is highly dependent on geographical location. In water scarce regions water is quickly becoming a very valuable resource although this is not necessarily reflected in its price. The influence of water pricing and actions to ensure sustainable water management on profitability is a concern as companies implementing high capital cost schemes (e.g. water recycling) may be exposed to short term pressure on profits before the financial benefits of the scheme accrue. Conversely, re-negotiating the water use tariff linked to a change in a company's water consumption might potentially increase short term profitability. The cost of investment for water treatment should not be compared only to the cost of water but also to the cost of not having water and being dependent on external water sources. The future price of water will be an important influence on margins. There is a need to move to a more realistic assessment of the real cost and value of water and this transition needs to be addressed urgently. The price of water is very much determined through regulation and policy and a value/cost positioning model is needed to provide confidence about long term sustainable supply scenarios.

3.1 MAJOR TRENDS IN THE EUROPEAN CHEMICAL INDUSTRY TO 2050

The current five main sectors of the European chemical industry (petrochemicals, basic inorganics, polymers, specialities and consumer chemicals) are unlikely to undergo major changes by 2050. However, there will be a need for substantial investment in new infrastructure as well as continuing modernisation of existing capacity, supported by a highly skilled and qualified workforce of chemists and chemical engineers. There is also an urgent need to employ more renewable energy sources as well as develop new energy sources for power generation as a solution provider. Industrial biotechnology will be a major growth sector but, perhaps critically, water will become a limiting factor to growth.

A greater emphasis on efficient management through supply and value chains was identified as a feature of the coming decades leading to increased concern about ensuring that the supply chain is

delivering sustainability and sustainable water management. In this context, water may also become a reputational risk issue.

There is no doubt that the chemical industry as a whole will need to change with further integration necessary and collaboration and cooperation across different sectors. However, the chemical industry has a great opportunity here as it is well placed to act as a solution provider for a wide range of social and industrial problems.

3.2 GEOGRAPHICAL DISTRIBUTION & LEVEL OF INTEGRATION OF THE CHEMICAL INDUSTRY IN THE EU TO 2050

By 2050 there are likely to be fewer than the current 30 main geographical clusters within which complete supply chain integration will be achieved to maximise efficient use of resources and reduce chemical transportation. It is also envisaged that new technologies will be developed and maximally efficient use of resources will be customary. Cross-sectorial symbiosis will play a crucial role in the future of the biotechnology sector. Although integrated water management solutions (including water cascading and value / benefit trading) are seen as desirable interventions to ensure sustainable water use, there are a number of obstacles to industrial and other symbiosis schemes. The Kalundborg example is often used as an exemplary case study of industrial symbiosis but its success is proving challenging to replicate elsewhere.

3.3 THE ROLE OF SUSTAINABLE MANAGEMENT AND RESOURCE EFFICIENCY IN RETAINING THE GLOBAL POSITION AND COMPETITIVENESS OF THE CHEMICAL INDUSTRY IN EUROPE BY 2050

By 2050 the European chemical industry will have to be more competitive in order to regain its strategic importance with future economic growth decoupled from environmental impacts. This will require a high level of effective innovation and quality research leading to the development of new chemistry based solutions, materials and technologies and creating new business opportunities. A successful chemical industry could provide cross-cutting solutions throughout the value chain (EC, 2009). The chemical industry already employs innovative processes that reduce wastewater production as well as energy consumption and this sort of practice could be more widespread by 2050.

Responsible use of natural resources will play an increasingly important role in the industry and increased competition for renewable raw materials will be balanced by development of a stronger, less water intensive and sustainable bio-based economy. Thinking ‘outside the box’ could be essential to reduce the dependency on oil and gas and ensure sufficient renewable feedstock.

It is well recognised that the European chemical industry should be highly integrated along the product value chain in order to secure its competitive performance. Such integration will involve closer cooperation with other sectors, governing bodies and the general public with the industry needing to initiate and sustain open and constructive dialog with all stakeholders (SusChem, n.d.). The design and delivery of more sustainable processes and their optimisation will require significant capital investment and a reliable water supply at competitive cost, independent of seasonal effects.

3.4 PRIORITIES AND TRENDS IN INNOVATION AND R&D

There will be a need for more effective innovation and quality research and prompt uptake of innovation. It will be important for new developments, technologies and knowledge to be shared not only within the chemical and related industries but also with other sectors. Good practise guidelines should be developed regarding industrial symbiosis and these should be shared with other sectors.

The following list is a summary of the key areas for investment discussed during both workshops combined with the priorities previously identified (RSC, 2007):

- **Materials technology :** New effective coagulants with minimum solids production; advanced absorbents for emerging contaminants removal; materials for remote wireless water sensors; smart pipe for in-situ water treatment; self-healing pipes for leakage minimization; novel anti-corrosion and scale preventing chemicals and coatings; all chemical products to have an end-of-life solution (to be easily treatable/ readily biodegradable/ re-usable)
- **Reaction and process design:** New waterless processes and technologies; improve quantum efficiency of UV treatment; new UV processes to treat water in distribution pipes and sewers; connecting bio-catalysis with high temperature catalysis; continuous fermentation with low cost separation; heat integration and control; utilisation of low energy waste heat; new technologies for energy production, including reverse electrodialysis (RED)
- **Biotechnology**
- **Separation technologies:** Membrane technology; selectivity of separation technologies on product and by product phase; liquid-liquid membranes
- **Nanotechnology**
- **Utilisation of (RO and other type) brines**
- **Cascade use in industry – online quality monitoring**

3.5 MAJOR CHALLENGES FOR THE CHEMICAL INDUSTRY'S RELATIONSHIP WITH WATER TO 2050

Minimising water footprint:

It will be important for the European chemical industry to be less dependent on external fresh water sources in the future. This can be achieved through a range of interventions such as increasing recycling including recycled urban wastewater, closing water circuits, employing new, less water intensive or waterless technologies, using rainwater harvesting and storage where appropriate and using water qualities tailored to product and process demand.

Address water-energy relationships and interdependencies:

By 2050 sustainable and efficient water management should also mean lower energy consumption and the utilisation of renewables, leading to zero or minimum carbon footprint. It will be increasingly important to have a clear understanding of water use associated with different types of energy. To make desalination sustainable, renewables will have to be employed and the environmental impact of brines produced during this process will have to be minimized. These types of initiative can be very complex as the water related drawbacks of some renewables will have to be considered. Some examples of new technologies include using the difference in concentration gradients to produce

energy by reverse ED or reverse RO when low-enough resistant thin layer materials will be available (pilot plan already working in Norway).

New water and wastewater treatment technologies:

New technologies helping to utilise wastewater as a source of energy more efficiently will have to be adopted, including primary anaerobic wastewater treatment leading to more biogas production and the use of dry dewatered sludge as a fuel. New energy efficient solutions for inorganic contaminants will also have to be employed. To substantially reduce the pollution associated with chemical products, a treatment solution for all industrial products will be required and this should become a standard**.**

4. MAIN CHALLENGES AND OPPORTUNITIES FOR A VIABLE FUTURE EUROPEAN CHEMICAL INDUSTRY (IN THE CONTEXT OF WATER USE)

The main challenges and opportunities faced by the European chemical industry in the years to 2050 with potential response options as well as barriers to their implementation are summarized in Tables 3-6.

Table 3: Water quantity challenges and opportunities (Workshop 1, EEA (2012), Shell (2011), Cefic (2011))

Challenges/ opportunities	Response options	Barriers to implementation
Limited access to water sources of sufficient quantity	Develop more independent sources	Licensing barriers to accessing new sources; geographical location prevents easy access
	Develop new technology for water re-use	Lack of relevant skills and knowledge; competing R&D priorities within the sector; lack of sufficient funding for R&D; new technologies not adopted fast enough; new technologies not competitive; prohibitive cost of new technologies; lack of regulations / regulation constrains; potential for increased energy consumption
Minimisation of water consumption and increase of resource efficiency; lowering the Water Footprint of industrial products as well as the customers' Water Footprint	Employ integrated solutions	Emerging health and safety issues and new risks; insufficient investment in required infrastructure; lack of relevant skills and knowledge; increased operating costs (increased energy consumption, additional monitoring, etc.)
	Reuse municipal wastewater; reuse and recycle industrial wastewater	Arising health and safety issues and new risks; insufficient water quality; potential for increased energy consumption; need for effective dialog with other sectors; lack of relevant skills and knowledge; generation of more concentrated waste streams; public acceptance
	New, less water demanding, process design; e.g. waterless cooling systems	Insufficient investment in, poorly targeted, or poor quality R&D; lack of skills and knowledge; prohibitive cost of new technology or the required infrastructure; increased operating costs

Table 3- continuing: Water quantity challenges and opportunities (Workshop 1, EEA (2012), Shell (2011), Cefic (2011))

Challenges/ opportunities	Response options	Barriers to implementation
Minimisation of water consumption and increase of resource efficiency; lowering the Water Footprint of industrial products as well as the customers' Water Footprint	Improved wastewater treatment and management	Insufficient investment in, poorly targeted, or poor quality R&D; lack of relevant skills and knowledge; constantly decreasing detection limits and new emerging contaminants; potential for increased energy consumption and increased operating cost
Deliver a more water sustainable industrial biotechnology	Utilise produced water	Insufficient quality of produced water; emerging health and safety issues; need to manage new risks; prohibitive cost of effective treatment technologies; insufficient investment available; current infrastructure (pipelines)
	Develop new water-less technologies	Insufficient investment in or poor quality R&D; competing R&D priorities within the sector; lack of knowledge and skills; need for significant capital investment; managing new risks; slow adoption of and lack of trust in the new emerging processes

Table 4: Water quality challenges and opportunities (Workshop 1 & 2, EEA (2012), Shell (2011), Cefic (2011))

Challenges/ opportunities	Response options	Barriers to implementation
Limited access to water sources of sufficient quality	Develop more independent sources	Licensing barriers to accessing new sources; geographical location prevents easy access
	Develop new technology for water re-use	Lack of relevant skills and knowledge; competing R&D priorities within the sector; lack of sufficient funding for R&D; new technologies not adopted fast enough; new technologies not competitive; prohibitive cost of new technologies; lack of regulations / regulation constrains; potential for increased energy consumption; lack of incentives to boost water re-use
Minimise pollution (water quality challenge)	Provide water treatment solutions for industrial products (hormones, pesticides, etc.)	Insufficient investment in, poorly targeted, or poor quality R&D; lack of relevant skills and knowledge; prohibitive cost of removing pollutants; challenge of achieving multiple pollutant removal with fewer stages; constantly decreasing detection limits; lack of appropriate regulations; increased product cost
	Improve the removal of trace contaminants (metals, etc.)	Unavailability of new technologies; insufficient investment in, poorly targeted, or poor quality R&D; lack of relevant skills and knowledge; potential for increased energy consumption

Table 4 - continuing: Water quality challenges and opportunities (Workshop 1 & 2, EEA (2012), Shell (2011), Cefic (2011))

Challenges/ opportunities	Response options	Barriers to implementation
Minimise pollution (water quality challenge)	Contributing better performing and efficient technologies	Unavailability of new technologies; insufficient investment in, poorly targeted, or poor quality R&D Lack of relevant skills and knowledge; regulatory regime in Europe
	Develop new wastewater treatment technologies	Insufficient investment in, poorly targeted, or poor quality R&D; lack of relevant skills and knowledge; potential for increased energy consumption and increased operating costs; necessary investment in a new infrastructure; constantly emerging new pollutants
	Removal of particulate matter, harmful dissolved components and salt	Disposal or reuse of generated waste streams; emerging health and safety issues; new risks; increase in operating costs, energy consumption
	Reduce pollution at source	Unavailability of new technologies; insufficient investment in, poorly targeted, or poor quality R&D; infrastructure: need for investment of difficulties for adaptation; lack of relevant skills and knowledge; potential for increased energy consumption; adoption of new practices slow; lack of regulations
Foster sustainable and competitive innovation	Improve quality in R&D	Lack of skills and knowledge; competition from other sectors for resources and funding; competing R&D priorities within the sector; cost of pilot lines and scale-up of new technologies; lack of effective routes to market for developed solutions
	Attract quality graduates into the sector	Competition for quality graduates with other sectors
	Lobby for wider government support for critical R&D	Competition for investment with other sectors ; long lasting approval process for new products/technologies
	Find incentives for cooperation with various stakeholders (win-win situations)	Lack of trust – IP rights; ineffective dialogue; conflicts of interest between stakeholders; local or regional bureaucracy
Increased demand for right water quality for the right use from industry	Develop new more efficient wastewater treatment technologies	Insufficient investment in R&D; lack of knowledge and skills; potential for increased energy consumption

Table 5: Energy and resources connected challenges and opportunities (Workshop 1, EEA (2012), Shell (2011), Cefic (2011))

Challenges/ opportunities	Response options	Barriers to implementation
Addressing the water-energy interconnection	Integrate renewable energy sources into operation	Geographical location; insufficient infrastructure investment; lack of skills and knowledge; continuity of renewable energy supply; storage systems
	Minimise fresh water consumption; implementing the "symbiotic approach" integration of industrial-urban and rural areas	Arising health and safety issues; new risks; insufficient infrastructure investments; potential for increased energy consumption; lack of skills and knowledge; need for dialog with other sectors; insufficient investment in, poorly targeted, or poor quality R&D
Make more effective use of industrial water effluents and water produced by oil and gas industries and other industries	Upgrading water for agricultural (non-food) and domestic purposes	Negative public perception of using industrial WW water produced in oil exploration; arising health and safety issues; new risks
	Internal water re-use	Arising health and safety issues; potential for increased energy consumption; lack of skills and knowledge; lack of efficient wastewater treatment technologies; cost and return of investments
Recovery of valuable materials from water that can be used in other processes and industries	Develop new technologies	Insufficient investment in, poorly targeted, or poor quality; R&D lack of skills and knowledge; potential for increased energy consumption; Lack of highly productive recovery technologies (cost competitive)
	Cross sectorial cooperation	Lack of trust; inefficient dialogue; conflict of interest; bureaucracy; non-competitive (cost, quality, quantity) production of secondary raw materials

Table 6: Non-technological challenges and opportunities (Workshop 1 & 2, EEA (2012), Shell (2011), EC (2009), SusChem n.d.)

Challenges/ opportunities	Response options	Barriers to implementation
Fully exploit the opportunities arising through the industry's strategic position as an enabler for the entire economy	Continue developing new products, materials and technologies that will support other sectors and help the other sectors to be more water efficient and sustainable	Insufficient investment in, poorly targeted, or poor quality R&D ; key innovation developments not taken up quickly enough, innovation networks don't share new knowledge effectively; lack of relevant skills and knowledge; competing R&D priorities within the sector
	Increased dialog with other sectors to enable the chemical industry to target specific needs and gaps in the market	Lack of trust between stakeholders; ineffective dialogue; lengthy and time consuming process
Decouple economic growth from resources, (higher) consumption and environmental impacts	Introduction of new working practises	Emerging health and safety issues; new risks; slow adoption of new practises; staff re-training and development of new skills; prohibitive costs of new infrastructure; might lead to higher level of reorganisation

Table 6 - continuing: Non-technical challenges and opportunities (Workshop 1 & 2, EEA (2012), Shell (2011), EC (2009), SusChem n.d.)

Challenges/ opportunities	Response options	Barriers to implementation
Decouple economic growth from resources, (higher) consumption and environmental impacts	Innovation and quality research	Insufficient investment in, poorly targeted, or poor quality R&D; competing R&D priorities within sector; key innovation developments not be taken up quickly enough, innovation networks don't share new knowledge effectively; lack of relevant skills and knowledge
Achieve wider sectorial integration and cooperation	Engage external stakeholders on a local level	Lack of trust and bureaucracy; conflict of interest; unavailability of new materials, technologies and processes
	Collaborate across the whole value chain	Bureaucracy and inefficient dialogue; time consuming and lengthy process; geographical location and proximity
	Contribute new solutions for other sectors (drought resistant seeds; more efficient fertilisers; new irrigation materials and technologies, etc.)	Lack of skills and knowledge; insufficient investment in, poorly targeted, or poor quality R&D; ineffective and prolonged routes to market for new products; prohibitive cost of new products
	Employ integrated solutions within a symbiotic approach	Arising health and safety issues; new risks; geographical distance; need to benefit to all stakeholders involved; lack of trust or desire to cooperate
'Sustain the gain'	Sustained investment in R&D, new technologies and infrastructure	Lack of relevant skills and knowledge; insufficient investment available throughout the value chain; lack of new financing mechanisms
	Risk management of increased vulnerability	Lack of relevant skill and knowledge; increased costs
Anticipate and respond to more stringent legislation	Develop new more efficient treatment technologies	Arising health and safety issues; new risks; insufficient infrastructure investments; increased costs and potential for increased energy consumption; long term approvals for new solutions (health concerns); lack of skills and knowledge; insufficient investment in, poorly targeted, or poor quality R&D
	Minimise fresh water consumption	Arising health and safety issues; need to manage new risks; increased operating costs and potential increase in energy consumption; need for effective dialog with other sectors Lack of relevant skills and knowledge and insufficient investment in R&D
Develop new environmental impact assessment tools	Collect local data on scarcity and availability of fresh water	Lack of data; lack of knowledge and skills
	Collect water footprint (WF) data, life cycle analysis (LCA) data of other relevant stakeholders	Stakeholders not willing to cooperate; lack of data
	Determine focus within the value chain	Need for effective dialog; conflicting priorities; bureaucracy

Table 6 - continuing: Non-technical challenges and opportunities (Workshop 1 & 2, EEA (2012), Shell (2011), EC (2009), SusChem n.d.)

Challenges/ opportunities	Response options	Barriers to implementation
Establish viable metrics for water sustainability	Cross sectorial cooperation	Lack of trust and real data; inefficient dialogue; conflict of interest; bureaucracy
Increase social awareness of water issues	Use water sustainability metrics on products	Lack of data or relevant skills; lack of regulations
	Minimise fresh water consumption	Arising health and safety issues; new risks; insufficient infrastructure investments; potential for increased energy consumption; lack of skills and knowledge; need for dialog with other sectors; insufficient investment in, poorly targeted, or poor quality R&D; insufficient or wrong messages to the citizens; lack of dissemination and communication campaigns
	Minimise pollution	Insufficient investment in, poorly targeted, or poor quality R&D; unavailability of new technologies; potential for increased energy consumption; lack of skills and knowledge
Respond to more specific product demand from other sectors	Stronger cross-sectorial cooperation Increase investment in R&D Develop new materials and technologies	Lack of trust; insufficient economic means to support required investments; potential for increased energy consumption; unavailability of required raw materials; lack of relevant skill and knowledge
Understand the appetite for risk in the sector as well as the risk sensitivity of interventions and innovations	New approached to minimise risks Increase cross sectorial communication Adopt new operational procedures and practices Increase awareness Increase resilience Incorporate back-up options	Lack of relevant skills and knowledge, lack of trust; bureaucracy; insufficient funds and investment; public acceptance
Implement solutions using existing infrastructure	New technologies using existing infrastructure Alternative solutions (tariff renegotiation)	Insufficient investment in R&D; insufficient innovation; resistance to change
Convince stakeholders of the feasibility of innovative and water sustainable solutions	Identify and set-up demosites Increase awareness of new technological development and the resulting benefits Education	Bureaucracy; lack of or ineffective communication; conflict of interest; competition for other investments

5. TECHNOLOGY DEVELOPMENT

The chemical industry's key position as a solution provider will enable the development of new processes and products informed by considerations of sustainability and whole value chain impacts. It will use existing technologies more effectively, increase their efficiency, and combine these in

innovative ways to create new solutions. By embracing the new market opportunities the EU chemical industry will increase its competitiveness.

Chemistry already provides established materials and technologies for the water industry and is also constantly seeking and developing new solutions. Table 7 highlights the areas where focus on novel and improved solutions should be towards 2050 in order to make future water use sustainable. More thorough technology development is captured in the further report (Deliverable D3.3).

Table 7: The role of chemistry in water related potential developments (RSC, 2007)

APPLICATION AREA	POTENTIAL FOR FUTURE DEVELOPMENT
Potable water treatment	
- New coagulants and technologies to reduce solids production - Technologies for coagulant recovery and reuse - Prevent formation of harmful by-products by ozone processes; make alternative UV processes more energy efficient and not forming other harmful by-products - New solution to prevent membrane fouling - Prevent formation of disinfection by-products, develop more energy efficient technologies	
Wastewater treatment	
- Efficient technologies for phosphorus and other valuable materials recovery - New sludge conditioning technologies and materials - Wastewater reuse - Oxidation technologies that can target specific compounds	
Industrial wastewater	
- Oxidation technologies that can target specific compounds - New materials, chemicals and technologies that are more efficient and can be easily degraded or re-used	
Water monitoring	
- New, more sensitive sensors deployable in the field; development of wireless sensor networks	

6. MAIN OUTCOMES OF THE WORKSHOP AND OVERALL CONCLUSIONS

1. There is uncertainty about the relative strength of different industrial sectors in Europe by 2050.
2. Significant changes are likely in the availability of water as well as how it is governed and allocated.
3. The water-energy nexus will be a decisive influence on process viability. There will be increasing pressure to minimize the total environmental footprint: energy / CO_2 / water.
4. New products and processes designed with minimal environmental impact will be preferred.
5. Innovation is needed to improve re-use and valorization of materials and water streams.
6. Greater integration of resource management strategies - look 'across the fence'- is necessary.

7. The chemical sector could face significant economic challenges: competitiveness, availability of materials and resources at the right place and moment and many others.
8. A standard approach is needed for evaluating process impacts based either on water footprint or LCA.
9. Awareness and education with regard to water use and the role water plays in the wider economy will have to be raised.
10. Harmonisation of the EU market requirements to simplify implementation of new technologies and shorten time to market.

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