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Roadmap Environmental Technologies 2020
Integrated Water Management

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Author: Nora Weinberger nora.weinberger@kit.edu
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Organizer: Institute for Technology Assessment and Systems Analysis (ITAS), Karlsruhe Institute of Technology (KIT)
Contacts: Armin Grunwald, ITAS, armin.grunwald@kit.edu; Jens Schippl, ITAS, jens.schippl@kit.edu
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Purpose

In the project "Roadmap 2020", funded by the German Federal Ministry of Education and Research, seven fields of environmental policy were investigated in order to explore to which extent research and development activities will be able to foster future environmental innovations. The purpose of the project was the identification of strategic options for research and development and their transfer into practice in the field of environmental technologies by 2020. The results were gained by literature and Internet research, an expert opinion survey and four workshops on different topics.

Technologies for the Environment

Global environmental problems such as climate change, limited access to clean water, decline in biodiversity or growing demand for raw materials put increasing pressure on socio-economic and political systems. Even if many of today's environmental problems are caused, directly or indirectly, by the application of technologies, at the same time, technologies have the potential to reduce these problems.

Fostering Environmental Innovation

Against this background, the project "Roadmap Environmental Technologies 2020" explores to which extent research and development activities will be able to foster future environmental innovations. The resulting recommendations will support the process of identifying strategic policy options for promoting developments and commercial applications in the field of environmental technologies.

Due to the duality of a research funding (Which environmental technologies require more knowledge and development?) and implementation in practice (What are the critical conditions under which existing knowledge and existing technologies are successfully put into practice?), the project aimed at a topical foresight as guidance for BMBF subsidies policy and the analysis of the practical implementation processes.

Qualitative Approach

The project comprised a complex process of acquiring, aggregating and evaluating expert knowledge from different origins. The knowledge was gained by literature and Internet research, an expert opinion survey and a number of expert workshops. Quality management and validation processes in terms of feed back loops were implemented in each step. In co-ordination with

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the contracting entity, the following seven fields of action were identified as of special importance to the public, to policy and to ongoing academic debates: climate protection, air pollution control, water management, soil conservation, protection of limited resources, waste management and biodiversity.

The above-mentioned classification defined the structure of the interim report about the current state of developments and applications. Based on this state-of-the-art report, hypotheses for further developments and critical aspects in each field of action were formulated. Focus was put on particularly interesting (individual) technologies and technology fields. For the purpose of the expert investigation, the seven fields of action were grouped into four theme complexes: A) water management, B) climate protection and air pollution control, C) soil conservation and biodiversity and D) enlargement of resource productivity and the recycling economy. The questionnaire was sent to 1,750 experts out of research, economy, policy and administration of which 440 answered. The preliminary results of the expert survey were used as a basis for four expert workshops. The aim of the workshops was a validation of the investigation results.

The following chapters focus on the "water management" results, which the experts identified as the biggest global challenge in this field of action.

Future Challenge: Integrated Water Management

Among the main future challenges are a sustainable supply of drinking and process water, the reduction of water contamination and the protection of hydrological cycles. Beneath the level of political, economical and institutional solutions, mainly technological innovation is needed to reach these goals. In the thematic field of water management, three strategies can be defined that require different technological approaches: 1) minimizing water consumption and maximizing water availability, 2) technologies for water treatment and 3) technologies for the preparation of water.

Based on the above-mentioned Internet and literature research, the project team chose 16 technologies or technology fields respectively, which are shown in Table 1, that were considered of major importance in coming to grips with the challenges of water management. It remains to be mentioned that the granularity of these technologies is quite different (from special processes over technology groups to paradigms).

Table 1: Resulting water technologies

Label	*Technology / technology field*
A01	Nutrient Regeneration Technologies
A02	Domestic Sewage Heat Recovery Technologies
A03	New Biotechnical Processes for Domestic Sewage Treatment with Anaerobic Technologies
A04	Technologies for the Elimination of Microcontaminations in Waste Water (e.g. drug residues and hormonally effective substances)
A05	Technologies and Processes for Retainment and Elimination of Nano Particles in Waste Water of Nano Technology Production Processes
A06	New Technical Approaches for Process Water Circulatory Management
A07	Chemical Independent Treatment Processes for the Drinking Water Production
A08	Membrane Development (sustainable resistance to biofilm vegetation, less susceptible)
A09	Technologies for System Supervising, Detection of Pipe Damages, Condition Evaluation and Redevelopment of Water Grids
A10	Technologies to Treat and Use Various Kinds of Contaminated Rain Water
A11	Technologies to Use Air Humidity
A12	Technologies for the Desalination of Sea and Brackish Water Using Renewable Energy
A13	Aquacultures with Simple and Robust Circulatory Technologies in Modular Process Plants
A14	Chemical Independent Treatment Technologies for Bulk Water from Ships
A15	Adequate Irrigation Systems based on Intelligent Control Systems ("precision irrigation")
A16	Technologies for the Improvement of the Water Storage Capacity of Soil (e.g. soil consumables)

Results

Hereafter, the results of the expert investigation of the above-mentioned 16 technologies were delineated acccording to their importance for water management.

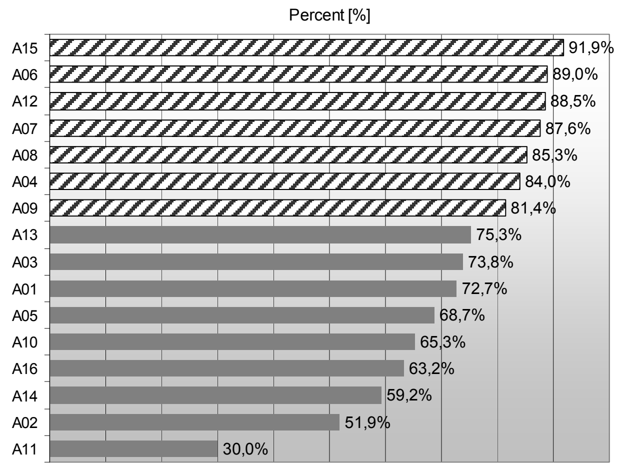

Figure 1: Ranking of water technologies according to their importance for addressing water management challenges.

Figure 1 gives an overview of the estimated importance of the 16 technologies for solving the water management problems. Adequate irrigation technologies (A15), circulatory process waters (A06) and the desalination of sea and brackish water (A12) are the "top three", whereas the technologies using air humidity are of minor interest.

During the workshop discussion, the experts explicitly indicated the high relevance of technologies for the elimination of microcontaminations in waste water (A04), which was already confirmed by the expert survey as shown in Figure 1 (84%). Apart from the technologies, a change from centralized to (semi-) decentralized water and waste water management systems was also discussed controversially. The experts pointed out that the (semi-) decentralized systems have to be combined with other systems like water intake, nutrient application, material flow, waste water and waste management.

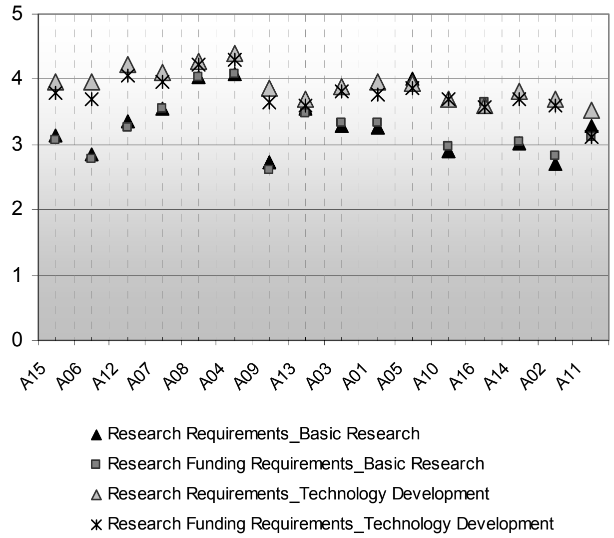

Figure 2: Research and Funding Requirements for Basic Research and Technology Development. Values are presented averaged on a scale from low (1) to high (5).

Figures 2 and 3 show the relationship between research and funding requirements in the fields of basic research, technology development, demonstration and marketing, on the one hand, and adaptation to the needs of emerging and developing countries, on the other. A tough correlation between research and funding requirements can be identified for all fields except for "demonstration and marketing". The close proximity of the ratings for research and funding requirements show that in fields with high research requirements funding requirements are also assessed as high. Mainly in the field of "technology development", the research requirements are quite high for all technologies whereas the research and funding requirements vary from technology to technology in the other fields. In general, the research and funding requirements for all technologies are ranked at least three or higher except for the adaptation to the needs of emerging and developing countries in case of (A05) "technologies and processes for retainment and elimination of nano particles in waste water of nano technology production processes".

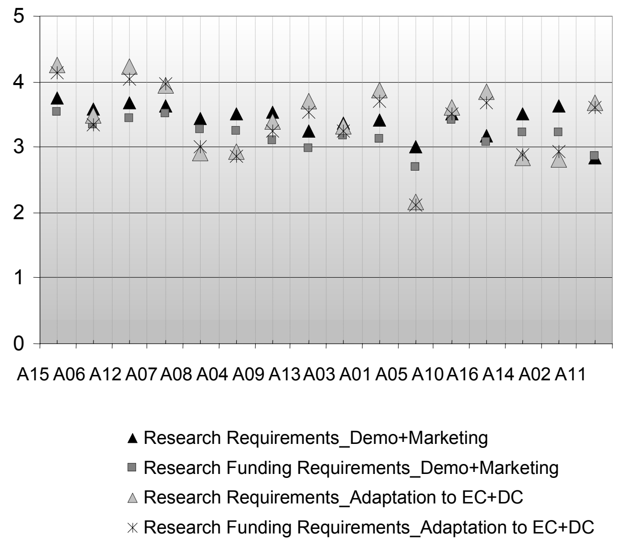

Figure 3: Estimated Research and Funding Requirements for Demonstration/Marketing and Adaptation to Emerging (EC) and Developing Countries (DC). Values are presented averaged on a scale from low (1) to high (5).

In order to identify the major constraints of a successful implementation of the investigated technologies, the experts had to choose between six constraints shown in Table 2. According to their assessment, "unsolved technical problems" and "insufficient prospects of economical success" are the main restricting factors. "Missing R&D capacities in small- and medium-sized enterprises" are also of great importance. Although the structure of the German water supply and sewage system is characterized by tough legal regulations, traditional duties (e.g. mandatory connection requirements and use constraints for grid-bound facilities) and heterogeneity of "counterproductive political regulations" were mentioned less than expected.

Table 2: Constraints in Germany

Constraint	*Percentage (of the experts)*
Counterproductive political regulations	14,3
Missing social acceptance	17,1
Unsolved technical problems	**50,9**
Missing R&D capacities in small- and medium-sized enterprises	**38,3**
Insufficient prospects of economical success	**46,2**
Insufficient networking of business and research	23,2

Need for Paradigm Shift

Concerning water management, the following conclusions resulted from the literature research as reported in the State-of-the-Art-Report (Schippl et al., 2008), the expert survey and the workshop.

The Implications of Demographic Change

Due to the demographic, social and climate change, a general revision of the traditional, rigid and gridlocked water management principles is needed. Demographic and migration-induced changes require a flexible and sustainable water supply and waste water management. The population numbers in many European and Japanese cities are declining, which means a decreasing settlement density and therefore a changing water demand. The low water demand in shrinking cities leads to an underutilisation of grids and components, which restricts their economical-technical efficiency. By contrast, the existing centralized systems of fast growing cities in Africa, Asia or Latin America cannot keep abreast with the explosive population growth and the uncontrolled urban development.

Climate change even accentuates this situation as the frequency of heavy rains accompanied by floods and the duration and intensity of drought periods will probably increase. In addition, the aging of the population can be expected to have potential side effects on waste water composition resulting from enhanced medicine use. As existing state-of-the-art waste water treatment plants are unable to remove the contaminants sufficiently, there is a high demand for research in this area.

Towards a Modular Approach to Water Management

According to the experts, one possible approach to these challenges is a modular, flexible and (semi-) decentralised water supply and waste water infrastructure with innovative technologies that are capable of transporting changing flow rates. Part of the water supply and waste water problems respectively could be avoided by connecting or reducing water circuits, for instance, re-use of grey water or rain water harvesting in order to save the resource water. A decentralised implementation of these technologies means the intentional use of water in the required quality at the point of origin (e.g. rain water to flush the toilet or drain the seeds). Therefore a paradigm shift is absolutely essential. Waste water is not waste but a valuable resource. Besides, a change from the existing mixed system to a separation system is required. Moreover, the traditional mandatory connection requirements and use constraints for grid-bound water supply and sewage facilities should be eliminated in Germany and all other countries with these restricting conditions. Hence, the German government is called upon to create the appropriate legal framework conditions.

The experts further mentioned that water management should not be seen as a single issue. In their opinion, water is a cross-cutting issue, thus soil protection and agricultural aspects (e.g. adequate irrigation systems, soil consumables in order to enlarge the water storage capacity), sanitary conditions, climate change as well as energy efficiency have to be taken into account. Concerning the development of membrane technologies or sea and brackish water desalination, renewable energy, like wind or solar, should be used to achieve higher energy efficiency. Therefore, a combination of different process-integrated technologies is indispensable.

New Governance Structures Needed

One of the main problems in reaching integration, system solutions and an overall concept is the lack of interdisciplinary and transdisciplinary collaboration. Thus, institutional cooperation in the research community is striven for.

The experts' consensus was that the pure technologies are of secondary importance. The success of German business depends on the actors and conditions "surrounding" those technologies. The technologies themselves are useless without adequate governance structures. Therefore, transdisciplinary projects become more and more important. Capacity building, optimized structures at the pit face, training of natives, regular examination of the requirements and, as the most simple measure, instructions in different native languages are essential.

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