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Foresight on environmental technologies: options for the prioritisation of future research funding – lessons learned from the project "Roadmap Environmental Technologies 2020+"

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A B S T R A C T

There is broad consensus that tackling the increasing global environmental problems will require the support of technology. Consequently, environmental technologies are regarded as one of the fastest growing global markets. Owing to the wide range of technologies available that can contribute to progress in this field, there is a high demand for prospective research setting priorities in a transparent way. Against this background, the presented study aimed at supporting the process of identifying and recommending options for the prioritisation of future research funding. Taking Germany as an example, this was done by analysing chances and perspectives of different environmental technologies as well as courses of action in combination with the aim of reaching new markets for seven environmental fields of action: Climate protection, air pollution control, water management, soil conservation, protection of scarce resources, waste management and biodiversity. As a key-element of the study, future environmental challenges and promising future technological developments were identified by an extensive literature review and internet research, followed by a large-scale expert survey and several topic-specific workshops. Results demonstrate that one focus of future funding should be put on technology development for meeting the demands of emerging and developing countries. Thus, an appropriate response for the German environmental industry to such global challenges requires the provision of exportable environmental technologies, although this will change the requirement profiles of the technologies. Many high-tech-products, developed for the European market, are not directly applicable or invaluable for emerging and developing countries. The study also recommends that funding should not concentrate on individual technologies, but rather on holistic views of technologies, processes, material and energy flows. Furthermore, the estimations of market potential for the investigated technologies are closely connected to the ecological problems and their social perception in different countries. Basis strategies should be developed, which take into account the technical development as well as the main drivers and constrains.

1. Introduction

Currently, the world is facing large environmental and social challenges related to population growth, industrialisation pushes (i.e. emerging countries), urbanisation and increasing material and immaterial prosperity, which are themselves external drivers of global change. Some of these challenges have led to global environmental changes (cf. Reijnders et al., 2010, p. 50), such as soil degradation, climate change, substantial loss of biodiversity, diminished supply of freshwater, ocean overexploitation and increasing ocean pollution as well as substantial consumption of non-renewable resources. However, there is no doubt that environmental crises are a known phenomenon. Many examples exist in the history and pre-history of human race that demonstrate how human economization drives changes in social and physical environments, with potentially catastrophic consequences for the living conditions of the population. However, in the past, these crises tended to be confined to specific regions, and could be solved via behavioural adaptation. The new quality in the relationship between man and environment is indicated by the fact that, for the first time in history, human activities are having an impact on earth

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as an overall system (German Advisory Council on Global Change, 1999, 2011; Pachauri and Reisinger, 2007). Above all, the public awareness of the threat of climate change has increased recently. In some cases, climate change will exacerbate existing problems: Droughts, shortages of drinking water, floods or storms may worsen living conditions especially in poorer countries in the global south, for example. Therefore, the current debate on environmental protection is marked by climate change (Cyranoski, 2005; German Advisory Council on the Environment, 2008; OECD, 2008a; Lahsen et al., 2010).

Alongside these changes, technology plays an important, but also ambivalent role (Verbeek, 2005; Vollebergh and Kemfert, 2005; Fleischer and Grunwald, 2008; Marchant, 2009). While technological advances directly or indirectly cause a large portion of current environmental problems, modern technologies concurrently possess significant potential for coping with environmental challenges. Especially in industrialised countries, a large number of technologies for air pollution control, wastewater treatment and waste management have emerged in recent years. In the face of industrialisation in emerging countries, rising energy and resource consumption, as well as increasing consumer needs, traditional forms of environmental technologies have reached their limits. It is no longer simply a matter of avoidance of direct environmental damages, including air pollution, soil acidification or eutrophication, but also a fundamental change in perspective is needed. Decoupling of economic growth from nature resource product- and process-integrated environmental protection and organisational/system transformations are required (cf. Ashford, 2002). This will naturally lead to an increase in the international demand for resource-efficient and ecological products and processes (EC, 2010; Machiba, 2010; OECD, 2011). In this context, special attention must be placed on ecological leapfrogging; in the best-case, unsustainable production technologies are "skipped" or excluded (Perkins, 2003). As the Federal Government emphasizes in the "High Tech Strategy" for Germany, neither the United Nations' millennium goals nor the goals of the German Sustainable Strategy are realisable without efficient, 'clean' technologies (Federal Ministry for Education and Research, 2006). Consequently, good opportunities and (market) potentials arise, particularly for Germany, a technologically advanced and export-oriented industrial country. The market for "green" technologies is currently one of the fastest growing markets internationally (Jänicke and Jacob, 2004; Williamson, 2005; OECD, 2008b; Roland Berger Strategy Consultants, 2010a, 2010b).

Also, technological developments are often a necessary, albeit not sufficient condition to solve environmental problems. In addition to technological solutions, an 'adequate embodiment' of technology in the societal (cf. Green and Vergragt, 2002, p. 396) and institutional context is required.[1] For example, targeted 'designs' of environmental and research policy framework conditions and regulatory systems must be implemented (Ashford et al., 1985; Del Rio Gonzales, 2004; Foxon and Pearson, 2007; Jordan and Lenschow, 2010). In addition, it is also important to impart (organisational) knowledge and know-how. Therefore, high-quality, knowledge-based services are gaining increasing significance. This includes, consumer and environmental consultation, knowledge-transfer and capacity building, environmental and sustainability impact assessment, environmental audits, life cycle assessments, and the like.

2. Study objective

Based on a broad term of "environmental technology", which explicitly includes techniques, concepts, products and knowledge-based services for the avoidance, reduction or elimination of ecological damage or the recovery of already damaged environmental functions and thus, contributes to sustainable use of natural resources, we examined the capabilities of different technologies that may foster future environmental challenges. This study focuses on the questions, which medium to long-term developments of environmental technologies are essential and foreseeable from today's point of view and which are desirable and essential in terms of preventive research. Answering these questions required both, problem-oriented (demand-pull) and technology-driven (technology-push) approaches. The problem-oriented approach asks which environmental problems trigger an urgent need for action and what kind of technologies are required, while the technology-driven approach asks what opportunities and prospects are offered through scientific and technical progress. Thus, in close coordination with the contracting authority, seven fields of action have become a focus of investigation: climate protection, air pollution control, water management, soil conservation, and protection of scarce resources, waste management and biodiversity. It should be noted that energy conversion, power generation and energy use technologies were subjects not included in this study. But, compared to other national foresight studies (see in this regard e.g. Schramm, 2010; Kristof and Hennicke, 2010; Störmer and Binz, 2010), which are generally restricted to a single field of action or a single field of environmental technologies, like "resource efficiency" or "water technologies", this study deals with environmental technologies in a comprehensive way.

3. Method and qualitative approach

The project was split into three phases, characterised by different methodological approaches. During the first phase, within the seven fields of action the main environmental problems and technological solutions to cope with these challenges were pointed out and then summarised in a state-of-the-art-report (Schippl et al., 2008). This report is based upon extensive literature review and internet research, complemented and validated by expert interviews. Using the state-of-the-art-report as guideline, technological areas which were assumed to have a high problem-solving potential according to results of Phase I were selected for each field of action (see ibid.). The selected 77 environmental technologies[2] were used for a large-scale expert survey in the second phase after anew validation by expert interviews. Due to reasoned interrelations between climate protection and air pollution control, soil conservation and biodiversity and increased resource productivity and the recycling economy, the seven fields of action were grouped into four clusters:

- Cluster A: water management

This cluster comprises 16 technologies (cf. Table A.1 in Annex), which include, first, technologies for wastewater treatment. The integrated approach of interdependent material flows, especially the handling of wastewater as resource not as garbage is the common feature of these technologies. Furthermore, it covers the complex of water conditioning. Since the global availability of high-

[1] Although technical and non-technical questions have to be considered to solve environmental problems, the main focus of this study was put on technological solutions on behalf of the client.

[2] Due to the chosen method and qualitative approach, this selection has been confirmed many times by experts – in the interviews, the survey and the workshops.