Global Research and Development on Renewables

The aim of the following paper is

- to emphasise the urgent necessity of global research and development (R&D) on renewables,
- to discuss the context in which R&D on sustainable energy systems must be viewed,
- to identify the favourable conditions for co-operative R&D and
- to summarise some ideas on the financing of global R&D on renewables.

The paper mostly focuses on public R&D.

Needs for global research and development on renewables

Transformation of the global energy system

The transformation of the global energy system towards a strictly sustainable energy supply scheme is one of the main global challenges. Many studies have shown that it is feasible to install a world wide sustainable energy system that is strongly based on renewables, thus avoiding unacceptable climate change and other non-sustainable situations in the future which are related to energy production and consumption *(fig.1)*.

In all such scenarios the contribution of renewable energy sources to the global energy supply is impressively high. These targets can be reached only if more or less all countries contribute actively to the transformation of our energy systems. Strong world wide activities in the research and development on renewables including efficient use of energy are an inevitable prerequisite for the success of such a global undertaking. These activities must be planned strategically and they must expand continuously while increasing the utilisation of renewable energy sources at the same time.

Main topics in R&D

From today's point of view the main relevant topics of R&D are [2]:

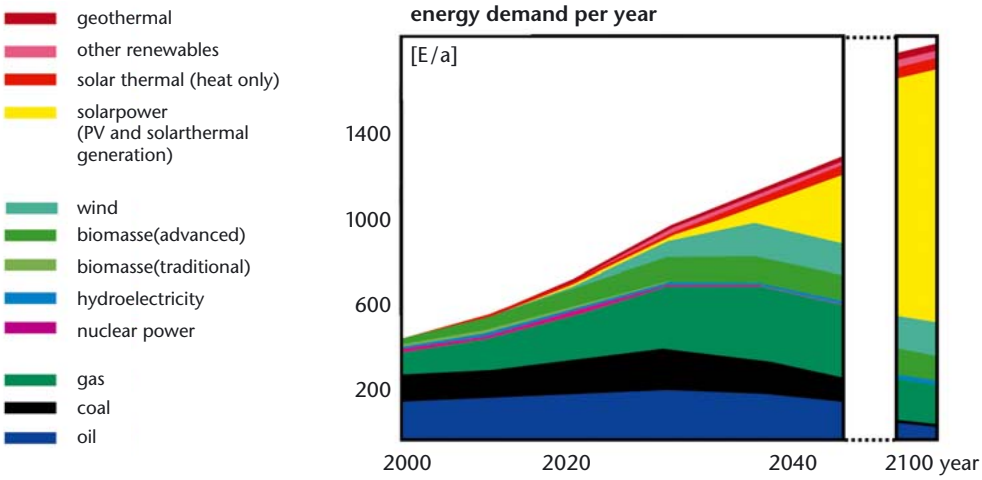

Figure 1
Exemplary path for the transformation of the global energy system [1].

This special scenario stipulates an extremely strong global economic growth. Even under the assumption of a significant increase in energy efficiency this results in a global energy demand that is by 2050 approximately three times larger than today. By the end of the century, the energy supply is mainly based on renewable sources. For a limited period geological CO_2 sequestration is applied. Under such assumptions the CO_2 concentration in the atmosphere will not be higher than 450 ppm. This will lead to a global warming probably not exceeding 2 °C.

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- Development of sustainable technologies: energy conversion, transport, storage and systems,
- Management of the global transformation process of the energy system, political, institutional, and economic schemes, including the monitoring of the transformation process,
- Implementation of new energy technologies into societies.

Thus, non-technological issues have to be addressed by the research community to a significant extent.

Technology oriented R&D

In the area of technology oriented R&D, the main goals are

- cost reduction (see below) and
- development of new technologies for the energy market.

Some examples of technologies to be (further) developed are: solar and energy optimised (low cost) buildings for various climates; water technologies (clean water based on clean energy); offshore technologies for wind; photovoltaic power plants utilising optical concentration; distributed electricity generation schemes including optimised grid structures and sustainable energy carriers for mobile applications, just to name a few.

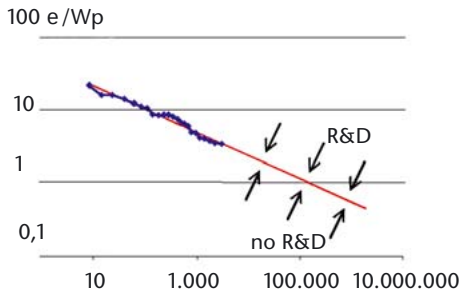

Figure 2
Price experience curve for photovoltaic modules.

Prices on the global market are plotted against the cumulated world wide shipment (logarithmic scales). Historically each doubling of the shipment resulted on the average in a price reduction of 20%. The extrapolation of such experience curves is of course speculative. Nevertheless, there are sound technological arguments that a further price reduction by a factor of at least two or even a factor of three is possible and likely. An essential prerequisite for this price reduction is strong R&D. Without this R&D, the curve will tend to show a lower price reduction characteristic.

Cost reduction through R&D

As with most emerging technologies during the early stages of market introduction, cost reduction is the most important issue for renewable energy technologies. Cost reduction in renewables will be achieved in particular through:

- optimised manufacture (economy of scale),
- higher efficiencies of energy conversion,
- less material consumption and
- longer technical life of components.

In order to achieve progress in these fields, targeted R&D is indispensable.

An impressive example is the achieved cost reduction experienced in photovoltaics (solar cells). The four points mentioned above contributed jointly to the steady decrease of the price experience shown in *fig. 2*. Without strong and focused R&D, such a curve tends to display a lower gradient. Benefiting from the profits of R&D, photovoltaic electricity will be cost effective within a reasonable time span, provided that external costs are implemented in the energy price system world wide.

Extensive global R&D on renewables

Although a first supply of reliable renewable energy technologies is available today, it will be necessary to activate further strong R&D resources world wide in order to bring down the costs of renewables, to develop new and regionally optimised technologies and to implement renewables into the different societies. This task can not be mastered by a small number of countries. In order to accomplish the necessary transformation of the global energy system in due time, almost all countries and regions have to be involved in targeted R&D as well as in the manufacture of renewable energy components and systems.

Context of R&D on renewables

R&D on renewables is not an end in itself. The focus of the R&D must be directed according to the demand of (regional) energy supply schemes and the industrial strategies (including export) specific to each country. Furthermore, in order to be effective, R&D on renewables

must be incorporated into existing academic structures or be developed in parallel to the evolving academic system.

Energy supply structures and R&D

Sustainable energy supply structures based completely on the import of knowledge and technology do not seem to be favourable for countries and regions. Local or regional R&D constitutes a good basis to optimise energy systems and to reduce vulnerability. Besides, the yield of renewable energy sources and the types of optimal technologies depend, in part, on local (climatic) conditions. Thus, specific technologies have to be developed – mostly by means of local or regional R&D.

Industry and R&D

A successful transformation of the global energy system will require renewable energy industries in most countries. In order to be competitive in the world market, it will be essential for such industry to focus on certain technologies. Since industry and R&D on energy technologies depend mutually on each other and since local R&D offers a considerable advantage for industry, it will be essential to tune local or regional R&D activities carefully with the strategies of industry. Private actors' R&D in industry and public R&D should complement each other.

R&D on renewables and the academic system

In order to be efficient, R&D on renewables has to be embedded amongst others into national or regional academic systems. An excellent training in science or engineering constitutes a R&D on renewables. This does not mean that a standard (canonical) academic training is an indispensable prerequisite for efficient R&D on renewables: an innovative structuring function of renewable energy R&D is well conceivable within the academic education. Semiconductor physics, as part of solid state physics, can be taught well using photovoltaics as a leading example. The same concept can be used regarding mechanical engineering and wind power or electrochemistry and fuel cells. Furthermore, a focus on solving real and pressing problems (here: the future energy supply) fosters an interdisciplinary approach to science which is a general prerequisite for future oriented academic activities and a great advantage to industry.

Co-operative global R&D on renewables

Without any doubt, co-operative global R&D is desirable when extensive capacity building and large-scale R&D activities have to be initiated in a short time span. In order to find the optimal form of coordinated capacity building and R&D activities and global co-operative action, potential sources of conflicts have to be analysed and identified. From such an analysis, optimal conditions for global co-operations may be derived.

Areas of tension

The principal advantages of joining forces may in part be compensated by conflicts that can arise in national and international R&D co-operations. Examples of advantages versus conflict areas are:

- synergies in R&D versus competition for intellectual property rights,
- open information transfer versus unbalanced opportunities of the partners to transform ideas into innovations,
- enhancement of coherence in R&D through binding co-ordination versus the reduction of diversity of scientific ideas and
- control of R&D via targeted management versus freedom of science.

The structured informality of innovation networks promises to combine the conflicting advantages best without compromising individual interests.

Favourable conditions for global co-operation in R&D

From this short compilation of possible areas of tension, favourable conditions may be derived under which global co-operation will prosper:

- if complementary skills and/or interests of co-operating partners are given,
- if the scientific and technological problems to be solved exceed the capacities of the individual partner countries or institutions and
- if sufficient budgets are available for international R&D clusters on renewables

In any case "complementary skills and/or interests" and "sufficient budgets" that will generate a stable and fruitful international R&D co-operation are the key points here.

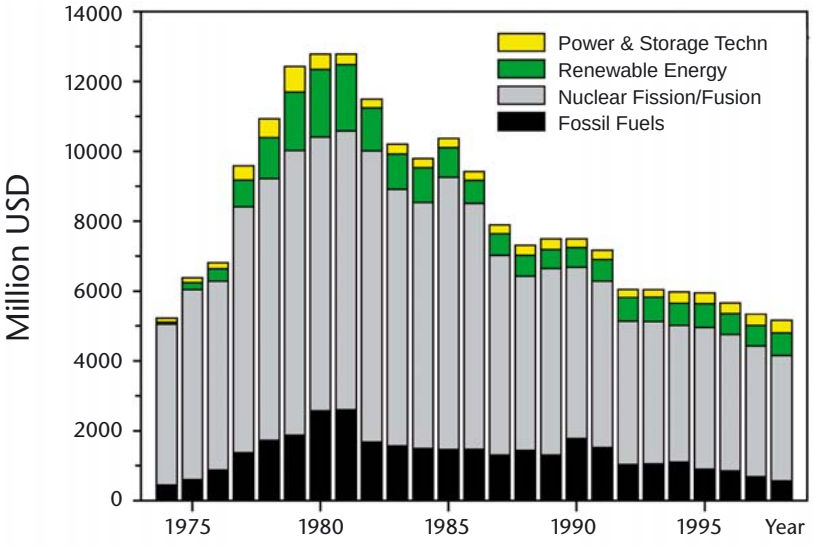

Figure 3
Public RD&D budget of 23 IEA member countries [3]

Financing global R&D on renewables

In contrast to the unquestionable needs for national, regional and global R&D on renewables, the public budgets in this area have been reduced considerably during the last decades. As an example, *Fig. 3* shows the research, development and demonstration (RD&D) budget of 23 International Energy Agency (IEA) member countries. Most of the money is still directed towards non-sustainable [1] energy technologies. This is definitely not in accord with the urgent necessity of a transformation of our energy systems towards sustainability within the next decades.

The need for strongly increased global R&D activities on renewables calls for new and strong budget sources. A large number of proposals exists how to raise needed funds [1]. The most important seem to be the following:

- The R&D budget for renewables of all industrialised countries should on the average be increased by a factor of ten until 2020. A large part of these funds should be used for global R&D.
- Financing of national and regional R&D in other countries should be realised through partnership activities from industry, private investments and as far as possible by governments.
- Financing of global R&D should be realised through charges on "emission trading", "clean development mechanism" and "joint implementation".

Benefits of global R&D on renewables

The main benefits of strongly fostering R&D on renewables on a national, regional and global scale may be summarised as follows:

- enabling a strictly sustainable energy system,
- reducing global conflicts,
- abatement of energy poverty and
- setting up new high technology industries with new products for the markets, strong growth rates and stable employment.

Without dedicated measures to set up a real co-operative, sufficiently funded global R&D system on renewables, these important benefits will not materialise in time.

Literature

[1] World in Transition – Towards Sustainable Energy Systems, Earthscan, London, ISBN 1-85383-882-9, http://www.wbgu.de/wbgu_jg2003_engl.pdf

[2] Research and Development – The Basis for Wide-spread Employment of Renewable Energies, Thematic Background Paper, renewables 2004 conference, Bonn 2004, http://www.renewables2004.de/pdf/tbp/TBP07-research_development.pdf

[3] IEA Energy Technology R&D Statistics Service, http://library.iea.org/rdd/eng/ReportFolders/Rfview/Explorerp.asp