Science Forum of the renewables2004

Networked Knowledge for Renewable Energies

Research, Development and Education – Basis for Wide-spread Deployment of Renewable Energies

FVS ForschungsVerbund Sonnenenergie
Solar Energy Research Association

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Internationale Konferenz für Erneuerbare Energien, Bonn
International Conference for Renewable Energies, Bonn

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Science Forum 2004

Organized by the Solar Energy Research Association
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Editorial: A Knowledgeable Strategy for the Dissemination of Renewable Energies

Energy was one of five foci of the World Summit on Sustainable Development (WSSD) in Johannesburg in 2002. While the access to modern energy is crucial for poverty reduction in particular and development in general, the way of producing and providing that energy is as crucial for environmental and social sustainability. Hence, the renewables2004 – the International Conference for Renewable Energies was the logical consequence and next step on the way forward. It was held from 1st June to 4th June 2004 in Bonn, Germany, and turned out to be a forum for stakeholders from all sectors: Governments as well as parliamentarians, the private sector, NGOs, International Organisations, and International Financial Institutions. On 1st June this multisectoral approach to the dissemination of renewables was completed by the Science Forum – Education, Research, and Training: Basis for Wide-spread Deployment of Renewable Energies. This one-day side-event brought together scientists and practitioners from allover the world, discussing the future requirements of research and development as well as needs and potentials of education and training for renewables in developing and industrialized countries.

Knowledge will be beyond doubt the source of power and wealth in the coming global knowledge-based society and, hence, is a leverage for all capacity building in sustainable development. The generation and distribution of knowledge, however, will not work the ways usual commodities do. Its value can hardly be priced, nevertheless it has value for actors in developmental processes. Knowledge can be characterized as public or at least semi-public good. Neither markets nor politics alone will be sufficient to provide the knowledge resources needed for the successful creation of markets for renewable energies.

Multisectoral partnerships of autonomous actors, who cooperate flexibly and provide each other with abilities, information, and complementary resources when needed, offer a new and increasingly prominent informally structured model for international cooperation for sustainable development. Knowledge networks combine efficiency of competition with effectiveness of cooperation. Those networks avoid situations of international stalemate and offer optimal conditions for the cooperative dissemination of renewable energies. One of the major, but not uncontroversial outcomes of the WSSD were the so called Type II partnerships, in all of which knowledge is an important resource to be traded.

Those organisational forms demand a strategy of management of knowledge in particular and of knowledge networks in general. That strategy has to complement self-organizing processes of markets with the mechanisms of political governance. It needs to connect decision-making to action and allow renewable energies through political interventions to compete on level playing fields.

The Science Forum achieved to gather the scientific community and contributed to the excange and elaboration of strategic knowledge, though a consistent strategy to manage networks and their knowledge resources for the dissemination of renewables is (still) missing.

The Science Forum would not have been possible without the generous sponsorship and support of the German Federal Ministry for Education and Research (BMBF). We are also deeply grateful to the Thematic Advisor of the Conference Renewables 2004, Dieter Uh, of the German Energy Agency (DENA), and Martin Schöpe of the Federal Ministry for the Environ-

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ment (BMU) for the thorough discussions and useful advice on the organisation. Special thanks deserve Hans-Josef Fell, MoP, who as parliamentary expert for research policy of Alliance 90/The Greens propelled the decision for the realisation of the Science Forum.
This volume presents the papers of the speakers at the Science Forum, complementing each other to make knowledgeable the strategic significance of knowledge, respectively research and education for sustainable development and the switch to a renewable energy system. It cannot give a recipe how to manage that switch, that puzzle is still to be resolved, even if the organisers of the Science Forum hope to have made another step on "the way forward on renewable energy".

Particularly one outcome (see annex) of the Science Forum proves this hope to be realistic. During the panel discussion the proposal of an open international university for renewable energies was taken up and launched:
On 2nd June, EUROSOLAR and the Solar Energy Research Association (FVS) initiated a foundation process of the Open University for Renewable Energies (OPURE), which was acknowledged as significant commitment and included in the Internatioanl Action Plan of the conference. For the time being the university will be internet-based. A respective platform will be developed by the member institutes of the FVS. OPURE is supposed to serve the exchange of information and impart knowledge on renewable energies, connect existig initiatives and multiply the impact. The UNESCO, continuing the GREET Programme, and the BMBF welcomed the proposal and plan to finance that initiative.

OPURE opens a new opportunity to disseminate R&D results, information, and knowledge, and to make them accessible on a global scale. For environmental problems and knowledge have one thing in common: they do not stop at national borders. The renewable energy technologies are already forthcoming in the industrialised countries, but they cannot resolve the global environmental problems and mitigate climate change without the developing countries.

Opening
Introductory Notes

- The Significance of Research and Education for Renewable Energies
- Science and Education as a Key to Development

The Significance of Research and Education for Renewable Energies

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Ladies and Gentlemen,

I am pleased to have this opportunity to address a few words to you, the participants in the Science Forum. This is an area in which I take a great interest against the background of the Renewables 2004 Conference which has just started. First of all, however, I would like to pass on greetings and best wishes from Minister Bulmahn who is unfortunately unable to be here today.

The agenda of the Science Forum is topical in the best sense and gives us good reason to expect an animated and result-oriented discussion. I support the Forum's objectives to analyse and improve the effects of research and education in the field of renewable energies under the different social conditions prevailing in the different countries of the world.

The Renewables 2004 Conference, at which, as I have heard, more than 1000 representatives of governments, international organizations and industrial companies are expected, is intended to advance the development and expansion of renewable energies world-wide in a win-win strategy for both industrial and developing countries. The Conference's political message is that renewable energies are of great importance for climate and resource protection, for fighting poverty, and for development, as well as for technological innovation, trade and industry, and employment.

Energy is a key issue for the future development of the world.

The World Summit for Sustainable Development in **Johannesburg** once again underlined the prominent role of access to energy. The global demand for energy is increasing rapidly, particularly in developing and threshold countries which want to catch up with the economic development of the industrial nations. At the same time, approximately 1.7 billion people, particularly in the southern hemisphere, have no access to electricity. Access to clean and affordable energy is a precondition for combating poverty, for economic development, and for improving the health of the population and their educational systems.

The catching-up process which is currently taking place in developing, threshold and transitional countries exacerbates the risks to the climate, the environment and safety which already prevail as a result of the largely unrestricted use of fossil sources of energy in the industrial states. The challenge which we are facing is to satisfy this demand for energy sustainably and to support renewable energies and the use of energy efficiency potentials as an alternative in all parts of the world.

However, sustainable development is not conceivable without the extensive reform of energy systems world-wide. To achieve this, we must increase efficiency at all levels of the energy system, reduce global emissions, and extend the technical-industrial energy base. All this must be done primarily through the mass use of renewable energies.

This means that the change in course towards sustainability in the field of energy is the first step into the solar age.

Sustainability begins in one's own country.

Allow me therefore to make a few brief observations on the Federal Government's energy policy. The Federal Government approved a strategy on sustainable development in 2002. The aim is to harmonize ecology and the economy in order to be able to ensure that the German population can continue to enjoy a high quality of life in future.
When we speak of sustainability on a national scale, we are talking first and foremost about the use and the consumption of energy. However, the emphasis on the promotion of renewable

energies does not mean that only the use of renewable energies or renewable resources is compatible with the guiding principle of sustainability. After all, the use of renewable energies, solar energy for example, is always linked with the use of non-renewable resources, for example non-energetic commodities and materials, whose supplies are also limited. The use of limited energy resources is only sustainable as long as we succeed in making a technically and economically usable energy basis available for coming generations which is at least equally large. Awareness of this fact is essential because we are dealing with a change in energy supply structures which will continue over several decades and in which non-renewable energies will continue to play a decisive role.

Economic efficiency is a central principle for the realization of a sustainable energy supply in this context, and it must also be the objective of research and development in the energy sector. Research must compensate for the consumption of resources. Energy research – energy consumption.

Germany aims to double its energy efficiency by 2020 (compared with 1990). This is not only wise from the environmental point of view, it also makes sense economically: only the prudent and responsible use of energy can release resources, extend economic opportunities and trigger a surge of innovations which create employment.

The Federal Government's energy policy is consistent. The environmentally friendly expansion of renewable energies is a cornerstone of sustainable energy supplies. We have succeeded in introducing new framework conditions with the Law on Renewable Energies (EEG), the "100,000 Roofs" programme and other funding programmes.

Renewable energies currently account for 2.9% of overall primary energy consumption in Germany and 7.6% of electricity production, with a rapid upward trend. Today Germany accounts for half the wind turbines that are built world-wide. In the meantime, the installed capacity of wind power plants totals approximately 13 GW. The Law on Renewable Energies (EEG), which is due to be amended soon, aims at increasing the share of renewable energies in electricity production to 12.5% by 2010 and to at least 20% by 2020. In its latest study entitled "Energy – the change of course towards sustainability", the Federal Government's scientific advisory council on global environmental changes assumes that renewable energies will cover over half of energy consumption by the middle of the century.

The large-scale expansion of renewable sources of energy represents a huge technological and social challenge which can only succeed if considerable efforts are made in the field of research and development throughout the world. This includes research in science and technology as well as in the social sciences. Steps must be taken to identify barriers to the rapid expansion of renewable sources of energy, and strategies must be developed to overcome these barriers. At the same time, research is also needed into strategies for acceptance and dissemination, both in industrial and developing countries.

The promotion of research in the field of renewable energies is an integral part of energy research policy. The significance of energy research for sustainable development is derived from the basic fact that an increase in knowledge enhances the ability to shape advancements – and the resulting progress in technology creates the basis for maintaining and expanding the scope of future generations for development. It is a well known fact that research and development are the only systematic way to achieve progress and innovations in energy supplies which are both economically feasible and adapted to the needs of generations to come.

The Federal Government is currently providing funds totalling more than 400 million Euro per year to energy research, more than two fifths of which are available for research and development in the field of renewable energies and the rational use of energy. In addition, it is also providing more than 200 million Euro to promoting installations for the use of renewable sources of energy, with emphasis on the heat market and photovoltaic systems in schools, as well as gaining energy from biomass.

Should Germany, together with other states in the European Union, succeed in realizing the goal of spending 3% of GDP on research and development in 2010, this will considerably extend the scope for energy research.

It is rightly expected that research and development should make a considerable contribution towards tapping the potential of renewable energies and offering corresponding energy services on the market. However, there are still a lot of problems to be solved from the technical point of view before energy from renewable sources can compete with energy from fossil sources or nuclear power as far as cost is concerned. We are on the right path, but we have not yet reached our goal.

In view of the long-term nature and the extent of the necessary changes in the technological and economic basis of energy supplies, the technology portfolio on which innovations are based must be sufficiently broad to ensure that new options for energy generation are available in good time. Priority should thereby be given to:

- Research into technologies which are essential for the long-term evolution of energy systems (e.g. photovoltaics, energy efficiency);
- The further development of technologies which only require small steps in order to open up new markets (e.g. solar-thermal power stations and wind energy in developing countries, biogenic synthesis gas);
- The optimization and adaptation of technologies which can already be used cost efficiently (e.g. solar and energy-efficient buildings, photovoltaic electricity generation for off-grid uses, the modern exploitation of biomass).

To this end, we are pursuing a funding policy aimed at securing Germany a top position internationally, ensuring technological diversity, the linkage of excellent basic research with technological development, the technical optimization of renewable energies, and integration in the national energy supply system.

I attach particular importance to one factor in achieving this task: The excellence of application-oriented and basic research in the use of renewable sources of energy. This is and will remain the precondition for the development of better conversion technologies and cheaper sustainable energy supply systems. Furthermore, important tasks must also be accomplished outside the field of energy research. Because, in principle, there are many different promising paths towards energy conversion, it is important to promote both application-oriented and basic research and market-oriented technological development. The BMBF is therefore providing 10 million Euro per year towards the specific formation of networks in the field of basic research between universities, institutes of the Max Planck Society and other non-university research establishments.

Let me briefly mention some important thematic focal points of national research funding:

- **Photovoltaics**: here the focus is on industrial processes to reduce the cost of producing solar cells and modules and to increase efficiency.
- Funding in the field of **wind energy**: here funding is aimed at the development of wind power plants for offshore operations. Research platforms are being erected in the North Sea and the Baltic Sea to test meteorological conditions and the effects on the ecological environment.
- In the field of **electricity generation using geothermal heat**: the hot-dry-rock process is being further developed at several sites. Furthermore, fundamental questions concerning the geo-scientific and economic conditions for the use of heat from hot deep waters are being examined.
- Research is being conducted into parabolic channels, tower and dish/stirling techniques for **solar-thermal power stations** with the aim of introducing these products onto the market. Apart from funding for new and further developments in receiver and storage systems, optics and controls, funds are also being provided for the construction of demonstration plants as the basis for commercial power station planning. The "Solarthermics 2000" programme is

examining the long-term performance of thermal solar systems using demonstration installations as well as techniques for the seasonal storage of heat.

- Funding in the field of **biomass** research focuses on obtaining fuels, improving both the technologies for using and the opportunities for exploiting heat, electricity and fuels from biomass, as well as obtaining biogas and the use thereof.
- Research funding in the area of **fuel cells** is focused on the development of technologies which can lead to less expensive production processes and more reliable operations.

The further development of existing energy supply structures in Germany will pay more heed to the increased use of renewable energies. This applies in particular to the structure of electricity grids, which in future must enable both a greater decentralization of energy production as well as stronger networks over in some cases greater distances. There are already signs that this is the case with the use of wind energy. Changes in the structure of fossil power stations due to the new buildings required must be included in measures to optimize the overall system. Approximately 60 % of today's power station capacity will have to be replaced by 2020. The demand for replacement technologies in German power stations over the next two decades will thus create the necessary scope for far-reaching changes in the type of energy supplies. It is important to make use of this scope now, and in the future, by providing sustainable energy services both as required and in good time.

Sustainable energy supplies, as a national and global task, and the contribution of renewable energies to solving this task demand a strong international orientation: Research and technological developments for applications in southern climate zones and Eastern Europe will have to play a greater role in future. Here it is a matter of including the extremely wide range of user requirements – such as energy supplies in rural areas with poor infrastructure, energy demand in large conurbations and the preparation of drinking water by means of sea water desalination – in the funding concept and closely linking the use of renewable energies with a very rational use of energy.

This means that international pilot projects are becoming essential in addition to national measures – always with scientific support and a sound evaluation of the experience gained.

One of the main obstacles to the broader use of renewable energies is the lack of knowledge about their functioning and lack of skills in their application. Providing such knowledge is the task of education and training.

Well-educated people are one of the most important driving forces for innovations and for economic and societal progress. Technologies which spare resources, ecologically and socially compatible forms of trade and industry, but also social modernization which concentrates on creativity, entrepreneurship and human responsibility cannot be realized without a corresponding range of educational services. The Federal Government together with the Länder has therefore introduced the so-called "Programme 21" for sustainable development. This will give important momentum in the following areas:

- Interdisciplinary teaching concepts which underscore the connection between ecological, economical and social aspects on the basis of concrete topics.
- Firms set up by school students to provide experience in sustainable commerce. The many forms of cooperation between schools, local authorities and companies within the framework of sustainable regional development are good examples of the opening of schools to practice-related activities. A good quarter of the schools involved gave clear priority to energy-related topics, including aspects of energy, energy consumption and energy savings. In the meantime, the operation of solar energy plants is a matter of course for a whole number of schools.
- In addition, the topic of energy is being discussed in more complex contexts in class, e.g. within the framework of a sustainability audit or cooperation in a Local Agenda 21 project.

The Programme 21 will be successfully concluded this summer. Now it is a matter of firmly anchoring this good practice in as many schools as possible and implementing the results of the programme in day-to-day activities. The Federal Government is in the process of tackling this task together with the Länder and is launching a corresponding transfer programme.

The United Nations have designated the years 2005 to 2014 the decade of "Education for Sustainable Development". During this decade, we will work intensively to expand and secure the position of education in sustainable development in the education system and to promote international cooperation in this field.

Apart from education in schools, there is also a growing demand for vocational training in the field of sustainable development. Considerable experience has been gathered at approximately 20 national conferences involving over 800 experts from various institutions in the field of vocational training at schools, firms and other educational establishments. This experience has been included in an orientation framework for vocational training. The following criteria have been established:

- Central competencies that are relevant to sustainability must be identified and taught as an integral component of professional activities. (Key words here are: systematic and networked thinking, the ability to deal with complex ideas and business cycle structures, social sensibility and a high degree of competency in the field of communications and counselling, also in an intercultural context.)
- Identifying and teaching specific vocational competencies. (The focus here is on the inclusion of the above mentioned aspects of professional activities by combining them with vocational and methodical topics in a general system of initial and continuing vocational training.)
- Recognizing future-oriented areas of activity in the field of sustainability at an early stage, training the necessary teaching staff, and developing new occupational profiles (preparing for the use of "clean" technologies); this also includes deliberations on "sustainable" mobility.
- Recognizing new fields of technology and branches of growth in order to put them at the service of society and trade and industry.

The introduction of these processes requires measures and agreements on increased cross-border international cooperation and on the development of a structure for communication and dissemination that also takes particular account of the requirements of the developing countries.

In Germany, we are including the guiding principle of sustainable development in all training directives which regulate the company-based part of vocational training. Extensive activities are still needed in order to realize this aim. We are just beginning a programme of pilot schemes to test ways of introducing sustainable methods in initial and continuing training.
By setting up an Internet portal and creating a community, the BMBF will establish a joint address for the numerous activities of the diverse stakeholders in vocational training as suppliers and demanders of knowledge and experience. We plan to steadily expand this communications platform and to give international partners the opportunity to participate in this exchange of knowledge and experience.

A sustainable supply of energy based increasingly on renewable resources is not feasible without qualified production and service staff, with responsibility for building and operating energy plants for example, as well as qualified personnel to advise users and clients. Qualifications are therefore a precondition and in a sense a synonym for innovative ability. Innovative ability means being fit for the future.

Thank you for your kind attention and thanks also to the organizers of the Forum [ForschungsVerbund Solarenergie].
I would like to wish this event every success.

Science and Education as a Key to Development

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Mr. Chairman,
Your Excellency,
Distinguished Participants,
Ladies and Gentlemen,

As the head of UNESCO delegation participating in this "Science Forum on Research, Development and Education – the Basis for Wide-spread Employment of Renewable Energies", let me first say how pleased I am to take part in this Opening Session of this Forum.

We live in the age of the "knowledge-based society" where knowledge plays an increasingly important role in sustainable social and economic development. Science and education is an essential and interlinked key to this very development.

Knowledge relates essentially to science and technology, and education and training are vital in networking and the transmission of knowledge to build capacity – so that knowledge can be applied where it is needed. For UNESCO, this includes a priority focus on the developing and least developed countries. For UNESCO, this also includes a focus on applications in science and technology – and this includes, importantly, energy and renewable energy.

The development of science and technology has brought tremendous changes to our lives. The exploration of outer space, the development of conventional, nuclear and now renewable energy technologies, the invention of electronic computers and a range of other innovations mark an epoch in the history of civilization. One is often tempted to ponder how many new discoveries and innovations are in the pipeline, and how they will affect our lives over the next few decades!

It is hard to imagine what our lives would have been like without all the benefits which scientific knowledge and engineering skill have given us. The crucial point here, of course, relates to access, as these benefits are unevenly distributed – there are millions of people who do not have such access to these benefits of science and technology, who live in poverty and destitution. This presents an ongoing overall challenge for research, development and education in science and technology, particularly in such an area as energy – where access is very unevenly distributed.

Strategy for Sustainability

The World Summit on Sustainable Development and the United Nations' Millennium Development Goals place the promotion of sustainable development and renewable energies high on the international agenda. In line with UNESCO's Medium-Term Strategy and our contribution to sustainable energy and development, UNESCO will continue to advocate for energy efficiency, diversification and renewable energy. This includes capacity-building, development of human and institutional resources, awareness raising and prioritising the use of renewable energies and provision of related policy advice. There is an emphasis on improving the living conditions in rural areas of poor countries, especially in the developing countries and small islands states.

Within the Global Renewable Energy Education and Training (GREET) Programme and its regional component, with particular emphasis on its African Chapter, we emphasise capacity building and development of co-operation in the renewable energy sector to promote renewable energies. Activities focus on the improvement of use, maintenance and management of solar energy projects and programmes, and transfer of technological know-how.

This involves the design and field implementation of training platforms, the elaboration and dissemination of learning and teaching materials, introduction of training programmes at all educational levels, setting of educational standards and certification of centres of excellence to serve as a catalyst. Concurrently, support is given to the definition of national energy strategies and experimentation of pilot projects focused on development goals. We also foster advocacy and awareness-raising to stimulate the use of renewable energies to meet the Millennium Development Goals and to improve living conditions in rural areas. Further extra-budgetary resources need to be mobilised to extend the scope of activities.

The promotion of renewable energies to address developmental goals will be pursued in association with UNESCO programmes in the Natural Sciences, Education, Social and Human Sciences, Communication and Information Sectors, and with intergovernmental programmes at UNESCO. Consultations with relevant and competent United Nations agencies and programmes will continue, including participation in the United Nations Ad hoc Inter-Agency Task Force on Energy and cooperation with competent national, regional and international NGOs.

Raising Awareness

UNESCO has contributed to the World Solar Programme in raising awareness on potential and opportunities for utilization of renewable energy. Projects implemented in this activity have created awareness at political and in particular government levels. The Honduran government, for example, used the Solar Village Demonstration Project to source funding for more solar village projects. Electrification of schools has provided a linkage between education and energy. Children have become aware of benefits of solar energy applications. The project has contributed to broaden children's knowledge through exposure to new educational technologies using computers, providing access to information, and communication via the internet.
Through such projects, rural business operators have realized opportunities to extend their business operating hours by using solar energy for lighting. The Honduran project has also contributed to raising awareness of the people in the community about the opportunities in micro-enterprises through television and via internet. Solar village electrification has also contributed to raising awareness on HIV/AIDS through public media such as television.

Capacity Building

Capacity building in renewable energies through implementation of education and training activities is the main focus of the GREET Programme. These activities have focused on the organisation of summer schools, training of trainers and implementation of the Renewable Energy Training Platform. Training activities aim at enhancing knowledge of managers, engineers, technicians and trainers on use, application and maintenance of renewable energy technologies.

Learning and teaching materials produced within the GREET programme serve as a tool to assist in teaching courses on renewable energy in universities and also as a reference material for the scientific community. The Renewable Energy Training Platform to enhance local capacity and expertise in renewable energy use and applications will be duplicated and implemented in other countries and regions to develop and enhance local capacity building on the use and maintenance of renewable energy systems. This will improve the implementation of renewable energy projects and contribute to their sustainability.

Through the GREET Programme, a series of books for use in primary schools has been developed for incorporation into the school curriculum for English speaking countries in Africa. This material has contributed to enhancing knowledge on renewable energy systems. A series of text books, composed of six volumes, has been produced and distributed through the Ministries of Education in 14 Southern African countries. This links to UNESCO's wider activity under the New Partnership for Africa's Development (NEPAD) and cooperation with the African Union in science and technology.

UNESCO has also cooperated with Wiley Publications in the production of a "UNESCO Energy Engineering Series" of learning packages. This series includes, amongst others, titles on Solar Electricity, Geothermal Energy, Electric Power Generation, and Energy Planning and Policy.

This series has been most successful, with some titles already in second edition. Most recently, we have updated and republished the volume on Geothermal Energy and published a new volume on Solar Detoxification and two related volumes on Solar Photovoltaic Systems and Project Development. We have also produced a video and booklet entitled "Rays of Hope: Renewable Energy in the Pacific" – which examines the pioneering use of renewable energy in the Pacific islands.

Mr. Chairman,
Ladies and gentlemen,

Let me conclude by noting again the overall importance of research and development, education and training in the knowledge-based society and economy. This is particularly important in promoting the development and widespread employment of renewable energies.

I mentioned at the beginning that knowledge relates essentially to science and technology, and education and training are vital in networking and the transmission of knowledge to build capacity – so that knowledge can be applied where it is needed.

To do this, it is essential to create linkages, to develop and share models and information, learning and teaching materials. This is what has happened at the solar school project facilitating internet access in Honduras, and the solar village project raising awareness on HIV/AIDS in Zimbabwe.

I also mentioned at the beginning that we need to promote access to the benefits of science and technology for the millions of people who live in poverty. It is no small irony that our planet receives enormous quantities of solar energy and that much of this energy falls on developing countries, where many poor people live.

We face a vital challenge to enhance our efforts to focus research, education and training on renewable energy for the benefit of developing countries. Promoting access to energy and the benefits of science and technology is a vital dimension for poverty reduction in developing and least developed countries.

Finally, let me say that, together with my colleagues from UNESCO, I look forward to the outcome of your discussions and hope that the Forum will succeed in laying the foundation and taking further actions that will result in a major drive to improve the world energy situation in this millennium.

I wish you every success in your important deliberations and look forward to the results of your presentations and discussions.

Thank you.

Introductory Overviews: Research, Development and Education

- Global Research and Development on Renewables
- UNESCO's Global Renewable Energy Education and Training Programme (GREET Programme)

Global Research and Development on Renewables

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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]:

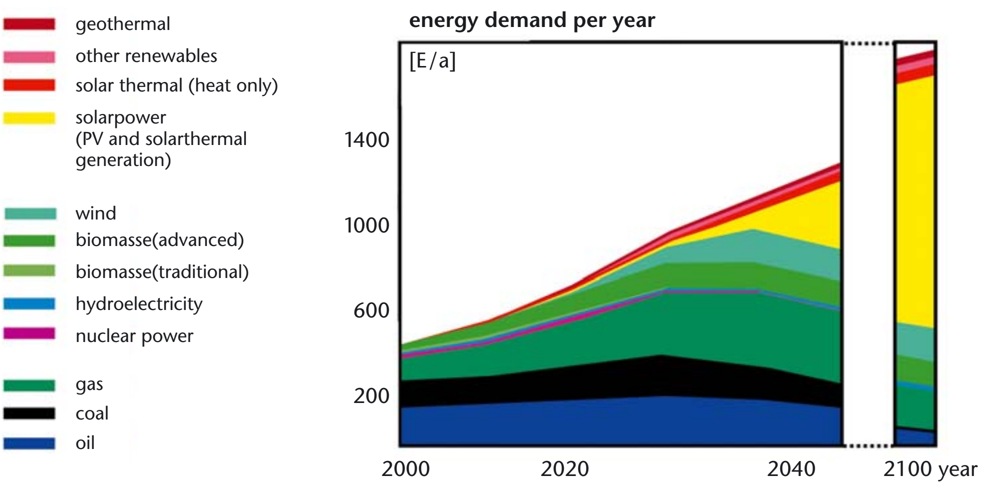


Figure 1
Exemplary path for the transformation of the global energy system [1].

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.

- 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.

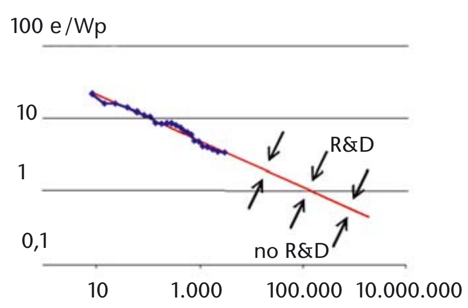
Thus, non-technological issues have to be addressed by the research community to a significant extent.

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.



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.

Figure 2
Price experience curve for photovoltaic modules.

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.

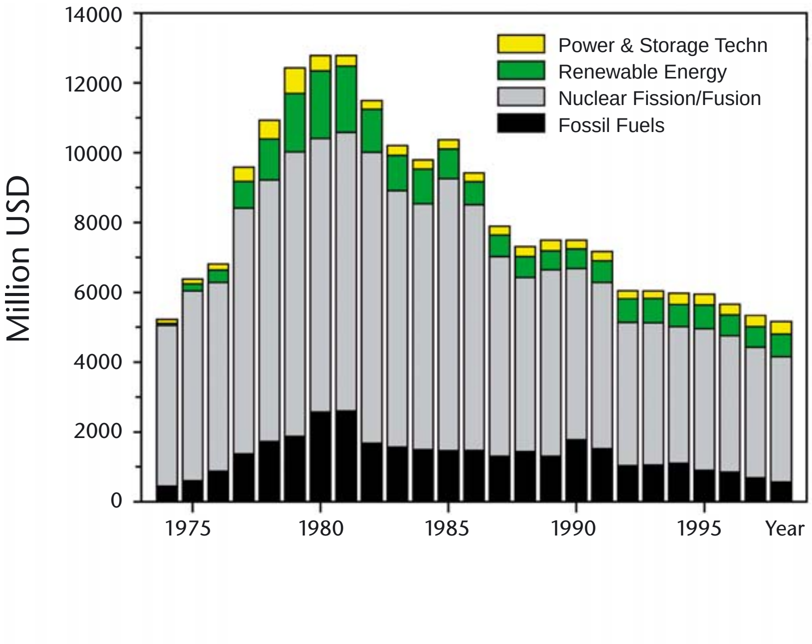


Figure 3
Public RD&D budget of 23 IEA member countries [3]

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.

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UNESCO's Global Renewable Energy Education and Training Programme (GREET Programme)

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Capacity Building for Human Resources and Renewable Energy

In every development process, there is a pressing need to increase the availability of qualified human resources. Developing countries tend to experience a crucial lack in precisely this area. They are confronted with many difficulties in developing scientific education. It is costly to teach in these countries and there is a lack of equipment and laboratory materials. Moreover, they often lack capacity for local production. Science and technology help forming a world view, including values, which stimulates creative capabilities, open mindedness, and a perception of nature and the environment that provide people with indispensable tools to cope with a globalizing world. The rational use of scientific and technological progress can contribute powerfully to solving development problems, particularly those of hunger and disease. Increasingly, science is becoming a direct productive force that underpins economic growth and social progress.

The role of training in the scientific field is apparent at three levels: for upper echelon staff and researchers, for mid-level technicians and for qualified workers. In recent years, important achievements have been accomplished in this regard, particularly in developing countries. Much work has been done in order to ensure a higher priority for the scientific teaching process, both to improve its quality and to direct it more towards solving problems related to everyday life.

A diversified training programme is needed to meet increasing demands for qualified personnel in the developing countries. This training should consider the latest developments in science and technology. It must strengthen competence and technical polyvalence, in such a way as to produce a technical staff of high quality in judgement and decision making. Both of these qualities are necessary for project planning and management, and for being able to identify the most appropriate application and utilisation for local conditions.

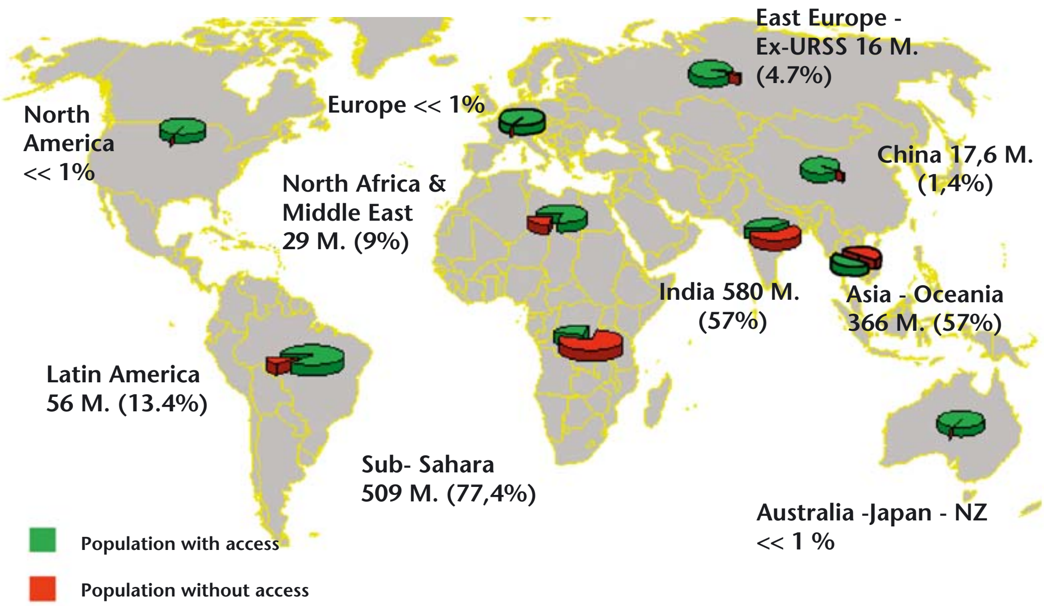
There is a particular need for training and education in energy technologies due to the key role energy plays in sustainable development for many other issues. In light of energy costs and energy's important role in the economy, recent growth in energy consumption has led all countries to formulate and execute various strategies in three interrelated areas to:
a) improve the efficiency of energy use;
b) increase energy conservation;
c) explore and develop new and renewable sources of energy.

At the same time, growing awareness of the role that renewable energies can play in the global energy system, especially for the supply of energy in rural areas, most countries are showing increased interest in creating appropriate training programmes related to these energy sources.

The training needs, important in the short term as well as in the mid term, can be understood in the context, that the desire of using renewable energies combined with the decrease in equipment costs stimulates the countries to conduct research on new equipment and on the utilisation of renewable energies.

It is evident that all programmes using renewable energy equipment depend upon the availability of specialists of various levels, who are able to use and properly maintain the supplied and installed equipment. Again, this underlines the crucial need for the training of specialised personnel. Several countries have strongly confirmed their interest in training staff and specialists who will be able to rationally utilise renewable energies.

Figure 1
Needs in term of electricity Access



Calculations based on data from World Energy Outlook 2002 -IRA

In order to be effective, training in the field of renewable energy must be ensured along four distinct axes: researchers, decision makers (engineers, economists, administrators, etc.), local maintenance technicians and users. It should concentrate on the following elements:

- progressive reinforcement of research centres and the development of qualified personnel,
- establishing better coordination between energy needs and the choice of appropriate equipment,
- creating maintenance teams capable of interacting with the rural population in order to solve technical problems, they might encounter, and to provide them with necessary information on operating installed equipment,
- raising the users' awareness on how to use this equipment effectively.

Following the identification of training candidates, every effort should be made to minimise the duration of training, especially for decision makers and those engaged in field activities.

The Way Forward for Renewable Energies

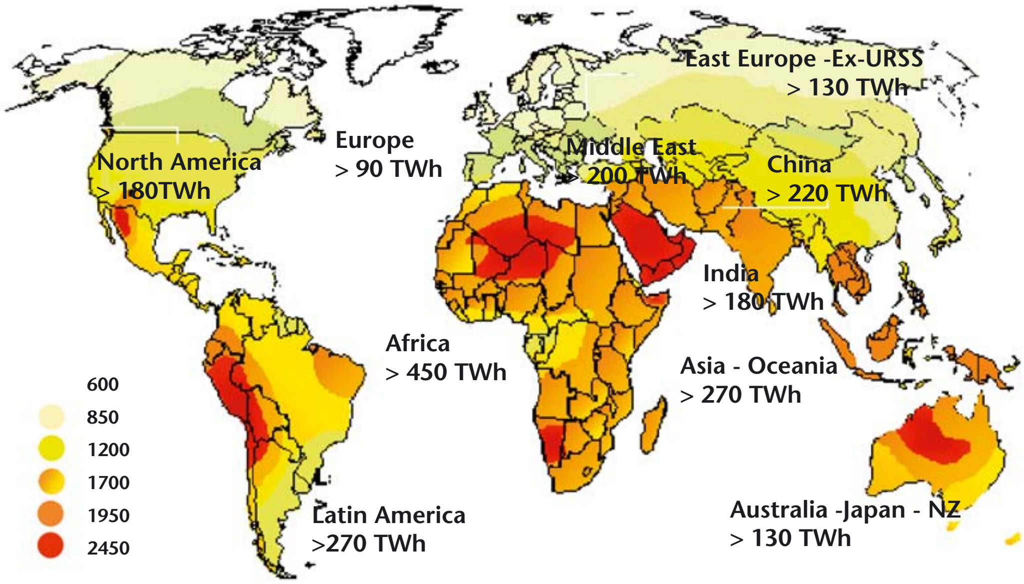
The necessity for renewable energy

The goal of education and training is to prepare a population for its future. In order to meet actual training and education needs, one must first examine societal needs for the first part of the 21st century, that is, for the period 2000 to 2030.

Energy is vital and essential for any society, but has two contradictory aspects. Firstly, it reflects the standard of living and the progress status of a nation. It also represents growing awareness concerning the level of risks that a given nation would face in attempting to satisfy its energy needs. The first half of the 21st century will certainly see rapid progress[1] in both the level of energy consumption and in the diversification of energy production methods, which can be linked to several factors:

- Population growth especially in Asia, Latin America and Africa will lead to overall increases in energy consumption.[2]
- Ecological risks associated with some energy sources are becoming increasingly evident

[1] Rapid, means here: "in some decades". It is the required time for a new energy source to become part of the energy system, even when a voluntary policy is continuously practised.
[2] Quantitatively, the future population growth is estimated with a good precision contrary to the development level. The scenarios for the future on this subject must take into consideration mere realistic hypotheses.



Based on data from B. Dessus & UNESCO´s Summer School of rural electrification

Figure 2
Solar Energy Reserves (yearly) > 2130 TWh forecast 2020

and worrisome. Two examples include the Earth surface warming due to the greenhouse effect caused by gas emissions[3] and the uncertainty regarding methods for long-term storage of nuclear residues.

- The need of humankind to follow a strong policies of improving energy efficiency in the North as well as in the South.
- The need to strengthen diversification of energy resources[4] and, more importantly, the growing need to use renewable energies in the future.

The preceding constraints lead to inevitable changes in energy strategies requiring a long-term obligation to move toward an energy flux, rather than continuing to rapidly deplete fossil fuel stocks.

Renewable Energy Credibility

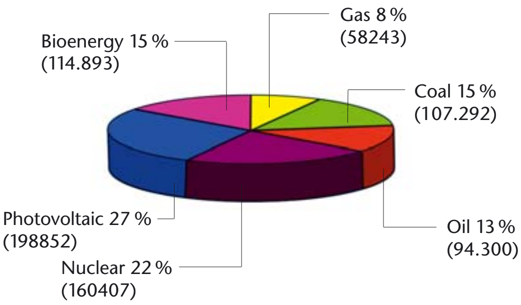
The successful path to a future sustainable energy system will depend on four conditions: technical credibility, economic credibility, ecological credibility and political credibility. Unless all four of these conditions are satisfied, the massive growth in the contribution of renewable energy during the 21st century will not occur.

Regarding technical credibility, the generation of energy splits up in the production of heat, of electricity and of fuels. There are numerous renewable energy technologies and applications having market potentials, as shall be listed briefly[5]:

Heat production: biomass if not causing deforestation and desertification; district heating through geothermal energy; solar architecture;

[3] The conten of CO_2 in the atmosphere has increased by 50 % since the beginning of the industrial era. The human activities (combustion of carbon oil and gas, the change in living habits) are mainly responsible. According to the "Intergovernmental Panel on Climate Change" (1996), "the earth surface temperature in average increased globally by 0.3 o 0.6 °C since the beginning of the 19th century…. Analysis of a group of elements suggests that, there is a perceptible influence of man on the global climate." This climate change evolution will continue with very serious consequences. We mention, as an example the more or less realistic figures: a warming-up of 2 °C and the increase of ocean's level by 50 cm by the year 2100.
[4] This trend will not evolve automatically. In the 19th century coal was dominating while for the 20th century it is oil. Fossil fuels accumulated during hundreds of million of years are being burned today at such a rate that they will be largely depleted in few centuries. For example, oil crisis in 1973 and 1979 have been overcome due to major discoveries (the North Sea, Alaska, Siberia). However, the likely absence of such discoveries in the future will affect the energy situation if the oil share in the energy balance continues as it is.
[5] For further details, refer to the following EU documents: "Renewable Energies in Europe", Int. J. of solar Energy No 1 – 4 (1994); and T. Wrixon, A.M.E. Rooney, W. Plaz "Renewable Energy 2000" (Springer Verlag, 1993).

figure 3
Job Creation for Energy Production



solar heating for crop drying, water heaters and space heating.

Electricity production: hydroelectricity if not flooding local environments; wind generators; thermal power plants burning organic residues; solar thermal power plants; stand-alone photovoltaics particularly for rural electrification or grid-connected and integrated in buildings.

Fuel production: alcohol from sugar cane; "green fuels" from biomass so called biofuels. Some of these are still in the research and development phase and show a reasonable, or even significant, level of progress, some are, with respect to economic credibility at the operational level and provided satisfactory results.

Particularly, in specific contexts certain renewable energy technologies are already today competitive or nearly competitive, as for example hydroelectricity and green fuels,or in some localities and under appropriate conditions wind generators, stand-alone photovoltaics, and geothermal and solar heat. With political support this competitiveness can often already launch technologies in the market. So, there is an actual niche of competitiveness, which will increase in the medium term as a function of research results and market growth.

At this point, it is important to introduce the concept of the social cost of energy. This reflects the actual cost paid for the consumption of energy, not only by consumers but also by citizens in general. In reality, the costs of classical energy sources are currently under-estimated, as they do not include important 'external' costs, related to factors such as environment protection, research subventions or the need to transmit a heritage unburdened or negatively influenced by present consumption to future generations. This problem is treated, for example in reference.[6] Increasingly, specialists are recommending the internalization of external costs. This would lead to the formal improvement of the competitiveness of renewable energies, which, in general, have a limited ecological impact.

All the above-mentioned techniques produce more energy than is necessary for their manufacture and installation. For example, photovoltaic systems have an energy return period of two to four years, compared to a lifespan of at least 20 years. In most cases, the ecological balance of renewable sources of energy is better than all other sources of energy. It is important to recall that a pro-active policy in the energy economy is beneficial for the whole planet, from both the economic and ecological points of view. "The best energy is that which we do not produce."

In addition, most of these techniques are ecologically benign (dams that retain water reserves of extended surfaces are an exception). The associated social costs of renewable energy are extremely small. As demonstrated by field inquiries in Great Britain, wind generators are very well accepted by the local population, proving the ecological credibility.

In reality, all of the above will depend on the political will of energy decision makers, both within individual countries and at the global level. Over the past 20 years, many major countries have shown a firm and constant will to develop renewable energies. State and private credits granted to renewable energies in these countries have increased on a regular basis. In addition, the European Union has a dynamic policy of research and development. Some other countries, in which public opinion is strongly against nuclear energy, are now at the forefront of the movement to utilise renewable energies. A smaller number of countries are more reluctant, but still active. Among developing countries, India, Brazil, China,

[6] O. Hohmeyer, R.L. Ottinger, Social Costs of Energy (Springer Verlag, 1994).

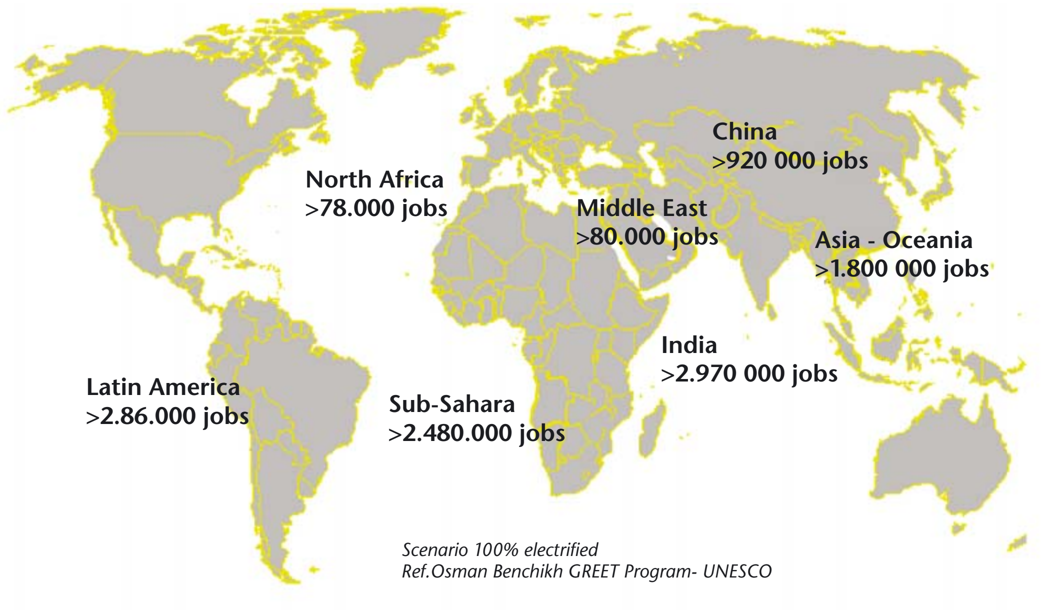


Figure 4
Direct Jobs in Operation & Maintenance Created by RE Electrification

Morocco and others are pro-active in some aspects; in 1993 the World Bank started financing renewable energy in these countries.

Nothing guarantees the permanence of a constant dynamic policy in favour of renewable energy. This depends on the political credibility. However, it is generally safe to presume that renewable energies will become more valued for their two favourable characteristics:

- Flexibility – the possibility of creating local energy sources, hopefully to complement and compete with the supply from large central grids.
- Responsiveness – the possibility of meeting the rising expectations related to sustainable development and environmental protection. The plan of implementation resulting from the World Summit on Sustainable Development (Johannesburg, 2002) and concerns on climate fragility expressed at Earth Summit (Rio de Janeiro, 1992) highlight the major role that renewable energies can play in both issues.

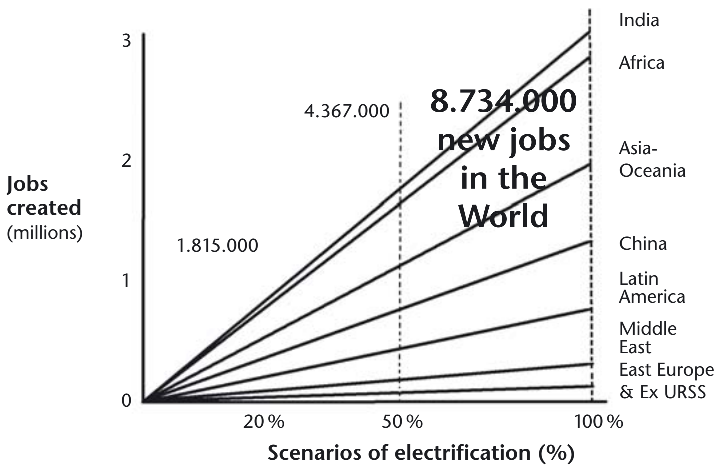
Admittedly, one of the principal obstacles facing the widespread use of these technologies is the lack of information. The GREET Programme aims precisely at improving knowledge on intrinsic merits that renewable energy possesses. Increased awareness of these merits should lead to a growing interest of use and applications of renewable energies at worldwide level.

Job creation

Comparing all sources of energy production renewable energy sources represent one of the most important reservoirs for job creation.[7] For the production of the same amount of energy, the job creation growth of renewable energies is higher than that of other sources such as gas, coal, oil and nuclear *(see Fig. 3)*.

Comparing jobs created by the different forms of energy *(see Fig. 3)*, biomass and photovoltaics generate the highest number of jobs. As these resources are particularly abundant in developing countries struggling with rural electrification,

Figure 5
Direct Jobs in Operation & Maintenance Created by RE Electrification



[7] J. Percebois, Vol. 2, Summer School „Solar Electricity for Rural and Isolated Zones“, Ellipse/UNESCO, 1993

the use of renewable energies apart from jobs creation will help to improve the local economy and ensure a better quality of life and decease poverty.
In only a few years, figures have passed from 1.5 to 5.6 jobs per installed megawatt – a sign of a more advanced industry. This brings to mind an indication from the World Watch Research Institute regarding the manpower needed to build a piece of equipment producing 1000 GWh annually:

Sector	No. of persons required
Nuclear	100
Coal	116
Solar thermal	248
Wind generation	542

These numbers will certainly decrease in the future. However, renewable energies will remain an important source for job creation compared to conventional energy sources. In general, renewable energies have high upfront investment costs, but lower operating costs despite of the higher employment rates. For conventional sources of energy have high operating capital costs due to the commodities like gas, coal, oil or uranium needed to operate power plants, not to mention the high costs of grid maintenance of centralised energy systems.

Those quantitative comparisons must be completed by new studies, updated and generalised to other technologies. They should also be performed for different regions, including rural zones of developing countries where renewable energies (basically photovoltaic) play an important role.

We can provisionally conclude that various renewable energy technologies are a significant source for new jobs. In just a few years, tens of thousands of jobs have already been created. The locations and natures of these jobs, as well as their number, are still evolving. Thus, it is clearly a sector for which an appropriate training policy seems absolutely necessary.

Training on renewable energy[8]

Current situation

Education in the area of renewable energy is certainly a field where almost everything still needs to be done. The current lack of ambitious educational programmes can be explained by two principal factors:

- the multi-disciplinary and diverse nature of the subject, and
- general non-recognition of renewable energies as a major component of the energy issue.

Specialisation in this field assumes a general knowledge of diversified technologies and their adaptation to different contexts and different fields of applications. At present, no specific, degree-granting university training and education programmes exist in the field of renewable energy. Another problem is the lack of information on the topic in general. Both of these issues must be adequately addressed.

1. Training

a) There is no specific secondary school course on renewable energy that is capable of capturing the interest of young people and orienting them toward choosing a career in this field.
b) There is a lack of coordination among the diversified activities related to renewable energy within the education field.
c) At the university level, very little information is available concerning prerequisites and the procedures that could lead to a degree or training programme in the renewable energy area.
d) Training needs in the area of renewable energy are poorly defined. Organisations concerned with energy and renewable energy issues, interested in training their own personnel, should be identified.
e) Very little information is available concerning needed training programmes to be initiated: specific technical as well as practical courses, advanced education, summer schools, etc.

Poor distribution of research and training centres is another issue. In many cases, the

[8] Since the GREET Programme has been founded under World Solar Programme the following remarks regarding the training needs for renewable energies will mainly focus on solar energy.

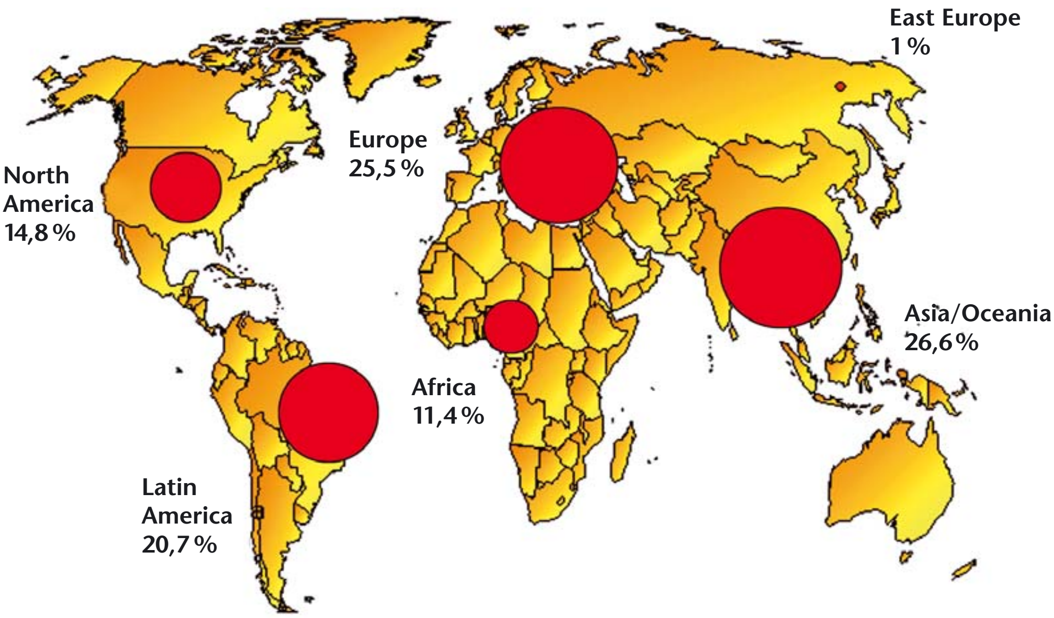


Figure 6
Distribution of training and research centers by region[9]

regions favoured by a high potential of solar energy and confronted by a deficit in electricity – mainly rural areas – are those that have the smallest number of specialised training centres. Similar discrepancies can be seen in the case of photovoltaics, whose potential is enormous on the international scale.

2. Lack of information

a) Both non-experts and the general public have very little information on the current state of the art in renewable energies, or on the true potential of these resources. More-over, the limited information they do have is often distorted by 'fashions' and 'anti-fashions' related to the environment and energy economy, particularly when this concerns renewable energies.

b) Very few practical educational manuals about renewable energies are addressed to the general public, especially for the youth adapted material is missing.

c) Very little information is addressed to secondary school students on the prospects and employment chances that would be gained by specialising in the renewable energy field.

Fig. 1, 2 and 6 combined show that the very regions with greatest energy poverty have the largest potentials but the least training capacities in relation to their solar photovoltaic energy potential.

Training needs

General aspects of the needs for training are analysed from two angles:

- What should be the foci for the educational process?

It is evident that renewable energies must become competitive to provide sustainable energy and thus that market development must be fostered. To this end, current needs are the actual prospects of the market.

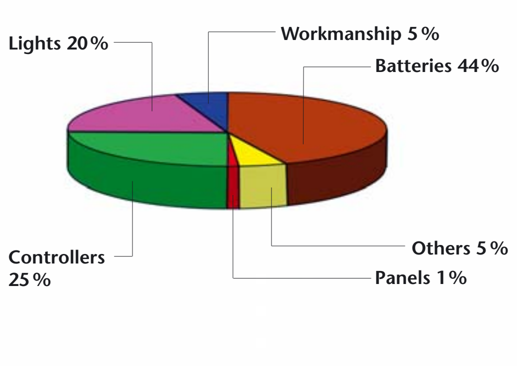
- What courses should be taught?

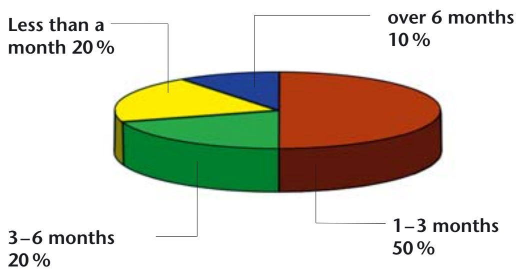
Training and education should be oriented to the demand of the market. Production, use and application of renewable energy systems require diversified components. These components should be improved by intensive research and development and by more efficient industrial production. However, it is not the fundamental research which presents the principal barrier to their development, but it is the lack of trained personnel to design, install, and maintain the systems. Most of the new jobs to be created do not require a radically new competence. The manpower

[9] UNESCO international directory of renewable energy information sources and research centres.

Figure 7 (left)
Contribution of components to systems fault

Figure 8 (right)
Time taken to repair a fault (average in Africa)





needs vary according to the different project stages and the systems' components. This can be summarized as follows:

- meteorologists and analysts for the identification of sites and appropriate programs,
- metal workers with good competence in hydraulics for the assembly of wind rotors and towers or assembly of solar collectors, plumbers and tube workers for the installation of solar heaters,
- electricians for photovoltaic and wind energy systems,
- carpenters and building craftsmen for the integration of solar systems in buildings and power plants,
- architects for the urban planning and building design,
- engineers and designers in several sectors: civil engineering, power electronics, electric engineering, process control, quality control, chemistry etc.

The various technicians mentioned above need an appropriate training based upon their original background. For instance, engineers, designers and architects do have sufficient basic knowledge. However a radical change in their usual behavior is necessary. They are used to work with conventional systems in always the same environment, while the renewable energy technologies depend on the site and climate as they also interact with consumers. They do not offer universal solutions (except for some applications, such as calculators and solar lighting kits). This constitutes one of the principal barriers to their wide-spread use. In general, they require more work than conventional systems for their design, adaptation, and use. This implies the creation of more jobs in order to get sustainable and efficient systems.

Specific training aspects[10]

In order to improve training of researchers, engineers, technicians and superior technicians, several specific considerations should be taken into account. This is also true for the information required by decision makers, local elected representatives, consultants and the general public. As an example, the following develops some of these considerations with a focus on the training of technicians. This is the most important and necessary action for the success of a renewable energy programme. Thus, it will be presented first.

Training for technicians

Technicians play a principal role in all aspects of solar energy projects: beginning with the levels of laboratory work, test centres, industrial production of components, commercial distribution, and system assembly, reaching to the optimisation of system design and size, which should be based on the precise needs of individuals or the village community, installation, operation and maintenance, in order to ensure the best quality of energy service. The success of solar projects will not be achieved unless each step is realised successfully by competent technicians. Thus, the most important requirement is the availability of competent technicians to ensure the installation, repair and maintenance of systems. Rural electrification will be achieved through technicians in local networks of service businesses.

[10] O. Benchikh, UNESCO, "Renewable Energy education and Trainig Program".

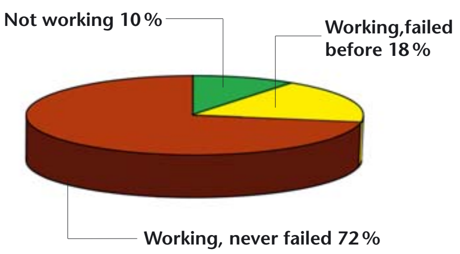


Figure 9
Fault occurences in Solar PV installations

Past experience reveals that, even if photovoltaic modules are of an extraordinary quality, they are subject to failures. These are most often caused by defects in classical components (switches, batteries, power conditioning, connections, etc.).

If one can rectify them in due time, such problems will be without consequences, but it is regrettable to neglect these aspects of after-sales service. So, there are very precise needs for training technicians in specialties.

Technical education institutes are obviously the best places to carry out this training. Therefore, institutes should work in close relations with the solar testing centres, particularly where it is possible to use their technical facilities to support training and education.

Continued education is another important aspect to consider for technician training. It should permit technicians qualified in other disciplines to acquire, in a relatively short time, the knowledge necessary to master one of the above-mentioned specialties. Organising this type of training represents one way of ensuring the formation of solar technicians.

The availability of high quality, specialised literature is a necessary and complementary aspect of technicians' training. Technicians will benefit greatly by acquiring material such as:

- Technicians' guide or handbook that collates, in a condensed manner, the theoretical results, schematic diagrams, basic formulas, rules and practical recommendations that would be useful to solar technicians.
- Documentation on components and solar equipment, which could serve as a kind of 'user's guide', indicating suppliers, cost, performance, best ratio of quality / price, etc.

Training for researchers

One must underline the importance of promoting a research programme in the relatively new sector of solar chemistry, which is dedicated to fuel production. It is convenient also to mention other research topics that are already well established, but should at least continue or even be amplified.

First of all, it is important to consider research on photocells and photovoltaic systems. The performance and cost of these systems still need to be improved substantially. As an outcome to the rural electrification programme and resulting market expansion, progress in this field will be accelerated. This dynamism would lead to an increase in industrial efforts and justify the reinforcement of research facilities in this sector.

Universities and schools of engineering, in the countries of the North and of the South, must committ to take up the mission of forming tomorrow's researchers. In turn, these individuals will ensure progress in the GREET Programme. The following actions can be adopted now to help these institutions achieve their mission:

- Reinforce theoretical and practical education in the basic disciplines, upon which the research depends. Within this frame, several other disciplines should be considered amongst the first rank: solid-state physics, physics of materials, molecular physics, thermo-chemistry, photochemistry, thermal sciences and thermodynamics.
- Define research topics in the field of photovoltaic (photocells, photo-chemistry, and solar fuels) for student thesis or graduate projects.
- Incorporate these research topics into a global vision of the role of renewable energies among the energy resources for the 21st century (analysis of energy supply and demand, economic considerations, and environmental constraints).
- Organise cooperation programmes amongst higher education institutions, in the North and South, on research related to solar energy. This collaboration could be made through

common studies of scientific projects and could lead to student exchanges.
- Create a 'think tank' (under the framework of the World Solar Summit, for example) on the training of researchers in the disciplines that would support the progress of solar energy. The task of this group would be to define the actions to be taken for training researchers, to elaborate a strategy, and to aid university departments in establishing such programmes.

Training of engineers

The realisation of renewable energy programmes, particularly solar rural electrification, constitutes a large industrial project for the coming decades. Industrialised countries can have an appreciable contribution in this area, which will also have a beneficial impact on job creation. This dynamic could help generate a domestic industry with the capacity to significantly contribute to those programmes as the GREET Programme.

The industrial boom foreseen in solar and wind electricity, as well as in passive architecture, requires a new generation of engineers whose work, initiatives and competence will be the best guarantee for success. There is a clear need to ensure the development and training of future engineers who will have the task of creating, organising and establishing the solar industry of the future.

The required fields of competence for engineering curricula are identical to those mentioned above for the researchers: solid-state physics, physics of materials, molecular physics, thermochemistry photochemistry, thermal sciences and thermodynamics. In addition, they would require expertise in power electronics, electrotechnology, and fluid mechanics.

In this educational process, practical aspects should have top priority. In fact, the course contents should leave a large portion for experimental work and for projects related to real equipment and full-scale installations. There is a strong interest in establishing the training institutions for engineers near solar testing centres, of which a certain number already exists.

Specialised education and training in renewable energy leading to a university degree, at the Master's level, represents a programme that could be proposed for both researchers and engineers working in this field. This type of education would allow planners and those who carry out renewable energy programmes to have access to complete information and know-how within a reasonable period of time (18 months).

Continued education represents another important aspect for the training of engineers. In fact, this would allow engineers who specialised in other disciplines to acquire, during a minimum of time, sufficient knowledge to enable them to work efficiently in a new field. Short training courses, such as summer schools, are very responsive to this need. The annual summer school on 'solar electricity for rural and isolated zones' organised by UNESCO presents an example of action in this direction. This initiative should be encouraged, continued, and even extended to other sectors such as biomass and wind energy, as well as other renewable energies.

To summarize, the following recommendations can be made:

- Encourage and support the activities of solar testing centers to promote their contribution in the education and training of engineers.
- Promote the engineering teaching of the above mentioned disciplines and encourage introduction of renewable energy topics on the occasion of practical training in enterprises, graduation projects, practical work, etc.
- Organize the exchange of students of engineering schools from the North and South, in a thoughtful study on topics related to renewable energy projects.
- Respond to the needs related to continued education on renewable energies. The model of summer schools programs should be reinforced and expanded.
- Set up an international advisory committee on education and training of engineers in order to elaborate a strategy in the capacity building and human resources development area.

Information for decision makers, locally elected representatives and service technicians

One of the difficulties to be overcome in promoting these programmes is convincing decision makers of the solid basis of these proposals, in order to get their support. The current context falls short by far of being favourable for such action. The current low cost of oil products and the existence of other technologies – considered, correctly or incorrectly, to be more credible – create a degree of uncertainty, scepticism and even hostility towards solar technologies amongst decision makers and experts. This difficult situation can also be linked to the lack of general knowledge of the results and successes of solar technologies in recent years.

This insufficiency of information on renewable energies is due to the limitations of the facilities offered to solar researchers in the past. A real effort is needed to improve general knowledge outside the solar research community.

Past experience shows that the main obstacle to the development of solar technology is the indifference or opposition of electricity-producing and distributing companies. This is coupled to the indifference of decision makers. For an electricity planner, rural electrification usually means the development and the extension of the existing grid. A locally elected representative, who does not have a good knowledge of the various available technologies, may simply go back to the national electricity utility. The final result is that the safest solution is adopted either by inertia or by tradition.

It is therefore necessary to convince both electricity utility staff and local representatives that the adoption of solar technologies is a bonus card for all stakeholders. Decentralised solar technologies are not necessarily antagonistic to interconnected networks, but rather are complementary to them. Certain electricity utilities hold this viewpoint, especially when the construction of new power stations or the electricity grid extension encounter financial, ecological or regulatory difficulties.

In developing countries, the concept of 'pre-electrification' would result in promoting certain solar technologies as a first step towards the construction of an interconnected network. Solar energy's best ally is the electrical engineer who understands that it is not a competitor of, but rather a tool for the development of electricity supply. A major effort to improve general knowledge and training in this field is still needed.

Actions required for the development of general knowledge programmes oriented towards decision makers should include:

- Organising seminars, workshops or summer schools that target decision makers and experts related to other energy fields. The goal should be to inform them about possible future solar applications, including the anticipated progress and economic aspects.
- Developing presentations on the possibilities of solar technology market penetration in the form of alternative scenarios.
- Reporting on the prospects of renewable energies in scientific and economic journals.
- Organising technical visits to the most outstanding solar energy installations.
- Producing audio-visual materials that illustrate existing solar installations, as well as future prospects for these technologies.

Information to the public

Training and information activities, similar to those elaborated in the previous section, should equally be undertaken for the general public. At present, most people are unaware of most of the achievements, possibilities and prospects of solar technologies. In countries where solar programmes could be implemented, or where the population would have direct contact with solar equipment, this information programme would join that for users.

There is much work to be undertaken in the information and training of the general public, including the following:

- Publishing information, in the form of study articles and comprehensive, well documented reports, on solar energy and its prospects.
- Distribute such information and/or documentation to consumer associations.

- Produce and broadcast programmes and documentary films for television.
- Create fixed exhibitions at technology parks to allow the presentation of a wide array of solar equipment and its applications. Organise general public visits to solar test centres.
- Encourage teaching of renewable energy technologies in primary and secondary schools. Within the context of courses in physics, chemistry and technology, a scientific base on solar energy can effectively be introduced to the thinking of young students. In the very near future, these individuals will be the implementers of the large energy programmes, currently being launched.

Table 1
Guide of technology options

Technology	Hydro-electric	Wind turbines	Photo-voltaics conv.	Solar therdyn.	Solar thermal	Geo-thermal	Biomass
Related disciplines							
Mechanics	••	••		•	•		
Geology	••					••	•
Atmosph. phys	•	••	•	•	•		•
Thermodyn.				••			
Thermal sci.				••	••	••	
Building eng.					••		
Chemistry			•	•	•	•	•
Chem. eng.			•	•			••
Phys.of mat.	•	•	••		•		
Electro. phy.		•	••	•			
Electro. tech.	•	•	•	•			
Agronomy							••
Bio. eng.							••

General contents of teaching programmes

The overall objective of education and training programmes is to address general problems related to energy, as well as the need to conserve energy and use renewable energy sources. At the same time, the particular technology should correspond to the competence of the instructor and the desire of the learner.

In the past, most training programmes focused on a specific type of renewable energy, concentrating on a certain technology without placing it in a more general context. In addition, existing general training programmes on energy conservation were not oriented toward a specific renewable energy form or a particular application. This situation is unsatisfactory in that it does not respond to real needs.

A general training programme on renewable energies and related technology options is proposed as an example. It could be compared to a ‘general store’ of basic courses and ‘menus’ from which particular options can be selected for each target audience (researchers, engineers, technicians, decision makers, industrialists, end-users, the general public, etc.).

At present, there is a scarcity of appropriate disciplines in relevant teaching programmes for each technology. If an individual would like to intensify his technical capabilities to solve the problems encountered, he must select one of these particular technologies. This should be supported by the usual basic knowledge, which remains the foundation for building up the trainee’s abilities, together with any other complementary knowledge that is necessary for the training.

The complementary knowledge would be acquired partially through the basic general courses mentioned above, which would help clarify the role of renewable energy in today’s world. Depending on each technology option, it would also include other particular points to help trainees to deal with problems in the field. Sensitising trainees to the real state of the art of the system’s use and manufacturing is a high priority; it will also help clarify the role and importance of the various technology options. Therefore, the proposed training programme should cover at least one or two of the technologies referred to in the following table.

Each scientific education unit will select its technology options according to its field of interests. It is important to note that this does not exclude a simultaneous selection of one renewable energy option and one other form of energy. In addition, sufficient time should be allocated to general knowledge. Units that currently specialise in economics or human sciences but wish to initiate training programmes on renewable energies could call upon external specialists to deliver the necessary information to the target audience. The most important consideration is that the information be realistic and cover the use and application of renewable energies, especially in different contexts. That is, trainees should be made aware of the potential of renewable energies to meet sustainable targets, to contribute to poverty reduction and to support job creation.

Economic and Political Aspects of the Transition to Renewable Energy Systems

- Policies and Measures for Renewable Energy and Energy Efficiency in South Africa
- Research and Development Needs for Renewable Energy Technology in Industrialized Countries
- The Challenge of Renewable Energies Integration in Energy Distribution Systems
- Integrating Renewable Energy into Society
- Promotion of Renewable Energies for Heating and Cooling
- Transitioning to a Renewable Energy Future
- Full Solar Supply of Industrialized Countries – The Example Japan

Policies and Measures for Renewable Energy and Energy Efficiency in South Africa

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Background

The South Africa democratic elections held of 1994 initiated a change in government policy across all sectors. With the new government in place, there was an in-depth review of all government policies in order to align them with basic principles of democracy and human rights. The new policy paradigm addressed issues of economic efficiency, access to affordable energy for all and environmental sustainability. This, however, was not an easy task for the newly elected government, especially in view of the economic and infrastructural constraints and challenges.

One of the key challenges that South Africa still faces is for development aspirations to bring on board racial equity, job creation, poverty reduction and economic prosperity while minimising the adverse environmental impacts. For a long period of time the South African energy scenario has been dominated by coal, one of the most carbon intensive fuels and associated with a high emission rate of carbon, responsible for the global environmental threat. While it is recognized that Africa does not contribute much to total global emissions, South Africa remains a notable exception, with carbon emissions per capita closer to industrialised countries that are the major contributor to this threat. This reason and others necessitate a change in policy framework in order to tailor it to fit the requirements of sustainable development, putting in the development domain issues of economic, environment as well as social development.

Renewable Energy Policy

In 1998 South Africa formulated a new energy policy, significantly different from the pre-1994 one, which provided energy services according to race. Major objectives of the new government policy for the energy sector were spelled out in the 1998 Energy White Paper as:

1) Increasing access to affordable energy services.
2) Improving energy governance – clarification of the relative roles and functions of various energy institutions within the context of

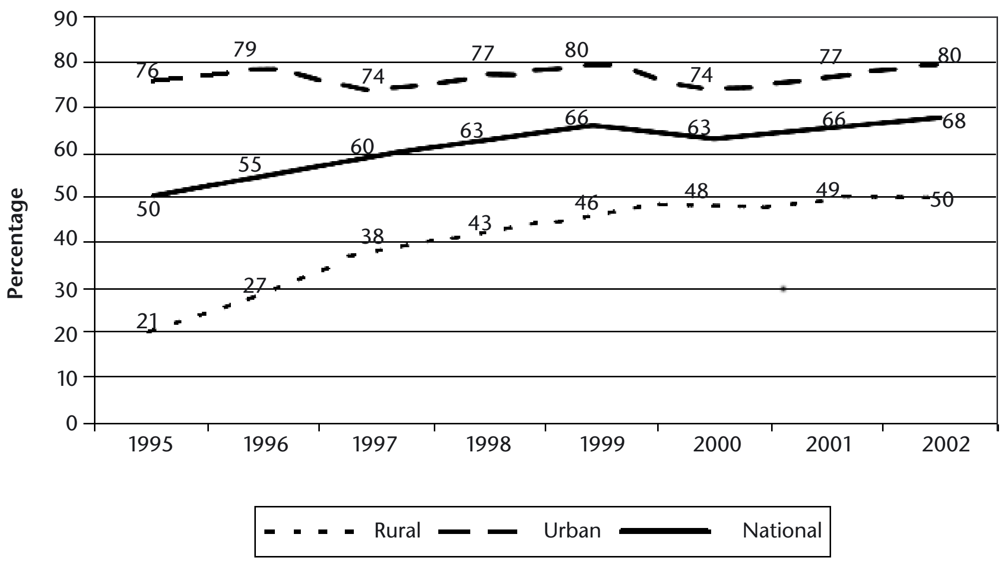


Figure 1
Trends in electrification of households in South Africa: 1995 – 2002

accountability, transparency and inclusive membership, particularly participation by the previously disadvantaged.
3) Stimulating economic development – encouragement of competition within energy markets.
4) Managing energy-related environmental and health effects – promotion of access to basic energy services for poor households while reducing negative health impacts arising from energy activities.
5) Securing supply through diversity – increased opportunities for energy trade, particularly within the Southern African region, and diversity of both supply sources and primary energy carriers.

The new energy policy helped to consolidate programs that were already in place in trying to improve provision of modern energy services to people. This included the National Electrification Program for 1994–1999, targeting to increase electrification level from 36 per cent in 1994 to about 66 per cent nationally by 2001. The target was exceeded, with 2.75 million connections achieved by end of Phase 1 of the Programme. By end of 2001 the National Electricity Regulator (NER) recorded 3.4 million connections.

Renewable energy policy

Recognizing the contribution potential of renewable energy sources to modern energy services in South Africa, the Government in 2003 released the White Paper on Renewable Energy. This had a number of objectives, including ensuring that an equitable level of national resources was invested in renewable technologies; directing public resources for implementation of renewable energy technologies; introducing suitable fiscal incentives for renewable energy and; creating an investment climate for the development of renewable energy sector. The key objectives of the White Paper were considered in the five major facilitative areas given below.

Financial instruments

- To ensure that an equitable level of national resources is invested in renewable technologies, given their potential and compared to investments in other energy supply.
- To set targets for directing of public resources for implementation of renewable energy technologies.
- To extend existing state financial support systems and institutions and introduce sustainable financing mechanisms for delivering renewable energy systems.
- To introduce suitable fiscal incentives for renewable energy.
- To make easy the creation of an investment climate for the development of renewable energy sector, which can attract foreign and local investors.

Legal instruments

- To develop an appropriate legal and regulatory framework for pricing and tariff structures to support the integration of renewable energy into the energy economy and to attract investors.
- To develop an enabling legislative and regulatory framework to integrate independent power producers into existing electricity system.
- To develop an enabling legislative framework to integrate local producers of liquid fuels and gas from renewable resources into their respective systems.

Technology development

- To promote the development and implementation of appropriate standards and guidelines and codes of practice for the appropriate use of renewable energy technologies.
- To support appropriate research and development and local manufacturing to strengthen renewable energy technology and optimise its implementation.

Awareness raising, capacity building and education

- To promote knowledge of renewable energy and increase their use.
- To promote and stimulate renewable energy market through dissemination of information on economic, environmental, social and trade benefits of renewable energy technologies and their applications.

- To persuade institutions to implement training and education programs on renewable energy.
- To actively involve women in decision making and planning on renewable energy activities.
- To improve communication and interaction between government and other institutions on renewable energy policies.

Policies and measures for renewable energy implementation

There is considerable potential for renewable energy sources in South Africa, from solar, wind, biomass, waves and hydro, but the key challenge is to translate this into technical, economic and market realities. Doing this would need careful thinking of policies and measures that could result in optimal tapping of the renewable energy sources, taking into account the prevailing national circumstances.

A number of policies and measures have been proposed by different players, and some of the extensively researched were those put forward in a study that was commissioned to Energy Research Centre (ERC, University of Cape Town) by the Sustainable Energy and Climate Change Partnership (SECCP), a partnership between Earthlife Africa Johannesburg and the World Wildlife Fund of Denmark[1]. The policies and measures proposed by ERC centred around attaining three main objectives:

- a portfolio of policies and measures for realising the potential for renewable energy and energy efficiency in South Africa.
- investigating how such policies and measures could form part of an effective climate change response by estimating the potential greenhouse gas (GHG) reductions.
- identifying and making projections of sustainable development impacts related to realising the renewable energy and energy efficiency potential.

With this background, and considering the unique South Africa energy circumstances, a number of policies and measures were proposed, including recommendations on how they could be implemented. The policies and measures were grouped into four main categories, as being market-based instruments, regulatory measures, institutional and legal measures, and voluntary measures, as shown below:

Market based instruments

- Financing energy efficient housing and appliances (bonds and loans),
- Incremental housing subsidy for energy efficiency upgrade in low cost housing,
- Concessionary loans for incremental costs efficient equipment and combined heat and power,
- Production subsidies for renewable electricity generation,
- Pollution taxes,
- Wires charge and additional sources of financing.

Regulatory instruments – targets, codes and standards

- Targets for renewable electricity generation,
- Strengthen commercial building codes,
- Residential building codes,
- Household appliance-labelling and mandatory energy performance standards,
- Commercial and industrial equipment labelling and mandatory energy performance standards,
- Government procurement standards for equipment and upgrading energy efficiency standards in government buildings,
- Compulsory fuel efficiency standards for corporate and institutional fleets,
- Particulate emission control and transport policy,
- Regulatory interventions to promote energy efficiency,
- Green tariffs, trading and renewable electricity.

Institutional and legal environment

- Strengthen the institutional framework for energy efficiency,

[1] This study was undertaken by the Energy Research Centre, Iniversity of Cape Town. The team of researchers involved included; Prof. Ogunlade Davidson (Project Leader), Prof. Kevin Bennet, Pierre Mukheibir, Stanford Mwakasonda, JC Nkomo, Randall Spalding-Fecher, Harald Winkler, Rodney Xali, Mark Howells, Alison Hughes and Frances Craigie.

- Renewable energy legislative framework,
- Research, development and demonstration,
- Awareness and education,

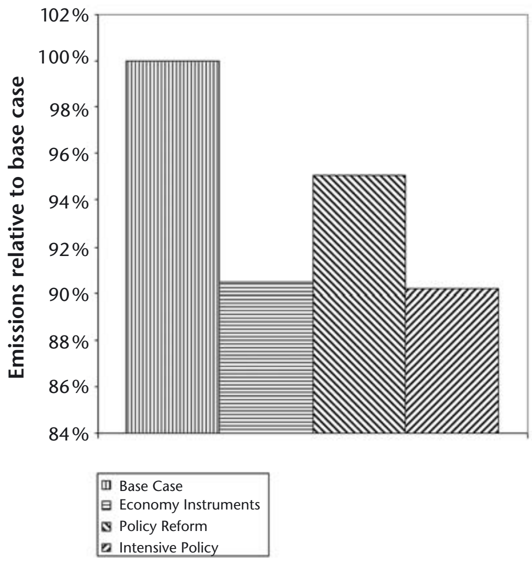
Voluntary agreements
The above policies and measures analysed with reference to three implementation scenarios in order to assess their impact of implementation. Modelling was used on certain aspects of the policies and measures. The three scenarios for implementation were as shown in *Tab. 1*.

Base case	Business as usual government policy, based on Department of Minerals and Energy (DME) official projections and public domain data
Economic instruments	Moderate; focus on economic instruments to correct market failures in relation to RE and EE
Policy reform	Moderate; focus on meeting targets for RE and EE cost-effectively
Intensive policy	Intensive; more focus on promoting RE and EE; stronger weighting of social and environmental concerns

Table 1
Scenarios for implementation of policies and measures for renewable energy and energy efficiency

It was observed that the three implementation scenarios each had benefits and costs across a range of different indicators. In the reduction of GHG emissions for example, setting a renewable energy target of 25 % for electricity generation over a 20 year period showed a significant level of lower local pollution (up to 10 %), as well as reductions in GHG emissions (6 – 10 %).

Figure 2
Relative emissions of carbon dioxide (cumulative over 20 Years)



After such analysis of different combinations of policies and measures, the following five policies and measures were recommended as priorities:

1) Mandatory codes and standards for energy efficient buildings in government, commercial and residential sectors
   - aiming to reduce commercial building energy consumption (excluding lighting)
2) Equipment standards for industry and commerce
   - development of mandatory performance standards for industrial equipment as well as a mandatory energy labelling system
3) Targets for renewable electricity generation
   - a target of renewable electricity generation providing 15 % of total electricity consumption by 2020
4) Production subsidies for renewable electricity
   - in order to make renewable electricity competitive
5) Pollution tax
   - A tax on air pollutants, levied per mass unit of emissions

Appropriate enabling conditions are an important prerequisite in order for any policies and measures to have the required impact. While recognising the role of market-based instruments, the right place for subsidies to contribute to their effectiveness is also crucial, especially in an immature market like the renewable energy. In any case, there can not be a "one-size-fits all" rule to the applicability of the above mentioned policies and measures. Each country need to make an in depth analysis of the prevailing circumstances before deciding on what to include in the shopping basket for policies and measures for either renewable energy or energy efficiency programs.

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Research and Development Needs for Renewable Energy Technology in Industrialized Countries

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Abstract

With a large number of users and high volumes of production, renewable energy technologies will be typical industrial mass products. Using photovoltaics as the example, we show that the most important research and development (R&D) function of industrialized countries in renewable energy is to focus on the reduction of cost per unit of power output. Reducing the cost/power ratio of renewables relies on the ability of developed countries to conduct advanced R&D.

Renewable energy – a large-volume industry

Renewable energy generation must be large to have impact on the global energy supply. Renewable energy will have many users, will produce large quantities of electrical or thermal energy or fuel, will use large quantities of material for their construction, and will require large investments of capital. These characteristics are typical of mass-produced industrial goods.

Therefore, renewable energy sources are following a path that is characteristic of modern industrial products like the automobile or the microprocessor. The widespread use of these was made possible by low cost, per passenger or per logic gate, of very advanced products. For the widespread use of renewable energy, low cost per unit of power or energy will be equally essential. For the eventual adoption of renewable energy by private users the cost of energy must be low. Its renewable character will be a secondary attractor for the vast majority of users in developed countries that we want to engage.

This argument applies to all sources of renewable energy produced in large quantity, whether in distributed or in central, bulk, form. Taking advantage of our own experience we employ photovoltaics (PV) as the vehicle for making our point. The present cost of PV is $ 3/W of module, and $ 6/W or more for the whole system. $ 3/W systems cost is the target for opening large markets for distributed systems. A system cost

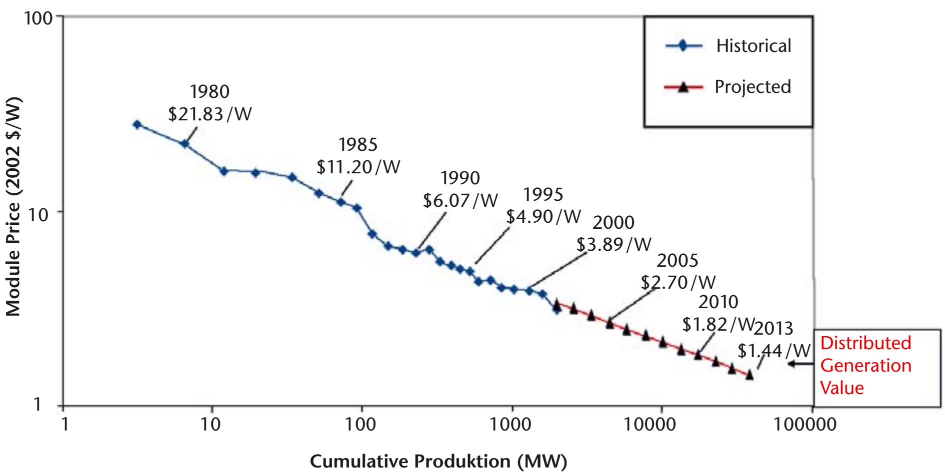

Figure 1
The experience curve for photovoltaic module price, and its extrapolation to the year of 2013.

The module cost of $ 1.44/W will open a large commercially viable market for distributed generation of photovoltaic electricity. From ref. [1].m ref. [1].

of $1.30/W is expected to introduce PV to the bulk power market. (We use $/W here to denote the cost per Watt of output power under peak insolation, which corresponds approximately to $0.25/We, the average output of a conventional power plant.)

Renewable energy cost reduction to date – the photovoltaic example

Like many mass-produced products, solar electric modules have come down in price with manufacturing experience. On average, the panel price has dropped to 81% of its value at the beginning of each period of doubling of cumulative production. The cumulative production counts all modules ever produced. This historical record is illustrated by *Fig. 1*, which also includes a projection of cost reduction anticipated over the next ten years. [1] (It is assumed but not assured that future cost will follow the historical trend of *Fig. 1*). While economists do not yet understand the semi-logarithmic dependence shown by this "experience curve," it is clear that the cost is coming down in part by R&D.

To understand the role of R&D in past cost reduction, and its leverage on cost reduction in the future, let us look at the components of module cost. The four main steps of module fabrication are reflected in the pie chart of *Fig. 2* on cost components of a PV module. These are (i) silicon refining and crystal growth, (ii) wafer cutting, (iii) cell fabrication, and (iv) module assembly. *Tab. 1* illustrates how each of these steps has contributed to the cost reduction depicted in *Fig. 1*. The manufacturing processes of all four steps have been improved.

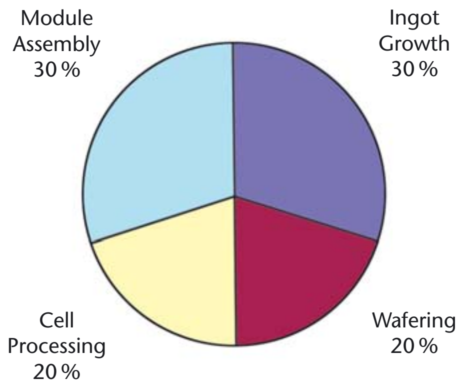

Figure 2
Main components of crystalline silicon PV module cost. From ref. [1].

Improving the cell efficiency is particularly important to cost reduction because of its leverage on the cost of the entire system. Raising the cell efficiency brings down the cost (per Watt) of the entire system, that is, it reduces the cost per watt of all manufacturing steps and of the balance-of-system.

Prognosis for further cost reduction – the photovoltaic example

The silicon solar cell roadmap foresees further improvements in cell and manufacturing efficiency, with module cost projected to reach $1.50/W by the year 2012. PV manufacturers are confident that the necessary technology can be developed. Cost reductions are anticipated in all steps of module manufacture, as described in the rightmost column of *Tab. 1*. Taking the balance-of-systems cost to be equal to the module cost, in 2012 the PV systems cost will become competitive for distributed application of PV. In other words, at this cost distributed PV no longer will need subsidies because it will be profitable.

Table 1
Improvements in silicon PV module manufacturing: history and projection

Process step	Material/process	Improvement to date	By2012
Silicon crystal	Polysilicon price	$300/kg → $30/kg	
	Larger diameter	75 mm → 150 mm	**200 mm**
Wafer Cutting	Wire sawing	< $ 0.25/W	
	Thinner Wafers	375 µm → 150 µm	**120 µm**
Cell fabrication	Higher efficiency	10% → 16%	**23%**
	Volume manufacturing	1 MW → 100 MW annual production	**500 MW**
Module assembly	**Automation**	**None → some**	**More**

The forecast for reaching the goal of PV to bulk power generation is less certain. For competitive bulk power generation the module cost will have to drop to $0.65/W, and the systems cost to $1.30/W. The scientific and technical path to this goal is not known, and finding it will need new discoveries, inventions, and manufacturing techniques.

Renewable technologies are complex products of advanced industrial societies

The preceding sections illustrate our main point: Because of their large numbers and extreme cost constraints, distributed systems for the generation of renewable power will have to be industrial mass products. Their introduction will follow that of other mass products made by demanding technologies, such as automobiles and microprocessors. They are invented, engineered, made, and first used in developed countries. In the past such advanced industrial products first have been imported to developing countries as status symbols of the wealthy. Because they turned out to meet basic societal needs and became affordable, large markets opened up for them in developing just as in developed countries. These markets were supplied with standardized products, which were adapted to local conditions in a kind of mass customization. When local markets in developing countries became sufficiently large, developed countries manufactured products tailored for export. Local manufacture in developing countries followed, which entrained the buildup of local base of suppliers. This flow of technological development that eventually becomes mutual is laid out in *Tab. 2*. Until sufficient income is generated locally from renewable energy sales, much of the sequence is financed by capital from developed countries.

How much subsidy is needed to make distributed PV power commercially viable?

Extrapolating the experience curve of *Fig. 1* shows that the commercially competitive module price of $1.50/W is attained when the cumulative production has reached 30,000 MW. *Fig. 1* allows to calculate the subsidy needed for reaching commercially viable distributed PV power. Assuming that manufacturers and installers are subsidized to receive $6/W of system, the total subsidy for bring systems cost to $3/W is $25 billion. This amount suggests that PV financing also will remain in the domain of the industrialized countries for some time to come. It is plausible that this need for subsidies, and their source, extends to several other renewable energy technologies.

Industrialized countries →
Exploratory research → invention → applied research →
→ product development → pilot production → field test
→ manufacture →
→ systems development → applications development → use
← Developing countries

Table 2
Entry points and growth directions in renewable energy industries of developed and of developing countries.

R&D entry for developing countries

While the need for mass production at low cost places the burden of development and financing renewable technology squarely on the shoulders of the industrialized countries, many developing countries have technology bases that enable them to make significant R&D contributions to renewables. *Tab. 3* lays out one possible approach.

Developing countries →
Energy conservation → heating/cooling → wind power
→ liquid fuels → PV electricity

Table 3
A possible division of labor in the development of renewable energy technology

Consequences on the division of labor in research and training

The preceding discussion served to highlight the most important need in R&D on renewable energy technology: to reduce its cost to a commercially viable level. Low cost is the key to successful market development. Once cost is low self-motivated and self-financed markets will spring up in developing countries, which then will begin moving in the direction from application to manufacture to R&D.

Reduction of the cost/power ratio must drive the research agenda for developed countries. This agenda will cover all aspects of the renewable technology, ranging from materials to physical function, to manufacturing, to systems development and installation. In technologies without local expertise in developing countries, developed countries will train local experts for applications and customization of systems. Where local expertise in renewable applications already exists, developing countries can help best by strengthening their R&D capability that helps local entry to cost effective manufacturing.

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The Challenge of Renewable Energies Integration in Energy Distribution Systems

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Introduction

Despite the global abundance of renewable energy resources, renewable energy generation capacity constitutes a small share in the global power capacity. The renewable energy capacity in 2000 was estimated to be around 102 GW (excluding large hydroelectric power) representing 3% of the world's installed power capacity. Since the past decade, however, there has been a renewed interest in many countries on renewable energy for power generation. Governments have intervened to promote renewable energy investments. In several developed countries, renewable energy policy interventions were driven by policy objectives such as greenhouse gas emission mitigation, internalisation of environmental externalities and energy security. The renewable energy capacity in EU member countries, for example, has grown 5 times from 1990 to 2001.

The integration of increased renewable energy capacity in electricity distribution systems could be held back by the limitations of the centralized power generation systems in accommodating distributed generation and by the full electricity market liberalization. The technical and regulatory frameworks of centralized power generation systems appear to be inadequate to provide support and incentives to distributed energy generation. While market liberalization increases opportunities for small and medium-sized renewable energy generators, it also exposes them to competitive market risks, thereby reducing the attractiveness of renewable energy generation.

The paper briefly reviews distributed energy generation, issues and options for power integration in electricity distribution systems and outlines research strategies for renewable energy.

Power generation integration in electricity distribution systems

Electricity generating plants utilizing either renewable energy or conventional fuels, integrated into distribution networks are broadly categorized as distributed generation. Renewable energy technologies suited for small to medium-sized distributed generation include photovoltaic cells, wind power and biomass-based technologies. Technologies fuelled by fossil energy are conventional steam turbines, combustion turbines, internal combustion engine generators, micro turbines, and fuel cells.

Key characteristics that differentiate distributed generation from the centralized power supply relates to location, capacity and grid connection. Distributed generators are located near the point at which the power is consumed. Distributed generation technologies are small in scale or can be produced economically in a range of sizes. Traditional electricity suppliers are connected to the grid at high voltage level while distributed generators are connected to the grid at distribution level.

Several developments have influenced the increased interest for distributed generation recently. These are
1) generation and distribution technology development;
2) liberalization in the electricity market;
3) energy supply security concerns; and
4) renewable energy policies driven by environmental concerns.

In Western Europe, particularly the European Union Member States, environmental policies, increased awareness on distributed generation technologies, and electricity market liberalization are the factors that generate increased deployment of distributed generators. In the

US, the growth of distributed generation is driven by issues related to poor power quality and supply security as well as increased recognition of environmental benefits of distributed generation.

The benefits of distributed generation include the following: greenhouse gas emissions reductions particularly for generation based on renewable energy and low carbon fuels; security and diversity of supply since various energy sources will be used in distributed generation; and cost reductions since electricity is generated by more efficient systems and close to the point of consumption. Additional benefits of distributed generation in general include deferral of upgrades from transmission and distribution systems, reduction of losses in the distribution system, and provision of network support or ancillary services.

In countries with liberalized electricity markets, distributed generation becomes attractive since it has short construction lead times, low capital costs, flexibility in operation, and its ability to expand output. It must be noted, however, that these attributes are mainly associated with fossil fuel-based technologies since most renewable energy technologies have intermittent electricity generation, high installation costs and limited flexibility in operation and expansion.

Issues and options

Grid interconnection

The existing electricity supply systems in most countries awre centralized systems where electricity is generated in large power stations and delivered to customers through transmission and distribution networks. Centralized systems support a unidirectional flow of electricity. The integration of small-scale generation at the distribution level can result in technical problems that may affect network stability and power quality. These problems include voltage control, reactive power control and islanding. For countries without grid interconnection standards, this may result in increased transaction costs since distribution network operators often require distributed generators to shoulder the grid impact assessment costs. The development of interconnection standards, guidelines for dealing with interconnection requests and procedures are often seen to reduce transaction costs for network operators and distributed generators.

In countries where distributed generation is growing rapidly, electricity networks are facing new challenges in terms of network stability and power quality. High penetration levels of distributed generation increase risks of serious network failures. In the case of Denmark where the penetration rate of distributed generation is high (around 35 % at present), it has been reported that the costs of network reinforcements have risen considerably. To allow further increase of distributed generation share, it requires new technological development. One possible development is for current passive distribution networks to evolve into actively managed networks. This means that the network must be treated not as a power supply system but as a transport system that provides connection between points of supply and consumption. In this case, bi-directional flows of electricity are possible, local control areas which enables local network areas to act as independent islands are used, and system services become specified attributes of a connection.

Intermittent distributed generation (renewable energy technologies) pose a different technical challenge. High penetration rates of intermittent distributed generation pose a serious technical constraint, which requires some form of back-up power or energy storage. The high share of wind power in Denmark is being backed-up with a large capacity from the Nordic electricity pool. To some extent, combined heat and power (CHP) plants have also provided back-up capacity. There is a revival of interest of energy storage as a technical option for intermittent energy generation. The current particular interest is on the production and storage of hydrogen from electricity at off-peak period and during the times where there is surplus of renewable energy.

Market liberalization

Under a vertically-integrated monopolistic electricity industry structure, electricity produced by distributed generators is purchased by utilities under various contractual arrangements. Under liberalized markets, opportunities for distributed generators are increased since they can sell their outputs directly to customers with the opening of access to networks. Limited reforms, however, may be unfavourable to distributed generators. If reforms are limited to wholesale competition, the conditions will be similar to monopolistic industry structure. In partial retail competition, utilities may practice anti-competitive behaviour by offering price discounts to contestable markets creating entry barrier to distributed generators. Full retail competition therefore is vital for the development of distributed generation. If cross-ownership is allowed under full retail competition, electricity distribution companies owning generators to supply electricity to their customers still have the incentive to discriminate against distributed generators. This incentive to discriminate is removed with the separation of distribution from generation.

The complexity in market structure, operation and pricing is increased with liberalization making it more costly for small-scale distributed generators, particularly small and intermittent producers, in dealing with market competition, in undertaking bilateral contracts with consumers, in meeting electricity dispatch requirements (balancing requirement), and in procuring back-up power. This could be mitigated by developing trading arrangements and market rules that provide correct signals and right incentives to facilitate the growth of distributed generation.

Regulatory frameworks

The integration of distributed generation in distribution networks presents costs and benefits to the network, which needs to be properly valued in order to facilitate the growth of distributed generation. The current regulatory frameworks often fail to recognize, allocate and evaluate most of these costs and benefits. The values (costs and benefits) of distributed generation can be categorized into capital and operational values. Capital values relate to generation and distribution facilities and these include the following: distribution capacity cost deferral, connection costs, metering costs, reserve capacity costs and avoidance of over capacity. Operational values include reduction losses, voltage support, reactive power support and balancing power. It must be recognized that economic values for reliable distributed generation are higher than those for intermittent generation.

A sustainable network regulatory system must provide correct signals to generators. This means that all distributed generation costs and benefits must be properly valued. Distribution network operators must be given regulatory incentives to consider costs and benefits of all network users related to network services. A sustainable regulatory framework uses a charging system that combines shallow connection charges, use of system charges with entry and exit charges, and performance based incentives.

Research Strategies for Renewable Energy Integration

The issues and options discussed above can be broadly categorized into issues related to distributed generation in general and those related more specifically to renewable energy generation. The generic issues affect both renewable energy and fossil fuel-based distributed generation. Research strategies must address both the generic distributed generation issues and renewable energy-specific integration issues. As discussed earlier, flexibility, reliability and low generation costs - attributes that are weak in renewable energy generation – are valued highly in competitive and complex electricity markets. Research strategies to facilitate higher integration of renewable energy generation in distribution networks must focus on these weak attributes.

Flexibility in generation maximizes economic benefits by increasing output at times of high pool prices. Intermittent generation from renewable energy can be mitigated and flexibility can be achieved through energy storage. With energy storage, scheduling of energy dispatch would also become possible for intermittent renewable energy generation.

Scheduled generation provide higher economic returns than unscheduled generation. There are several options for storage, but current industry interest is on hydrogen production and storage. There is a current need for research, development and demonstration of energy storage systems.

Predictability of output is very important in balancing actual and forecasts generation. Penalties are high and producers are required to pay higher prices for imbalances in competitive electricity markets. This penalizes the highly variable renewable energy generators. Energy storage could mitigate variability problems. Another area where there is a need for research, development and demonstration is on the improvement of predictive capabilities, such as the development of better weather forecasting techniques and software. With these technologies the variability of forecasts and actual outputs could be significantly reduced.

In competitive markets, renewable energy generation need to compete with central power generation. At present, small-scale renewable energy generation remain uncompetitive unless subsidized for grid applications. Despite the decline of generation costs of several renewable energy technologies since the past decades, technology costs need to further decline in order to become competitive in displacing grid-power. Continued research on renewable energy technology cost reductions and efficiency improvements remain important.

The above strategies can be reinforced by research strategies on generic distributed energy generation. Technical research strategies can be divided into those dealing with the issues associated with the existing centralized power systems and those related to future system design and operation. The former includes research and development of new control technologies (current fault and voltage) as well as distribution management systems while the latter includes interconnection and active network management. Research strategies for electricity system regulation can be focused on the valuation of distributed generation costs and benefits as well as on various regulatory incentives to distribution network operators to connect distributed generation.

Integrating Renewable Energy Into Society

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Introduction

This paper summarizes some of the non-technical aspects of renewable energy, from local and national to regional and global. How both technical and non-technical knowledge of renewables is used in the societal, political and economic processes of development, and how these processes might be managed to achieve the transition to more sustainable energy systems. Due to space and time limitations, this paper focuses primarily on grid-connected bulk renewable generating facilities. That does not in any way diminish the value and importance of solar design in the building sector, solar water heating, small on-site generation, or the future use of renewables in the transportation sector some of which I will only lightly touch upon.

Integrating Renewables into the Electric Utility Structure

Probably the largest use and the greatest impact of renewable energy is for the generation of power in the electric utility sector. This includes grid-connected bulk power (most commonly wind, solar, biomass/biogas, geothermal, and hydro), and grid-connected, on-site generation most commonly from solar electric (PV) and small wind generators. In rural areas, both in developed and developing countries there is also widespread use of solar electric, small wind, small- and micro-hydro, biomass and biogas that are sometimes developed through electric utility programs, through special rural utility districts, and cooperatives. Each of these has their own set of benefits and issues. The following are some of the significant non-technical issues in the electric utility sector.

Socio-Economics – The economics of bulk renewable power generated into the electricity grid has improved dramatically over the past five years. This is due to the reduction in the cost of renewables and the increase in the cost of some conventional fuels, particularly as environmental controls become more stringent. In addition, the volatility of fossil fuel prices, particularly natural gas, makes many sources of renewable power competitive today with conventional sources. Added to that is the need to diversify the power generation mix while also reducing dependence on imported sources of fuel. As a result, domestic renewable resources become a more attractive choice than ever before. The environmental benefits of renewables come as a bonus. Here is a summary of some of the benefits:

- **Renewable Technology Costs:** Improved technology performance and reduced installed costs are continuing to improve renewables competitive position;
- **Environmental Compliance:** Increased costs of conventional fuels and costs of the technical requirements to meet modern generation performance standards bring the costs of conventional power generation within a similar range as renewables;
- **Competition for Water:** Increasingly short supplies of water needed for conventional power plant cooling (and washing of coal) will put more and more pressure on the siting of new thermal plants;
- Stabilize Electric Portfolio Costs: Volatility of natural gas prices and shortages of natural gas supply – renewables tend to have 80 percent or more of their costs fixed and thus can help to stabilize electricity rates;
- Balance of Trade: Desirability of using domestic renewable resources to generate power, while selling domestically produced fossil fuels for hard currency;
- Economic Development: Interest in local jobs and potential for domestic renewable energy manufacturing;
- Rural Development Costs: Renewables are frequently more cost effective than extending transmission lines from central generating stations into rural areas.

Transmission / Distribution System (T / D) – Even with favorable economics, there are many barriers to renewable development and several of those are related to the electricity T/D system. This is a topic that could consume a whole paper. Here are some of the issues.

Transmission / distribution interconnection – Though the technical issues of renewable interconnection into the electricity system are pretty straight forward, how the costs are calculated and who should pay what costs can involve years of political wrangling. Because the existing electricity transmission system has, in almost all cases, been designed to accommodate large central station conventional power generation, revising that system to accommodate small, embedded generation, intermittent and renewable facilities located where the resources are located (rather than load) can be challenging and expensive.

In addition, the transmission and distribution system operating rules can be written in a way that adds more costs than are necessary to small, embedded, and intermittent resources. It is important that T/D operating rules be based on performance rather than technical specifications (i. e. what performance you need from the system rather than what piece of hardware has always been used in the past).

Distribution system upgrade and support – Many renewable generators (as well as co-generators – CHP) are interconnected at the distribution rather than transmission system level. This means that the distribution system may require system reinforcement in order to accept the power and avoid a situation where the renewable generator is not able to operate for significant periods of time. The issues are: Who decides what reinforcements will be made, and who should pay for these system reinforcements? In addition, when renewables are interconnected at the distribution system level, they may bring a variety of benefits to the system, are those benefits calculated and netted against the costs?

Intermittency and control – Probably the most vexing T/D issue has had to do with the intermittency of some types of renewable generation. This debate often expands outside the bounds of technical fact and into the realm of myth. Many utility transmission operators believe that anything above some specific percentage of intermittent resources (some believe this is as low as 5 percent) will totally disrupt their system. Resource planners everywhere need better information, hard data and knowledge of the variables that affect those data. In addition, the fact that smaller generators (often renewables) and intermittent generation is not controllable like large conventional central generation causes more upset and debate than is justified by the actual facts of the situation.

Line extension versus off-grid and mini-grid installations – The politics of transmission line extensions drive much of the rural renewable energy development in developing countries. The determination of where transmission lines will be extended is often determined by political considerations. Moreover, politicians like to make campaign promises about delivering rural electrification. But those promises may never be met. As a result, many rural communities do not support renewable facilities because they think they will soon have 'real' electricity from the grid (but that electricity never comes). The simple requirement that electric utilities announce several years in advance their line-extension plans and then be compelled to follow those plans could help rural communities make more informed decisions about their energy options.

Institutional Culture – The institutional culture within some electric utilities mitigates against the incorporation of renewable resources. Some utility managers still believe 'bigger is better.' They did not get into the utility business to build 'wimpy' renewable energy and energy efficiency projects. "Real men build nuclear and large central fossil generating plants. Countries that are going to move economically and be a power in the world must have nuclear power plants not renewable power plants. That might bring into question the judgment and potential influence of the utility manager."[1] This type of thinking buttressed by myths about how renewables will 'screw-up the electricity system,' pervades many parts of the electric utility industry serving as a silent barrier to the incorporation of renewables into the affected utilities.

It is important to note that many of the barriers faced by renewable technologies are likely to be faced by any new generating technology whose proponents and/or manufacturers do not already have a market share and where the technology is different in size (e.g. modular), pattern of use (e.g. behind the meter), or ownership structure (e.g. non-utility). Incremental changes to existing technologies that are already well established in the energy sector generally have few problems of acceptance and implementation. But because new technologies introduced by new players upset the status quo and conventional ways of thinking, they can face significant barriers.

Integrating Renewables Through Government Policies & Programs

More and more, robust government policies and programs are being put into place to stimulate the development of sustainable renewable resources. The expanding use of these policies by OECD countries is documented in a soon to be released report by the IEA – Renewable Energy Market and Policy Trends in IEA Countries, 2004. Meanwhile, many emerging economies and developing countries are also creating innovative renewable energy policies and legislation. The Renewable Energy Promotion Law being developed by the People's Republic of China is an example of that trend.

Overview of Policies – Countries, states and provinces have introduced a variety of policies to support the deployment of renewable energy technologies. The following figure shows some of the Market Deployment Policy Instruments used to stimulate renewable energy development and use. (This diagram was borrowed from the draft IEA report cited above):

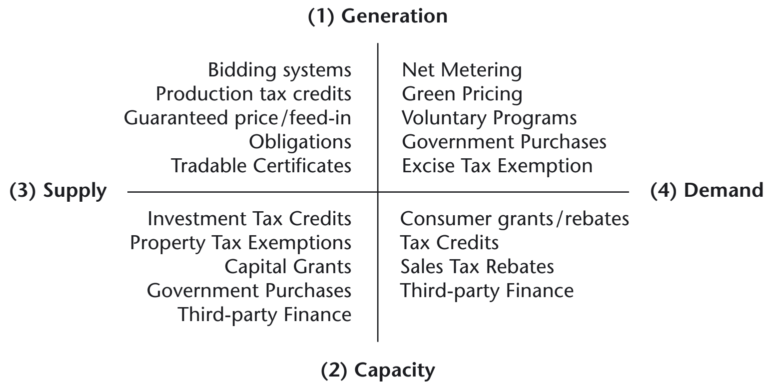


Figure 1
Market Deployment Policy Instruments

This figure illustrates the type and application of market instruments used to stimulate: (1) Generation (energy production); (2) Capacity additions; through (3) Supply-side incentives; and (4) Demand-side Incentives

Looking at the broader spectrum of policy instruments, there are seven primary types of regulatory and legislative renewable energy strategies:

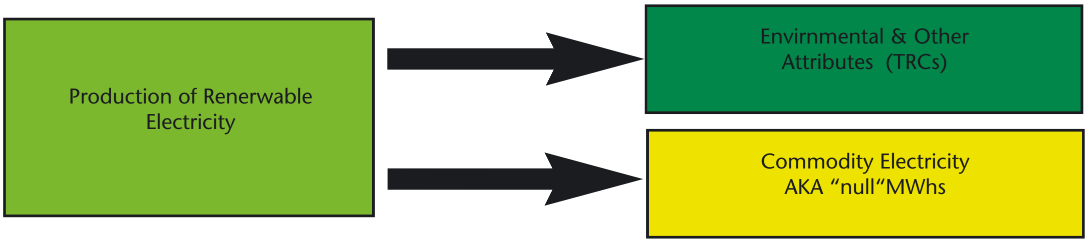
- Research, Development and Demonstration (RD&D) Incentives
- Investment Incentives
- Tax Measures
- Incentive Tariffs
- Voluntary Programs (e.g. Green Tariffs)
- Mandatory Programs or Obligations
- Tradable Certificates (these can also be combined with either voluntary or mandatory programs)

Initially OECD countries tended to adopt these different types of measures and programs more or less sequentially. More recently, countries/states/provinces have tended to adopt a package of policy measures at one time. Many of these policies are complementary and not necessarily mutually exclusive. Through experience we have found no single policy addresses all the market barriers and that a combination type policy framework can be more effective.[2]

Separation of Energy from Environmental and Social Attributes – A few years ago, the concept was conceived of separating the social and environmental characteristics of renewables

[1] This was actually told to me by the CEO of a large electric utility company.
[2] For more information on this report, contact Rick Sellers, Renewable Energy Director, International Energy Angency, Paris, France

Figure 2
Relationship between Renewable Energy, TRCs, and Commodity Energy



from the commodity energy (electrons). This separation is facilitated through the issuance of tradable renewable certificates (called: TRCs, or RECS, or Green Tags, or certificates). These certificates represent the non-electricity related attributes associated with the generation of one MWH of power. They provide for a liquid certificate market separate from the commodity energy market and thus a second potential source of revenue for renewable generation plants. These certificates have become an important financial instrument in the wholesale renewable energy market in the U.S.

Establishing Legal Ownership of the Attributes – One of the challenges with renewable energy certificates is establishing the legal ownership of the attributes as well as the ability to ensure they are not being double counted. The solution to this problem is the development of renewable energy certificate tracking systems. These systems, developed in Europe and the United States, provide a platform through which a variety of renewable energy transactions can be supported. These systems can verify compliance with renewable energy mandates, support Green Pricing and resource labeling programs, as well as support a variety of voluntary ‘green’ markets and product certification.

These tracking systems are also compatible with greenhouse gas registries and other types of air pollution abatement programs and can help measure and establish the validity of pollution mitigation claims from renewables. These tracking systems can be adopted to small renewable generating systems as well as large as well as thermal solar systems.[3]

The Role of Renewable Certificates in International Financing – Another new concept is the use of renewable certificates to support the financing of renewable projects particularly in developing countries. The diagram *(Fig. 3)* illustrates how such a system might be designed.

Integrating Renewables for End-use Customers

Up to this point, the discussion has been almost exclusively about the supply-side of the energy equation, but the demand-side – the end-use Consumer – deserves some attention as well. The following is a very brief description of some of the socio-economic concepts in the retail energy market.

The Building Sector – Renewable energy and energy efficiency is coming of age in the building sector. Building codes and standards have resulted in the recognition of the importance of the design and materials being used in new buildings from both an energy and resource sustainability perspective. Through codes and standards as well as through green building recognition programs like the Leadership in Energy and Environmental Design, or LEED program, passive solar design is being reintroduced and recognized as the appropriate way to design sustainable buildings.

Laws like the proposed California Solar Law requires some percentage of new housing to have solar electric panels, could change the future housing landscape. This could be partic-

[3] Though collection of credible measurement data is more difficult for small to very small systems. The concept could also be applied to energy efficiency though agreement on measurement and the issuance of certificates is more difficult than for power generation from metered systems.

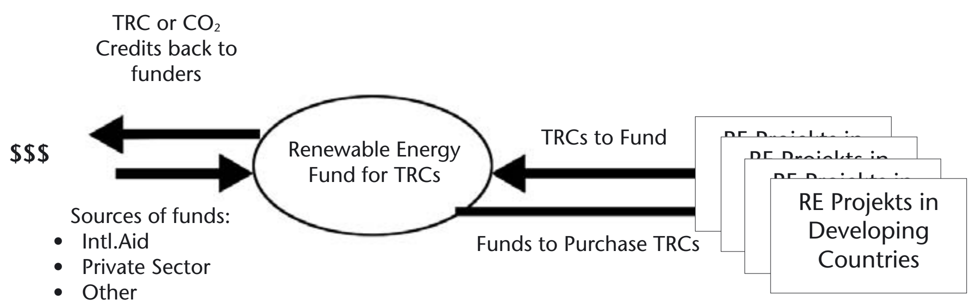


Figure 3
TRC Based International Financing Mechanism

ularly powerful when combined with lending institutions that provide incentives for energy efficiency and renewable energy options that are integrated into the building and its financing.

Another innovative approach is exemplified by the proposed Chinese Renewable Energy Promotion Law that would mandate all new buildings (in areas where the annual sunlight exceeds 1500 hours / year) must have installed solar hot water systems or be plumbed to allow for such systems to be easily installed at a later time.

The Voluntary Green Market – In the United States, voluntary green markets (where electricity consumers voluntarily purchase a higher proportion of renewable energy than they would otherwise receive from their regular utility supply) are growing rapidly. There are over 300 electric utilities that offer Green Pricing programs to their customers. In addition, one of the fastest growing markets is for the purchase of renewable energy by commercial / industrial customers who now purchase more then 23 % of the Green-e certified renewable energy sales. Green-e certified renewable energy sales topped 2 million MWh in 2002 (40 percent of the market) and are expected to double again in 2003.

The Role of Certification / Verification – Credibility is the foundation of the voluntary renewable energy market. The voluntary renewable energy market's credibility depends upon the certification and verification of the renewable energy products sold to end-use customers. There is almost no way individual customers can verify for themselves whether they are receiving what they paid for when they purchased renewable energy: Was the renewable energy actually generated and put into the electricity grid proportional to the amount purchased? Did the power actually purchased come from the type of renewable facility claimed by the seller? Are the product claims reasonable and verifiable? Is there a quick and credible way the consumer can tell if the renewable energy being sold meets some reasonable minimum environmental standard? Certification / verification are critical to the establishment and maintenance of retail green power markets.

The Environmental Market – No discussion of renewables would be complete without mentioning their environmental benefits and the market that is developing around those benefits. Though as everyone knows, the US has not ratified the Kyoto Protocol, nonetheless, concerns about climate change are a key driver for the U.S. renewable energy market. Commercial / industrial customers purchasing renewable energy do so because of their environmental benefits. Most renewable energy incentive policies are rooted at least partly in the desire to capitalize on renewables' environmental benefits. TRCs can be disaggregated and their environmental benefits (e. g. CO_2 , NO_x, mercury) sold separately.

The Role of Outreach and Education – Public education to increase the awareness of the renewable energy options available in our society goes hand in hand with political support for favorable renewable policies and with the public's acceptance of renewables that are available in the marketplace today. You need demand-pull as well as supply-push to establish a sustainable environment for renewable energy development. The following are some examples of the types of innovative outreach campaigns we are seeing in the retail renewable energy market:

Clean Energy Advertising Campaign – This public education campaign is designed to inform the common person (not just an environmental elite) about the benefits of renewables. The purpose is so renewable programs are not viewed as just another government program but seen as something that benefits all parts of the population. One example is the "Clean Energy Advertising Campaign" launched by five northeast/mid-Atlantic states and is expected to eventually expand into several other states in the region. This is a basic advertising campaign with a 'public good' – renewable energy – as the product being advertised. It has funding from state renewable energy funds as well as a number of private foundations. It is a model of cooperation that we hope will provide useful results.

Product Labeling and Made With Renewables – An exciting concept is the "Made with Renewable" label that can be put on consumer products that have 50 percent or more of the electricity used to manufacturing of the product comes from renewable power. Claims such as "**Made with Renewable Energy**" and "**We Buy Certified Renewable Energy**" will appear on consumer products, accompanied by the Green-e logo and website. The Product Labeling Initiative opens up a new communication channel for company promotion of renewable energy purchasing, and through package labeling, brings renewable energy to the attention of millions of diverse consumers. Green-e is in the process of launching this program in the U.S. and we have more than twenty companies who have applied to use this logo. They include several food companies (rice products, natural juice, energy bars, etc.) as well as a carpet company and some beverage firms (beer and wine). By using the Made with Renewables logo and label on the products they sell, they are setting an example that can encourage their customers to do the same. The companies are interested in showing their environmental responsibility as well as setting an example for others both industry peers and customers.

Point of Purchase Tags (POP Tags) – Earlier there was a discussion about the purchase of renewable certificates to "green" the electricity used by the purchasing customer. But a new product has entered the market, the use of mini-tags (certificates less than one MWh in size) that are being sold at the point of purchase (also called POP Tags) specifically to offset the carbon emitted by the drive to the ski resort, or by the electricity used to power the rock concert, or the carbon emitted by the airplane flight to a vacation resort. These types of products allow the consumer to offset the carbon that results from many of their leisure activities. Because these POP Tags are in small sizes (and therefore a small cost – <$5), and sold at the point of sale/use, they become an 'impulse' purchase by the more affluent population.

Summary and Conclusions

We sometimes think that the public, utility managers, building contractors, government officials and others will just see the logic of integrating renewables into our daily activities once they have the facts. But integrating renewables into the electricity, building and consumer products sectors is a labor-intensive task that requires sticks as well as carrots and a lot of outreach and education. Making these types of fundamental changes in our energy and building infrastructure is challenging and time consuming. But we have come further in a shorter period of time than I had thought possible thirty years ago at the dawn of the renewable energy market. The non-technical activities that go hand-in-hand with technology innovation are absolutely necessary if we are to achieve a transition to a sustainable energy system.

Promotion of Renewable Energies for Heating and Cooling

The Background

The promotion of renewable energies is a worldwide crucial challenge. Those sources contribute to the security of the energy supply as they reduce the use of fossil resources and nuclear energy, thus alleviating dependence on energy imports. This is an important fact, regarding costs, balance of trade, political autonomy, economic security, etc., for most of the industrialised countries in the European Union as well as for most developing countries. Renewable energies are as well the important strategy to reduce greenhouse gases and to gain energy, therefore essential to meet the Kyoto-goals, to mitigate climate change and to build up a sustainable energy system.

The European Union as a leading region in renewables has shown at the world summit in Johannesburg and in its white paper and renewable energies-directive that the promotion of renewables is an important political issue. The EU instructs the member states to increase the share of renewable energies of the total electricity supply to 12 per cent in the year 2010. However most of the activities of the EU-member states concerning regulations and other promotional actions are addressing only the power sector – due to the directive 2001/77/EC. For instance the German Act on Granting Priority to Renewable Energy Sources (Renewable Energy Sources Act) as the most important regulative initiative worldwide addresses only the power sector. This successful instrument has led to a renewables share of more than 8 per cent to the overall power consumption.[1] The reason for the focus on the power sector so far is lying in its less complex structure compared to the heating and cooling sector: the widespread and nearly complete power supply system (grid) makes regulatory instruments work easily compared to other sectors.

The Challenge – Promotion of Renewable Heating & Cooling

Although there is a huge potential for using renewable energies for heating and cooling in nearly every industrialised country, only a few of them explore this option seriously.

Renewable heat is produced from
- the traditional resource **wood and other biomass** with old and innovative technologies (local space-/hot water heating, combined heat and power-plants and distributed heat, district heating)
- active **solar systems** (e.g. local space-/hot water heating)
- **geothermal sources** (including heat pumps).

The untapped potentials of renewable heat are large. *Fig. 1* shows the example of Germany. In the year 2003 only 58 TWh of renewable heat were produced, resulting in a percentage of 3.9 % of the total heat consumption in Germany. Studies have identified a potential of 820 TWh per year. This corresponds to a rate of 55 % of the present heat consumption. Considering that the total heat consumption is going down due to increases in efficiency, the rate of renewables can get even higher.

Regarding the expansion of renewables in the power sector we see some success stories in countries like Germany, but we also see the overall EU target to reach 12 % renewables of the electricity consumption by 2010 likely to fail if no progress is made in the heat sector. The European Commission itself states in its evaluation report about the contribution of renewable energy sources in the EU: „With the measures that have been put in place, the Commission estimates that the share of renewable energy sources in the EU 15 is on course to reach 10 %

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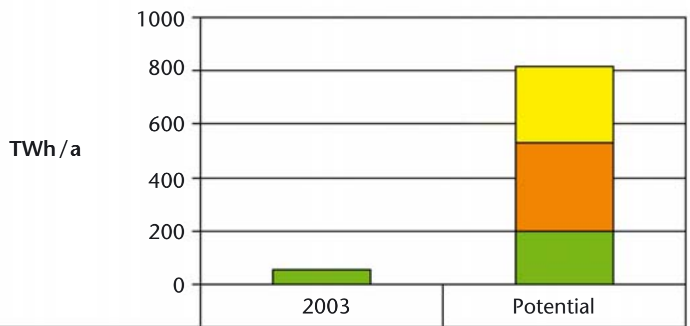
[1] See Hirschl, Bernd et al. (2002): Markt- und Kostenentwicklung Erneurbarer Energien. 2 Jahre EEG – Bilanz und Ausblick. Erich-Schmidt-Verlag, Berlin; and Hirschl, Bernd et al. (2004): Gutachten zum 2. EEG-Erfahrungsbericht (forthcoming).



	2003	Potential
solar thermal	2	290
geothermal heat	2	330
biomass	54	200
Percentage of total heat consumtion	3,9 %	55 %

Source: own diagram, data from Nitsch et al. (2004): Ökologisch optimierter Ausbau der Nutzung erneuerbarer Energien in Deutschland, BMU, Berlin.

Figure 1
Present use of renewable heat in Germany compared to potential use

in 2010. The shortfall compared to the 12 % target is caused by sluggish growth of renewable energy markets for heating and cooling, leading to the conclusion that considerable additional action is needed in this sector to allow the full 12 % target to be reached."[2]

Discussion on instruments

Renewable heating and cooling technologies cannot reach significant market shares without political support. This is a crucial regulatory challenge of the years to come, because – as mentioned before – the heating & cooling market situation is much more complex than in the power sector. Innovative instruments with a wide-scale impact are rare as well as national regulatory attempts are.

The production of heat shows some specific problems that complicate the search for suitable solutions. First, in most countries there is an insufficient grid system. While in European countries electricity grids are almost everywhere, heating grids are concentrated in big cities and densely populated regions. The systems are mostly decentralised and, second, private resulting in a considerable amount of actors involved in the production of renewable heat, thus making it difficult to address these actors by political measures. Third, the demand for heat is unsteady due to seasonal influences and the possibilities to store heat during a longer period are still a matter of research.

In contrast to the electricity sector, there exists almost no systematic approach to political support systems for heating or cooling. Some countries address parts of the market, such as Israel, Spain and Australia that have regulations on solar thermal heat. Other countries like Germany and Austria search for solutions but are still in a conceptual phase.[3]

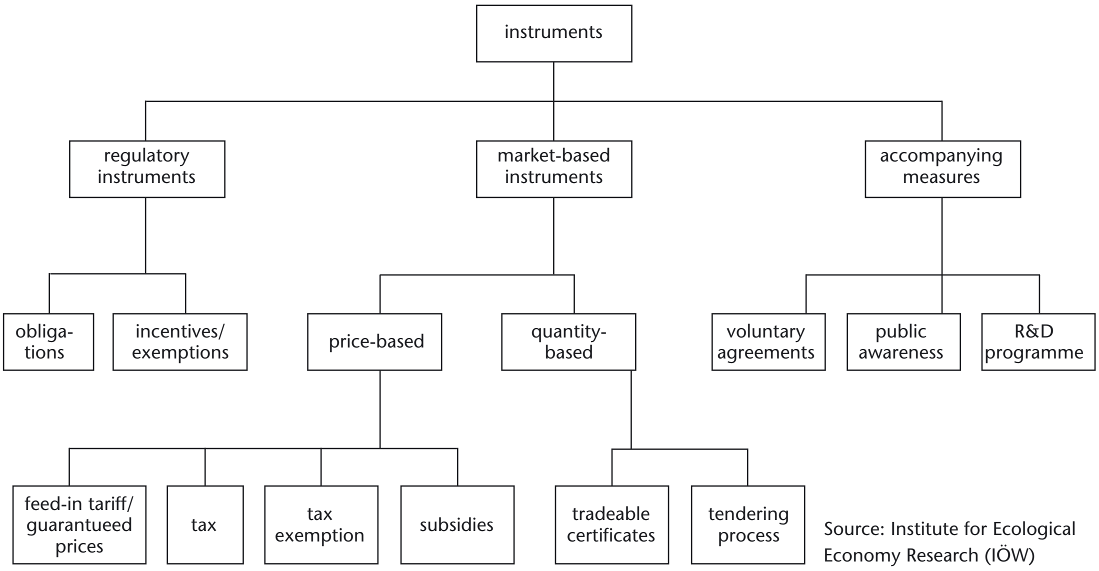
Fig. 2 gives an overview about possible political instruments for the heat sector. They can be distinguished in regulatory and market-based instruments, as well as accompanying measures.

Regulatory instruments are obligations and incentives or exemptions. Israel and some communities in Spain have applied obligations to install solar thermal systems when constructing or rehabilitating a building.

Market-based instruments can be distinguished in price-based and quantity-based instruments. Price-based instruments steer by the price. These are for instance feed-in tariffs, which are applied in the electricity sector. The German Renewable Energy Sources Act is an example for such a feed-in-tariff together with the prioritisation of grid-supplied electricity from renewable sources. It is difficult to adopt such a regulation for the heat sector that has no comparable grid, infrastructure and "simple" value chain. Thus, guaranteed prices for heat production are discussed. Other examples, which are already applied, are taxes (e.g. on

[2] Communication from the Commission to the Council and the European Parliament: The share of renewable energy in the EU Commission Report in accordance with Article 3 of Directive 2001 / 77 / EC, evaluation of the effect of legislative instruments and other Community policies on the development of the contribution of renewable energy sources in the EU and proposals for concrete actions. COM (2004) 366 final, Brussels, 26.5.2004

[3] The Institute for Ecological Economy Research (Institut für ökologische Wirtschaftsforschung IÖW)is currently working on a policy advice project on renewable heat instruments. the aim of the project is to develop assessmant criteria, to assess different instruments and to develop alternative instruments. The project is commissioned by the German Environmental Ministry and the German Environmental Protection Agency.



Source: Institute for Ecological Economy Research (IÖW)

Figure 2
Possible political instruments for the renewable heat sector

fossil fuels or carbon dioxide), tax exemptions, and subsidies. In Germany, for instance, the present approach is a large subsidy programme which includes subsidies for the construction of solar thermal, geothermal and biomass heating systems. In times of decreasing public budgets, subsidy programmes are criticised and they are usually not sufficient to reach a significant market share of the supported technologies.

Quantity-based systems steer by the quantity. These are for instance tradable certificates and tendering processes. Australia has a certificate system for renewable electricity that additionally addresses parts of the heat market since solar thermal systems are included if they replace electrical heating systems. Tendering processes or bidding systems have so far been applied in the electricity sector, only.

Accompanying measures consist of voluntary agreements, public awareness campaigns, R&D programmes, and other measures. The city of Berlin went into a voluntary agreement with the local housing sector and the local industry, in 1997. This voluntary agreement contains the installation of solar thermal systems, thermal insulation of buildings, and the installation of district heating. Hitherto, this voluntary agreement did not meet the targets set for the installation rate of solar thermal systems. Public awareness campaigns are a useful tool for increasing the knowledge on and the interest in renewable heating systems. Moreover, eco-labelling can be used to promote renewable heating systems. Since renewable heat technologies are rather young, R&D is needed to improve the systems and for cost cutting. The companies involved in this sector are mostly small or medium-sized and need financial support for R&D. In addition, the education and training of engineers, architects, and craftsmen have to be improved.The instruments most discussed for the heat sector are tradable quota-based certificates, guaranteed prices, and obligations. As shown above, obligations and tradable certificates are already applied to a certain extend, but larger experiences have to be made to get the possibility to assess them.

The side-event at the renewables

Against that background the Institute for Ecological Economy Research (Institut für ökologische Wirtschaftsforschung IÖW) organised together with the German Renewable Energy Federation (Bundesverband Erneuerbare Energien BEE) and the European Renewable Energy Federation (EREF) a side event at the RENEWABLES 2004 in Bonn, titled:
Promotion of renewable energies for heating (& cooling) – Innovative instruments in industrialised countries and initiatives in the EU

The intentions and objectives of the planned side event were

- to provide an overview on innovative instruments/mechanisms to promote renewable heat (with the focus on industrialised countries)
- to show good practise examples (selected countries and models respectively experiences) to foster discussion between politicians from different countries
- to stimulate/present national and EU-initiatives

Therefore a wide range of speakers had been invited to give "good examples" and to discuss perspectives and needs for the promotion of renewable heating and cooling.[4]

The first speaker was Esther Hoffmann from the Institute for Ecological Economy Research. She opened up the side-event by giving an overview on the subject. Main intention of her lecture was to show the points which are important to discuss within the field of renewable heat production and instruments to support it. She gave a short introduction about the situation in other countries. Although there is no systematic instrumental approach to promote renewable heating and cooling, some countries do already address parts of the market (e.g. Israel, Spain, Australia). Some countries like Germany and Austria are working on the development of broader instruments (see IÖW-project mentioned above). Esther Hoffmann explained also briefly the technologies available, the possibilities to use them and the main problems regarding a support-mechanism, which are: an insufficient grid, often decentralised and private systems and an unsteady demand.

The following speakers reported about the national situation concerning renewable energy instruments addressing heating and cooling in different European countries that can be named as "good practises" or instructive examples. All speakers are high representatives from national or international renewable energies associations.

Christiane Egger from an Austrian association (Oberöstereichischer Energiesparverband) focussed on biomass heating, which is a very fast growing field in Austria since many years now. So 14 % of total energy consumption comes from biomass at present. Main instruments to support renewable heating in Austria are legal and administrative measures and financial support as well as consulting for business and private sector to improve the awareness for possibilities of using renewable energy sources. She pointed out that positive and target group oriented communication and marketing was and is a crucial point to the success of any measures.

The example of Sweden was reported by **Peter Danielsson**, president of the European Renewable Energies Federation (EREF). In Sweden a share of 21 % of total heat consumption is provided by biomass and biofuels. Whereas renewable heat has been supported in an indirect way by raising taxes on fuels, certificates are introduced at present to ensure a further growth of this share. The certificates mainly address larger plants. Therefore further improvements concerning the renewable heat in general and for smaller plants in particular are needed.

The third national example – Spain – has been depicted by **Raffaele Piria** from the European Solar Themal Industry Federation (ESTIF). He focused on solar thermal heating and explained an action plan, which has allowed a very fast rising of installed capacity of solar thermal installations in Barcelona. In this example, an ordinance on solar thermal installations were given, which made solar thermal installations obligatory in case of new buildings or major renovations of such buildings which have a great demand of hot water. Within 15 months the capacity of solar thermal installations rose from 1,1 m^2 up to more than 10 m^2/1000 inhabitants. Advantages of this so called "Barcelona model" are lower prices for solar thermal energy, awareness about the possibility of using renew-

[4] The side-event was moderated by Bernd Hirschl (Institute for Ecological Economy Research) and Johannes Lackmann (German Renewable Energy Federation)

able energy sources, a consolidating of market structures and of course several long-term effects. Piria introduced a Joint Declaration as well, presented in January 2004 at the European renewables conference in Berlin, the so called "RES-H initiative".[5] A broad coalition of European industry, research and NGOs called for:

- Verifiable national and EU targets
- Strong regulations
- Financial incentives
- Promotion campaigns
- R & D

Burkhard Sanner from the German and European Geothermal Association put a focus on geothermal power. The principal advantage of geothermal power compared to most of the other renewable energy sources is the stability of availability. However there is no possibility to transport geothermal power. It has to be used very close to the place where it surfaces. Sanner reported about some good examples concerning grid-use and supporting instruments in Sweden and Italy.

The situation and possible measures in Germany have been discussed by Hans-Josef Fell, member of the German Parliament (Green Party, Eurosolar). He pointed out the problems with national finances and subsidies when households are short of cash. Possible instruments for Germany could be a modification of the German building act, to obligate people to use renewable energies, as well as increased prices through taxes for fossil energies.

Karl Kellner from DG TREN (transport and energy) of the European Commission explained the EU-policy for renewable heating and cooling. In his presentation he accentuated the relevance of cooling besides renewable heating and prospected the consideration of cooling within the next EU research program (FP 6). Kellner agreed that a legal base is needed, one example he mentioned is the European building directive. Furthermore he stresses the need of using cogeneration. The new member states of the EU have started wide-spread activities in this field.

Finally **Mechthild Rothe**, member of the European Parliament (her paper was represented by an assistant) pointed out the role of EU policy for renewable energies and presented a second declaration for the promotion of renewable heating and cooling that was passed at a conference in Bielefeld, Germany (the "Bielefeld declaration"[6]).

The final discussion about national good practises and instruments for supporting renewable heating and cooling was dominated by the agreement, that a legal framwork at a European level like the directive for the renewable power sector is needed. The side-event closed with recommendations for the further national development of instruments, the sharing of good practises, the development of differentiated and integrated approaches for all relevant renewable technologies and the creation of a framework and the expression of binding targets on a European level.

[5] See http://www.estif.org
[6] See http://www.rothe-europa.de

Speakers at the Side-event Promotion of RE for Heating & Cooling – Innovative Instruments in Industrialized Countries and Initiatives in the EU

Bernd Hirschl/Johannes Lackmann
(IÖW, BEE)
Short welcome by organisers, facilitation

Esther Hoffmann
(IÖW)
Introductory input – the importance of renewable heat and instrument overview

Peter Danielsson
(EREF)
National example 1: Sweden & focus biomass

Christiane Egger
(Oberösterr. Energiesparverband)
National example 2: Austria & focus biomass

Raffaele Piria
(ESTIF)
National example 3: Spain & Focus solar thermal

Burkhard Sanner
(Geothermal Association e.V. GtV)
Focus on Geothermal Energy

Hans-Josef Fell
(Member of the German Parliament (Bundestag) Green Party; Eurosolar)
National example 4: Germany & policy for renewable heat

Karl Kellner
(DG TREN)
EU policy for renewable heating & cooling – state of the art and perspectives

Mechthild Rothe
(MdEP, Eurofores)
EU policy for renewable heating & cooling – the need for new initiatives

Transitioning to a Renewable Energy Future

Rian van Staden
ISES – International Solar energy Society
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ISES is one of the world's largest scientific and technical non-governmental organisations in the field of Renewable Energy. It is recognized by the United Nations as a consulting, non-governmental organisation (NGO) and is a member of the United Nations Economic & Social Committee (ECOSOC).

Founded in 1954 as an international, non-profit organisation, the International Solar Energy Society was formed with the goal of promoting the use of solar and renewable energy world-wide. It has some 30,000 members in more than 110 countries. They are interested in all aspects of the environmentally friendly use of energy, especially Renewable Energy. ISES sees itself as a forum for everyone who deals with this topic.

The goal of ISES is to support sustainable development world-wide with the intelligent, appropriate use of Renewable Energy technology. The Society promotes the research, development, and use of technologies dependent either directly or indirectly on the sun that reduce the damaging effects of energy use. In this context, ISES has focused on three basic fields for the future: cities/urban areas, rural areas, and social responsibility. In the process, ISES also aims to raise awareness both among the public and decision-makers in politics and the industry of newest developments and findings in the research and application of solar energy. This awareness is aimed at furthering the growing understanding of and willingness to use solar energy in everyday life. ISES has internalised the concept of "thinking globally and acting locally" as an intrinsic part of the Society's structure.

Since the Rio Conference in 1992, ISES has launched a multitude of projects and initiatives in conjunction with economic, political and research leaders to support the increased use of Renewable Energy and to help industry to realise them.

The members of ISES form the foundation upon which the ideals, goals and activities of the society are built. A rich source of knowledge, experience and ideas, it is commitment and participation that set the ISES membership apart. Drawn from all over the world, our members form a global community, unified through common goals. Their service requirements drive the services and products the Society offers.

Communication between researchers, industrialists and politicians is actively supported by ISES through activities such as journals, magazines, meetings, conferences, congresses and a website. With the help of partners, ISES has established a communication system called WIRE (World-wide Information System on Renewable Energy, http://wire.ises.org/) to allow the creation of a global 'one stop shop' for renewable energy information with links to all other important renewable energy sites.

The ISES journal (Solar Energy Journal) and conferences allow excellent technical exchange to occur between renewable energy engineers, architects and physicists. ISES also welcomes non-specialists to participate in ISES congresses and conferences, as well as to exchange view-points in the magazine (Refocus) and meetings. ISES is rapidly and proactively increasing its project programme to ‚seed' renewable energy technology world-wide. It co-operates with many other international organisations.

Transitioning to a Renewable Energy Future

At the Science Forum in Bonn, ISES used the opportunity to introduce the salient points of its new white paper of the same title.

The White Paper provides a rationale for effective governmental renewable energy policies worldwide, as well as sufficient information to accelerate effective governmental policies. It is the thesis of this White Paper that a worldwide effort to generate the renewable energy transition must emerge at the top of national and international political agendas, starting now.

In the history of human energy use, the White Paper records that sustainable resources were the sole world supply, even in nascent industrial development well into the 1800s, and that the world will necessarily again have to turn to sustainable resources before the present century is over. The fossil fuel period is therefore an "era", not an age, and highly limited in time in comparison with the evolution, past and future, of civilizations and societies. Accordingly, it is critical for governments to view what remains of the fossil fuel era as a transition.

The White Paper reveals that policies now in existence, and economic experience gained by many countries to date, should be sufficient stimulation for governments to adopt aggressive long-term actions that can accelerate the widespread applications of renewable energy, and to get on a firm path toward a worldwide "renewable energy transition", so that 20 % of world electric energy production can come from renewable energy sources by 2020, and 50 % of world primary energy production by 2050. There can be no guarantee for this to happen, but the White Paper presents compelling arguments that show it is possible, desirable, and even mandatory.

The window of time during which convenient and affordable fossil energy resources are available to build the new technologies and devices and to power a sustained and orderly final great world energy transition is short – an economic timeline that is far shorter than the time of physical availability of the "conventional" energy resources. The White Paper argues that the attractive economic, environmental, security and reliability benefits of the accelerated use of renewable energy resources should be sufficient to warrant policies that "pull" the changes necessary, avoiding the "push" of the otherwise negative consequences of governmental inaction. There is still time left for this.

The White Paper presents three major conditions that are driving public policy toward a renewable energy transition: 1) newly emerging and better understood environmental constraints; 2) the need to reduce the myriads of risks from easy terrorist targets and from breakdowns in technologies on which societies depend; and 3) the attractiveness of the economic and environmental opportunities that will open during the renewable energy transition.

The renewable energy transition will accelerate as governments discover how much better the renewable energy policies and applications are for economies than the present time- and resource-limited policies and outmoded and unreliable centralized systems for power production and distribution.

Today, it is public policy and political leadership, rather than either technology or economics, that are required to move forward with the widespread application of the renewable energy technologies and methodologies. The technologies and economics will all improve with time, but the White Paper shows that they are sufficiently advanced at present to allow for major penetrations of renewable energy into the mainstream energy and societal infrastructures. Firm goals for penetrations of renewable energy into primary energy and electrical energy production can be set by governments with confidence for the next 20 years and beyond, without resource limitations.

Specifically, with regard to the renewable energy technologies, the White Paper shows the following:

Bioenergy:
About 11 % of world primary energy use at present is derived from bioenergy, the only carbon-neutral combustible carbon resource, but that is only 18 % of today's estimated bioenergy potential. Estimates for world bioenergy potential in 2050 average about 450 EJ, which is more than the present total world primary energy demand. Fuel "costs" for the conventional resources become instead rural economic benefits with bioenergy, producing hundreds of thousands of new jobs and new industries.

Geothermal Energy:

Geothermal energy has been used to provide heat for human comfort for thousands of years, and to produce electricity for the past 90 years. While geothermal energy is limited to those areas with access to this resource, the size of the resource is huge. Geothermal energy can be a major renewable energy resource for at least 58 countries: thirty-nine countries could be 100% geothermal powered, with four more at 50%, five more at 20%, and eight more at 10%. Geothermal energy, along with bioenergy, can serve as stabilizing "baseload" resources in networks with the intermittent renewable energy resources.

Wind Power:

Global installed wind power capacity exceeded 32,000 MW by the end of 2002, and has been growing at a 32% rate per year. Utility-scale wind turbines are now in 45 countries. The price of wind-produced electricity is now competitive with new coal-fired power plants, and should continue to reduce to where it will soon be the least expensive of all of the new electricity-producing resources. A goal of 12% of the world's electricity demand from wind by 2020 appears to be within reach. So is a goal of 20% of Europe's electricity demand by 2020. This development pace is consistent with the historical pace of development of hydroelectric and nuclear energy. The 20% penetration goal for the intermittent renewable energy resources is achievable within present utility operations, without requiring energy storage.

Solar Energy:

The energy from the sun can be used directly to heat or light buildings, and to heat water, in both developed and developing nations. The sun's radiant energy can also directly provide very hot water or steam for industrial processes, heat fluids through concentration to temperatures sufficient to produce electricity in thermal-electric generators or to run heat engines directly, and produce electricity through the photovoltaic effect.

It can be used directly to enhance public safety, to bring light and the refrigeration of food and medicine to the 1.8 billion people of the world without electricity, and to provide communications to all regions of the world. It can be used to produce fresh water from the seas, to pump water and power irrigation systems, and to detoxify contaminated waters, addressing perhaps the world's most critical needs for clean water. It can even be used to cook food with solar box cookers, replacing the constant wood foraging that denudes eco-systems and contaminates the air in the dwellings of the poor. Buildings: in the industrial nations, from 35% to 40% of total national primary use of energy is consumed in buildings, a figure which approaches 50% when taking into account the energy costs of building materials and the infrastructure to serve buildings. Letting the sun shine into buildings in the winter to heat them, and letting diffused daylight enter the building to displace electric lighting, are both the most efficient and least costly forms of the direct use of solar energy.

Data are mounting that demonstrate conclusively enhancements of human performance in day-lit buildings, with direct economic and educational benefits that greatly multiply the energy-efficiency "paybacks". The integrated design of "climate-responsive" buildings through "whole building" design methods enables major cost-savings in actual construction, normally yielding 30% to 50% improvement in energy efficiency of new buildings at an average of less than 2% added construction cost, and sometimes at no extra cost.

Serious long-range goals for the application of solar domestic water and space heating systems need to be established by all governments, totalling several hundred million square meters of new solar water heating systems world-wide by 2010. A worldwide goal of 100,000 MW of installed concentrating solar power (CSP) technology by 2025 is also an achievable goal with potentially great long-term benefits.

Photovoltaic (PV) solar electric technology is growing worldwide at an amazing pace, more than doubling every two years. The value of sales in 2002 of about US$ 3.5 billion is projected to grow to more than US$ 27.5 billion by 2012. PV in developed and developing nations alike can enhance local employment, strengthen local economies, improve local environments, increase system and infrastructure reliability, and provide for greater security. Building-integrated PV systems (BIPV) with modest amounts of storage can provide for continuity of essential governmental and emergency operations, and can help to maintain the safety and integrity of the urban infrastructure in times of crisis. PV applications should be an element of any security planning for cities and urban centres in the world.

Policy:

The White Paper stresses the importance of governmental policies that can enhance the overall economic productivity of the expenditures for energy, and the great multiplier in the creation of jobs from expenditures for the renewable energy resources rather than for the conventional energy sources. Utilities are not in the job producing business, but governments are, supporting the need for governments to control energy policies and energy resource decisions.

National policies to accelerate the development of the renewable energy resources are outlined, emphasizing that mutually supporting policies are necessary to generate a long-term balanced portfolio of the renewable energy resources. Beginning with important city examples, the discussion moves to national policies, such as setting renewable energy standards with firm percentage goals to be met by definite dates. The specific example of the successful German "feed-in" laws is used to illustrate many of these points.

Market-based incentives are described in the White Paper, to compare with legislated goals and standards, and discussed in terms of effectiveness. It is shown that various voluntary measures, such as paying surcharges for "green power", can provide important supplements to funding for renewable energy, but that they cannot be sufficient to generate reliable, long-term growth in the renewable energy industries, nor to secure investor confidence. Reliable and consistent governmental policies and support must be the backbone for the accelerated growth of the industries.

It is also shown in this White Paper that the energy market is not "free", that historical incentives for the conventional energy resources continue even today to bias markets by burying many of the real societal costs of their use. It is noted that the very methodologies used for estimating "levelized" costs for energy resources are flawed, and that they are not consistent with the more realistic economic methodologies used by modern industries. Taking into account future fuel supply risk and price volatility in net present valuations of energy resource alternatives paints a very different picture, one in which the renewable energy resources are revealed to be competitive or near-competitive at the present time.

The White Paper concludes with the presentation of two comprehensive national energy policies to demonstrate the method of integration of various individual strategies and incentives into single, long-range policies with great potential returns, including

- National multi-year goals for assured and increasing markets for renewable energy systems, such as „Renewable Energy Standards" (also called, in the U.S., „Renewable Portfolio Standards", or RPS), or the EU Renewables Directive, especially when formulated to support balanced development of a diversity of renewable energy technologies;
- Production incentives, such as "feed-in" laws, production tax credits (PTC), and net metering;
- Financing mechanisms, such as bonds, low-interest loans, tax credits and accelerated depreciation, and green power sales;
- System wide surcharges, or system benefits charges (SBC), to support financial incentive payments and loans, R&D and public interest programs;
- Credit trading mechanisms, such as Renewable Energy Credits (RECs) or carbon reduction credits, to enhance the value of renewable energy, to increase the market access to those energy sources, and to value the environmental benefits of renewables; specific governmental renewable energy "quotas" for city and state renewable energy procurements;

- Removal of procedural, institutional and economic barriers for renewable energy, and facilitation of the integration of renewable energy resources into grids and societal infrastructure;
- Consistent regulatory treatment, uniform codes and standards, and simplified and standardized interconnection agreements;
- Economic balancing mechanisms, such as pollution or carbon taxes (which can then be diverted as "zero sum" incentives to the non-polluting and non-carbon technologies);
- "Levelling the playing field" by redressing the continuing inequities in public subsidies of energy technologies and R&D, in which the fossil fuels and nuclear power continue to receive the largest share of support.

Solar Energy from Then to Now and Beyond

Solar energy is not an "alternative energy". It is the original and continuing primary energy source. All life and all civilizations have always been powered by solar energy. Expanding the technical applications of solar energy and its other renewable energy cousins to carry civilizations forward is simply a logical extension of its historic role, but also the inescapable key to achieving sustainability for human societies.

The White Paper is available from http://whitepaper.ises.org/

More Information about the "Energy Rich Japan" Project (Reports, Simulation, Animation): www.energyrichjapan.info

Full Solar Supply of Industrialized Countries – The Example Japan

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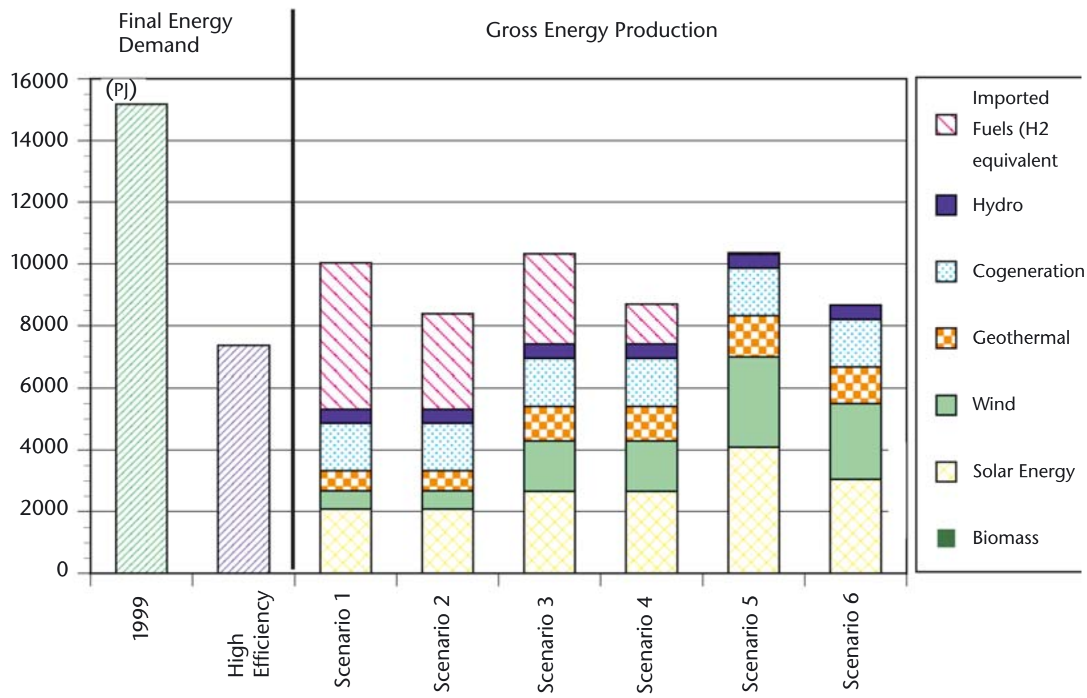
It has long been known that to protect people and the environment from both nuclear risks and dangerous levels of climate change, we must phase out the use of nuclear and fossil fuels, and switch to clean energy technology instead. Using Japan as a example, the “Energy Rich Japan” Project illustrates that the vision of a clean, green, energy-rich future is not only possible, but globally feasible.

Renewable energy technologies using regional or global sources, coupled with a reduction in energy use by adopting energy efficient technologies, offer the only safe and proven option open to us for future energy needs. The objective of this study is to show that a region such as Japan is able to supply all of its own energy needs with this option, and to use the report to influence the discussion over the change from fossil and nuclear energy sources to a sustainable energy system.

Japan is a heavily industrialised country, with a population of 127 million living in a small island nation, yet in 1999 it was the world’s second most powerful economy, with an industrial base that was recognised as one of the most energy efficient globally.

Japan was forced to become relatively energy efficient because it has very little domestic supplies of what are known as conventional energy sources. This industrial powerhouse meets the bulk of its energy demand by importing nuclear

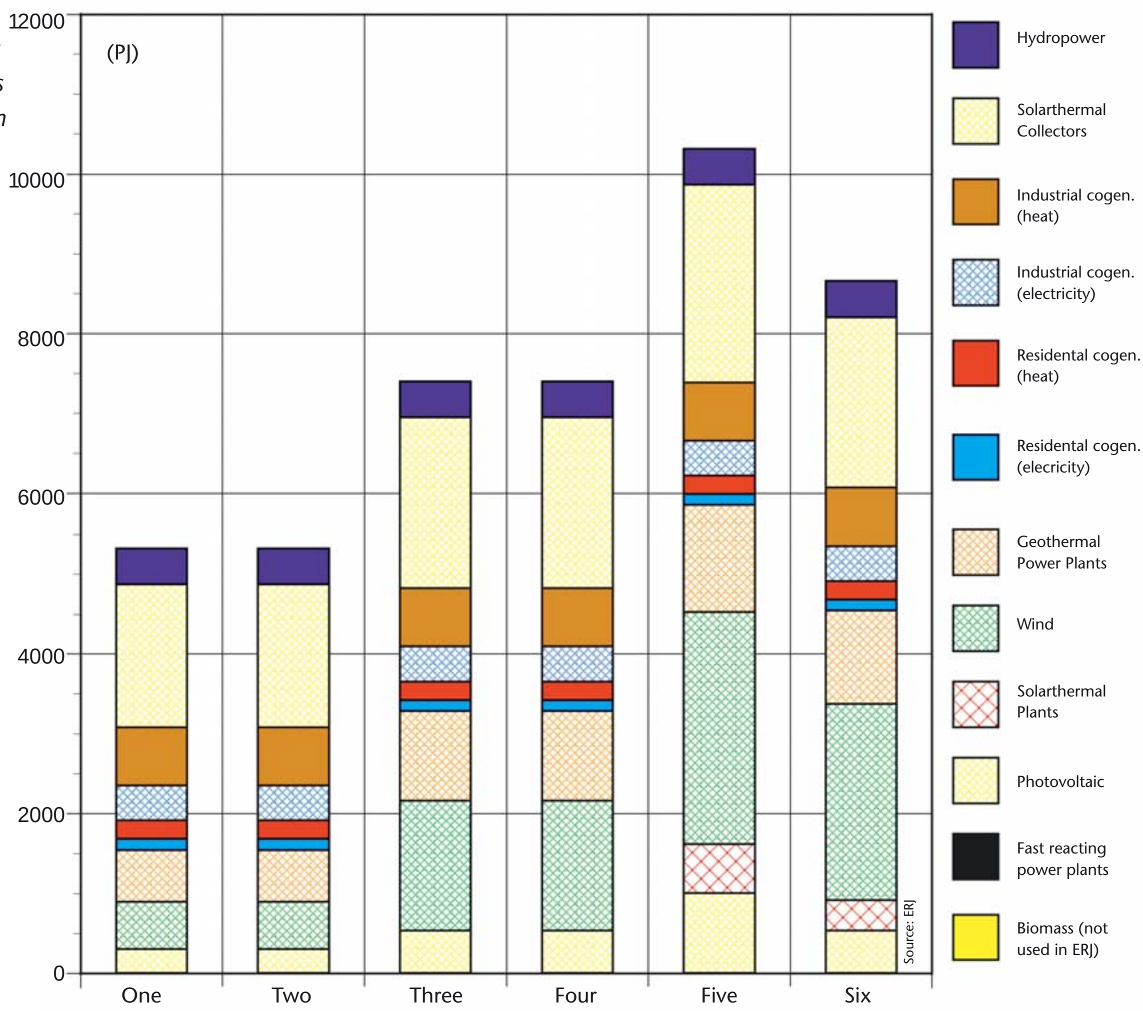
Figure 1
Demand 1999 and the High Efficiency Model



Six Supply scenarios with different dependance from imports (Imported Fuels). Scenarios 2,4 and 6 assume a decreased population of Japan. Biomass is set to zero because of not having enough data about the sustainable potential in Japan. Knowing this potential it can substitute Hydrogen fuels.

[1] Contributors: Institute for Sustainable Solutions and Innovations: Martina Kruska; University of Lüneburg: Gary Evans, Stefan Herbergs, Daigo Ichiro, Karl Mallon, Mika Ohbayashi, Stefan Peter, Kae Takase, Iida Tetsunari; Wuppertal Institute: Dirk Aßmann; EUTech Aachen, ISEP Tokio; Commissioned by Greenpeace International and Greepeace Japan

Figure 2
Domestic gross energy production in petajoules using energy conversion technologies from renewable sources in Japan as used in the six scenarios.



This is the production of electricity and heat in the installed power plants. Biomass, although listed is set to zero because of the unavailability of the potential of sustainable produced biomass.

and fossil fuels, supplemented by a small amount of domestic oil and gas production, as well as some hydro and geothermal power. Japan's total primary energy consumption in 1999 stood at just over 22,970 Petajoules, (A Petajoule is a 1000 million, million joules). Of those, 18,500 Petajoules (80 %) were imported as nuclear and fossil fuels.

Yet Japan could be independently rich in energy. Using baseline data from 1999, the "Energy Rich Japan" report shows how a combination of the best energy efficiency technologies available today, and a massive investment in renewable energy, could ultimately provide Japan with 100 % of its energy needs from renewables – including transportation fuels – without expensive and environmentally damaging imported fossil and nuclear fuels. Rather than seeking "energy security" through its hugely expensive and polluting nuclear program, for example, Japan could instead build its own renewable energy industry. As an energy-hungry and supposedly "resource- poor" country, Japan could make this transition to clean, renewable energy without any sacrifice in living standards or industrial capacity.

The report takes Japan's current energy use, based on 1999 levels, and shows that demand could be reduced by 50 % with energy efficient technologies that are already available around the world today. The "ERJ High Efficiency Demand Model" showed that using highly energy efficient technologies could save nearly 40 % of today's energy consumption in the

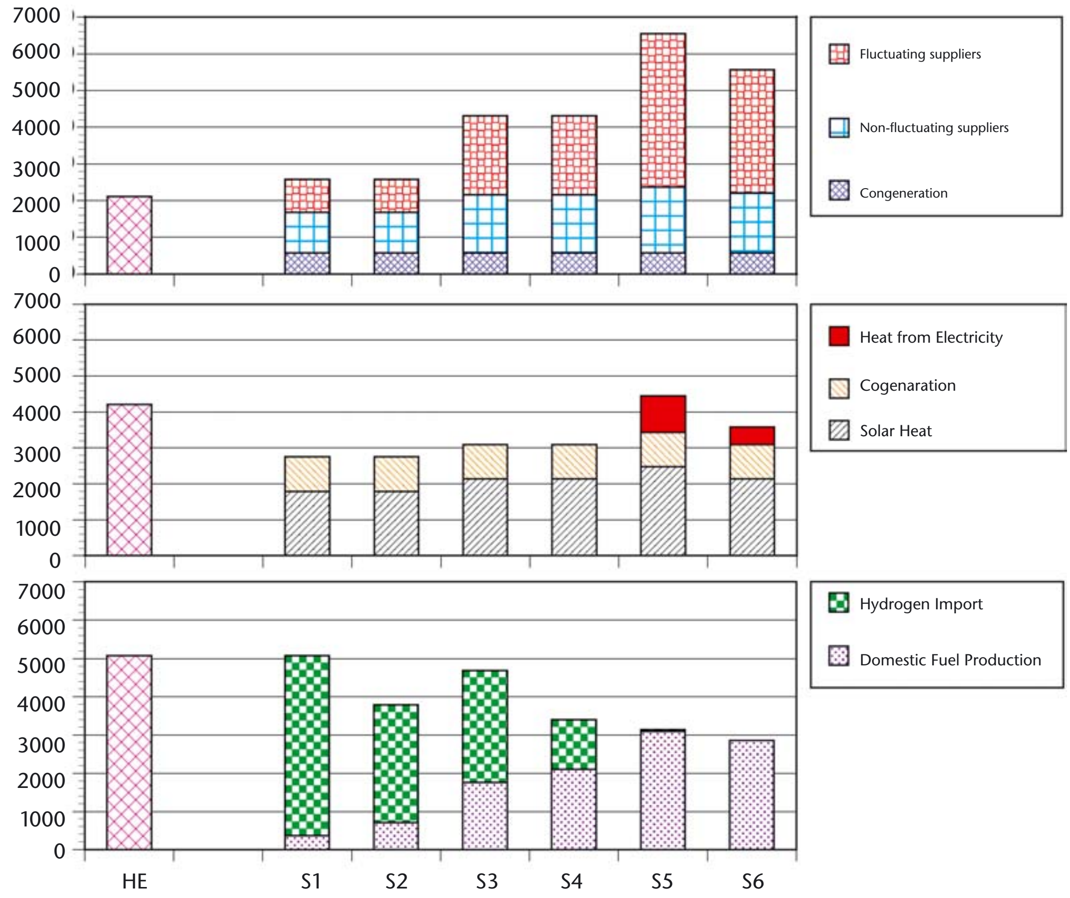


Figure 3

Electricity, heat and fuel production in all six "Energy-Rich Japan" scenarios.

Electricity surplus is used for heat and fuel production. Biomass, although listed is set to zero because of the unavailability of the potential of biomass produced in a sustainable manner.

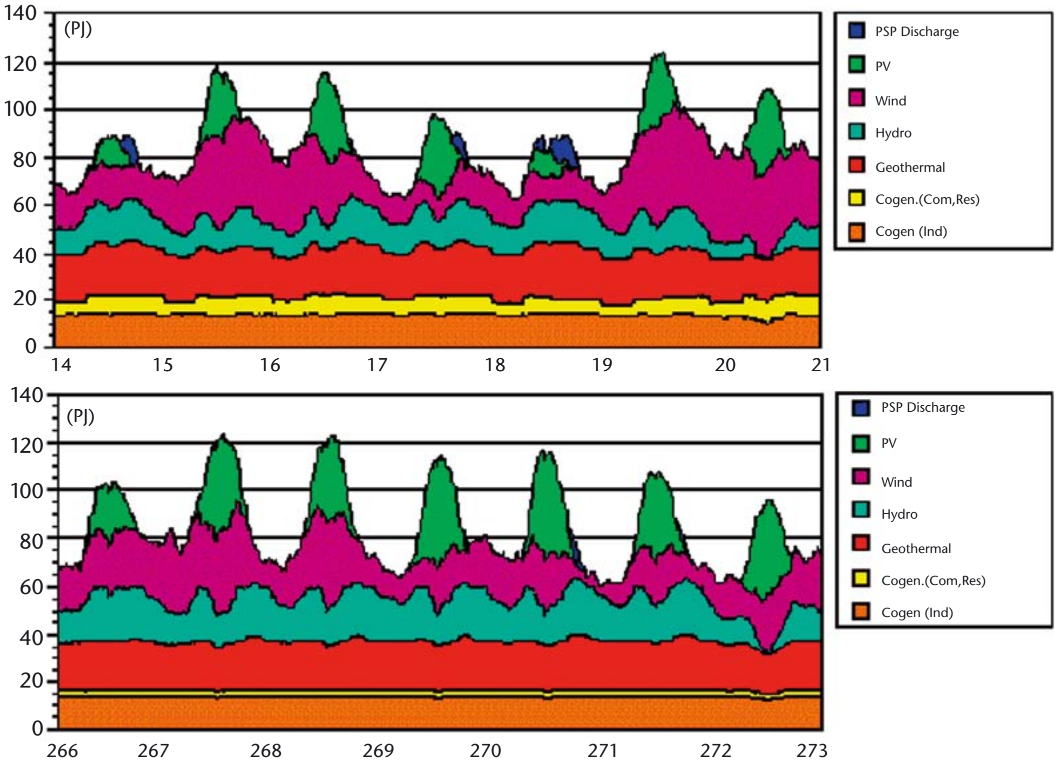
industrial sector, more than 50 % in the residential and commercial sectors and about 70 % in the transport sector.

It then shows how renewable energy could be used to meet that new level of demand, reducing and ultimately eliminating the need for imports. Six scenarios of how this might happen are outlined in the report, all of which can provide 100 % renewable energy for Japan. Starting from a basic model (Scenario One) providing more than 50 % of total energy needs from domestic renewable sources, each subsequent scenario provides variations or expansions on Scenario One, gradually reducing the reliance on imported energy, factoring in different population projections and expected improvements in renewable generation capacity and energy efficiencies, until by Scenarios Five and Six, no energy imports are required.
As supply reliability is most acute in the electricity sector where supply and demand must be fully matched in time, a simulation of the Japanese electrical power system and part of the heating system was done with the computer programme SimREN.

This study does not attempt to answer two key questions: How quickly can such a system be implemented and how much will this system cost? To demonstrate the possibility of a solar energy supply for Japan, it is not necessary to specify the costs and the timeframe such a development will require.

The systems described here provide a framework for a debate about the restructuring of the Japanese energy economy. However restructuring with renewable energy does not need to be limited to the ideas described in this report. Other systems that can supply Japan with renewable energy are also possible.
All of the scenarios are able to be met in Japan, both in technical terms and in terms of natural

Figure 4
The figures show the dynamics of electricity generation for two weeks of the year.



The supply-system always produces enough electricity to cover the demand. If there is low electricity production of windenergy and photovoltaics at the same time, pumped storages get used to guarantee full supply (see days 14, 18, 19 and 271).

resources, such as wind, solar radiation and geothermal capacity. The decisive factors will be public acceptance, priorities set by national policy in terms of energy security and international commitments and the future development of renewable energy technologies. “Energy Rich Japan” is an ambitious concept, yet conservative in its methodology. Admittedly its implementation would involve considerable investment in infrastructure and far reaching changes to the way Japan designs and builds its future industrial, residential, commercial and transport sectors. Compared to the environmental dangers faced globally by climate change and nuclear accidents, the costs of not developing sustainable energy systems, be they in Japan or anywhere around the world, are potentially far greater.

How to achieve to a sustainable energy system is the question, we hope, we have addressed with this study. What we need now is the desire and will to make it happen.

More Information about the “Energy Rich Japan” Project (Reports, Simulation, Animation): www.energyrichjapan.info

Knowledge for Development: Capacity Building in Renewable Energies for Poverty Alleviation

Research and Development Needs for Renewable Energies in Developing Countries

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Abstract

The future for renewable energy sources ("renewables") in the developing world, if properly harnessed, looks bright and the prospects are good. There are vast reserves of and high potential for the use of different renewable energies (RE), be they solar, hydro, wind, wave, hydrogen, waste, etc. However, these remain largely unexploited due to a combination of facto; particularly economics, lack of appropriate research and development and the absence of enabling policy instruments. At the same time, access to modern, commercial energy services is usually too low to facilitate meaningful economic development in developing countries. Sub-Saharan Africa, the world's most underdeveloped region, with 17% of the world population and blessed with abundant mineral resources, consumes less than 3% of the world primary energy supply. Most of the developing world's energy needs could, theoretically, be met by the vast renewable energy potential. However, despite decades of attempts to supply modern renewable energy technologies (RETs), the energy landscape remains largely unchanged. Traditional fuels (biomass in Africa) continue to dominate the energy use patterns. There have been numerous spectacular instances of failed RETs, uncoordinated renewable energy programmes and piecemeal demonstrations or pilot projects. Even in the case of successes, these have largely remained undocumented and lessons learned are therefore lost.

This calls for a paradigm shift in R+D, particularly relating to RET solutions. There is a need for R+D which does not ONLY focus on flooding the developing world with an array of technologies that deliver short term benefits, but an R+D process that addresses the expressed needs of the users in an integrated manner. Such an approach will provide answers to the key questions: What are the energy needs specific to the users and how do they link to other development needs? How to transform the energy needs to effective demand? What is the best technology mix to meet these needs? The R+D needs of developing countries relate to challenges that address embedded socio-economic needs, identification of appropriate energy technologies that are informed by local conditions, and the need for R+D on sustainable business models to stimulate local renewable industries.

Introduction

There is currently a global optimism regarding the future for RE and its potential role in sustainable development. While there are different justifications for the introduction of RE into the mainstream national energy economies, the potential to sustain economic development, while minimising the adverse effect on the environment, is a common rallying point. There is also a high level commitment globally to accelerate the use of renewables. This commitment is supported by the ready availability of capital from multinational agencies, national governments and the private sector to fund viable RE projects. The World Summit on Sustainable Development (WSSD) in Johannesburg provided a necessary platform to initiate unified and purposeful global efforts, known as Type II activities, towards accelerating actions designed to exploit renewables worldwide. One of the key outputs of the 2004 World Renewables Conference in Bonn is to provide concrete implementation strategies and joint RE projects.

[1] The author acknowledges the technical support provided by Dr. Gert Venter, Thomas Roos, Stefan Szewczuk and Sydney Parsons (all of CSIR). A special thanks to Dr. Pete Ashton for his useful comments and thorough editing. While most issues expressed herein represent the CSIR Energy Trust, the conclusions are those of the author alone.

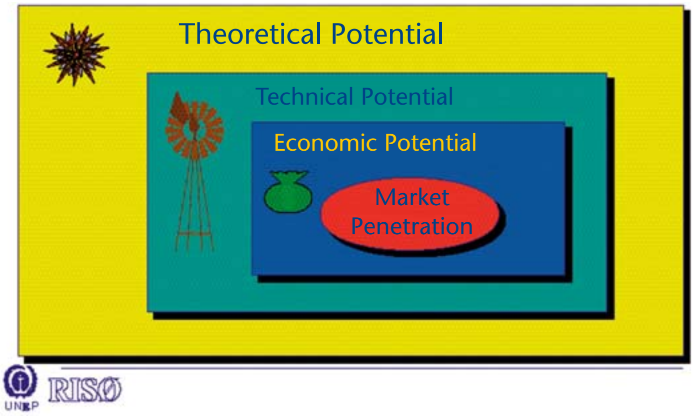

Figure 1
Potential for Renewables [1]

With respect to the developing world, the accelerated use of renewables in countries' energy mixes has important additional benefits. Access to modern fuels in many developing countries is a cause for concern. In the 'business-as-usual-scenario', more and more households, particularly in rural regions of Africa, will forever rely on dwindling biomass fuels to meet their energy needs. Estimates indicate that the current reliance on biomass (mainly woodfuel) is between 70–80 %. Providing conventional energy in the form of electricity is usually uneconomical, and the costs are beyond the reach of many households situated in rural areas. This scenario certainly does not encourage economic growth and development in these areas. Access to affordable, adequate and modern energy services is the engine for a country's development and a cornerstone in alleviating poverty. Effective introduction of renewables in developing economies could facilitate and fast-track development processes, while improving the options and quality of life available to the poor.

Despite this situations, there are many dynamic challenges to be faced in attempting to accelerate the uptake of RE in developing countries. These relate to policy frameworks that favour renewables, availability of appropriate RETs, focussed R+D on appropriate technologies and project implementation strategies, lack of baseline studies, funding, etc. Most of these barriers have largely been removed, though several critical ones still remain. This paper argues that now is the opportunity to devise effective implementation strategies that are informed by past experiences, and based on international best practices. The focus of this would be to isolate the key needs of developing countries, related to renewables, that can be addressed by innovative R+D, whilst creating and embedding local skills and expertise in the process.

The Future for Renewable Energy in the Developing World

Global Push for Renewables

The positive euphoria regarding the enormous potential of RE should be viewed against the global fear of the consequences of relying too much on fossil fuels for economic growth. A lot has been said about the negative effects of emissions from the production, transmission, distribution and consumption of fossil fuels, particularly oil and coal. Much of the global agenda on renewables (and energy efficiency) is driven by this fear, as well as the need to ensure the long-term – and diversity of – supply of environment-benign energy.

As most developing countries are net exporters of energy, as well as possessing few energy intensive industries, their emission levels are insignificant on a global scale. Therefore, the agenda for renewables in developing countries should be to satisfy the energy needs of two billion people without access to modern and clean energy sources. The question, therefore, has to be 'Can renewable energies meet the needs of developing countries?'

Theoretically, all the global energy needs/demand could be provided by RE [1]. However, currently used technologies cannot tap the current potential. Even the market penetration of RETs is below the economic potential. At the level of a developing country, penetration of RETs is least. Even the number of RETs currently in circulation remains unknown because of lack of reliable data on RE projects. The point, therefore, is that on their own, renewables cannot meet the energy demand of developing countries. At a practical level, renewables in developing countries should be introduced as one of the energy options (including non-renewables) in the context of "Energisation" (see below).

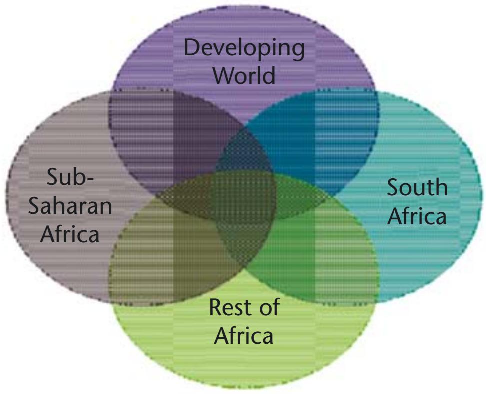

Figure 2
Heterogeneity nature of developing countries

Prerequisites for Sustainable Renewables Takeoff

The global (read "developed" countries') push for renewables will not attain any sustainable level of success if developing countries are not supportive or receptive. Pro-activity is the keyword for success and developing countries must want renewables. The "want" should be determined by the policy frameworks that favour renewables and contribute to the growth of RET businesses in local economies. Unfortunately, in many instances, the push for RE comes from developed countries since there is a dearth of proactive policies in developing countries. For instance, few countries in Africa have renewables energy policies. Most attention is, understandably so, focussed on coal, gas, oil and large-scale hydropower projects. It is significant to note that the energy desk of NEPAD – a framework for Africa's economic revival – does not have a renewables mandate. The latter is located within the broader environmental desk. Most regional power pools do not prioritise renewables as they do non-renewable energy. A key prerequisite for sustainable RE takeoff is arguably harmonised regional policies and strategies. The effectiveness of projects funded by multinational agencies and intergovernmental entities will come to be well below desired levels if this prerequisite is not addressed.

However, one of the often cited barriers to formulation of realistic, informed and effective policies, particularly in Africa south of the Sahara, is lack of validated data, which in turn are determined by the absence of R+D institutions to conduct this research [2]. These facts are recognised in the WSSD Plan of Implementation, which advocates the promotion of technology development, transfer and diffusion to Africa, and the further development of technology and knowledge available to African centres of excellence [3].

Developing World: Different Contexts, Different Needs

While all developing countries share common features or indicators vis-à-vis developed countries, it is important to mention that they are definitely not a homogenous entity *(Fig. 2)*. This distinction is very significant, particularly as far as the energy landscape is concerned. The energy needs of developing countries are influenced by their varying degrees of "development", or simply the prevalence of widespread poverty. For instance, sub-Saharan Africa (SSA) is considered the least developed region in the world, well below the levels of other developing countries. The IMF projections show economic growth in all developing countries as averaging 6% per year (2003 – 05) compared with 4% per year in SSA. Therefore if this region has to halve poverty levels by 2015, the GDP growth must more than double from current levels of 3% to 7% per year [4].

In energy terms, this means that the poorer the region, the more different and precarious its energy needs will be, and the more complex the solutions should be. A significant number of the two billion people worldwide who do not have access to modern energy services live in SSA.

Hence, the SSA economic priorities are strongly informed by the need to alleviate poverty. With more than 500 million people currently without access to electricity and with more than 600 million people dependent on traditional biomass for survival, SSA has a dire need for safe, affordable and clean forms of energy to enable productive economic activities to generate much needed income [5]. *Tab. 1* underlines the African reliance on traditional fuels, as compared to the more affluent countries in Europe [6].

On the other hand, countries of the SSA need to develop. Owing to its developmental status, exacerbated by emigration of skilled people, Africa lacks the human capacity and technical strength to achieve the necessary progress within a ten to fifteen year time frame as required

Table 1

Energy indicators for 1999 for a selection of african & european countries, 1990 US$ (Source: International Energy Agency, Paris)

Country	Population (M)	GDP (US$B)	TPES/ Capita	TPES/ (000$)	Electr (KWh/ Capita	Electr Cons (KWh/US$)
Morocco	28.2	38.4	0.35	0.26	538	0.40
Senegal	9.3	5.5	0.32	0.54	122	0.21
Algeria	30.0	47.0	0-94	0.60	960	0.81
Egypt	62.7	74.6	0.71	0.60	960	0.81
Ethiopia	62.8	7.1	0.29	2.59	24	0.21
Nigeria	123.9	31.0	0.70	2.82	89	0.36
Kenya	29.4	9.9	0.50	1.48	127	0.38
Angola	12.4	6.4	0.61	1.18	92	0.18
Zambia	9.9	3.8	0.63	1.61	568	1.46
Zimbabwe	11.9	8.4	0.85	1.22	940	1.34
Mozambique	17.3	3.4	0.40	2.04	48	0.24
South Africa	42.1	164.4	2.60	0.67	4479	1.15
NOTE: No recent info available for Botswana, Lesotho, Swaziland						
United Kingdom	59.5	1256.0	3.87	0.18	5901	0.28
Germany	82.1	2603.0	4.11	0.13	6480	0.20
France	60.3	1698.0	4.23	0.15	7142	0.25
Sweden	8.9	267.3	5.77	0.19	15450	0.51

TPES: Total Primary energy Supply
toe: tonnes of oil equivalent

in the NEPAD position. It is almost certain that Africa would neither be able or allowed to follow the developmental pathways that brought other countries to their current position in the world. New and innovative systems-dynamic approaches are needed [6].

Therefore, the ideas and analysis presented in this paper apply to varying degrees to different regions and countries that are, by definition, considered to be “developing”. However, most of the arguments presented concern the underdeveloped regions within the developing world. The bias is intentional because these are the regions that most need innovative renewable energy solutions, and these are regions that have acute energy needs. The term ‘developing’ is used in this sense throughout the paper.

Renewable Energy Trends in Developing Countries

The Social and Economic Dimensions of Renewables

Energy is an essential consideration in development, and choices taken in the near future will have far-reaching consequences on development, impacts on global change and the sustainable use of ecosystems and non-renewable resources.

The need for access to energy is pervasive. *Fig. 3* indicates how every facet of an economy requires access to energy services in one form or another for sustainable development [6].

It stands to reason that the most important aspect of the energy debate is the type and quality of service that energy provides to the users. Decisions as to what is the best energy source for specific needs, are determined by how an energy service comes about. With respect to developing contexts, the decision to use certain types of energy sources will be influenced by considerations such as accessibility of the fuel resource; efficacy to perform specific tasks; and the speed and reliability of service. More importantly, however, such decisions will be based on costs and affordability vis-à-vis available options. Therefore, for renewables to gain social acceptance, they need to fulfil specific criteria. The needs of developing communities are simple: they need clean water; warm houses; cooked food; to engage in agriculture and other income generating activities; easy access to health and school facilities; and so on. The energy infrastructure provided should assist in meeting these broad social and economic needs. Sadly, in many instances, renewable energy options have been introduced with scant regard to the community needs they seek to address. For example, solar PV projects have been imple-

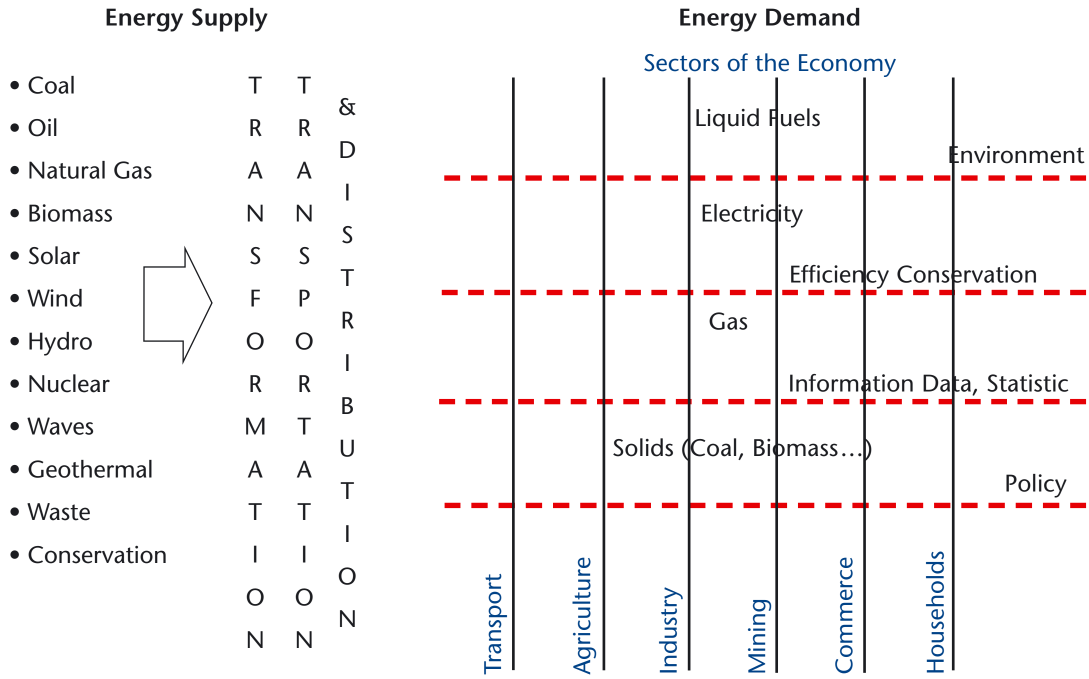

Figure 3
Energy in the economy [6]

mented in areas where the priorities of targeted communities were clearly thermal (cooking and heating).

Technology Options

Linked to the socio-economic dimensions of energy options is the question of the energy technology choice. While the potential for an array of renewable energy sources is prevalent in developing countries, the technology choices selected are, unfortunately, seldom informed by local conditions. For instance, issues such as community preferences, energy-use behaviour (e.g. cooking inside or outside; time of cooking, etc) and multiple-fuel use are often overlooked when technologies are introduced, particularly renewable energy technologies. In selecting technology options, care should be taken to consider aspects such as community fit, and cultural traits. In some communities, for instance, the use of human excreta to generate biogas goes firmly against the local culture and community etiquette.

It is also important that whatever viable technologies are selected, they should serve broad development needs – more importantly they should provide income-generating opportunities. For example, the majority of RET components are wholly imported to developing countries. This has ramifications as far as social acceptance is concerned. Where local production is non-existent, communities benefit little apart from selling the technologies. Local production of at least some components of RETs is crucial not only in providing much-needed job opportunities, but in ensuring a sustainable local production industry. Technology transfer should not be defined as indiscriminate distribution of renewables, but as skills and knowledge transfer, particularly in the manufacturing and maintenance of technology components. Most developing countries are considered as the market for ready-made, off-the-shelf RETs. Surely, this attitude needs to change.

Policies on Renewables

It is unfortunate that RE policy instruments are non-existent in many developing countries. This goes against the global pattern which prioritises renewables in countries' energy policies. How many countries in Africa, for example, have renewable energy policies? Where policies exist, how many countries have RE implementation strategies? The absence of such policy frameworks impedes the introduction of RETs as projects to accelerate renewables are often ad hoc and do not follow a strategic direction. This is a recipe for failure. To be fair to developing countries, national priorities often dictate that the focus should be on pressing and immediate needs, such as combating deadly diseases,

Figure 4 (left)
Village with renewable energy access

Figure 5 (right)
Collection of fuelwood is time-consuming and detains people from income generating productive activities

alleviating malnutrition, providing clean water, etc. Focusing on RE which is perceived (though may not be necessarily so) as small-scale, rural and therefore less important than large-scale capital projects. Also, it appears that the policy vacuum is also caused by a dearth of information that would facilitate the introduction of renewables, such as baseline studies on energy needs. The challenge this poses to RE practitioners is how to explicitly link renewable energy production, distribution and consumption patterns to national priorities.

At regional level, policies or approaches to disseminate RE are seldom harmonised. Regional institutions such as power pools and development communities exist and can be used as platforms to harmonise RE policies, as well as assisting member countries to formulate appropriate policies. All things being equal, the cornerstone to relevant and informed policies is the availability of research centres at national and regional level to provide updated baseline information as well as to develop new technology options. The developing world has fewer centres of excellence to support policy decisions, particularly on renewables. Some of the existing centres lack capacity as the best personnel emigrate to developed regions of the world due to lack of adequate resources (mainly lack of funding and institutional support) to implement appropriate R+D programmes.

A Paradigm Shift to Technology Development: Renewables and Sustainable Development

Whose Development, Whose Problem? Thinking with the People and not for the People

The above discussion suggests that perhaps one of the impediments to uptake of renewables is the manner in which solutions are conceptualised and implemented. In many instances, the energy problems of developing countries are assumed, and there is no proper research done on how such problems are viewed by the people concerned. Even when such problems are properly researched, solutions are often planned far away from the target communities. Surely, if the poor can articulate their problems and needs, solutions should also be discussed with them as well. In many instances, it may not matter so much what type of energy technology is provided, but the service that such technology provides is of crucial importance.

Thus, there is a need for a paradigm shift to development, not only in theory, but also in practice. People in developing countries should not be passive actors in their own development. Granted, they may not be aware of technological innovations, but this does not justify their exclusion in problem-solving strategies. The overriding reason for introducing RETs in developing countries should not only be driven by the need to open up new markets or to serve the concerns of the affluent about environmental issues, but by the expressed desire to complement strategies aimed at reducing poverty. For instance, the primary development problem of the developing world is poverty, not access

Figure 6
Solarhome system as example for a decentralised distributed electricity generation

to energy. The latter is the symptom of the former. RE dissemination strategies should be informed by this fact, and should be directed at poverty alleviation.

Appropriate Technology Options

The paradigm shift mentioned above suggests that education is essential before solutions can be devised. This education must be two-pronged: firstly about assuring that the developed countries understand the real needs of the developing countries and, secondly, the developing countries learning about new technologies to address energy needs. The infusion of this two-pronged education should form the basis for effective partnership in halving the levels of world poverty by 2015, as espoused by the Millennium Development Goals. Indicated above is that some wonderful technologies introduced in developing situations become spectacular flops. This may not be caused by an inferior type of technology. The failure is often due to the fact that such technology does not serve the community's expressed needs, or that the community does not understand the technology. Appropriate technology options are arrived at by understanding the developing world's priorities and the provision of technology options to match such priorities. It is therefore important not only to think of the technology, but also the downstream issues related to the use and maintenance of the technology.

Overcoming Research and Development Barriers: The Challenge for Developing Countries

The above discussion highlights that as far as developing countries are concerned, addressing energy needs is not simply the provision of technologies to meet the needs of society. Energy poverty is simply an indicator of general development challenges, which are defined by levels or degrees of impoverishment. Besides the obvious reason that most RETs that are introduced in poor rural areas are unaffordable to many people, these technologies are not used on a large scale even if they are heavily subsidised, or provided free of charge through grant funding. Does this mean that RE is 'the most expensive energy option for poor people' as it is viewed in some circles? This question can be answered by posing another question. Why, even when RETs are given for free, do they not gain widespread acceptance by people who use inferior fuels? In answering these questions, the R+D capacity in developing countries needs highest consideration. Without adequate capacity, such countries will not have the ability to develop home-grown policy frameworks, innovative technologies and processes of implementation. All things being equal, the development needs of RE can be achieved through three interlinked actions:
(a) appropriate technology;
(b) appropriate business models; and
(c) local production of RETs.
Once all these are achieved RE options would, for all intents and purposes, gain local acceptance. A brief discussion of each action plan is presented below.

R+D Focus 1: Appropriate Renewable Energy Options

At the end of the day, solutions (i. e. technology choices) have to reflect the needs and preferences of the target community. What is the community preference: do they prioritise thermal needs over lighting or vice versa? Examples abound of solar PV for lighting projects where a community's expressed need is for thermal energy services, for cooking and heating.

Figure 7 example for the utilisation of wind energy

Secondly, technology solutions mean little if they are not explicitly linked to other development needs. Does the introduction of a technology improve people's lives in terms of facilitating other important services such as the availability of vaccines, clean water, better transport, user-friendly appliances (that meet local preference), warm houses, etc? To what extent are technology sources or renewable energy choice in harmony with regional, country or government development priorities?

Thirdly, communities need to be exposed to an array of technology options available, so that they could make informed decisions as to the best option to meet their needs. Such exposure enables the users to select options that meet a variety of needs. Introducing only a technology that meets a single need may be counterproductive in promoting renewables. For instance, when a solar PV system is introduced for lighting, other solar technologies, such as solar cookers, solar water heaters, passive solar designs, should also be introduced in order to cater for most household and community energy needs.

Fourthly, education and public awareness are crucial for renewable technologies to be accepted by communities. Public perception on the quality and performance of RETs has long been identified as the key barrier to renewables in poor areas. Such perceptions – that renewables are energy supplies of second choice – are informed by past experience with low quality, fly-by-night technologies which flooded the market in the early days of renewable energy penetration. News travels fast in developing areas, particularly in Africa. Many people who have negative perceptions of the performance of renewables may not necessarily have experienced renewables first hand. These perceptions can only be addressed by a targeted public awareness and education processes that are aimed at both the users and producers of RETs.

Fifthly and related to the above, there is a widespread perception that renewables are second grade sources of energy. Such perception can be illustrated as thus:

Renewables = solar PVs = energy of 2nd choice = rural applications = poor people

This equation often results from the way in which renewables are promoted in developing countries. Renewables projects often promote a single technology (which is often solar PV or solar cookers) and promoted by people who themselves have never used this technology choice in their households. Again, the tendency is to concentrate on rural applications when grid electricity is not financially viable. Urban centres, where substantial economic activities are situated are often served with conventional energy sources. Sadly, this leads to the conclusion that renewables and its technologies are reserved only for the poor. As a starting point, it is important to ground the use of renewables firmly in developing countries. The best way to start is to focus more on urban centres where economic activities are centred and on urban households most of which could afford to pay for the new technology options. This requires (including capacity building as illustrated above) an innovative marketing strategy.

Lastly, it must be recalled that current renewable technologies may not address all the energy needs of developing countries. Therefore, RE should be promoted as one of the energy options that can perform certain tasks well. RE options can work better if introduced in a basket with other energy options, such as gas, i. e. energisation.

R+D Focus 2: Effective Business Models to Promote Renewables

When renewables are viewed as energy options for the rural poor, the tendency is to provide these at little cost to the users. This 'developmentalist' approach was preferred especially by multilateral organisations and by other international institutions. The rural 'markets' were flooded with technology, wholly imported from the north, with little consideration to their long-term sustainability. The track record of donor programmes is poor in creating and sustaining rural enterprises for RE delivery, and has, in fact, contributed to the negative perceptions outlined above. There is a realisation now that donations (of renewables) without cost recovery actually destroy the market. Still, some donors continue to provide capital cost subsidies in order to boost the renewable energy market. There is a growing consensus that commercialising renewables could work positively for the dissemination of these energy sources in a sustainable manner. However, proper research and development on effective business models is in its infancy. Various models are being piloted across the developing world, ranging from vendor-supplied credit, micro credit, equipment rentals, etc. The bottom line is that new business models are needed with the focus on entrepreneurship and innovative finance schemes. However, the danger here could be that purely market-driven approaches may leave the very poor behind.

With respect to developing countries, there is a need for an R+D process that has the following components:
(a) as a clearing house of innovative business plans;
(b) international best practices and amplification of success stories;
(c) innovative finance which does not only provide start-up finance, but also provides for business development training; and
(d) as a source of skills to select technologies.

It should also be remembered that business models become effective if there is a market and a demand for the services provided. Unfortunately, this aspect resides outside the realm of renewables, to the broader development of the society as a whole. The market is defined here as the demand for the services and the ability of consumers to pay for them. This is different to the need for energy services. One of the downsides of renewable energy dissemination strategies is the virtual absence of viable markets. Therefore, RE strategies, including new business models can only succeed in so far as the community is developed enough to demand and afford such services. This calls for the integration of RE to other development needs, such as employment creation, increased household income, education, etc. It is often said that sustainable solutions to energy problems rely mostly on non energy interventions.

R+D Focus 3: Local Manufacture of RETs Components

Most RETs currently in the developing markets are fully imported. Even in fairly advanced countries in the developing world, more than 50 % of renewable energy components are imported from the north. This asymmetrical situation needs to be changed if the renewables industry is to be sustainable in developing countries. There should be a long-term strategy in place for knowledge transfer. Granted, some technologies cannot be fully manufactured in developing countries and may need to be imported. However, if the rationale is to increase the share of renewables in the national energy economies, significant investments have to be made in local production of RE components. This area requires immediate intervention as it could have positive spin-offs: increased technical capacity and innovation in science and technology in developing countries, more jobs created due to the labour-intensive nature of renewable energy production, etc. Local production of RETs may be a long-term source of revenue for municipalities, and can, as well, be integrated in other municipal issues such as landfills, sewage treatment and waster disposals). [1]

Concluding Remarks

The R+D needs in developing country on renewables clearly go beyond technology solutions to encompass social and economic considerations, i.e. the so-called "downstream" issues of technology. The above discussion highlights these broad development issues associated with technology options. Having identified these issues and needs, what is then the way forward as far as renewable energies are concerned in the developing world context? Before proposing some recommendations, it should be emphasised that energy poverty in developing countries cannot be addressed using purely market approaches, nor can they be resolved by a strictly developmentalist approach. The solutions lie somewhere in the middle. Below are value propositions on the way forward.

Regional Cooperation in Research and Development

Energy development knows no boundaries. In fact new strategies work better when they are implemented across a region, rather than only in a country-specific context. Global partnerships are a testimony to this development. Partnership is not simply about brotherhood, but a conscious strategy to mobilise scant resources and share experience across more than one country. Research and development of a technology, process of implementation or financing strategy stand more chances of success if the focus is cast wider than a single country. There is cooperation at the regional levels in many developing countries. The mandate of regional cooperation should be expanded to include research and development.

Database of Renewable Energy Technologies

It is very difficult to formulate effective policies based on insufficient and often invalid data sets. Many experts agree that lack of information on energy demand and consumption makes it near impossible to devise effective implementation and planning strategies. It is not even known how many renewable energy technologies are currently in use in developing countries. In addressing the question of data gaps, national and regional databases need to be created and periodically updated. R+D centres of excellence, such as the Global Research Alliance partners can be utilised to maintain these databases.

Innovation in Rolling Out Renewables

There is a glimmer of hope as far as innovative strategies to disseminate renewables across the developing world. In Africa, the UNEP funded programme, AREED (African Rural Energy and Enterprise Development) in partnership with E+Co is implementing an entrepreneurial approach in energy service provision. This programme is still very small-scale and also promotes other cleaner fuels such as bottled gas. In South Africa, a concession model, public-private partnership provides a fee-for-service mechanism to provide poor households with a basket of energy options including renewables. This model is, however, heavily subsidised by the national government. Across the continent and in South Asia, various ESCOs models are being piloted. These attempts provide a shift from a conventional developmentalist approach to more sustainable, profit-driven implementation strategies. Be that as it may, the impacts of these new models remain largely untested, and experiences have not been properly documented. In addition, recent experience shows that these innovative strategies do not reach the poorest sectors of the developing world.

Harmonisation for Energy Policies

Linked to the above points, an enabling environment has to be created for renewables. All developing countries have to have policy instruments to regulate renewables imports, production, dissemination and use. Moreover, as stated above, technology knows no boundaries. Therefore, policies should be harmonised so that a sustainable market for RE would be created. Prevailing policy instruments can be used and/or adopted to perform this task. Regional cooperative trade agreements between countries can be utilised to assist in the harmonisation of the renewable energy policies and assist countries that are without policy frameworks.

The discussion in this paper points to the fact that the developing world is willing and ready to take a centre stage in accelerating the use of renewables. It also argues that the best way to go about this is a formation of an effective partnership between North and South, as well as South and South. The former ensures skills and knowledge transfer and the latter ensures that best lessons are learned. The time is now!

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Capacity Building for Sustainable Energy Development and Poverty Alleviation in Sub-Saharan Africa – the Contribution of AFREPREN

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About AFREPREN

African Energy Policy Research Network & Foundation for Woodstoves (AFREPREN/FWD) is an African initiative on energy, environment and sustainable development. AFREPREN/FWD brings together 97 African energy researchers and policy makers who have a long-term interest in energy research and the attendant policy-making process. AFREPREN/FWD has initiated policy research studies in 19 African countries, namely: Angola, Botswana, Burundi, Eritrea, Ethiopia, Kenya, Lesotho, Malawi, Mauritius, Mozambique, Rwanda, Seychelles, Somalia, South Africa, Sudan, Tanzania, Uganda, Zambia and Zimbabwe.

AFREPREN/FWD's ultimate goal is to promote the greater use of cleaner energy options such as renewables for poverty alleviation in Africa. The near-term objective of AFREPREN/FWD is to strengthen local research capacity and to harness it in the service of energy policy making and planning. Initiated in 1987, AFREPREN is a collective regional response to the widespread concern over the weak link between energy research and the formulation and implementation of energy policy in Africa.

Since its initiation, AFREPREN has successfully implemented over 90 research projects involving 234 African researchers and policy makers in 19 countries of Eastern and Southern Africa and forged collaborative links with West, Central and North African energy researchers and policy makers. Findings of the research undertaken by AFREPREN have been published in 13 major publications, one Energy Policy special issue journal, 24 Occasional Papers, 37 journal articles, 23 book chapters and over 300 Working Papers. Since 1987, AFREPREN has had an ongoing major research programme on renewables.

The current phase due to end in 2004 also has a major programme on renewables. Entitled "**Renewables and Energy for Rural Development**" the programme is examining options for the provision of modern energy services to low-income rural areas of Africa with special emphasis on the commercial/services/productive uses of energy.

Other ongoing major programmes of AFREPREN include:

- Energy Services for the Urban Poor
- Energy Sector Reform
- Special Studies of Strategic Significance for the Energy Sector in Eastern and Southern Africa (ESA)

Additional information on these programmes is available on the AFREPREN website (www.afrepren.org).

AFREPREN's Renewable Energy Research Programmes

As mentioned earlier, AFREPREN has undertaken extensive research work on renewables in all the research phases running from 1987. The past research phases examined the fundamentals of renewable energy technologies, and the status of their dissemination in selected African countries.

In the ongoing research phase of 1999–2004, one of the core research theme groups was titled "Renewables and Energy for Rural Development". The theme-group objective is to identify options for the provision of renewable and sustainable energy services to low-income rural areas of Africa with special emphasis on commercial/ service/ productive use of energy.

Objectives of the Theme group

- Analysing the impact of current renewables and rural energy policies.
- Assessing current rural household and community energy practices and technologies.
- Reviewing rural income generating activities and energy technologies used.
- Establishing what is hindering the removal of identified barriers in the dissemination of renewable energy technologies (e.g. absence of rural entrepreneurs, funding mechanisms, capacity building and policy).
- Assessing the gender dimension of renewables and rural energy.

Key Research Issues

- Impact of the government and utilities policies, programmes and institutional framework on the provision of renewables to rural areas.
- Analysis of existing decentralised private sector energy production and distribution activities in rural areas.
- Comparative analysis of renewables and rural energy use in rural areas.
- Analysis of components for promoting the production and deployment of renewables and rural energy by private entrepreneurs.
- Gender sensitivity of government and utilities' policies and programmes on the provision of renewables and rural energy for domestic use and for income generating activities.
- Gender analysis of energy practices in rural households and energy use in rural income generating activities.
- Impact of the gender derived and gender driven power relations at the household and community levels in the use of modern energy.

Based on the above research work, AFREPREN has over the years published a wide range of journal articles, research reports, working papers, occasional papers and major publications on renewables. These publications are distributed widely to energy sector stakeholders in Africa, as well as other parts of the world. The objective of these publications is to inform decision makers in policy making. Some of the key publications on renewables published by AFREPREN are provided in Annex 1.

AFREPREN's Energy Training and Capacity Building Programme

The number of African energy policy analysts has grown in the last few years as a result of training programs and capacity building initiatives of various training institutes, development programs and networks such as the African Energy Policy Research Network (AFREPREN). The supply of skilled energy policy analysts is, however, still insufficient. This is partially due to the difficulties faced by formal education institutions in Africa. African policy analysts have identified important constraints facing formal energy education in Africa. Key problems include the following:

- A high attrition rate of senior and experienced staff from institutions of higher learning due to the erosion of teaching and research conditions;
- Inadequate remuneration for the academic and supporting staff;
- Lack of funds for research, conference attendance and institutional attachment;
- Inadequacy in the provision of external examiners and opportunities within these institutions for staff exchanges; and
- Scarcity of funds for the purchase of textbooks, journals and equipment.

AFREPREN's training and capacity building program is designed to assist capacity building in the region and to address the above shortfalls by building on the substantial expertise and information that AFREPREN has developed over the last 10 years. AFREPREN has built substantial expertise in energy policy analysis as well as published a large body of literature on African energy issues. It has published 11 major books and over 200 Working Papers on the African energy sector as well as a diskette set and CD-ROM on African energy issues. AFREPREN has also established a substantial library of over 20,000 documents, books and journal articles covering various energy issues. It also has access to a wide range of diskettes, CD-ROMs, audiotapes and videos on energy issues. With links to over 100 African energy experts and numerous international energy agencies and experts, AFREPREN is well placed to assist in training and strengthening up coming African energy professionals in energy policy analysis skills.

AFREPREN runs the following key training and capacity building programmes:

Masters Program:

- Support for MSc or MA research studies on energy policy
- Support for MSc or MA in energy policy subjects

In future, AFREPREN plans to launch a joint AFREPREN / Universities MSc / MA training programme in Africa.

To date, a total of 15 scholarships have been offered to candidates from Eastern and Southern Africa.

Regional Short Term Training Courses:

- Short-Courses for energy policy makers
- Research Techniques and Methodology Workshops
- IT Workshops

A total of six courses have been undertaken in the 1999 – 2004 research phase, and about 80 African energy researchers and stakeholders have participate in these courses.

Regional/National Policy Seminars:

Regional and national events organised by the AFREPREN Secretariat and the national focal points in AFREPREN member countries. The main objective is to disseminate research findings to national policy makers and researchers. In the 1999 – 2004 research phase, over 25 national and regional policy seminars have been organised in AFREPREN member countries.

The training and capacity building programmes mentioned above cover a wide range of energy subjects including renewable energy. The next section describes AFREPREN's renewable energy programmes and contribution to the international conference on renewables held in Bonn, June 1 – 4, 2004.

Figure 1
East and Horn of Africa: Ethiopia, Kenya, Uganda and Tanzania

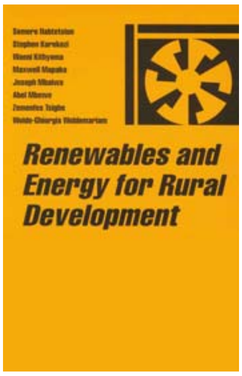
Contribution to the International Conference on Renewable Energies

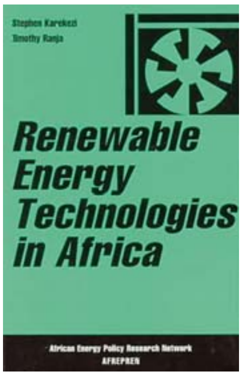
AFREPREN, with support from Sida / SAREC and the Heinrich Böll Foundation, organised a side event titled: 'What are the Benefits of Renewables in Africa?' This side event, the only one with a dedicated focus on Africa, was organised to present the findings of the study on Renewables in East and Horn of Africa, which is coordinated by AFREPREN with funding from the Heinrich Böll Foundation office for East and Horn of Africa. Approximately 50 – 80 people attended the side event, drawn from different geographical regions and institutional affiliations. The bulk of participants, were, however, Africans.

The study was launched by AFREPREN and HBF (Regional Office for East and Horn of Africa) and its main objectives were:

- To examine the viability of 10 % renewables target proposed at the Johannesburg WSSD Summit in selected African Countries
- To assess the benefits and drawbacks of the 10 % renewables target in Eastern Africa

The study was undertaken in four countries: Kenya, Uganda, Tanzania and Ethiopia *(Fig. 1)*. In parallel to the country studies, a regional study was also prepared. The study also included national level consultations in the four countries, *AFREPREN's Renewable Energy Title Series:*





as well as regional consensus building and brainstorming on the regions' priorities for renewables.

One of the key outcomes of the study was the dissemination of information on renewables to policy makers in the four East and Horn of African countries participating in the study. In addition, renewable energy technologies that have a direct impact on poverty alleviation were also highlighted, and are beginning to receive attention from policy makers in the region.

Contribution to the International Action Plan – Renewables 2004 Conference

AFREPREN in conjunction with the Heinrich Böll Foundation, Regional Office for East and Horn of Africa, submitted a commitment, which was included in the International Action Plan. The International Action Plan was one of the major outcomes of the Renewables 2004 conference, and is a compilation of voluntary actions from governments, international bodies, NGOs, national and regional institutions.

The Action plan submitted by AFREPREN and HBF has a strong focus on the dissemination of small and medium scale renewables, which can alleviate poverty. The objective of the action is to develop a prioritized listing of small and medium scale renewables and cleaner energy options suitable for poverty alleviation in Africa that can be implemented in the region.

A growing number of experts within the AFREPREN Network believe that these technologies would have the greatest impact on alleviating poverty and enhancing economic development in sub-Saharan Africa. AFREPREN will continue to promote these technologies, and undertake research studies and assessments, which can be used to lobby policy makers and other stake-holders.

Other Contributions

AFREPREN participated in the conference plenary sessions, namely:
(i) Multi-stakeholder Dialogue
(ii) preparation of a summary for one of the conference ministerial sessions
(iii) participation in the Science Forum.

Annex 1: AFREPREN's Renewable Energy Title Series

Renewables and Energy for Rural Development in sub-Saharan Africa

Edited by Maxwell Mapako and Abel Mbewe (2004)

Energy supply is a key factor in economic and social development, but too little attention has been given to the needs of rural households, farmers and small businesses. Rural households in sub-Saharan Africa still derive most of their energy from biomass sources. Lack of modern energy supplies in rural areas constrains efforts to alleviate poverty and improve living standards. Renewables and Energy for Rural Development in sub-Saharan Africa addresses this situation.

The original research contained in this volume identifies the options for the provision of modern and improved energy services based on renewables to low-income rural areas, with special emphasis on the productive uses of energy. In the five countries represented – Botswana, Eritrea, Ethiopia, Zambia and Zimbabwe – the volume focuses on whether a decentralized approach to energy delivery is better than more centralized provision, the role of income-generating activities in attracting modern energy services to rural areas, and the barriers as well as opportunities that exist in the promotion of renewable energy technologies in the rural areas of sub-saharan Africa.
This latest volume is a further contribution to addressing the practical energy needs of sub-Saharan Africa.

Renewable Energy Technologies in Africa

Stephen Karekezi and Timothy Ranja (1997)

The energy sector is widely acclaimed as the heart and lungs of any programme for economic development. At the same time, energy at household level and in the rural areas is essential for everyday life. Renewable energy technologies can play a major role in both respects. This book sums up across the whole of Eastern (including the Horn) and Southern Africa (including South Africa itself) what is now known about the innovation and deployment of renewable energy technologies in the region.

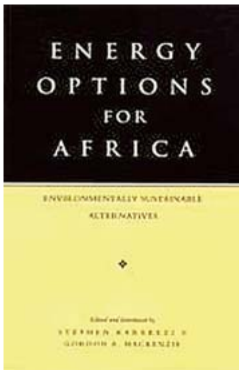
Successive chapters deal with bio-energy, solar and wind energy and small hydro technologies. The authors examine the African energy sector's overall geo-political and socio-economic setting as well as specific non-technological factors that impinge on renewable energy development, namely: financing, institutional structures for energy management, human resource development, equity and access, and environmental considerations. The book, which concludes with a special section on policy recommendation, provides an essential text for training a new generation of African energy specialists.

Energy Options for Africa: Environmentally Sustainable Alternatives.
Edited by S. Karekezi and Gordon Mackenzie. (1993).

As African economies seek to recover from what is commonly now described as the 'lost' decade of the 1980s, energy policy has become a crucial component in the region's industrial, transport and environment strategies, and in meeting household fuel needs.
This volume is a guide to policy makers and development agencies for determining environmentally sound energy options and priorities for the region. The contributors – leading energy and environment specialists from Botswana, Ethiopia, Ghana, Kenya, Nigeria, Senegal, Sierra Leone, Sudan and Uganda – identify the key requisites for such development: innovative policy instruments and institutions, and incorporation of environmental costing; mobilization of both local and external financial resources; management training and technology acquisition; energy efficiency; increased supply of environmentally benign modern fuels and energy technologies.

Energy for Rural Development.
Edited and Introduced by M.R. Bhagavan and S. Karekezi. (1992).

This book contains essays presented at a United Nations Meeting of Experts on the Role of New and Rural Development. With an introductory essay by the Swedish-based energy policy analyst Dr. M.R. Bhagavan and the Kenya Based Facilitator of the African Energy Policy Research Network (AFREPREN) Stephen Karekezi, the volume comprises national and regional studies examining the technological, economic, political, social issues concerned with energy for rural development, raising questions on productivity, income, institutions, local participation, information and assessment of resources and technologies. The studies relate to the rural situations in sub-Saharan Africa, North Africa, North Africa and the Middle East, South and East Asia, Central America and the Caribbean Eastern Europe and the Soviet Union. Each study is written either by local energy specialists and academics or by experts associated with the United Nations and its Agencies.



Energy Options for Africa

Energy for Rural Development

Annex 2: AFREPREN Journal's Articles on Renewables, Rural Energy And Poverty

[1] "Domestic Use Versus Income Generating Activities in Delivering Modern Energy to Rural Botswana." Joseph Mbaiwa and Oganne D. Gontse in Journal of Energy, Published by JESA. February 2004.

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[9] "Rural Energy Access: Promoting Solar Home Systems in Rural Areas in Zambia – A Case Study". Oscar Kalumiana. In Renewable Energy, Published by Elsevier Science Limited, Oxford, United Kingdom, 2002.

[9] "The Potentials of Wind Energy Applications in Eritrea". Semere Habtetsion. In Renewable Energy, Published by Elsevier Science Limited, Oxford, United Kingdom, 2002.

[10] "The Case for De-Emphasizing PV in Renewable Energy Strategies for Rural Africa". Stephen Karekezi. In Renewable Energy, Published by Elsevier Science Limited, Oxford, United Kingdom, 2002.

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[18] "The Impact of Large Renewable Energy Development on the Poor: Environmental and Socio-Economic Impact of a Geothermal Power Plant on a Poor Rural Community in Kenya". Nicholas Mariita. In Energy Policy, Volume 30, Nos. 11-12. Published by Elsevier Science Limited, Oxford, United Kingdom, 2002.

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Annex 3: AFREPREN's Occasional Papers on Renewables:

No. 1 AFREPREN Regional Policy Seminar on Renewables – Focus: Cogeneration
S. Karekezi, J. Kimani and J. Wangeci (eds)

No. 2 Bagasse-Based Cogeneration in Mauritius – A Model for Eastern and Southern Africa
Kassiap Deepchand

No. 3 Energy for Rural Development in Botswana – Proceedings of a National Policy Seminar
B. Mogotsi & S. Bok (eds)

No. 4 Energy for Rural Development in Zimbabwe – Proceedings of a National Policy Seminar
M. Mapako (ed)

No. 6 Energy for Rural Development in Zambia – Proceedings of a National Policy Seminar
L. Chandi, A. Mbewe & C. Mulenga (eds)

No. 9 Energy for Rural Development in Eritrea – Proceedings of a National Policy Seminar
S. Habtetsion and Z. Tsighe (eds)

No. 10 Renewable Energy Technologies in Africa – An Energy Training Course Handbook
S. Karekezi, W. Kithyoma & L. Majoro (eds)

No. 11 Energy for Rural Development in Ethiopia – Proceedings of a National Policy Seminar
M. Teferra (ed)

No. 12 The Socio-Economic and Environmental Impact of Geothermal Energy on the Rural Poor in Kenya
N. Mariita

No. 19 Cogeneration in Zimbabwe – A Utility Perspective
B. Batidzirai

No. 21 Opportunities for Cogeneration in a Reforming African Power Sector
Kassiap Deepchand (ed)

No. 22 Renewables and Rural Energy Development in Botswana: Proceedings of a National Energy Policy Seminar
J. Mbaiwa (ed)

No. 24 The Potential Contribution of Renewables in Ethiopia's Energy Sector: An Analysis of Geothermal and Cogeneration Technologies
Prof. W. Wolde-Ghiorgis

Copies of the Occasional Papers and abstracts of the journal articles can be downloaded from the AFREPREN Website (www.afrepren.org).

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Possible Cooperation between Arab and European Countries in Energy, Water and Environmental Issues

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Abstract

The Arab countries, in general, lack energy and water. The average annual rain level in Arab countries is from 5 to 45 mm while in European countries it ranges from 200 to 400 mm. The total internal water reserve is only 100 km^3 for Arab countries, while in Europe it may exceed 400 km^3; bearing in mind that the world internal water reserve is 43764 km^3. Nearly more than 50 % of the Arab countries have water availability per capita less than the absolute water scarcity level (200 m^3/capita/year) while the rest, except Iraq, are in water scarcity threshold level (1000 m^3/capita/year) [1]. In Europe, the per capita water resource is as high as 85478 m^3/year (Norway). In fact among the countries with least water resources [2] we have 13 Arab countries (Kuwait, UAE, Qatar, Libya, Saudi Arabia, Jordan, Bahrain, Yemen, Oman, Algeria, Tunisia, Egypt, Morocco and Palestine) where the per capita water resource is ranging from 10 m^3/year (Kuwait) to 971 m^3 year (Egypt).

On the other hand, the electricity consumption per capita in West Europe per year has never been less than 4000 kWh in 1999 while it is as low as 46 kWh in Sudan. In the majority of the Arab countries, except Arabian Gulf countries (GCC), each person consumes annually only 1200 kWh electricity (on average)! Probably more than one million of Arab citizens (out of ~300 million) have no access to electricity [2].

Furthermore, the European OECD countries are emitting 3800 Mt of CO_2, which is 15.2% of the global emissions (25000 Mt). In 2001, the share of global CO_2 emissions from Middle East is only 4.8 % – compared to North America (27.7 %), East Europe (12.6 %), West Europe (15.6 %), Africa (8.8 %), central and South America (4.1%), Far East and Oceania (31.5 %). According to latest reports, Germany has managed to reduce emissions of CO_2 by – 20 % (compared to the base year), U.K. – 12.5 %, Italy – 6.5 %, France 0 %, Russia – 6 %, USA – 7%, Japan – 6 % [4]. Moreover, according to Swiss Re [4], in its report on Natural catastrophes and man-made disasters in 2003, nearly 36 natural accidents have occurred in Europe with 424 victims wasting US$ 2173 million (11.8 % share) while in middle east Asia 178 accidents have occurred with 51894 victims costing US$ 1447 million (7.8 % share).

Therefore, cooperation for a mutual benefit between Arab and European countries in the field of energy production using the abundant solar radiation is favorable.

Clean and sustainable energy could be exported to Europe in a form of High Voltage Potential, produced in Arab countries using solar thermal or photovoltaic technology. A part of the produced energy from renewable sources can be used for water desalination in Arab countries. For 65 % of water resources are politically in debate with non Arab countries – which may ignite Water Wars.

The Arab countries are characterized and blessed with abundant direct solar radiation, i. e., ranging from 4.1 kwh/m^2/day, Mosul, Iraq to 6.7 kwh/m^2/day, Nouakchott, Mauritania [5,6]. Even more, the maximum recorded annual mean sunshine duration ranges from 7.5 hrs, Tunis, to 10.7 hrs, Egypt. These figures are larger by, at least, 3 times compared to European Countries [5].

The temporal behavior of electricity demand in Arab and European countries is found to complement each other. Therefore, this vision of cooperation, will enhance the renewable energy utilization worldwide and it will increase to be more than the current level, i. e.,13.8 % from the total primary energy supply, where 2.3 % come from hydro, 11.0 % from com-

bustible renewable and waste, and only 0.5 % are covered by solar (0.039 %), wind (0.026 %), tide (0.004 %), and geothermal (0.440 %) sources. The solar power market is already growing, in year 2000 by 1000 MW, for instance, and is expected to be 14000 MW by 2010 and up to 70000 MW in year 2020 [3]. This, of course, will minimize the cost per watt per each renewable energy source, especially solar thermal and photovoltaic ones.

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Capacity Building in Developing Countries – Bringing Renewable Energy to the People

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General

"More than half the world's population lives in rural areas, nearly 90 % of them – some 2.8 billion – in the developing countries. The vast majority of these people is dependent on the traditional fuels of wood, dung and crop residue, often using primitive and inefficient technologies. For many, this combination barely allows fulfilment of the basic human needs of nutrition, warmth and light, let alone the possibility of harnessing energy for productive uses which might begin to permit escape from the cycle of poverty" (World Energy Council 1999, p. 7).

The international postgraduate study "SESAM-Sustainable Energy Systems and Management" at Flensburg University in Germany with nearly 20 years of international experience is offering a MSc course for participants from developing countries to tackle the global challenge of using renewable energy systems. The course is partially carried out in Germany and partially with partners overseas, like United Nations Development Programme (UNDP) in Nepal, and has produced graduates in more than 50 countries worldwide and numerous international co-operations in Africa, Asia and Latin America.

Energy and Development

Although energy is still not considered as a basic human need it is required for meeting all of the basic needs such as food and health, and in this context also agriculture, education, information, and other infrastructure services and shows clear correlation with the Human Development Index HDI.

In order to tackle the core problems of environmental degradation, diminishing natural resources and increasing poverty an important "tool" in this process is the use of sustainable energy systems which represent an essential precondition for social and economic development of a country – together with the changing of attitudes, community mobilisation and transfer of knowledge.

"Among the key lessons learned in the provision of modern energy services in the developing world (particularly in rural areas) is that the services must give rise to greater productivity if they are to be sustainable. The facilitation of new productive activities is what creates sustainable livelihoods for poor people and makes the energy projects financially viable. Productive services include a wide range of activities such agro-processing, transport provision, battery charging, and small-scale manufacturing. Very often, particularly in dry areas, power is needed for water pumping to supporting agriculture. Various options, ranging from manual and animal power to photo-voltaics or wind pumps should be considered against the dual criteria of sustainability and affordability" (Khennas 2002, p.10).

Indeed – energy and development are closely related and energy was a prerequisite two

Figure1
HDI and Commercial Energy Consumption

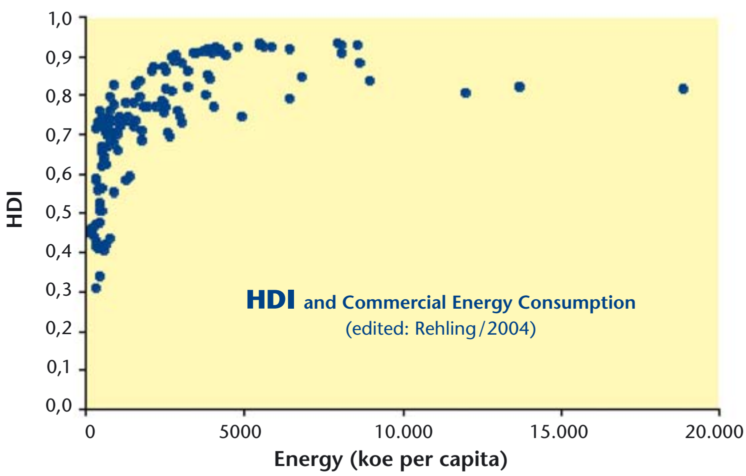

Figure 2
Micro hydro station

centuries back for the breakthrough in economy and productivity in the nowadays industrialised countries. This interrelation of energy and development might be the base for the view that "Energy has many links with sustainable development, notably through productivity, income growth, environment, health, education, gender issues, macroeconomic stability, and governance" (Interview with Jamal Saghir, World Bank, in: Morales / Johnson 2002, p.3).

But how to make best use of that interdependancy of energy and development? What is the role of human resources? Learning lessons of various countries, organisations and projects can help to understand the mechanism….

A typical Example: Renewable Energy for Rural Electrification (SESAM 2002)

The Government in an Asian country commissioned a project in a village in 1991 and after installation it was handed over to the local Agriculture Collective to manage and operate it. The unit operated from 6 pm to 10 pm every day. Six years later in 1997 failures of the system were visible which seemed to be technology based:

- No frequency control equipment was installed on the existing system.
- Wooden poles were rotten and aluminium conductors were undersized, resulting in low voltage.
- Quality of the power was so low that the system lost paying customers and income revenue.
- Revenues from the sale of power were used to pay for projects unrelated to the operation and maintenance of the turbine system. Thus no funds were available when maintenance or repairs were required.
- The operators were insufficiently trained to do anything more than start up and shut down the plant.

So the technical part of project was redesigned with new micro hydro station plus installation of a diesel generator, reconstruction of the electricity distribution system, and establishment of a battery charging system *(Fig. 2)*. The total budget for the project was 85,600 USD.

Running the system after re-opening for another 3 years the villagers were asked again whether positive changes had come from the project (in the graph dark colour means "no positive changes"):

The graph *(Fig. 3)* shows that improvement in income and employment as the main requirements and expectations were not fulfilled and so again the project came under financial crisis: about 50 % of the customers did not pay or could not pay because the income and employment situation had not increased.

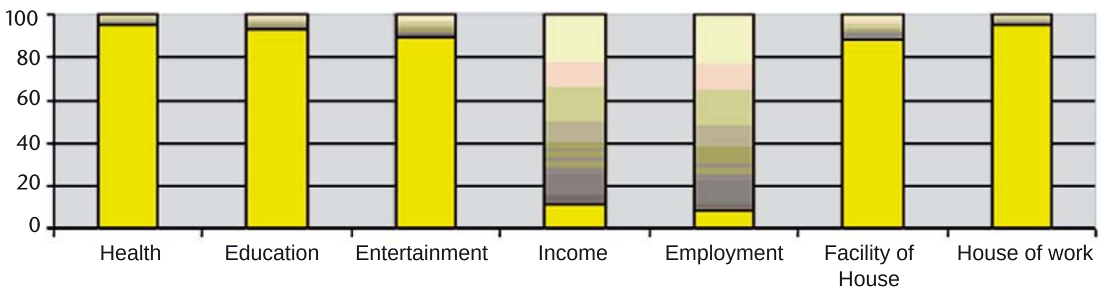

Figure 3
Fulfillmet of requirements and expectations

= degree of fulfillment

Conclusion: latest renewable energy technology was provided but the planners had no idea of the non-technical aspects and the target group (villagers) did not participate in decisions, human resources were not trained or developed, economic situation did not improve: this kind of renewable energy project is not sustainable. In more than 100 similar case studies of SESAM in Africa, Asia and Latin America this kind of experience is (unfortunately) quite typical.

Human Resources for Renewable Energies:

To analyse, understand and solve the complexity of problems it is no longer suitable to just have a "tunnel" view which means just narrowing the view on aspects you like to see and not being capable to understand interdependancies with related aspects. Typical for tunnel views are technical solutions for development problems and under this category also falls "renewable energy for development".

Project evaluations and research studies clearly prove that the failures in implementation of energy technologies are mainly found in non-technical reasons and very often related to lack of awareness and lack of capable human resources: "In general, economic and information/awareness barriers were the most important obstacles across the countries and RETs (renewable energy technologies, author). This points to the low level of awareness and information on RETs among the potential users. Therefore, better ways to raise awareness are required… Small size of market, unfavourable policies, and subsidy to competing conventional fuels were other reasons that affected the economics of RETs further." (Painuly J.P./ Fenhann, J.V., 2002, p.37)

"A further factor that constrains the effectiveness of decentralised planning is the lack of sufficiently skilled people to carry it out. While collecting data … it is necessary, in addition, to introduce higher level training of planners." … "A further important lack of information is the one felt by rural people themselves. Although they know a great deal about traditional energy supplies and end-use options, very few of know about the potential of new technologies and modern fuels, making it difficult for them to contribute meaningfully to much of the planning process." (World Energy Council 1999, p. 101)

Therefore the international MSc-course "SESAM-Sustainable Energy Systems and Management" aims to prepare participants to work in leading positions in national and international organisations as well as in businesses in order to promote sustainable development strategies and to implement energy concepts in the context of sustainable development. Of great importance in this context are key qualifications:

- ability to view problems/solutions in their entirety, i.e. a holistic approach
- creativity and openness to innovation
- inter-disciplinarily approach
- problem-solving ability
- social competencies and the ability to operate in teams.

Besides interdisciplinary study phases on technology and management with emphasis on renewable energy, project management and development strategies, environment and economy and socio-cultural aspects (10 months in Germany) participants will take part in a five months international study programme: two months with all participants as a group in an "International Classroom" and three months as individuals in field research. The international phase is in collaboration with partners like United Nations Development Programme (UNDP) in Nepal with its "Rural Energy Development Programme REDP". The partnership is to provide opportunity to apply the theoretical knowledge and skills in practical projects.

Experiences of the International Classroom with UNDP Nepal:

Every year the SESAM group went to Nepal to evaluate rural energy projects and to learn the phases of project implementation. Vice versa staff members of REDP/UNDP participated in project orientated seminars in Nepal during the Interational Classroom and staff members were

SESAM– Building Bridges between North and South

also taken for full SESAM MSc study course and within their own field research also evaluated technical, economical and socio-cultural changes, benefits and failures.

The Rural Energy Development Programme (REDP) is a joint programme of UNDP / World Bank and His Majesty's Government of Nepal which adopts a holistic approach for sustainable rural development, to enhance rural livelihoods and to preserve environment through the promotion of renewable energy systems (micro hydro, solar home systems, biogas, improved cooking stoves etc.) where possibilities of commercial energy supply do not exist. Specifically, the programme aims to have impact in the areas of

- promotion of efficient end-use technologies, including non-farm actitivies
- improved quality of life, especially for women and children
- rural capacity building and
- restoration of the natural environment.

Capacity building is a focus for REDP and SESAM: staff of both the institutions are in a continous learning process with different professional, technical and socio-economic experiences on one hand based on academic background, and on the other hand based on practical programme experience. Linking these two elements offers the chance for synergy-effects: academic training and education with application to programme identification, implementation and evaluation gives benefit to the international SESAM participants and the REDP staff likewise.

Especially the implementation of projects through community mobilization, bottom-up participatory planning and decentralized decision-making in energy development as well as producing human resources in renewable energy on national level down to grass-root level for nearly 1500 village technicians, about 4350 income generating and micro-enterprises, awareness and orientation on rural energy technologies for about 6000 people in the districts in Nepal and has successfully established more than 125 community owned micro-hydro schemes, about 3500 biogas plants and 1700 solar home systems (REDP 2003).

Main experience of the common learning process of SESAM and REDP / UNDP is:

- Renewable energy as a tool for social changes, for creating awareness and changing the role of gender is an encouraging perspective for rural development.
- Human Resource Development is an indispensable component of a country's development process: this is a must for national project and development planning and it is essential for the capacity of local groups (community members, locally elected bodies, NGOs, private sectors) to manage and operate rural energy projects in a sustainable manner.

Figure 6
Energy Wheel
Source: REDP 2002

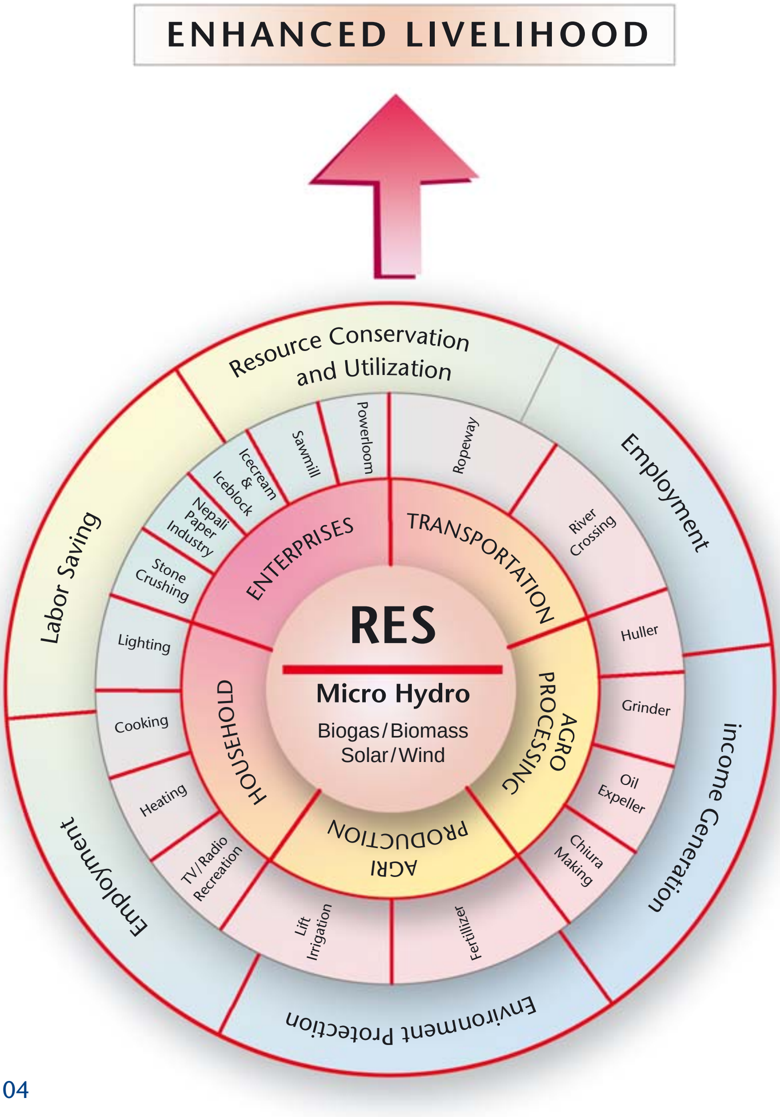

Figure 7 (left)
Practical Training for Rural Technicians (REDP 2000)

Figure 8 (right)
Awareness on rural energy in villages (REDP 2000)

- Basic energy services alone do not bring positive changes in the society: for sustainability people's participation is a must. Bringing people or mobilizing them (both men and women) into the mainstream of development process is essential before any kind of technology intervention
- Never promote energy projects in isolation: in rural and generally poor communities, the design must be essentially aiming at integrated development.
- Renewable energy projects are not auto matically sustainable: economic aspects with generating additional income is the most challenging task. Income generating activities through locally produced goods and services also depend on access to markets, number of potential customers (difficult in remote areas), diversification of products, and purchasing power in the villages.

And last not least:

- Combining university's academic education of SESAM with project implementation of UNDP/REDP as International Classroom has contributed in a significant way to the competency of the participants in both the institutions preparing them for leading positions in international projects.
- Since a number of years SESAM also uses internetbased course facilities to give more people the opportunity to participate in this global learning in the coming years.

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UNESCO's Global Renewable Energy Education and Training Program in a Latin American View

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Introduction

The Global Renewable Energy Education and Training Program (GREET) is implemented by UNESCO in the scope of the World Solar Programme with the aim to contribute to increase through education and training the capacity at national level to accomplish a sustainable energy development path.

The Latin America and Caribbean Region (LAC) are characterized by ample differences among countries in the region in relation with the energy situation, the social economic development and sustainability and capability in the society to advance in the process to meet the Millennium Development Goals.

Setting up of the GREET LAC Chapter would be a fundamental contribution to increase and consolidate the regional capacity to support the Renewable Energy development. For this reason, it is foreseen to start a consultation process that involving the key regional actors would make possible the design of the most appropriate Renewable Energy Education and Training Program for the Region. This document is a first step and its purpose is to develop a general description about how could be foreseen this program for the region.

International Commitment for a Sustainable Energy Development

The international community has expressed his commitment for a sustainable development approving the Millennium Development Goals (MDGs) during the Johannesburg World Summit on Sustainable Development (WSSD). The role of Energy for the achievement of the Millennium Goals is shown in Paragraph 19 of the World Summit on Sustainable Development (WSSD) Plan of Implementation adopted in Johannesburg. In particular request to:

> With a sense of urgency, substantially increase the global share of renewable energy sources with the objective of increasing its contribution to total energy supply, recognizing the role of national and voluntary regional targets as well as initiatives, where they exist, and ensuring that energy policies are supportive to developing countries' efforts to eradicate poverty, and regularly evaluate available data to review progress to this end.

Latin American Authorities have actively expressed their support to the conception of Sustainable Development and to meet the MDGs. Demonstration of this priority approach to the topic is the "Latin American and Caribbean Initiative for Sustainable Development", approved by the Seventh Meeting of the Inter-Sessional Committee of the Forum of Ministers of Latin America and the Caribbean on May 2002 in Sao Paulo, Brazil, that calls to adopt priority actions to address, among others, the sustainable generation of energy and the increasing participation of renewable sources. Particular significance in this context has the Brazilian Energy Initiative that called countries during the WSSD in Johannesburg to assume the compromise to "increase the use of renewable energy to 10% as a share of total by 2010".

Energy and Sustainable Development in Latin America

It is used to consider three main dimensions of the sustainable development: Environmental, Social and Economic. A brief remark about the connection of energy with every one of these dimensions in the region would be:

Environmental: Latin America is in general as for greenhouse gas emissions in particular a low emissions region. Those emissions due to burning of fuels in the region, account for less than 4% of global emissions and 7% of emissions in OECD countries (excluding Mexico). The energy system is relatively clean and emissions due to energy production, in particular, are among the lowest on the planet. However, the intense process of deforestation, overgrazing, and agricultural expansion that is seen in almost all countries in the region means carbon release, and most importantly, a decrease in the carbon sequestration capacity because of a decrease in forest coverage.

Social: In Latin America, poverty, especially rural poverty, continues to be one of the major problems assailing the region, with approximately 44% of its entire population and 64% of the rural population, living below the poverty line. The rural poor are thus generally worse off than those in the urban areas. No matter to the relative high rate of access to electricity services in the region, this fact affects significantly the affordability to theses services for greater part of the population.

Economic: In the region there is very important petroleum exporting countries like Venezuela and Mexico, 5th and 9th exporting countries in the world, and other petroleum producing countries that can satisfy a significant share of the national demand of petroleum products. Brazil, Argentina, Colombia, Ecuador and Trinidad Tobago are included in this group. But there is also an important group of countries that heavily depend of the petroleum product imports; this dependence represents a significant burden over their economies. Examples of countries included in this group are Guyana, Nicaragua, Honduras, Haiti, and Paraguay that consume 13.6, 8.3, 6.2, 5.7 and 4.2 tep/102 1995 US$ of GDP correspondingly .

Energy situation

Some remarks that could characterize the energy development in the region are:

The share of electricity in the total primary energy supply varies significantly from country to country. While there are countries with a share of electricity in the total primary energy that is higher than 30% (Argentina, Venezuela, Brazil, Uruguay, Chile), another group of countries shows figures less than 15% (Honduras, Nicaragua, Guatemala and Haiti).

The production of electricity using renewable energy has in the region outstanding examples with a share higher that 90% based mainly in the utilization of the hydropower (Paraguay, Costa Rica, Brasil and Uruguay), while in Mexico, Nicaragua, Cuba and Dominican Republic) is produced less than 25% of the electricity from renewable sources.

The electricity consumption per capita also shows a disperse distribution: A group of countries has a high electricity consumption per capita per year, higher than 1,5 MWh, (Venezuela, Uruguay, Mexico, Argentina and Chile), but also there is another group of countries with an annual consumption less than 0,5 MWh (Bolivia, Nicaragua, Guatemala and Haiti).

The annual conventional fuel consumption per capita indicator takes values higher than 0,9 tep/inhab in petroleum exporting countries like Mexico and Venezuela and in net importing countries like Chile, Dominican Republic and Cuba. On the other side, in countries like Colombia, Peru, Bolivia and Haiti the annual fuel consumption per capita is less than 0,45 tep/inhab.

Particular interest has the energy use of the forestry biomass. Despite the more or less uniform distribution of the biomass resources in the region, it can be also observed big differences in the forestry biomass consumption. The relatively higher forestry biomass consumption per capita in the region (more than 0,5 tep/inhab per year) is found in Paraguay, Honduras, Guatemala, El Salvador and Chile, while the lower consumption per capita (less than 0,2 tep/inhab) corresponds to Venezuela, Peru, Bolivia and Argentina.

The significance of the total biomass (fuel wood + sugar cane bagasse) consumption in the total direct fuel use has achieved different extent in the region. In countries like Haiti, Paraguay, Honduras Guatemala and El Salvador the biomass consumption is determinant in the direct fuel use, consuming more than 1,3 tep of biomass per tep of oil products while in Argentina, Mexico, Venezuela, Ecuador and Dominican Republic the direct use of biomass is very low, in those countries it is consumed for direct use more than 4 tep of oil product per tep of biomass consumed.

In conclusion, it is clear that the pattern of energy use and renewable energy production and delivery has significant differences within the region. Even, the fact to be a country producing petroleum or to be a country where the electricity produced from renewable sources is significant do not prove any regularity in the whole energy picture for the specific country.

Development indicators: But the challenges to meet the Millennium Development Goals in the region also are different from country to country. Some of the basic indicators included in the Human Development Report 2001 produced by UNDP can be used to confirm this assertion. The selected indicators are the GDP per capita, live expectancy at birth and the adult literacy.

The GDP per capita has the higher values (more than 8000 US$/inhab) in Argentina, Chile, Costa Rica, Mexico and Uruguay and the lower ones (Less than 3000 US$/inhab) in Haiti, Bolivia, Honduras and Nicaragua.

There are countries with a live expectancy at birth in the rank of the developed world (more than 75 years): Chile, Costa Rica and Cuba, but also with less than 66 years: Bolivia, Guatemala and Haiti.

In the case of the adult literacy, no matter that the general figures for this indicator are positive ones, there are significant differences among countries: a group of countries have reached more than 95% of adult literacy (Argentina, Chile, Costa Rica, Cuba and Uruguay) but for another group it is under 80% in this indicator (El Salvador, Guatemala, Haiti, Honduras and Nicaragua).

Sustainable Energy Development Paradigm

The relevancy of the role that renewable energy sources are called to play in the efforts to meet the Millennium Development Goals could be briefly justified by the following reasons:

- The Climate Change mitigation only can be achieved if the share of renewable energy sources in the world energy balance would be actually significant.

- The technological development has guided a process of price reduction for the energy that is produced using renewable energy sources. While this trend should be even reinforced in the future, it is foreseen that the prices of the petroleum products will grow incessantly. These changes of pricing will contribute to create a situation where the renewable energy should be competitive with the conventional ones in market conditions. At that moment, the commercial balance of the countries where renewable energy technologies would be introduced as bulk energy will receive a great benefit.

- Poverty reduction in rural areas is closely related to the widespread use of decentralized energy systems, most of them based on renewable energy sources.

Actually, the current technological development is enough to support a more intensive expansion of applications of renewable energy sources in commercial or close to commercial conditions. The main fields of applications for renewable energy technologies could be grouped in centralized power production, renewable commercial fuels and rural energy services.

The availability of renewable energy resources is plenty in most of the countries of the Latin American and Caribbean Region. Special significance has biomass (25% of world forestry area and 40% of the world potential production of bagasse), hydropower (20% of the world technically exploitable capability), solar and wind energy resources in the region.

But no matter to this technological development and availability of renewable energy sources, the use of these technologies is very far from the potential penetration that they could have in the mix of primary energy sources. This situation habitually is explained introducing the concept of barriers that are classified as technical, economic, financial, legal and institutional ones.

But a more thorough reason to explain why it is so difficult to introduce the renewable energy technologies is the fact that the energy development paradigm that currently is applied to evaluate the goals, ways to meet these goals, and performance indicators in the energy field appeared in the world two centuries ago with the industrial revolution. The main target at that moment was to develop energy sources and technologies that could replace the low energy intensive renewable energy technologies that were used until that time. But this energy paradigm has led the world not only to the fast economic development that the developed world enjoys today, but also to the reality of the climate changes, to a life in poverty for a great portion of the humanity and to the depletion of the petroleum reserves.

But to meet the Millennium Development Goals and to facilitate to remove the barriers to a massive renewable energy deployment, it is necessary to move from an energy development conception centred mainly in the development of national economics, to a new one centred in a world wide sustainable development and it is only possible if the energy development paradigm used by the whole society is changed.

This new development energy paradigm should recognize as its main goals among others:

- Reduce drastically GHG emissions from power producer facilities as a result of the radical increasing of renewable power production and the use of cleaner technologies for power production using fossil energy sources.

- Provide access to electricity to isolated communities to guarantee services like health care, education, communication, drinking water, etc. It should be done based on a rational sustainable use of local natural resources and the most appropriate combination of available energy technologies.

- Increase the affordability of low-income population to electricity and to quality fuels.

- Extensively introduce the use of biofuels for transport, cooking and process heat improving the energy efficiency and sustainability of these services using modern technologies with enough maturity.

The Global Renewable Energy Education and Training Programme to meet Millennium Development Goals in Latin America

The role of capacity development "understood as the process of creating, mobilizing, enhancing, or upgrading, and converting skill/expertise, institutions and contexts to achieve specific desired socio-economic outcomes, …." is critical to create the conditions for a sustainable energy development. In this scope, the role of education and training, as capacity building activities that are included in any capacity development program, is widely recognised.

The Global Renewable Education and Training Programme Latin American Chapter is called to become an agent to develop the capacity in the region to transform the individuals, institutions and the overall policy framework as a force able to meet the challenges that represent to implement the new energy development paradigm and to overcome the different barriers to renewable energy technologies expansion.

The actions of the program would be directed to relevant stakeholders involved in the framework of a renewable energy development focused to meet the Millennium Development Goals. Among those stakeholders should be included not only governmental officials, representatives from the productive, academic and specialized sectors, from financing and planning systems and from the media, but also those linked to MDGs achievement: education, health care, sanitation, water supply and environment fields.

The aim of the program is to transform the approach of those relevant stakeholders to the Energy Development Paradigm and to the role of the RETs to meet the MDGs and to the actions that should be undertaken to reinforce it.

Some of the expected outputs of the program could be formulated for some of these relevant stakeholders as:

Governmental officials: They will understand the predicted evolution of the conventional energy supply, the connection between energy and climate changes and the role of renewable energy technologies in a future sustainable energy scenario.
They will be aware about the decision making process related to energy services necessities to meet the MDGs and will conduct analysis not only using strictly techno-economic indicators.
They will recognize the priority to create an appropriate legal and regulatory framework to promote the widespread use of renewable energy.
They will accept the need to introduce the question about the sustainability of the energy development in the national political agenda.

Planning sector: The understanding of the performance of RETs and its potential to be integrated in the energy systems will be improved.

The capacity to use new planning tools will be developed to consider the introduction of renewable energy sources into the planning process to meet country energy demands and MDGs.

The personnel from the sector will be aware of the need to increase the use of specific indicators for sustainability in the planning of the energy development.

Utility personnel: They will be updated about technological development and performance of RETs.

They will be trained to evaluate integration of renewable energy technologies into the power grid.

They will have a better understanding about decentralised power systems and the use of hybrid solutions.

Specialised sector: Company staff will be trained in the design, installation and maintenance of RET facilities.
The capacity to make the renewable energy resource assessment will be developed.

Finance sector: Specialists will be aware of the specific characteristics of the renewable energy technologies.
The capacity to develop specific instruments for financing investments in the renewable energy sector will be achieved.
The skills to evaluate renewable energy project risks and revenue streams will be developed.

Science and technology sector: Science and technology people will have achieved a good understanding about the renewable energy equipment and technologies and will be ready to adapt and to develop them to the specific conditions in countries of the region.

The regional capacity will be developed to execute non-technology research and development studies of issues related to public awareness, economic and financial assessment, legal and regulatory supportive frameworks, policies to promote RETs, etc.

Some of the possible actions to be implemented to achieve expected outputs described before would be:

- Establish national training programs in vocational schools, universities and other appropriate institutions.
- Provision of specialized courses on renewable and a consensus with academic institutions to include a stronger coverage of renewable energy technologies in traditional academic courses.
- Provide information at all levels of education (from primary schools to universities) about the potential and benefits of renewable

energy, state of the technologies, and other relevant issues.
- Development of guidelines on public education and certification schemes.
- Creation of internationally recognized academic and vocational qualifications in renewable energy technology design, installation, and maintenance.
- Dissemination activities, actions and programs geared towards demonstrating the importance of the renewable energy development at policy decision-making levels and, above all, creating the awareness about the fact that to establish a new sustainable development paradigm should become a priority for the whole society.
- Training courses for local authorities to help them identify opportunities for renewables.
- Establishment of regional networks of universities and even virtual R&D institutions.
- Short courses, workshops and updating seminars directed to maintaining governmental institutions' human resources up-to-date.
- Implement courses and develop graduate programs for the technical-scientific sector.
- The promotion of academic and professional exchanges with developed countries, and between countries within the region, including capacity of experts. The development of joint international programs and networks in thematic fields

Action Plan

The aim of this action plan is to design and to make operational the GREET LAC Chapter. The main activities that have been identified are:

Activity 1: Education and training needs

- Diagnosis of priorities for sustainable energy development to meet MDGs and increase renewable energy share in the national energy balance;
- Identification of relevant stakeholders and its functions to fulfil identified priorities;
- Formulate education and training needs of relevant stakeholders to be able to perform their functions.

Activity 2: Educational and Training capacities

- Survey of training and education capacities and expertise in the region;
- Formation of clusters of countries using the criteria of the similarity of education and training needs;
- Design of activities to meet E&T needs;
- Improving of regional capacity to E&T activities.

Activity 3: Establishment of Partnerships for program implementation with

- Ongoing regional projects that include activities related to E&T;
- Regional and sub regional organizations (CEPAL, OLADE, CARICOM, etc.);
- Professional associations involved in renewable energy technology;
- International Centres of Excellences.
- National Energy Agencies.

Activity 4: Program Implementation

The first action to implement the activity 1 will be a Meeting in Havana on December 2004 with the main regional stakeholders to launch the Latin American and Caribbean Chapter of the Global Renewable Energy Education and Training Program.

Launching the Open International Solar University (OPURE)

- The EUREC's Master in Renewable Energies – Educating Renewable Energy Engineers
- Renewable Energy Education Network:
  The International Institute for Renewable Energies (IIRE)
- European Network on Education and Training in Renewable Energy Sources (EURONETRES)
- Renewable Energy Research and Education Network

The EUREC's Master in Renewable Energies – Educating Renewable Energy Engineers

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Introduction

EUREC Agency is the initiator and the coordinating body of the graduate programme "European Master in Renewable Energy". A network of eight European universities, members of EUREC agency, having a leading position in renewable energy RD&D, runs the course. The European Master in Renewable Energy is directed towards engineers that want to specialise in one of the renewable energy technologies, such as wind, biomass, photovoltaics, or in one application domain of these technologies, such as solar in buildings or hybrid systems.

From a survey[1] undertaken by EUREC Agency as part of an ALTENER project, a growing shortage of suitably trained technical staff for the RE sector and a distinct demand for postgraduate courses have been highlighted. The survey indicated a severe lack of high level teaching materials, due to inertia in higher education institutions and the slow rate of recognition of the renewable energy's increasingly important role in the energy mix.

Regardless the fact that the EU does not seem on track to meeting its targets[2], the European renewable energy industry is today one of the fastest growing industry sectors in the EU: it has reached a turnover of EUR 10 billion and employs some 200.000 people. The renewable energy industry, creates employment at much higher rates than many other energy technologies. New research, industrial and craft jobs appear directly in R&D, production, installation and maintenance of renewable energy systems. Backward linkages to other sectors triggering demand for technical RE expertise exist for consultancies, insurance companies and even law firms performing technical due diligence. Predicting precisely the number of people to be trained is difficult. However, various projections for employment in the renewable energy industry have been made. Currently, around 85.000 jobs have been created in Europe in the field of wind energy alone. According to estimations of the European Renewable Energy Council[3], by 2010, there will be 184.000 full time jobs in the wind sector, 338.000 in biomass, with 424.000 additional jobs for biofuels. Small hydro and geothermal power are expected to provide for 15.000 and 6.000 jobs respectively, while PV and solar thermal will employ another 30.000 and 70.000 people. This presents a total of over 1 million jobs for the RE sector by 2010, an impressive number that is to double for the new RE sector target of 20 % by 2020! Even if it is only a small proportion of these employees who require education at graduate level, it is clear that the demand for technical RE expertise is growing.

A response to the demand for specialised engineers

Renewable energies cover a wide range of diversified technologies, and each domain requires specific skills and know-how a general engineer does not automatically get. How

[1] Published in June 2000 "European Master Degree on Renewable Energy" in Proceedings EuroSun 2000
[2] EU Renewable Targets for 2010:
- RES-E Directive on the promotion of electricity produced from renewable energy sources (RES): 22.1 % of gross electricity consumption from RES
- White Paper and Action Plan on Renewable Energy Sources (1997): 12 % of energy consumption from RES
- Biofuels Directive on the promotion of the use of biofuels or other renewables fuels for transport (2003): 5.75 % of sold gasoline and diesel

[3] European Renewable Energy Council EREC: "Renewable Energy Target for Europe", January 2004, Brussels. See www.erec-renewables.org for details

much does a biofuel expert have in common with a turbine developer? Even within one technology, such as PV, experts either focus on systems or on materials. Until recently, there was no university training to be found that went into sufficient depth to provide its graduates with the relevant expertise and specific training was left to the employer.

Most of the companies that make up the RE industry landscape are of small and medium size. Even if there are recent tendencies for consolidation of the sector like the takeover of MADE by Iberdrola or the expected merger of the Danish wind turbine manufacturers Vestas and NEGMicon, the majority of companies do not count as large enterprises. Given the fact that the launch of new products is a cost-intensive exercise involving heavy investment in research and development, the sector is certainly not making large enough profits for single companies to embark on expensive training programmes for new employees. However, new recruits, even if they might hold an engineering degree, are not *per se* fit for a company's daily job requirements and typically need a minimum of six months on-the-job training before being able to contribute tangible results.

Driven by the fact that there is not enough supply in the labour market that qualifies to meeting the specific demand of the different RE companies, EUREC Agency set up a graduate degree course to satisfy industry needs in human resources: the European Master in Renewable Energy. This full-time technical course provides its students with the state-of-the-art skills and expertise required for employment in the RE industry. By turning out experts in the respective RE technology, the course significantly reduces the time and financial burden of training new employees for the potential employers.

A European Master run by renewables-experienced universities

The European Master in Renewable Energy has been designed in cooperation with eight universities in five EU countries, with each institution adding its specialised technological knowledge to the programme.

The core is taught by universities having a strong record in general renewable energy technology teaching. They are the following :

- Loughborough University, UK (language: English)
- Carl von Ossietzky University at Oldenburg University, Germany (language: English)
- Universidad de Zaragoza, Spain (language: Spanish)
- Ecole des Mines de Paris at Sophia Antipolis (Nice), France (language: French)

The core lasts from October to December and ends with a series of exams.

The specialisation providers propose a specific focus on one renewable technology or on one domain of application: Five specialisations, all taught in English, are available:

- Wind energy – at the National Technical University of Athens, Greece
- Biomass – at Universidad de Zaragoza, Spain
- Photovoltaics – at University of Northumbria at Newcastle, UK
- Hybrid systems – at Kassel University, Germany
- Solar in buildings – at University of Athens, Greece

Each specialisation lasts from January to April and ends with a series of theory and practical exams.

In the coming years, it is expected that the list of specialisations available will grow. A specialisation in water power (to include micro-hydro, wave and tidal power) would be especially welcome and relevant as this domain is expected to grow in a near future.

The twelve-months programme is divided in three parts, getting progressively more and more practical:
The "core" provides a firm comprehensive background in the key renewable energy technologies (wind, solar, biomass, water). It concentrates on energy production and use and addresses the socio-economic context. Mostly theoretical courses are completed with laboratory workshops. The "specialisation" focuses on the specific technology and implementation aspects of one renewable energy discipline of the student's choice: Wind energy,

biomass, photovoltaics, hybrid systems, or solar energy in the built environment. In-depth theory classes alternate with extensive practical work in laboratories and testing facilities, while study excursions illustrate real-life implementation.

The balanced mix of theoretical and practical courses optimally prepares graduating engineers for jobs in the growing renewable energy industry. An extensive 5-months company placement for hands-on project work is an integral part of the programme. It provides students with valuable working experience, while allowing companies to fill their short-term human resources needs and to "try out" potential future employees. During this period, a tutor from the host company supervises and guides the student during project work, while a second supervisor from the university at which the student will undertake his or her specialisation helps the student with his/her project work.

Different to the few other existing Master-level RE courses, the European RE Master plays the European card: students are required to study in at least two different European countries. This feature reflects the fact that there is at present a tendency to cross national borders and set up foreign representations or carry out project work abroad, even for small and medium RE companies. Clearly, intercultural awareness and foreign languages are assets that present a plus for any employer today.

Coordination and management

To guarantee the academic quality and level of the course and to delegate the academic programme management to the adequate body, a Scientific Committee exists, made up of the academic responsible persons for the project at the partner universities.

This Scientific Committee has final authority over any management decision affecting the European Master in Renewable Energy. Regular contact between the members of the Scientific Committee guarantee a smooth communication flow and successful implementation of the course.

Examination and assessment results are expressed in grades. There are many different grading systems in Europe. The ECTS (European Credit Transfer System) serves as tool for mutual recognition of student achievements.

ECTS credits are a value allocated to course units to describe the student workload required to complete them. They reflect the quantity of work each course requires in relation to the total quantity of work required to complete a full year of academic study at the institution, that is, lectures, practical work, seminars, private work – in the laboratory, library or at home – and examinations or other assessment activities.

ECTS credits are also allocated to practical placements and to thesis preparation when these activities form part of the regular programme of study at both the home and host institutions.

ECTS credits are allocated to courses and are awarded to students who successfully complete those courses by passing the examinations or other assessments.

ECTS grades are quoted alongside grades awarded according to the local grading system. Higher education institutions make their own decisions on how to apply the ECTS grading scale to their own system.

Conforming to the tendency towards EU-wide uniformity and comparability of university diplomas, the European Master in Renewable Energies leads to a final degree mutually recognised by the different countries' universities. The labelling is the equivalent of "European MSc in Renewable Energy" in the language of the core university (i.e. the University of Zaragoza issues a "Master Europeo en Energias Renovables"). The degree is issued by the core university according to its respective national standards. It has been decided that students only register with the core University, which then becomes responsible for awarding the degree. This is to ensure that the degree will be recognized universally as a Masters. The consequence of this is that the awarding institution must recognize the credits of the other participating Universities.

Table 1

2003 – 2004 Student Overview Core / Specialisation

	biomass	wind	PV	hybrid systems	solar build		Total
Zaragoza	2	2	2	2		EU non-EU	8
Loughborough	3 1	3 1	3 1	2 2	0	EU non-EU	11 5
Ecole des Mines	0	2	0	6	0	EU non-EU	8
Total	6	8	6	12	0		32

EU students	27% EU students:	84,38%
Non-EU students	5% Non-EU students:	15,63%

Considerable co-ordination and management is required to organise such a course involving 12 different organizations in total. EUREC Agency plays a central co-ordination role and provides the initial point of contact for students. It is responsible for admissions, marketing, informing the Scientific Committee and implementing its decisions.

Companies are encouraged to contact EUREC Agency with a project proposal they would like to have a trainee for. EUREC Agency then finds trainees for them. All trainees already hold an engineering or other relevant degree and have followed the European Master in RE core and specialisation by the time they enter a company; they are already junior RE experts.

Target students

The course is of strictly technical nature and thus only applicants with an engineering, physics or relevant scientific university degree are admitted. Beyond this, applicants must have a very good command of English language in order to follow classes.

Typically, a student applies to EUREC Agency responsible for the admissions procedure. His application is reviewed by the academic partners of the core university and the specialisation university the student has chosen. The core university then registers the student for the whole course. Classes start in October for the core where the student learns about the different RET's in a general but technical manner. He does laboratory work and passes a series of exams. During this period he also looks for a placement in the RE industry with the help of the core director. In January, the student moves on to the specialisation university. Here, he will only focus on his specialisation to get as deep an understanding as possible in the four months period. Guest lecturers add latest research findings or illustrate practical applications of the technology, and the student visits installations, and experiments with the technology in laboratories. Then he starts his internship period with a company. Leading to a report on his project work and the preparation of a presentation that he holds in September in Brussels in front of an academic panel composed of the course directors. His fellow students as well as interested industry or research representatives assist at this event. He gets graded on both project report and presentation.

EUREC Agency is creating an network of former students to keep track of their career development, to monitor which percentage of graduates find work in the RE sector as planned, which sectors are most likely to employ graduates and how long students have to look for a job upon graduation. The results of this monitoring are not available yet, as the first students have only received their final diplomas at the end of 2003. However, half of them is already working in their discipline of specialisation, an encouraging sign *(see Table 1)*.

6. Outlook

The medium objective consists in establishing the European Master in RE as a reference in the field of Master-grade RE education on EU level, while taking into account the EU enlargement. In practical terms, this means promoting the course with the renewables industry, increasing the number of participating universities within the EU in order to cope with the growing number of students and extend the geographic scope to the East.

Given the high number of applications received from developing countries' students, an adapted replication of the course is under consideration for Asia and later on for Latin America and Africa.

EUREC Agency, the European association of renewable energy research centres, makes sure the course curriculum fully and timely integrates all relevant new R&D results. EUREC members being R&D centres and universities as well, the network takes care of transferring knowledge from research laboratories into the classrooms. On the other side, the continuous dialogue with the RE industry guarantees that the teaching remains sector-relevant. After all, the course has ultimately been set up to serve the RE industry.

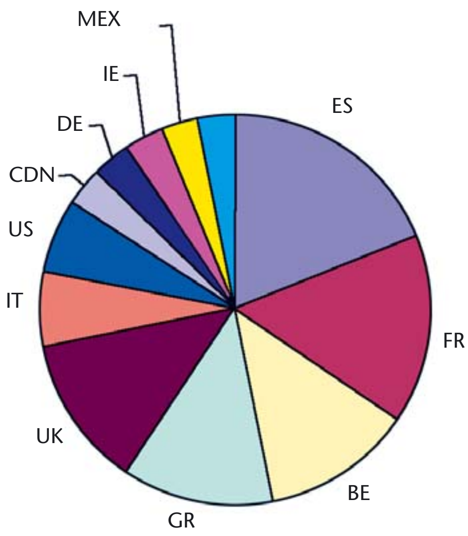

Figure 1
Nationality mix of students in 2003–2004

Renewable Energy Education Network: The International Institute for Renewable Energy (IIRE)

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Introduction

Naresuan University has entered an agreement for the establishment of the International Institute for Renewable Energy (IIRE) in cooperation with the following universities:
Curtin University of Technology (Australia),
University of New Brunswick (Canada),
Yunnan Normal University (China),
Claude Bernard Lyon University (France),
Kassel University (German),
Tokyo University of Agriculture (Japan), and
Tribhuvan University (Nepal).
IIRE is located at the Research and Training Building, Energy Park, Solar Energy Research and Training Center, Naresuan University.

IIRE is a non-profit making, international institute that is concerned primarily with the promotion of research and development, testing and demonstration of renewable energy technologies and the diffusion of knowledge and information gained as widely as possible. IIRE will facilitate research cooperation among institutions, arrange training to enhance competence, and organize meetings to increase awareness, thus contributing to the development and promotion of renewable energy.

IIRE will continue to seek collaboration with international organizations and sponsors for joint activities, ranging from research and development through to the training of technicians and information dissemination.

The mission of IIRE is to be an effective center for the generation and sharing of information relating to renewable energy and for the development of the human resources required to successfully promote its use through the provision of training, the facilitation of international cooperation.

IIRE is organized into three departments; the Secretariat Office, International Cooperation Office, and Renewable Energy Information Center. Each department is sub-divided into sections according to their respective functions *(Fig. 1)*.

The sections and functions of the Secretariat Office consist of Administration, Human Resource, Finance & Accounting, Public Relations, and Meeting & Seminar.

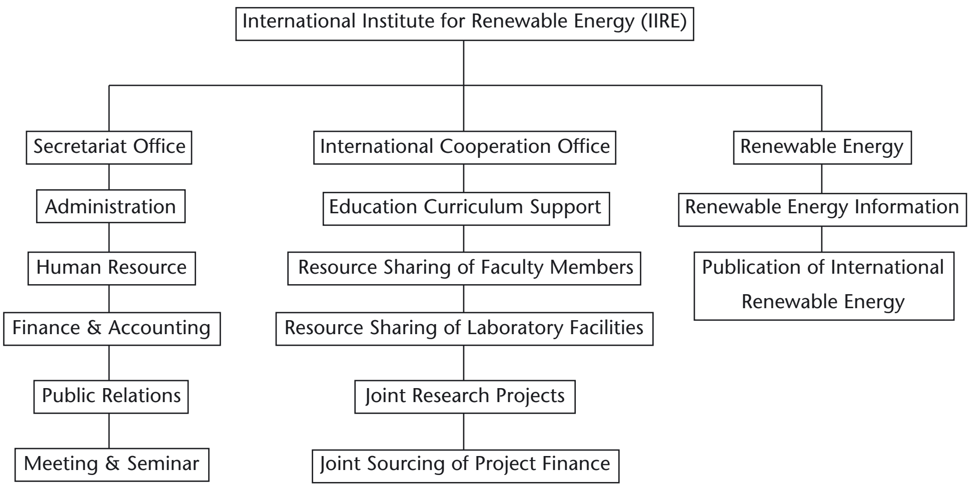

Figure 1
Functions and Organization of IIRE

The sections and functions of the International Cooperation Office consist of Education Curriculum Support, Resource Sharing of Faculty Members, Sharing of Laboratory Facilities, Joint Research Projects, and Joint Sourcing of Project Finance.

The sections and functions of the Renewable Energy Information Center consist of the Renewable Energy Information Service and publication of the International Renewable Energy Journal.

Research, education and training for the global

IIRE aims to be an excellent institute for the research and development of renewable energy technology such as solar thermal, PV, solar hydrogen, biomass and energy economics. With high quality research, it aims to solve any potential energy crisis in the future in this country and the world.

To conduct the Doctor of Philosophy on Renewable Energy to enable the development of human resources in the field of renewable energy through study and research in order to advance knowledge for efficient utilization of renewable energy at the local, national and international level. Our goal is to develop professional personnel in the fields of renewable energy, energy conservation, energy management and environment conservation. Our program promotes research work in renewable energy in order to keep pace with current advances in technology and new innovations in the academic field.

Renewable Energy Training Program

The main renewable energy application areas are wide rural regions. Most people there are poor and have low education. They need to be trained to use the renewable energy. Our experiments let us know that the suitable knowledge and technology are important to the popularization of renewable energy application. Developed countries can support the expertise for Mekong Region to hold the different level training classes in each developing country, various training programs as follows:

- Rural Energy Camp
- Solar Dryer System Use
- Renewable Energy Database Management
- Technology and Solar Energy Applications
- Biogas from Animal Dung
- Photovoltaic System for Remote Area
- Roof-top grid Connected

Standard Testing for Renewable System for the Mekong Region

The production of electricity from photovoltaic system needs a proper design for its efficient and continuous operation. The standard testing of photovoltaic module and balance of system (BOS) is very important for sustainable implementation of the photovoltaic system. Mekong countries do not have professional people who can do the standard testing of the photovoltaic system. We realized the importance of conducting a training course for standard testing of photovoltaic module and BOS to related government technical staff for meeting the standard of international standard testing. The training course is aimed for developing reliable photovoltaic system that will be suitable and beneficial for rural community in the region.

Strengths, expanded and financed

IIRE have to survive by financial support from the following sources

- University budget
- Government budget
- Benefit from business
- Donation budget
- Subsidy from other sources:

1) Domestic Fund

- NEPO: National Energy Policy Office
- NRCT: National Research Council of Thailand
- TRF: Thailand Research Fund
- NSTDA: Thailand's National Science and Technology Development Agency

2) International Fund

- ADB: Asian Development Bank
- ADEME: Agence de l'Environnement et de la Maîtrise de l'Energie
- AERECA: Asia Europe Renewable Energy Consortium Agency
- APEC: Asia Pacific Economic Cooperation
- AREDO: Asia Renewable Energy Development Organization
- ASEAN: Associate South East Asia Nation
- AusAID: Australian Agency for International Development
- CIDA: Canadian International Development Agency
- CORE: Council on Renewable Energy in the Mekong Region
- CRESTA: Center for Renewable Energy Systems Technology Australia
- DFG: Deutsche Forschungsgemeinschaft
- DLR: Germany Aerospace Center
- EC: European Commission
- ESCAP: Economic and Social Commission for Asia and the Pacific
- Fraunhofer ISE: Institut Solare Energiesysteme
- GEF: Global Environment Facility
- GTZ: Deutsche Gesellschaft für Technische Zusammenarbeit
- IEA: International Energy Agency
- InWEnt: Internationale Weiterbildung und Entwicklung gGmbH
- ISET: Institut für Solare Energieversorgungstechnik e.v.
- JICA: Japan International Cooperation Agency
- NEDO. New Energy and Industrial Technology Development Organization (Japan)
- NREL: National Renewable Energy Laboratory (USA)
- PSA: Plataforma Solar de Almeria
- RARC: Robotic Agriculture Research Center
- RBF: Rockefeller Brothers Fund
- UN: The United Nations Organization
- UNDP: United Nations Development Programme
- UNEP: United Nations Environment Programme
- UNESCO: United Nations Educational Scientific and Cultural Organization
- USAID: U.S. Agency for International Development
- WB: World Bank

The strength of the International Institute for Renewable Energy (IIRE) is the network which contains of various countries including developed and developing countries as well who have the same goal to protect and respect the natural resources and the environment. Capacity building for renewable energy will foster technology transfer and human resources development.

European Network on Education and Training in Renewable Energy Sources (EURONETRES)

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The EURONETRES has been planned as a regional voluntary cooperative framework, uniting academic institutions of the European countries, interested in the capacity building on RES[1] at national and regional levels and in particular, in education and training of specialists in RES for the extended use of RES in Europe as well as in other regions of the World.

EURONETRES has been foreseen as an integral part of the Global Renewable Energy Education and Training (GREET) Programme of UNESCO, which is a priority area of the Organization's actions in the field of engineering sciences and RES as approved by the 32nd Session of the UNESCO's General Conference, which took place in September-October, 2003 in Paris, France. The Network will be sponsored by UNESCO through the UNESCO Office in Venice – Regional Bureau for Science in Europe (ROSTE).

Members of the Network

The membership of the Network is open for educational-R&D institutions in Europe, which have a certain experience in RES education and training and have the intention to share this experience with partners, to contribute to the improvement of educational process on RES and to undertake new initiatives in this particular field. The membership of EURONETRES should be confirmed by the directorates of those institutions which also nominate their official representatives in the Network, one representative from each institution.

Working Groups Composition

- A Working Group is composed by specialists in the specific field, members of the EURONETRES Institutions
- A member of the Working Group is nominated by the Steering Committee {or the Executive Committee} as coordinator of the Group, with the responsibility to coordinate and to operate the Working Group, in consultation with the Executive Committee
- The Working Groups can invite experts in RES from institutions which are not members of the EURONETRES

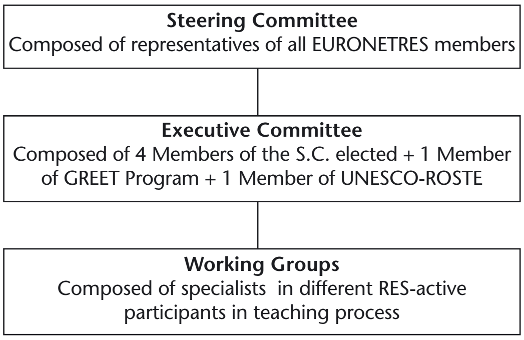

Figure 1 (above)
EURONETRES Structure

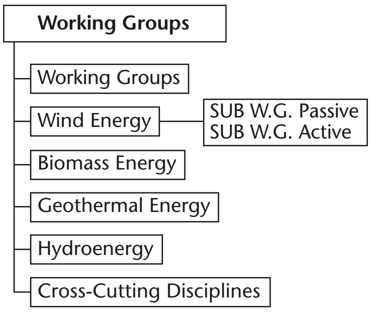

Figure 2
Structure of Working Groups

The Education Levels of EURONETRES

A. University Level Education
A.1. UnderGraduate Education
A.2. PostGraduate Education
B. Retraining Education for Diploma Holders
C. Technicians Education and Retraining (or Specialisation)

[1] RES = Renewable Energy Sources

D. Students Education in Primary and Secondary Schools
E. Mass Media for Initiation – Education of the Citizens on RES

EURONETRES will be activated progressively into the different levels of Education. The time to initiate the Education in the various levels will be decided by UNESCO. The modalities and the content of the Education in the various levels will be elaborated and decided by EURONETRES. The University level education will be the first to come in action, because the other levels need larger number of specialists to educate the educators.

A. University Level Education

A.1. Undergraduate courses on RES

Taking into account the differences in knowledges needed in the various University Departments (Department of Engineering, Department of Sciences, Department of Economics, Department of Social Sciences, etc), it is necessary to facilitate the responsible Departments to adopt the appropriate content of their courses to RES. The opportunity will be given by the elaboration of the program of studies followed by text books CDs, elaborated from the working groups (eg. basic knowledge, solar energy courses, biomass energy courses, the economics and social aspects of RES, the environmental aspects of RES, etc.). The responsible professors and other teaching staff in a Department have to adopt the EURONETRES material as a minimum for their students.

Advantages from the Adoption of the Undergraduate EURONETRES Education

- The students who have passed the examination in a specific course, prepared by the Working Groups, will obtain a specific Certificate of 2nd cycle by the Department. This Certificate will be valid for all the Universities participating in the EURONETRES. Thus, among other things, the students will be facilitated in their mobility within EURONETRES Universities (stimulation of cooperation and mobility).
- The Engineers or other scientists who obtained their diploma from their University and in parallel have earned a number of Certificates on RES, will have the advantage to find more easily a job related to RES.
- Other advantages for the Universities to adopt the common rules for such Certificates, are coming from the fact that there are normally very few Universities that can offer courses for ALL THE RES, so, if they participate in EURONETRES, their students can collect Certificates in different disciplines (Solar, Wind, Geothermal, Hydro, Biomass Energy and also Economic, Social and Environmental aspects of RES) from other Faculties/Universities participating in EURONETRES (accredited Certificates).
- Another very important advantage is that the Diploma holders can participate in a specialization (retraining procedure) on RES, collecting Certificates from different EURONETRES Universities and so, they will create new opportunities to find jobs as specialists. That will be valid not only for EUROPE (the job creation is stemming from the targets adopted by the E.U. towards RES), but also worldwide.
- The EURONETRES Universities are expected to accept many engineers and other Diploma holders from other parts of the world, to be specialized on RES.
- Moreover, students who have obtained one or more Certificates and their normal Diploma and wish to continue their studies for a M.Sc degree will be more easily accepted in a EURONETRES University.

A.2. Postgraduate Education on RES

An assessment, made under the initiative of UNESCO/ROSTE, showed that there are only a few (2–3) cases in Europe, where there are pure Postgraduate studies, in the level of MASTER on RES. On the other hand there is a huge demand, already established, from private companies and research centers for highly specialized engineers and other scientists on different sectors of RES. This demand will become higher and higher in near future. A higher demand is expected also in the developing countries and in the International Organisations dealing with RES.

The wish of UNESCO, adopted from EURONETRES, is to elaborate and to adopt common rules and common content of studies at a HIGH LEVEL. Only those Departments which are able to fulfill the rules and requirements and dispose the necessary facilities for one or more postgraduate studies in specific disciplines of RES (Solar, Wind, etc) will be accepted to the common effort in EURONETRES.

The Working Groups will elaborate dynamic curricula and the requirements needed for each discipline (Solar, wind, etc.).

The Postgraduate Diploma (Master) given from a Department under the common rules and conditions, will be equal for all the Universities of EURONETRES. The Departments wishing to participate in EURONETRES but do not fulfill all the requirements concerning the teaching staff, the Practice and Laboratory facilities, can elaborate and present a cooperation agreement with other Departments, by visiting professors and research laboratories in the same country or within other countries.

The Working Groups will evaluate the demands from the departments and will propose to the Executive Committee of EURONETRES for the final decision. The evaluation of the students and their final examination will be done under STRICT RULES, that the Working Groups will elaborate and the Steering Committee will adopt, in order to guarantee the objectivity about the merit of the Master of Science or Diploma. The Diploma of MSc will be awarded from the Universities concerned, but will be accompanied with a separate Certificate from the Executive Committee of the EURONETRES and so the MSc Diploma will be equivalent in all WORLDNETRES members.

Renewable Energy Research and Education Network

Introduction

Increasing global energy consumption and the use of fossil fuel to cover most of this demand as shown in *Fig. 1* leads to an increasing concentration of CO_2 in the atmosphere with possibly dramatic consequences on our future climate. The correlation between the rising figures of consumption and the CO_2 content as given in *Fig. 2* underlines this tendency clearly. But this is not the only risk of our current energy system: The scarcity of our resources comes immediately into our focus, if instead of a static estimation as normally done and as shown in *Fig. 3* the future exponential growth of energy consumption is taken into account. Considering this assumption, the cumulative reserves including uranium, which are already explored today will be exhausted after 56 years as given in *Fig. 4.* But what is even more severe is the finding that, under the assumption of future growth, even ten time bigger reserves would be fully exhausted after another 70 years as shown in *Fig. 5*.

Due these circumstances, a radical change of our energy system is without any alternative, and today renewable energies are to become the only major source of energy in future. There have been developed many technologies in this field. To the end of a wider development, however, the lack of information exchange and the lack of education is seen as a big barrier today. It is the purpose of the initiative, which will be presented here, to overcome the problems mentioned above, the basis will be centred around the realisation of appropriate networks.

Existing Networks in Renewable Energies Research and Education

To begin with a very successful network, the German Association on Solar Energy Research (FVS), will be presented. It consists of eight

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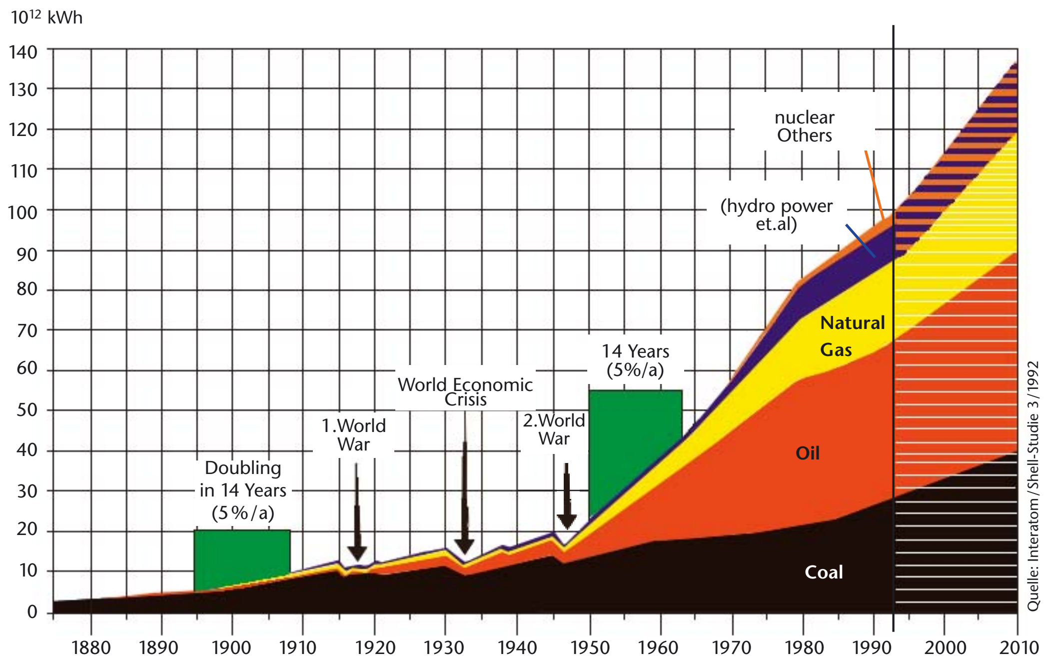
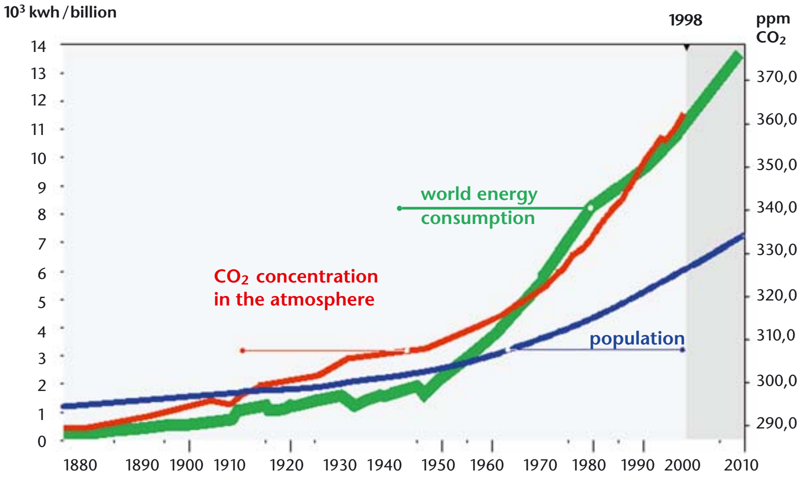


Figure 1
Global Energy Situation and Trends



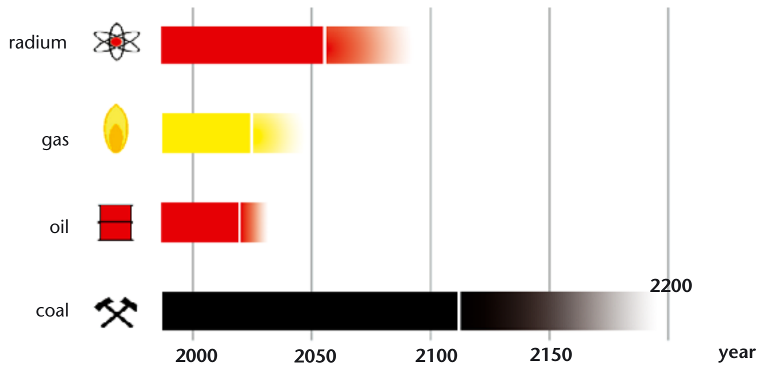


Figure 2 (above)
Growth rates for population, energy consumption and CO_2 concentration in the atmosphere

Figure 3
Range of fossil energy resources; source: OECD

research institutes or centres which are shown in *Fig. 6*. This association covers research in nearly all fields of renewable energies and represents about 80 % of the German research capacity in this area. Besides cooperation, the FVS is organising annual conferences on selected research subjects.

In the European area, the EUREC Agency represents 20 research centres and ten universities. This network has already started a very successful initiative in the sector of education, namely a Master course in Renewable Energies provided by seven leading universities. *Fig. 7* shows a description of the consortium. The students of this Master course, which have done their specialisation in hybrid systems in Kassel, are shown in *Fig. 8* together with some teachers. As a second network, the European Academy of Wind Energy is shown in *Fig. 9* and *Fig. 10*. This network consists of four European research centres and seven universities performing academy research and education equally.

On a global level, the International Institute for Renewable Energy (IIRE) has been created in 2002. It represents a network of universities and research centres from Australia, Canada, France, Germany and Thailand. The coordinating institute is the School for Renewable Energy at the Naresuan University in Pitsanulok, Thailand.

These networks can be seen as a sound basis for a wider and more systematic information exchange and educational activities on a global scheme. The proposal to establish a renewable energy information and education structure on a global scale can be seen as a result of the situation described above and will be presented in the following chapters.

Setup of a Renewable Energy Information and Education Network

Open University for Renewable Energies (OPURE)

There is a lack of information on actual research results, on the application potential, on economic figures etc. on all levels. This situation is true for Germany, but even more for Europe as well as for countries outside of Europe. In general this problem may be characterised as follows: There is very much information existing today but access to this information is difficult. For there is no systematic procedure of such access and the quality of such information is widely scattered. As a consequence effort and money is wasted by doing research on subjects, already performed by others, by delays in product development or its proper use, and by setting up wrong legal framework due to a lack of appropriate and up to date information.

On the other hand, new technologies in the ICT sector can provide a powerful tool to a fast, interactive exchange of information to an unlimited member of users. Such a platform could be realised with a small budget or even be integrated into the existing ”Bildungs-Server” of the German BMBF (Federal Ministry for Education and Development). The remaining

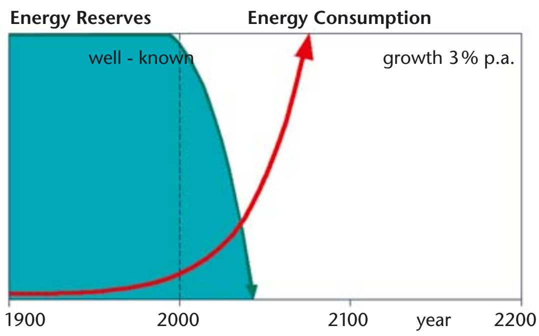


Figure 4
Range of the well-known energy reserves for a constant growth of the energy consumption of 3%

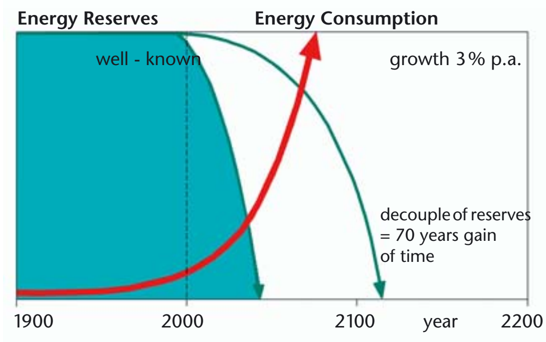


Figure 5
Range for a decuple of the well-known energy reserves for a constant growth of the energy consumption of 3%

problem is to organise the collection, the review, the grading or certification of the information and the provision of education material in a systematic way. Since it is expected that success of this initiative will heavily depend on its proper functioning in the initial phase, a multi-step process in the build-up is proposed:

- In a first step, which is the subject of the current proposal, this structure will be set-up in Germany. Languages of the material will be German and English.

- In a second step, the structure will be extended to Europe. For this step it is planned to seek for a support from the European Commission. Translation of information material into different languages will need to be provided in this phase.

- After successful implementation of the second phase, the system will be extended to global coverage with a special emphasis on developing countries. In addition to translation of languages, the transformation into different cultures will need careful adaptation of the information material and, as a consequence, the involvement of professionals from the anthropological, psychological and pedagogical sector.

Organisations of the Review Committees

For each subject and for each level (scientific, school-level or professional practitioners' skills) a committee will be organised, which will evaluate the information and education material in the same way as is traditionally done in high level, peer-reviewed scientific journals. As a consequence the process for scientific material is identical, which means a full text review including interaction with the author by at least three peers. Regarding education material, the level and quality of information, including ECTS-credits, will be classed by the review committees. As it is tradition in the scientific community, all committee members will act on a voluntary basis free of charge, but their names will be shown in the editorial sector.

Figure 6
Members of the German Solar Energy Research Association

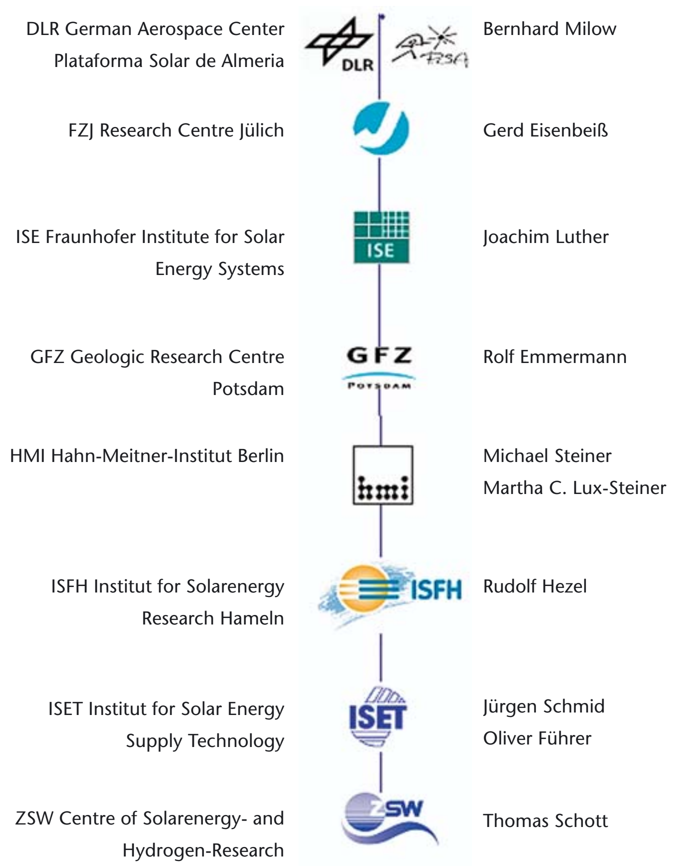


Figure 7 (left)
Research Centres and Universities of EUREC Agency

Figure 8 (right)
Participants of the EUREC Master Course 2004

Since the presentation and discussion of the basic structure of the proposal during the Science Forum on the Renewables 2004 Conference in Bonn, many stakeholders have expressed their interest to support or to participate in the proposed initiative.

Supporting Public Institutions in Germany

For Germany the following institutions have offered support:

1. BMWA – Dr. Knut Kübler
2. BMU – Dr. Wolfhart Dürrschmidt
3. BMVEL – State Secretary Matthias Berninger (tbc)
4. dena – Stephan Kohler
5. DBU – Dr. Wulf Grimm
6. FVS – Dr. Gerd Stadermann and Dr. Gerd Eisenbeiß

Participating Institutions in Germany

7. ISET – Jürgen Schmid
8. Universities:
   Kassel, Magdeburg, Berlin, Oldenburg
9. Technical Colleges:
   FH Berlin, Aachen, Hamburg, Biberach, Internet-FH

Figure 9
European Academy of Wind Energy

European Institutions

- EUREC-Agency – Didier Mayer (10 Universities, 20 Research centres)
- European Academy of Wind Energy – Jürgen Schmid (7 Universities, 4 Research Centres)
- KFPE-Switzerland – A.-C. Clottu Vogel

Global Institutions

- International Institute for Renewable Energies Thailand (4 Universities, 3 Research Centres)
- UNESCO GREET-Programme, Paris

Organisation of the Programme

- General Coordinator: ISET, Kassel
- Coordination of scientific committees: FVS, Berlin
- Coordination of membership: University of Magdeburg
- Coordination of education for professional practitioners (vocational education) DBU, Osnabrück
- Coordination of schools
- Coordination of hardware infrastructure: ISET, Kassel
- Coordination of European actions: EUREC-Agency, Brussels
- Coordination of Global actions: UNESCO GREET-Programme, Paris

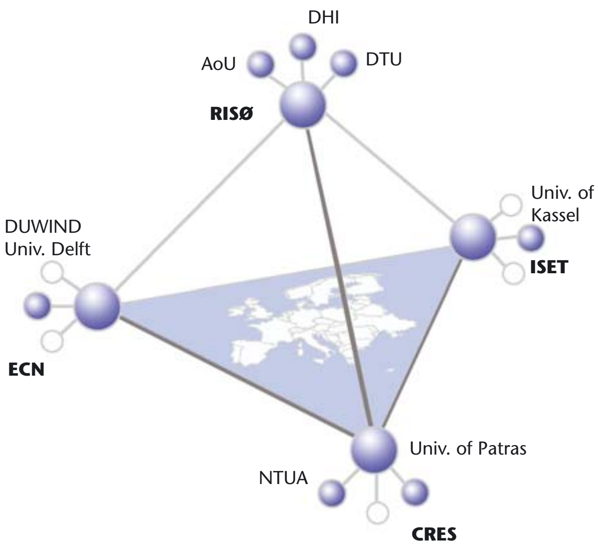


Figure 9
Member Institutes of the European Academy of Wind Energy

Work Programme

1. Building of a management team (one secretary, one scientist, one ICT technician)
2. Formation of the review panels
3. Set-up of a flyer and homepage explaining the target and content of the initiative
4. Hardware realisation
5. Organisation of annual meetings for all programme participants and supporters

Review Committees

1. Rational use of energy
2. Systems analysis and scenarios
3. Resource assessment for solar, wind, hydro, biomass, geothermal
4. Solar buildings
5. Thermal collectors and systems
6. Solar thermal electric power systems
7. Photovoltaics
8. Wind energy systems
9. Hydro power plants
10. Marine energy systems
11. Biomass energy systems
12. Geothermal systems
13. Storage devices and applications
14. Hybrid systems and minigrids
15. Social aspects
16. Grid design and grid management
17. Economics of renewable energies

Panel Discussion

- Opportunities and Necessities of Research and Education

Panel Discussion[1] Opportunities and Necessities of Research and Education

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Introduction

In the animated and strong panel discussion the different subjects of the conference day were summed up and different points of view were outlined.

In particular, the requirements for international education, training, and future research programs were thoroughly discussed. In this context, the contribution of research institutes should be considered carefully, because they are of vital importance for an advanced development.

Another topic of the debate was the issue, in what manner cooperations should be organized, what topics should be treated in networks, and what financing instruments can be provided to arrange such vital structures of cooperation.

The issue of cooperation, i. e. to operate in a global perspective with regard to research and education, represented the focus of the discussion. In order to achieve a sustainable development, to promote renewable energy technologies and to create capacities in developing countries successfully, the OECD countries need to contribute their share both in training of researchers and practitioners as well as in the basic research and the development of applications. In both fields, developed and developing countries must collaborate closely.

The question of how to organise this kind of cooperation basically means how to promote research and education. Necessary networks and urgent needs for public support were vividly discussed as a possible answer. Today, there are already tendencies to establish far reaching networks in order to generate and distribute knowledge for the promotion of a sustainable development; for the organisational form of network structures allows to combine cooperation and competition in order to enhance the top efficiency of research and development. The discussion culminated in the promising outlook that these networks may be an innovative and more effective type of international institution – a conclusion that matches with the announcement of the political declaration of the governmental delegates of the Renewables2004 to work together within a global policy network in the near future, that will include all different sectors of stakeholders.

Consequently, the lively panel discussion offered far-reaching results and clearly provided, on the basis of a thorough discussion, opportunities heading for the further development of renewable energies, thus fulfilling the expectations raised in the forefield of the event.

Therefore the participants of the panel discussion deserve my very special thanks for their committed contributions to the current debate.

[1] The statements of the speakers are adapted for the print by the editors. The messages are those of the speakers, the wording is revised editorially.

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Discussion

Lux-Steiner:
I want to start with the introduction of the participants of the panel: On my right side is Dr. Hermann Schunck, representing the Federal Ministry for Education and Research. He holds the position of the director general of the department for basic research, transport, and aerospace research. Next to him is Dr. John M. Christensen, head of the UNEP Research Centre. Dr. Christensen performs a special task in the field of renewables. He is head of the Secretariat of the Global Network on Energy for Sustainable Development. Next is Hans-Josef Fell, member of the German Bundestag and spokesperson on research and technology of the Alliance '90/ The Greens parliamentary group. The next person is Prof. Didier Mayer. He is acting as the president of the EUREC Agency. And last but not least Dr. Osman Benchikh, responsible for the energy and renewable energies at the UNESCO, he is head of the research activities.

Necessary Future Actions

Lux-Steiner:
I think you have heard a lot of general statements and I would like to start the discussion with the question if we will be able to realize all those activities and action plans. What do you think are the achievements by 2010? What is the most important achievement for you, your organization, or your country?
I suggest everybody gives a short statement. Starting on your side, Osman Benchikh. The most important but only one.

Benchikh:
Research and development must accelerate the cost-cutting process. Costs going down for the end users may be the most important development to provide more people with an affordable access to modern energy. This is something that can be feasible, it is not impossible. Realistically this can happen, if market development will be connected to research and development.

As representative of UNESCO I would like to add to that R&D goal the aspiration to have improved partnership and cooperation by 2010 not only in R&D. The North has developed research and centers of excellence which can help to improve the situation of the people in the South. UNESCO is aiming to use R&D as a tool for sharing the natural resources on a global scale. In this context we should understand sustainability as solidarity between the North and the South.

Mayer:
I will only complement what Osman Benchikh said. As a representative of the European research, at least our members in EUREC, I will start with a remark on research budgets for renewable energies. In the last 30 years we have had a decrease by a factor of at least three to ten in the research budgets of the renewable energies, as Prof. Luther has shown earlier this day. It is really important to recover this level. Those budgets must be applied to renewable energies and not distributed allover what we call new energies, like for instance CO_2 sequestration, which is an important technology. We have to keep our budgets. It is now and not in 50 years that we have to build the future for the next 50 years, we have to start now.

Regarding education we have already started. It is no simple task to organise a collaboration of European universities, but EUREC has made the first steps in the field of renewable energy research and training and has built something that works. After having developed a strong basis, the next steps will be to use our experience and to expand our collaboration in other continents.

Fell:
The worldwide demand for energy is increasing rapidly, and it cannot be met by fossile or atomic energy sources. Renewable energy systems are badly needed.

Two years ago, the German Bundestag received an independent and scientific report telling that the oil reserves are decreasing. At the moment, we can observe the high oil price as result of scarce resources in relation to the extraordinary high demand particularly of the Southeast Asian countries, picking up in their development. In the next decades, more developing countries will increase their demand for energy. As a politician, I have to react to those global developments, otherwise we will end in a crash of world economy. And the industrialised countries will be hit hardest.

There are no other energy sources in question which could possibly cover the rising demand, at least nuclear energy could do that. And therefore we have to change to a renewable energy system. We have to introduce the existing technologies like windmills, like biogas, and others like geothermal energy.

And we need also a big research offensive to create new technologies. There is a huge range of possibilities, but we have nearly no research money for this. In the past 50 years, 80% of public funds for energy research went into nuclear research on fission and fusion. Nuclear energy covers today 5% of world energy demand. The investments in nuclear power are the biggest flop in research history. Only 2 or 3% were given to renewable energies in the last 50 years worldwide, resulting in covering 12% of the world energy demand.

If politics increase continuously our budgets for renewable energy research, we will soon reach a 100% renewable energy system. And this is the most important target because of climate change and the world running out of oil.

Christensen:
It is very difficult to come after this kind of political statement. I agree with all the previous speakers on what I would call the big picture. But I may be urged because my world is mainly on issues in developing countries. It is important to emphasize that the growth in consumption will mainly come from the developing countries. Right now, there is a very big political push with a G7-report and a number of other initiatives that say: "Renewables are very good for the developing countries". And I agree they are. But renewables need to be implemented in OECD countries to realize extent initially. The political push for renewable energies has to come from the OECD countries.

You have to introduce those technologies in developing countries very carefully. For, you get a very negative reaction from countries which are basically interested in energy, not necessarily renewable energies, but energy for development, if new technologies are introduced and do not work properly or cannot meet the rising expectations. So, it is important that the OECD countries take the lead also in actually doing what they preach.

And then it is important to make the link. It needs to come in a realistic manner otherwise we risk to hand over several things too early and to have a backlash. We have seen a lot of success stories on role expectations using Photovoltaics, but there is a lot of failure also. They can deliver a little power, maybe lighting or something on a very small scale. So, if you overrate it once it is very difficult to convince people and come back later. Renewable energies can contribute to resolve energy access prolems in developing countries, but they need the push from the OECD countries and they are not the sole solution. So, you need to do it in the right way. That is the main message that I would like to come up with.

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But I agree on the principles and targets and so on, but to be realistic, what can be done: If I just take my own little angle from the position why I am here, from the Global Network on Energy for Sustainable Development which is trying what was proposed in the closing session: We can and we should link together regional centers of excellence in developing countries with European and Northamerican centers and try to work on common themes and developing this kind of sharing of experience, mainly on policies so far. I think there is a lot of room for technologies and a lot of other areas to do the same.

Schunck:
I am trained as a mathematician, not as a physicist. I am an engineer. Prof. Lux-Steiner put a precise question forward, and I am trying to give two answers. As I said, I am trained as a mathematician, so I am giving an answer as mathematician.

I hope that in two or ten years or shortly after that some of those exponential learning curves, giving the correlation of costs per unit energy and of installed renewable energy capacities (from which experiences and learning will follow), will reflect the increasing investments in research and development and the improving competitiveness of renewable energies in the market. Now, my second answer I can not refine from politics. I hope that the problems we have ahead of us can resolved in a peaceful environment. And that takes – and now I go back to the first speaker – solidarity.

Global Cooperation in Research

Lux-Steiner:
After having heard these short statements I want to come back to the presentations of today and I would like to ask the panelists: Do we really need a global perspective for research and development in the energy field? We have heard the provocative statement that industrial countries have their task in doing advanced research studies and while developing countries' research needs to be rather application oriented. And they should come together. So I want to ask Osman Benchikh, what do you think about this statement?

Benchikh:
I do not think that we really seriously have to make this distinction. Obviously, the South needs the North and the North needs the South. And there is a need for more solidarity between the North and the South. The term sustainable development is meaningful, but very general. We need to be more specific if it shall have significance for real international development assistance. Therefore I already proposed to understand sustainability as solidarity. We have to promote solidarity among the various actors from the North and the South.

The field of renewable energies offers a true option for a peaceful development. For the South is a region that needs to share know how, while technology and knowledge is now mainly based in the North. Hence, the South presents new opportunities to apply innovations from the North.

Schunck:
It comes down to one question: On a global scale, there is roughly speaking a situation in which the North has high-tech and the South or the developing countries have the adapted technology. It is necessary to transfer as fast as possible technologies and high-technologies to highly qualified Third World developing countries of the South.

However, we should be very careful. I was very much impressed by the lecture of Mongameli Mehlwana who presented the equation Renewables = solar PVs = energy of 2nd choice = rural applications = poor people. That happens if we do not give taxes to high technology as fast as possible and as intensive as possible.

Christensen:
Just adding to the last comment: First of all it is important to have, like Mongameli Mehlwana was saying, a more differentiated understanding of what the North and the South is. Because the South is very many different things. If you go to Brazil, India, China you have quite advanced technologies and policies especially in renewable energies. They are even in front of European countries in some areas.

On the other hand, in many developing countries the situation is a completely different one. Regarding the presentation of Prof Schmid, proposing an open internet-based university to promote training in renewables in developing countries, we really need to understand the local conditions that we talk about. We must not come with a preconceived idea about "This is good for you, because I think this is good for you". We rather need to understand what the local conditions are and what the right technology for that particular need is.

If that match in what we talk about works out, it is a little partnership. That bridge is not very difficult to get across. If, however, you come and think we know what the right technology is, it is very difficult to communicate that kind of information gap on technologies. So, it is the kind of partnership approach which will help to explore which are the right technologies.

Fell:
I agree on that last point. The North or the industrialised countries have the research basis and the industries to develop those technologies, therefore it is their task to develop affordable and cost-effective renewable energy technologies which are competitive in energy markets. However, it has to be checked if, for instance, five mega watt offshore windmills are the right technology for the South. It has to be analysed exactly what the needs of the South are.

Developing countries mostly need low technologies adapted to their capacities to research, develop and produce them on their own. To this end, the education process for capacity building must have two directions in general: first, the North has to learn what the South needs, and second after having funded and developed basic research potentials in the North the education must be application oriented in the South.

This education process can be organised through an open internet-based university as proposed by Prof Schmid. A such university can contribute to knowledge sharing between the North and the South. The North can learn about the South's needs and provide the South with knowledge and technology already available, while the South can learn about the technological opportunities and adapt them to their needs and capacities in an application oriented manner.

Building Human Capacities

Lux-Steiner:
It was mentioned that we need education of experts on all levels. Especially in Germany, for instance, I can say we have a lot of PhD students who finished their thesis and maybe less than 50% find a job in the field of renewables. On the other hand, we learnt that the South has not enough human resources. So, I want to ask Didier Mayer how we have to deal with this problem.

Mayer:
I agree with you that this is a very difficult problem, but I would say in France we have not the same as we have not so many PhD-students that are interested in renewable energies. This is a day to day business to welcome them.
I already said in my presentation that it was a very important job to find or to create some employment and jobs in the field. Otherwise it is nonsense to educate people in this field. But I was talking about the European level. All kinds of energy are well distributed all over the industrialized countries – the normal energy powerplant and so on, which is not the case for renewable energies, which are not distributed equally. Some different countries are better placed to give employments. So that is why I have talked about the European level which certainly offers enough job opportunities and a fairly high demand for engineers in renewable energy technologies all over Europe.

Regarding the students from developing countries studying in Europe we face another problem than the lack of job opportunities: the brain drain. They stay in Europe – they do not go back. The problem in our case was to educate them to go back and apply their knowledge in the developing countries. So we thought about adding a collaboration to welcome them perhaps for only one year in Europe but to leave them in their universities. So we can educate them and keep them in their home countries at the same time. We try to to create a scheme in order to train the trainers for the education process like the Master and even the thesis afterwards. To create education schemes and to create the trainers in their own countries means to build local capacities for education and training. Because otherwise there will be always the possibility for those students to come to Europe and then to organize to stay here and not to contribute to the local development in their own country. This is a problem, obviously, shared by all developing countries. We have to develop solutions for this problem, and one good solution is to go in their places and train the trainees in their own country locally.

Christensen:
I just add a little bit to that, because I agree very much to that. One additional angle, which was the other part of my work for quite a long time, maybe the inner research in development institutions. For, if you look at the political declaration here in the draft which is available now, for instance, research is meant to be on technologies and business models but not on development work. We talked a lot about research and research funding and so on. When you really look at what is done in the development agencies, research is almost a sort of forbidden word in many of them. I think sometime ago the Swedes had something called the Swedish agency for research cooperation where they were organizing this kind of partnerships. This was one of the very few development assistance agencies that actually had a specific research focus at the time. It has now been rolled in into SIDA and disappeared, though it is partly there. But there are very few institutions and agencies that have a dedicated focus on research. So, it is an important message that if they really want to follow up on the declaration. They also need to put research into the kind of development work that they want to fund.

Benchikh:
In fact I raised this issue this morning: the regions where you have the largest potentials of renewable energy resources are the regions where you find the least capacities for reseach and development and training. In order to reverse that experts from the North have to assist in the South to train the trainers within the bilateral cooperation, as Didier Mayer proposed it. This cooperation with the South is even necessary for Europe to reach the adopted target that 12% of the energy supply shall come from renewables by 2012. Without the South Europe will not manage to have enough renewable resources.

However, not only in the South human resources are lacking. The North lacks experts that have full knowledge on the different forms of renewable energies. Most of the experts are specialised in one area, but we are in need of experts with a broader know how and knowledge on the different forms and technologies and on, for instance, the economic part of the introduction of renewables.

The approach of a European Master degree is contributing to bridge that gap. However, there is no need to multiply the different Master degrees, for in the end that would be less transparent and could be a barrier for renewable energy experts to enter the market.

Global Research and Development Networks

Lux-Steiner:
Actually, I would like to ask how this R&D should be organized and also how do you think can these experts be included. Today I have heard many ideas of networking and I want to insert into the following question: Is networking compatible with intellectual properties? I see that high technology research activities are mostly done in closed groups. So what is the advantage of networking?

Mayer:
The advantage of networking has been stressed by Prof. Joachim Luther in his presentation. The mechanisms in question were coordination versus fragmentation. It means, what is the benefit of coordination and what is the benefit of competition? And the answer on it is: We need both, it is very important to have a kind of coordinated competition. Competition is always something really important as new ideas are emerging and competition creates room for new ideas.

But we need also coordination. There are different debates going on all over Europe how the budget of the different member states could be more coordinated in order to increase the efficiency. Because figures tell that Europe as it comes to the European Union's budget plus the member states' budgets reaches the budget of the United States or of Japan. But the efficiency seems to be less because there is research on the same questions supported twice or three times in different member states. So the crucial question is: How can we coordinate this competition between the different member states in order to increase the overall efficiency of R&D. I have no answer. This is another good wish for the ten years coming, I would say. For this is really an important topic. Coordination means to enter the policies of member states, which is very touchy, competition reaches as far as the autonomy of the member states. Optimally, competition shall instigate actors to innovate and give opportunities to launch inventions while coordination shall organise this process more efficient and avoid races that destroy valuable and scarce public resources Both is a question of governance and management.

Lux-Steiner:
In Germany there have been some activities within the last five years, especially networking between research centers and universities. And I would like to ask you, Dr. Schunck, what is your opinion about the results?

Schunck:
May I first go back to your former question. I think we all want renewable energies to become competitive in markets. If that is so, we need people that are knowledgeable in using them. Therefore we need to educate people and we need to disseminate knowledge. I think there might be a stress situation between intellectual property and cooperative networking, but it is inevitable. Because in the end we want companies to be successful with products in markets. But these markets have to be created first. And if people in the South are not able to buy something, to apply things and to use things there are no markets. So in a certain way we need that networking towards the other side to come to a better sustainable development. And if we do not do that, I think we might end in applying what a famous British author once said to East and West "Never the train shall meet". We could refer this to North and South if we are not really careful and try to organize technology transfer and to organize knowledge transfer. The setting up of networks is the best what we can do. I was really impressed by the idea of Prof. Jürgen Schmid in his last talk, proposing an open internet-based university. That is a really practical thing, we should talk about.

Christensen:
The network I am representing deals with policy analysis, which includes intellectual property rights in that area. At least the experience we have so far is that the "cross knowledge", based on comparative policy analysis, is really very valuable both in terms of North-South and South-South. It has a rather strategic value than a technological one for which intellectual property rights are applicable. For you can sit and analyse the problem and then you can come up with some kind of theoretical solution. But if we actually see that something has worked in Brazil and understand why it has worked, what elements are transferable to another region, if it is relevant for them, and

then pick it up there, it is much stronger than somebody coming with a mere theoretical argument of how to do it.
Hence, you can come out with a very strong message on policies, if there is a strong network behind it with, for example, ten developing countries and ten industrialized countries. If they come out with a such common message saying "These are the overall results looking at virtually all subregions in terms of how it works", you come up with a very strong political message, also in terms of pushing the policy agenda.

For you really have to insist to reach the policy makers and start cooperative networks. It could be wonderful if you can get people to initiate to have a such look at that kind of technology cooperation as a long term thing where you create the markets by being more open in the beginning, because otherwise you are not going to move anywhere.

Fell:
If we want to have a real change in the promotion of research and education programmes in the world for renewable energies we have to learn from other areas of energy. The International Atomic Energy Agency is some decades old. Nearly every country of the world gives millions of dollars every year to finance it, and they organize education and research for atomic power. It is a huge and powerful institution. Nothing comparable exists in the world for renewable energies. Therefore we need a similar agency. The World Council for Renewable Energy held a big conference in the last three days here in Bonn. They made a call for an International Renewable Energy Agency (IRENA) to organize the know how transfer in the world in education programmes, in research programmes, in programmes to bring the best political instruments to the countries and much more. Therefore we have to organize a process leading to the setting up of IRENA.

Now, I want to ask you Dr. Schunck as representative from the German Federal Ministry for Education and Research, which helped to organise this conference: Would it be possible that Germany takes a leading role in the financing and in the follow up process for a such organisation like an open internet-based university or anything else comparable?

Schunck:
That is a question put forward to me. I was almost afraid you would ask me whether I could be able to give you an answer regarding the International Organisation – I could not do that. But I tried to listen very carefully to what was put forward today. And it was really very interesting, especially the last lecture – this very precise proposal of Jürgen Schmid was the climax for me. Now, I can do as much as saying I would be very happy to take this back home to our ministry and take a very good look at such a proposal. You know there are questions like that you have to finance techniques and make sure that you do not double something, which perhaps is already there. You have to look at things like that before, but I would be very optimistic that if we meet a year from now we could say we started it here.

Fell:
Thank you very much.

Christensen:
These are very positive news. I have just two points applicable to a couple of things.

The first one is, I also liked the presentation that we have heard before. Maybe one caution is, there has been quite a lot of initiatives after the world summit 2002 creating relatively big internet set up portals, but we have already talked about that before. Though they sound very reasonable, this is the same caution as with some technologies. I mean you are talking about target groups where the access to internet is quite weak in many cases. That needs to be done in a way that the people you are targeting can access. So do not make it too fancy. Because when you are sitting on a very slow connection in Guadeloupe, you have absolutely no chance opening even the front page. There has been quite a lot of talk about internet portals for the Least Developed Countries. But it is a contradiction in terms. They have connections so poor, but we do not realize it. Nevertheless, the idea is good, it has nothing to do with that.

My second point concerns the making of IRENA. You make something what I call a logical leap in the argument: Because we had that for nuclear we need to have this for renewables. But things have changed since, and maybe there the decisive question is: With the new communication technologies and networking and all the other things, do we really need an agency? Just building up an agency like a UN-agency takes five to ten years. And if there are other ways of acting – I do not know, I am asking the question – are they more efficient and effective? Is there actually another way to do the same thing, which would be more efficient and gets started quicker and can be built on somebody's initiative that is already there?

I do not know the answer. I would love to see an agency, but I am just worried that to keep talking about only one solution, we may limit the span of options. For we have talked about IRENA for about ten years. I was before Rio together with Hermann Scheer in the Solar Group for Rio and it has not moved since then. If it were happening, it would be a great idea. But I am not so optimistic on that. Maybe talking too much about it prevents other things from happening. That is why I am worried, although I am not against IRENA.

Fell:
To discuss the foundation of IRENA one has to understand it in historical terms. In comparison the International Atomic Energy Agency was founded in a process starting with only ten nations. They did not ask the United Nations for allowance. It is not the realistic way to bring all nations of the world together. That foundation process will probably take some 20 years. For the time being we just need to start the process with, for instance, ten leading nations, provide that agency with funds, and five years later there will be hundred nations to join in the process.

Then we will have a law for this agency, a law particularly for renewable energies instead of fossile or atomic. For those are the basics when the International Energy Agency comes up with a statement. Therefore we need to organise a standing alone process for renewable energies.

Lux-Steiner:
I would like to come to another issue. Actually it is now the period of writing road maps, there are road maps for almost all nations as well as on the European level. In this context there has come the time for advisory boards. So, I wanted to ask you: Do we need international advisory boards? How many do we need and how should they be organized? This is a question for you, John Christensen – I think you have some experience?

Christensen:
I think that is a bigger scale than what I am working on. Mine is more modest. It would be nice if there were some of the recommendations here for some kind of stakeholder work or forum. I do not disagree that to have an organisation in a somehow institutionalised form would be of great benefit. I am just wanting to move it on. And if we can move it on in a pragmatic way it will be very important.

Because it is important that something comes out of these big meetings and summits, what I have called "care the ball", whatever the ball is. It is important that we have some kind of set up, that we have a message to take from here and keep working on it. If it is possible to set up this kind of agency with a limited number of countries that could be one option, a sort of multistakeholder forum, for instance, that was also discussed at the ninth session of the Commission for Sustainable Development (CSD-9), which was focussed on energy. The proposed International Science Panel on Renewable Energy could be another option. I think it is important for the message coming out, that there is some kind of specified follow-up, and then you can discuss the details, terms of reference and so on, when you move on. But if we leave here at the end of the week without any kind of follow up apart from that we meet for the CSD in 2006 and 2007, it will be like any other major meeting that recommended an action plan but in fact had no action.

Benchikh:
One of the major problems to launch renewable energies is what the policy changes require from the decision makers. These people are in need of information and advice. An international

advisory council, or what form it may ever take, can provide advice and promote a change in mentalities. This change of thinking is only possible through education. Education with an international background is today the only education to promote that change in awareness and understanding. An additional argument is that the switch to renewable energies makes necessary an adaptation of the people, of ourselves, to the new form of energy. To conclude, I believe a such body is absolutely needed, and the proposal that has been made this morning is clever and will work out.

Now I am coming to the question of founding an agency. The intention of an eventual international agency for renewable energy is to create an institutionalised body promoting renewable energy for the reduction of poverty. However, if such an agency is to be founded it has to be tied in some organisational form to the UN-system, otherwise it will just be another bilateral initiative not acting on a global scale. I am not saying I am for or against a such agency, but indeed it is necessary to change something in

order to reach out to the people, raise their awareness, and provide the infrastructure or other preconditional resources needed for development.

Fell:
The crucial question of creating an international agency is not to build it with or against the UN. The question is how to exceed the pace of normal UN-processes. The agency should be created in an open process, always consulting with the UN. Although to speed up the process a combined effort by some nations willing to take the lead and the UN – the UNESCO might be the most appropriate UN organisation – should be made. They should found something like a network of universities, a network of research centres, or an internet university, or something comparable. This process will instigate a process with the UN-system. So the process will neither include nor exclude the UN but the UN will be part of the process. That is what counts.

Financing for Research and Development

Lux-Steiner:
Ok, let us move to the next topic: money, or the financial resources. The trend in research and development expenditure is going down. Industrialised and developing countries are mainly differing in their financial capacities. My question is based on the statement Sigurd Wagner made today, that by the year 2013 we do not need any subsidies anymore, for instance in photovoltaics. What would you suggest to do? Wait and see how the learning curve is going down, maybe not so fast if we do not have research and development? Should we wait or can we find private investors? Or should we push the market launch of renewable energies, following the German model of feed in tariffs, which is a very costly alternative? How are we supposed to manage this?

Schunck:
It is very easy to say we need more research. Of course we do. But we do not decide ourselves how much money we get. I am a bureaucrat – Hans-Josef Fell is the member of parliament – we are organising processes to get money, but budgets are scarce today.

Some speakers have made a very important remark today. The steady support is important, the continuity of funding instead of something going up and down. Sigurd Wagner did not say that in ten years from now all by itself there will be no more subsidies necessary. There is a shortage of money that has to be paid in between. We have to organise a stable support system, we have to organise markets, perhaps in the way of the much debated renewable energy law in Germany. It creates a market, which would not have been developed by itself, and we know we need to introduce that technology. The much we have to develop new technologies or try to be careful that our scope of technologies that we pursue is broad enough, we might miss something that – only in years from now we will understand – is interesting and important.

Creating markets, in the end, is most important. There are some examples how that can be done in this country with – and I pass that to Hans-Josef Fell if he wants to explain it – the renewables energy law.

Fell:
To explore the question how to promote the introduction of a sustainable energy system based mainly on renewable energies, we have to look at the whole chain from mostly public funded basic research to private industrial application-oriented research to market launch. And the whole chain has to be supported. For to set incentives for private investments in research there has to be a market. If, however, more actors enter the competition for the best technology in the market the overall effects of the research process will improve.

Apart from that we have to explore the market as well. Photovoltaics are already today competitive without subsidies, not only in 2013. On a global scale the half of the regional markets for photovoltaics work without subsidies. Photovoltaics generate the cheapest electricity in African regions where no grid is accessible.

In fact, the research process and the incentives in markets to invest in research and renewable energies are interlinked in feed back loops. If we achieve to speed up the cost cutting process, renewable energies will be more competitive in markets without subsidies and attract more investments, which will speed up the whole process of research and market launch of new technologies and hence the switch to renewable energies.

Benchikh:
I want to add to what Mr. Fell has said, that taking the point of view of developing countries I would not even call it a subsidy. I will call it social solidarity, equality among the population in the same country. The example of Spain and the Spanish islands may illustrate that.

It is well known that to get the electricity on an island it costs more than in the mainland. Nevertheless the price on the islands is the same as in the continent. The price of electricity on Teneriffa is the same as in Madrid. For a single reason: it is social equity and equality. This shall be done and applied for renewable energies, too. Why do we have to call it a subsidy when it comes to renewable energies? No one calls it a subsidy if the costs for production in other energy areas like nuclear energy are compared, though full-cost accounting of all external effects shows something else.

Mayer:
In order to link the research and education process to the private sector and the needs of the market EUREC Agency is in connection to all European industrial associations. We are starting a discussion and preparing a position paper on the short, medium, and long term needs, looking at the demands of end users as well as market opportunities. This coordination of research and industry is necessary, for the private sector is much more focussed on the short and medium term while basic research has a long term perspective. It is particularly the task of research centres to make out opportunities for renewable energies today and to analyse long term perspectives. So the research has to bring in what is not yet in the market, but only the consultation between research and industry can produce strong positions, that can be communicated and introduced to policy makers.

Actions and Commitments

Lux-Steiner:
Unfortunately, we are runnning out of time now. So, before we finish the discussion I would like to have a short statement of each panelists: What will be their own contribution in the next few years?

Schunck:
I gave my answer already. Thank you.

Christensen:
Maybe I did so, too. But since I have my thing up I will just point out one thing, I hope to do. Regarding the statements on photovoltaics in

Africa, I hope that I can help get rid of some of these myths, because it is basically not what is happening. There are very isolated projects where you can do this, where photovoltaics are the cheapest and most competitive technology for energy access. But as a general statement: It is one of the things that create misconceptions about what the renewables can do. If you look at South Africa, ESKOM has to pay the whole investment just to make it run as a programme. Photovoltaics have high upfront investment costs, hardly affordable for the poor. For the time being the use of renewable energies must increase in industrialised countries, thus bringing down the costs and making them more affordable for developing countries.

I hope really that we can get rid of some of these myths and overrated expectations because it has got to be the way forward for renewables in order to provide energy for sustainable development and to provide the poor in developing countries with access to modern energy in the long run.

Fell:
Instead of announcing what I will do to promote renewable energies, I would like to raise what I need to be proactive. I need the scientific support of the research community. You do not imagine how much weight your word has in the political arena. Policy makers perceive scientists as most highly qualified. The research community has to demand the funds for research in renewable energies. For there has been research in fusion technology for fifty years now, and they continue to receive their public funding, however, there are nearly no programmes worldwide for renewables research. And there will not be any if the research community do not demand public funds for renewables research. Furthermore, the scientific community has to demand from policy makers to change. It is not sufficient to spend money for research without putting in place the research results. To generate new knowledge does not change the world, we have to act on what we know. To phrase it with Erich Kästner: 'There is nothing Good except You do it'. Only then we might succeed one day and create a sustainable energy system.

Mayer:
As I already mentioned earlier the work plan of EUREC Agency includes a discussion between research and industry leading to a position paper that shall help to increase budgets for renewable energies. On the other hand my particular responsibility is in the field of education. We will continue on our path and will extend our activities, for instance by contributing as much as possible to the internet academy proposed by Prof. Schmid. The internet is one way to reach out to a greater number of people, however, this action has to be paralleled by existing initiatives. For the physical meetings and the availability of test facilities are still important. Either those facilities will be used in Europe or, as already pointed out before, those facilities have to be built up elsewhere. This brings me to the question of financial resources for funding. Just very briefly: Since financial resources are very scarce nowadays, actions have to be as efficient as possible, so we have to design the education capacities to be built up very carefully before.

Benchikh:
First of all I would like to thank the organisers of this excellent meeting which gave opportunity for an exchange of ideas and concepts that were missing in the field so far.

UNESCO welcomes the different ideas that have been brought forward in the discussion and will consider cooperation with the proposed agency or network that will deal with science, technology, and education.

To conclude, I would like to express my hopes that we will see within this decade more knowledge sharing and thus more solidarity in the field of renewable energy.

Lux-Steiner:
I would like to thank all the panelists and give the floor to Prof Jürgen Schmid, who held the scientific responsibility for the organisation of the Science Forum.

Annex

- International Open University for Renewable Energies (OPURE)
- International Organisations Concerned with Energy Issues
- Press Conference
- Press Release
- List of Participants
- Member Institutes of the Solar Energy Research Association (FVS)
- Photographic Credits
- Imprint

International Open University for Renewable Energies (OPURE)

One of the major results of the international conference for renewable energies in Bonn is the initiative for an International Open University for Renewable Energies (OPURE). The memorandum of the World Council for Renewable Energy (WCRE) of their conference, 29th to 31st May, Bonn, renewed the proposal, originally stemming from EUROSOLAR, at the World Renewable Energy Forum, held in Bonn in the days before the renewables2004, and put it in the focus of attention.

During the renewables2004, the Solar Energy Research Association (ForschungsVerbund Sonnenenergie, FVS) organised the Science Forum, funded by the Federal Ministry for Education and Research (Bundesministerium für Bildung und Forschung, BMBF), as an official side event. In the final panel discussion Hermann Schunck, representative of the BMBF, indicated, when approached by the chairperson of EUROSOLAR Germany Hans-Josef Fell, the willingness of Federal Minister Edelgard Bulmahn to financially support the start up of the university for renewable energies.

This was an important signal, initiating many talks and activities during the Bonn conference in order to start the foundation process. The initiative mainly came from FVS's vice spokesman Jürgen Schmid, director of the Institute for Solar Energy Research (Institut für Solare Energieforschung, ISET) in Kassel, MoP Hans-Josef Fell, chairperson of EUROSOLAR Germany, and Osman Benchikh, UNESCO, Paris.

Fortunately, the Call for Actions of the renewables2004 responded immediately and accepted to include OPURE in the International Action Plan, one major outcome of the international conference.

The name OPURE stands for Open University for Renewable Energy. This name indicates that the university will be organised initially as an internet platform. The long term goal, though, is to transform the internet university into an ordinary university. Most important mission of the university will be generally speaking: the exchange of know-how, education and training, and networking of renewable energy research.

All national as well as international institutions can be participating actors, particularly those which are universities, research centres, and institutions specialised in renewable energy research.

For the time being, the foremost task of OPURE will be to organise the exchange of information, communication and cooperation in science and research for renewable energies. At the centre of activities will be training programmes on all levels of education, translated in as many languages as possible, programmes for research and development, the exchange of results of most recent research as much as the development of national strategies and policy tools for renewable energies.

Thus, the Bonn conference signalled other Governments, the private sector, and NGOs to contribute to the financing of OPURE.

Under the roof of UNESCO's active support to coordinate individual activities soon and global acceptance will be achieved.

Now, it is necessary to elaborate a realistic concept for which the BMBF will provide the funds as promised. A such concept will be worked out by and in the responsibility of Prof Schmid and the FVS in the next weeks. EUROSOLAR will continue to actively support that process.

Nationally as internationally the idea has received great attention. Many institutions,

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universities, or other educational organisations have already stated that they were interested to participate in OPURE, approaches have been coming even from China and Brazil.
It is remarkable that the German parliamentary committee for education and research has made the decision to support OPURE in their first session immediately after the renewables2004 and that all parties agreed on this question unanimously. And last but not least, this decision proves that the proposals of EUROSOLAR and of the FVS receive wide support from all sections of society, in politics and science.

International Organisations Concerned with Energy Issues

SF – Science Forum
→ – connected with

AFREPREN (SF chair Kithyoma)
African Energy Policy Research Network
Network of more than 100 energy researchers in Africa who conduct technological research as well as policy research to provide policy makers with information and recommendations.
Leading actor in → GNESD for the subject of access to energy.

BEE
Bundesverband Erneuerbare Energien / German Renewable Energy Federation
Lobbying for renewable energies, coordinating activities of members, providing policy makers with expertise and studies on renewable energies.

CENERG (SF speaker Mayer)
Centre d'Énergétique
Conducting research on the environmental impacts of human made technologies of energy supply and conversion.
Belongs to École des mines, Paris.

CRS (SF speaker Hamrin)
Center for Resource Solutions
Independent research institution. Fostering human capacity building for sustainable technologies and international leadership in sustainability to meet economic, environmental, and cultural needs. Disseminating knowledge, promoting demonstration projects.

CSIR (SF speaker Mongameli)
Council for Scientific and Industrial Research
Conducting research on the context of labour, environment, and man, and disseminating knowledge. (South Africa)
Member of → GRA.

DAAD
Deutscher Akademischer Austauschdienst / German Academic Exchange Service
promotes financially and in various programmes the exchange of foreign academic staff and students coming to Germany and German academic staff and students going abroad.
Funded by German Federal Government.

DLR
Deutsches Zentrum für Luft- und Raumfahrt / German Aerospace Center
Conducting research among others on thermal solar power, fuel cells, and system technology.
Member Institute of → FVS.

ERC
Energy Research Centre
Conducting policy research, consulting policy makers, building human capacity in Africa.
Member institute of → GNESD, and other international cooperations.

EREC
European Renewable Energy Council
Umbrella organisation of European renewable energy industry and research associations, as for example → EURECA.

EREF
European Renewable Energy Federation
Building a network of renewable energy producers and raising awareness in Europe.
Lobbying for feed-in systems, labels on electricity, levelling playing field.
Cooperates with UN organisations and European organisations devoted to renewable energies.

ESMAP
Energy Sector Management Assistance Program
Comprising all particularly energy focussed activities of the Worldbank.
Belongs to the Worldbank.

SF – Science Forum
→ – connected with

EUEI
European Union Energy Initiative
Aims to eradicate poverty and to promote sustainable development focussing on the role of energy. Disseminates knowledge. Builds capacity. Develops strategies. Works through partnerships with civil society, private sector, financial institutions, end users.
Secretariat within the EU Commission's DG Development, Type II partnership of the → WSSD. Funds coming from partners.
Cooperates with NEPAD, GVEP,GNESD, UNDP, UNIDO Energy Initiative, GFSE

EUREC Agency (SF speaker Mayer)
European Renewable Energy Centres Agency
Disseminates knowledge, fosters contacts and cooperation between the scientific community and the industry as well as policy makers, develops strategies for R&D. Manages projects, promotes professionalisation of education and training. Cooperation of renewable energy R&D centres in Europe.

EURONETRES (SF speaker Kyritsis)
European Network on Education and Training in Renewable Energy Sources.

EUROSOLAR (SF panellist Fell)
Lobbies for renewable energies as basis for a sustainable development and for the mitigation of climate change. Produces studies, raises awareness.

Forschungszentrum Jülich
Research Centre Juelich
Member Institute of → FVS.

Fraunhofer ISE (SF speaker Luther)
Fraunhofer Institute for Solar Energy Systems
Member Institute of → FVS.

FUE
Forum Umwelt und Entwicklung /
Forum Environment and Development
Awareness raising for environmentally sustainable development.
Association of German development NGOs (VENRO) and German Nature Protection Circle (DNR), funded by the German Federal Ministry for Economic Cooperation (BMZ).

FVS (SF speaker Schmid, Luther, Lux-Steiner)
ForschungsVerbund Sonnenenergie /
Solar Energy Research Association
Coordination and cooperation of research on renewable energy technologies in networks in Germany.
Research association of nine independent research institutes carrying out research on renewable energies.

GEF
Global Environment Facility
Provides funds for environmental projects in developing countries, focusses under its climate programme on renewable energies. Partners with private sector, promotes market-oriented solutions. Aims to reduce costs, where high investment costs might hinder long term-developments of new technologies. Founded at the → UNCED. Run by → Worldbank, → UNDP, → UNEP, which are the implementing agencies.

GEPROP (SF speaker Curbelo)
Gerencia de Programas y Proyectos Priorizados del Ministerio de Ciencia, Technologia y Medio Ambiente

GFSE
Global Forum on Sustainable Energy
Multistakeholder platform for dialogue. Supports networks of donors, holders of technological know-how, project promoters from developing countries. Organises events, conferences, annual meetings.
Cooperates with EUEI. Funded by Austrian Government.

GFZ
GeoForschungsZentrum Potsdam
Member Institute of → FVS.

GNESD
(SF chair Christensen, SF speaker Pacudan)
Global Network on Energy for Sustainable Development
Network of 20 academic institutions of high excellence in the field of energy. Major foci on energy access and renewable energy. Promotes research on those topics, coordinates, builds capacity.
→ UNEP funds GNESD secretariat.

SF – Science Forum
→ – connected with

GRA (SF speaker Luther)
Global Research Alliance
International research alliance of nine knowledge-intensive technology organisations from industrialised as well as developing countries. Aims to use resources of members efficiently in order to produce knowledge to the benefit of society at large. Energy is one of the research topics among others.
Independent research association.

GREET (SF speaker Benchikh)
Global Renewable Energy Education and Training Programme
Aims at training and education, and dissemination of information at global, regional, and national level. Develops ways of financing, and raises awareness.
Programme of → UNESCO.

GTZ
Gesellschaft für Technische Zusammenarbeit / Society for Technical Cooperation
German Organisation which carries out technical development assistance of the German Federal Government. Supports renewable energies and energy efficiency through capacity building, developing markets, disseminating knowledge, building of networks of relevant actors, and strategic consulting / analysing energy policies. Cooperates with private sector (public private partnerships), → EUEI, → GVEP.

GVEP
Global Village Energy partnership
Promotes coordination of energy development projects in developing countries, managing relations of different actors.
Originally funded by Worldbank and UNDP, in the meantime independent, secretariat decentralised at the moment.

HMI (SF speaker Lux-Steiner)
Hahn-Meitner-Institut Berlin
Member Institute of → FVS.

IEA
International Energy Agency
Agency of the OECD for all energy concerns of OECD as well as developing countries, not particularly for renewable energies.
Belongs to OECD.

IFEU
Institute for Energy and Environment
Conducting research on different environmental topics.

IIRE (SF speaker Rakwichian)
International Institute for Renewable Energy
Develops human resources globally (capacity building), facilitates research on renewable energies and disseminates information on them (knowledge sharing) in order to meet the needs of a successful implementation of renewable energy technologies.
Six founder universities, cooperation with / funding supposed to come from various international organisations.

IÖW (SF speaker Hirschl)
Institut für ökologische Wirtschaftsforschung / Institute for Ecological Economy Research
Combining economic and environmental research questions, developing strategies for a sustainable economy, and providing expertise on evaluations of urban, transport and business developments.

IPCC
Intergovernmental Panel on Climate Change
International scientific panel, which elaborates regular updates of conclusions on the knowledge about climate change and recommends necessary action. Independent scientific panel.

IRENA
International Renewable Energy Agency
Proposed originally by the Brandt-Commission in their North-South-Report, 1980. In analogy to International Atomic Energy Agency, in order to support the technological transfer and dissemination of renewable energy technologies in developing countries, and to develop markets. German Bundestag decided that the Federal Government should take the initiative to found an IRENA.

ISFH
Institut für Solarenergieforschung
Member Institute of → FVS.

ISET (SF speaker Schmid)
Institut für Solare Energieversorgungstechnik
Member Institute of → FVS.

SF – Science Forum
→ – connected with

ISES
International Solar Energy Society
Supporting the advancements of renewable energy technology, implementation, and education, to the benefit of sustainable development, a multisectoral global community. Disseminating knowledge and connecting actors in the field of renewable energies. Collaborates in international networks.

ISUSI (SF speaker Lehmann)
Institute for Sustainable Solutions and Innovations
Providing expertise in eco-evaluations and the elaboration of scenarios for the transition to a completely renewable energy based energy system.

JREC
Johannesburg Renewable Energy Coalition
First international leadership initiative, founded at the WSSD, consists of approximately 80 countries (EU and Small Island States), committed to promotion of renewable energies for a sustainable development and to stop climate change.
Secretariat at the EU Commission, Bruxelles.

REEEP
Renewable Energy and Energy Efficiency Partnership
Implementation-oriented initiative, which works through knowledge sharing and matchmaking of different partners whose resources complement each other.
Funded by UK, Spain, Austria, Netherlands, EU.

SEFI
Sustainable Energy Finance Initiative
Provides information, develops partnerships, facilitates networks. Organised by → UNEP.

SERT (SF speaker Rakwichian)
Solar Energy Research and Training Centre, Thailand

SESAM (SF speaker Rehling)
Sustainable Energy Systems and Management
International MSc course for the promotion and implementation of sustainable development strategies.
Partnership with UNDP / Nepal.

UNCED
United Nations Conference on Environment and Development
3 till 14 June 1992 in Rio de Janeiro:
→ UNFCCC, Rio Declaration on Environment and Development (raises the significance of the complementarity of human development and environmental sustainability), Agenda 21 (blueprint for (local) action towards global sustainability).
Belongs to the UN-system.

UNCSD
United Nations Commission on Sustainable Development
Founded at → UNCED to monitor and report on the follow-op process on local, national, regional, and global level. Organising sessions annually to particular topics of sustainability. The 9th session, 16 – 27 April 2001, was on energy, and established an Ad Hoc Inter-Agency Task Force on Energy for coordination and cooperation among UN agencies and programmes.
Belongs to the Division on Sustainable Development of the United nations Department for Economic and Social Affairs (UNDESA)

UNDP (SF speaker Pacudan)
United Nations Development Programme
Organises the technical development assistance of the UN, supposed to coordinate development assistance within UN-system. Improves access to modern energy as a means of poverty reduction, considers sustainability goals through energy efficiency, renewable energy, low greenhouse gas-emitting technologies.
Belongs to the UN-system. Programme status implies that UNDP' funding depends on donations, no independent regular funding as an organisation has. Implementing institution of → GEF.

SF – Science Forum
→ – connected with

UNEP (SF speaker Pacudan)
United Nations Environment Programme
Supposed to promote coherent implementation of policies regarding the environment within the UN-system. Works through analyses, dissemination of information, fostering international cooperation, providing policy advice, and serving as a link between scientific community and policy makers. Focusses on sustainable use of natural resources and the protection of the environment for a better human well-being.
Belongs to the UN-system. Funded by the Environment Fund, made up of voluntary contributions. Launched the → SEFI, implementing institution of → GEF.

UNESCO (SF speakers Benchikh, Erdelen)
United Nations Educational, Scientific and Cultural Organization
Promotes environmental research, free dissemination of information, and education for all as a means to human development and peace, protecting cultural and natural heritage.
Belongs to the UN-system. Independent funding as status of an organisation.

UNFCCC
United Nations Framework Convention on Climate Change
Negotiated at the → UNCED, amended by the Kyoto-Protocoll 1997.

UNIDO
United Nations Industrial Development Organisation
Supports development of industrial capacities, and of cleaner and sustainable development
Belongs to the UN-system.

WBGU
Wissenschaftlicher Beirat der Bundesregierung Globale Umweltveränderungen
Scientific Council of the Federal Government for Climate Change
Expert group to the German Federal Government on questions of global change regarding environment and development. Regular reports with conclusions and recommendations for action and research.

WCRE
World Council for Renewable Energy
Analyses potentials of and barriers to renewable energies, and disseminates information on best practices. Lobbies for policies to introduce renewable energies.
Secretariat at EUROSOLAR.

WERCP
World Energy Research Co-ordination Programme
Proposed by the WBGU, in analogy to World Climate Research Programme. Shall coordinate national research activities, and provide consulting.
Possibly established within the UN-system.

WI
Wuppertal-Institute for Climate, Environment, Energy
Exploring and developing strategies and models for a sustainable development on local, national, and international level. Conducting research on the interrelation of society, environment, and economy, in order to decouple the increase of wealth and the exploitation of natural resources.

Worldbank (IBRD)
International Bank for Reconstruction and Development
Energy is part of the infrastructure vice-presidency, though there all over the Worldbank people concerned with energy topics. The environmentally sustainable access to modern energy for the poor is the goal, not particularly the transition to a renewable energy system.
Since there is no particular energy department, the Worldbank has established → ESMAP.
Implementing institution of → GEF.

WSSD
World Summit on Sustainable Development
26 Aug till 4 Sep 2002 in Johannesburg.
One of the major outcomes was the recognition of “type II partnerships”, which comprise partnerships with the private sector. These partnerships may promote private investments in the development process and organise it closer to free markets. Four bigger energy-related partnerships: GVEP, GNESD, EUEI, REEEP.

SF – Science Forum
→ – connected with

WWI
World Watch Institute
Research organisation. Works for social and environmental sustainability, provides information in order to encourage new lifestyles, investment patterns, and policies. Promotes renewable energies.
Independent NGO.

ZSW
Zentrum für Solar- und Wasserstoffforschung / Centre for Solar and Hydrogen Research
Conducting research in key technologies of future industries, like photovoltaics, battery / fuel cell technology, renewable fuels, energy systems.

Press Conference

The Solar Energy Research Organisation / ForschungsVerbund Sonnenenergie (FVS) has published a press release in cooperation with United Nations Educational Scientific and Cultural Organization (UNESCO) and the German Federal Ministries for Research and Education (BMBF) and for Environment, Nature Protection and Nuclear Safety (BMU). (See page 161).

On the 1st of June 2004 the FVS organized a press conference with the participating organisations to present the science forum to the public.

Participants:

UNESCO
Walter Rudolf Erdelen
Assistant Director-General for
Natural Sciences

BMU
Rainer Hinrichs-Rahlwes
Director General

BMBF
Hermann Schunck
Ministerialdirektor / Head of the
Department Research

FVS
Jürgen Schmid, ISET
Responsible for the scientific programm
of the Science Forum

Press Release

Research and Education as a Basis for the Wide-spread Deployment of Renewable Energies

Sustainable future only with R&D on renewable energies

Sustainable development is inevitably connected with Research and Development (R&D) on renewable energies. Therefore, the Solar Energy Research Association (ForschungsVerbund Sonnenenergie) is hosting a Science Forum in the context of the renewables 2004 conference in Bonn (Germany) on the 1st of June. Prof. Dr. Jürgen Schmid, scientific manager of the Science Forum, emphasises: "Research and development enable cost reductions, and they are pre-requisites for access to modern energy and for poverty reduction. The renewable energy technologies have to be adapted to the diverse conditions of the countries in the world; and the knowledge about the utilisation of renewable energies must be made available through a world-wide education process."

Energy R&D needs a global perspective

R&D are pre-requisites for the evolution of global civilisations towards sustainability in its various aspects: New technologies have to be developed. For existing renewable energy technologies cost reductions have to materialise. Addditionally, sociological and economic issues for integrating renewable energies into energy supply structures have to be investigated and taken into account. Country-tailored approaches are therefore an essential element of research planning.

Research requirements have to be well-analysed in respect of time and place. For some countries, it might be beneficial to work primarily on the adaptation of existing technologies to local needs. For some countries it appears to be advantageous to develop novel high-technologies.

BMBF strengthens renewable energy research

Dr. Hermann Schunck, head of the Department Research at the German Ministry of Education and Research (BMBF), states that the BMBF strengthens renewable energy research by supporting basic and applied research in science, engineering, economics, social sciences and other areas. BMBF supports multidisciplinary research on renewable energy sources by funding National Research Centres and project networks. Dr. Schunck underlines the need for additional targeted research and development with particular emphasis on affordability and reducing cost, on innovative business and financing models and on cost-effective, consumer-friendly cost-recovery models, recognizing that different renewable technologies offer different opportunities and face different constraints.

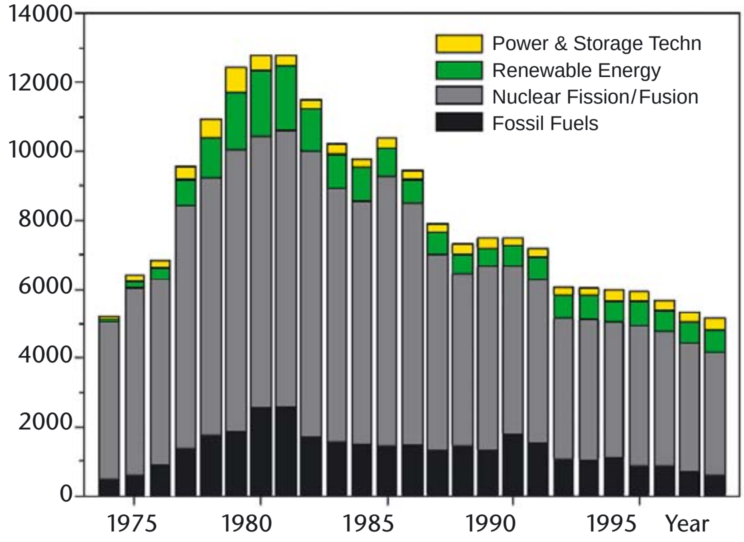
Education of experts on all levels

For a successful deployment of renewable energies, education and training is a key element. There is a lack of appropriate educational material, in developed countries as well as in developing countries. By means of modern communication structures, it is possible to improve information transfer and education in this field very efficiently.

During the Science Forum existing initiatives will be presented and discussed. Recommendations on the set-up of an international

Press Release Partner:

UNESCO
BMU
BMBF
FVS



Only 10 % of the energy-related expenditure was spent on renewable energies, while about 70 % was spent on nuclear fission and fusion. The overall energy R&D expenditure peaked in 1980 and has continously been declining to less than half its maximum level since then. Source: IEA Energy Technology R&D Statistics Service

Figure 1
Public R&D Budgets of 23 IEA member countries for selected fields of energy related research

network in research, education and training will be discussed.

UNESCO fosters Education Networks to build up capacities

In 1997 the UNESCO established the "Global Renewable Energy Education and Training" (GREET programme) which aims at improving the use, maintenance and management of renewable energy projects and programmes, as well as transfer of technological know-how. Beside UNESCO the international organizing partners are UNDP and the European Commission, as well as institutions and organisations at the national and regional level.

Prof. Walter Rudolf Erdelen, UNESCO Assistant Director, states: "To achieve the Millennium Developmental targets, UNESCO will continue to advocate for renewable energies, capacity-building, and development of competent human resources with emphasis on improving the living conditions in rural areas of poor countries, especially in the developing countries and small Island States, particularly for women, young people, and girls, and facilitating the extension of learning opportunities. In the years 2004 – 2005 the UNESCO's GREET programme will involve the design and field implementation of training platforms, elaboration and dissemination of learning and teaching tools, the introduction of training programmes at the various educational levels, the establishment of educational standards and the certification of centres of excellence, which will serve as a catalyst. Concurrently, support will be given to the formulation of national energy strategies and experimentation of pilot projects aiming at developmental purposes."

According to Erdelen, the UNESCO has also launched the European Network on Education and Training in Renewable Energy Sources (EURONETRES) established as a regional voluntary framework, uniting universities and other educational academic institutions of the European countries, interested in capacity building at national and regional level for the extended use of RES in Europe as well as in other regions of the world. Similar regional networks for Africa, Latin America and the Caribbean region as well as other regions are planned to be launched during the current biennium 2004 – 2005.
In conclusion, Erdelen heads the following call: "UNESCO invites all Governments and concerned institutions to joint efforts and partnership for the implementation of this initiative related to the human resources development and networking. Furthermore we aim at enabling actors in this specific area to share investment costs for research and education as well as outcome."

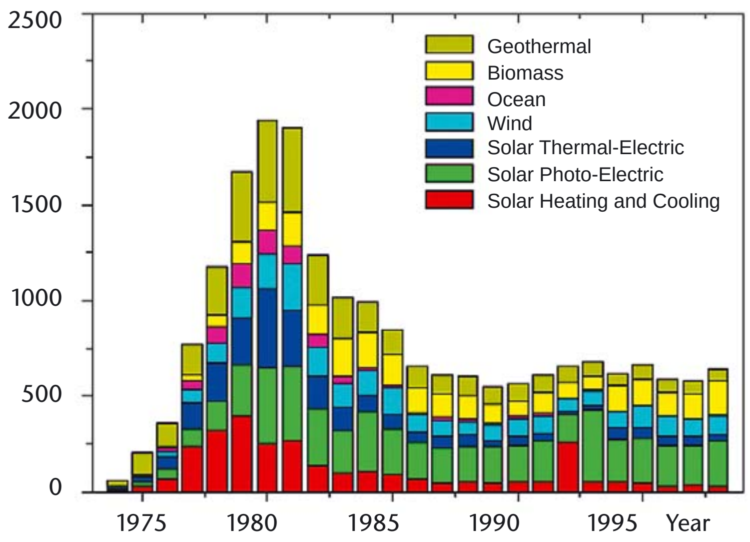
BMU strengthens communication link between science and politics

Rainer Hinrichs-Rahlwes, Director General within the German Federal Ministry for the Environment (BMU), announces that the BMU will strengthen renewable energy research: "At present the research programme comprises annual funds of EUR 65 million and is aiming at driving the high level of technological innovation in the photovoltaics, offshore wind energy and concentrating solar power stations. The support focuses on projects carried out by private enterprises and academic institutions as joint ventures, and on accompanying socio-ecological research, in order to sustain the use of renewable energies. Environment and climate have one thing in common with the sciences: national borders become more and more meaningless."

Furthermore Hinrichs-Rahlwes adds: "It is important that the political implementation of a sustainable energy system with a steadily increasing share of renewable energies receives continuous support through independent scientific research and promoting awareness. It is essential to shift this scientifically based knowledge into various options for action as a basis for policy-making bodies to adopt preventive strategies and bring existing policies into line with new challenges. For that purpose a global science network with a policy mission, an "International Science Panel on Renewable Energy (ISPRE)", composed of universities and research institutes, shall be established. The ISPRE will be charged with analysing and evaluating global R&D activities in the field of renewable energies. ISPRE shall be initiated at the conference renewables 2004 aiming at manifold support from various institutions, with a small secretariat to set up the initial phase. Other countries as well as research institutes are invited to participate actively. This panel will function as a vital link between the scientific community and political decision makers."

Active role of UN for a strategic research and development

R&D activities in developing countries are quite limited, and it is evident that only a small number of the larger countries have real R&D programmes on renewable energy technologies in place. Thus it is necessary to build up R&D programmes fostered by the UN including the many smaller countries that are in need of renewable energies but yet not able to invest in R&D. A strategic global fund for R&D on renewable energies should be established perhaps within the UN system.



RD&D expenditure on renewable energies follows the trend in regressing overall RD&D expenditure on energy: It peaked in 1980 and has since declined to about one third of its maximum level. Within the overall renewable energy RD&D budget, biomass and photovoltaics show a trend to rising proportions, while the other sectors remain on a constant or slightly decreasing relative level.
Source: IEA Energy Technology R&D Statistics Service

Figure 2
Budgets of 23 IEA-member countries for Research on Renewable Energies

Alarming global trend in R&D expenditure

From 1974 to 1998 in the twentythree IEA-Member countries only a 10 % share of the respective budget was spent on renewable energies, while about 70 % of the energy related expenditure was spent on nuclear fission and fusion. The overall energy R&D expenditure peaked in 1980. Since then it has been continuously declining to less than half its maximum level. *(Fig. 1 and 2)*

Since less investment means less innovations, this global trend of cutting energy-related R&D funds is in clear contrast to the importance of the energy sector for evolution in general and especially to the ever-rising importance of renewable energies. In order to give renewables the necessary support, the average direct state expenditure for R&D in the renewable energy sector in industrialised countries have to increase at least ten-fold until 2020. At the same time, significant international support must also be directed to R&D in developing countries.

Goals of R&D

Both non-technical and technological R&D on renewable energies are essential for the evolution of the energy sector towards sustainable schemes. The wide span of interrelated R&D challenges includes e.g.:

- R&D on non-technological aspects (economic, sociological, political)
- R&D on renewable energies for electricity production
- R&D on renewable energies for the production of heating and cooling energy
- R&D on solar and energy optimised buildings
- R&D on renewable energies for fuel production
- R&D on comprehensive technological aspects

In all these fields two main approaches must be followed:

- New technologies have to be developed in some areas. Three examples: biogenic-energy carriers for a decentralised supply of storable energy, low-cost energy efficient houses, storage technologies for high quality energy.
- Cost reductions for existing renewable energy technologies have to materialise. This includes: higher efficiencies of energy conversion, longer service life of technical components, less maintenance, less material consumption.

Renewable Energies need politically supported markets

Modern energy and its sustainable provision is necessary for nearly all fields of development. Most renewable energy technologies are local, they can start locally based value chains, renewable energies and related knowledge-based services generate income, improve the environment as well as health situation, and foster education in developing countries. As such renewable energies help to reduce poverty and build up capacity. The Science Forum contributes to the development of a strategy how to produce new knowledge and how to disseminate it most widely in industrialized as well as developing countries.

A significant time lag between R&D and market launch must be considered. R&D on renewable energies is therefore a strategic field of research and industry policy which is inadequately steered and supported at present. Governance following the logic of political management, on the one hand and self organised processes following the logics of markets, on the other hand must complement one another.

Internet based education

Properly managed, internet-based dissemination, education and training will provide a huge support for renewable energy deployment for a relatively small effort in budget and hardware. Internet-based education can be realized directly by interactive procedures, but knowledge transfer into different cultures may need special preparation in addition to simple translation. Based on modern IC-technologies, dissemination to an unlimited amount of users is possible. It can also be made affordable fore those having no access to conventional educational materials such as books and journals.

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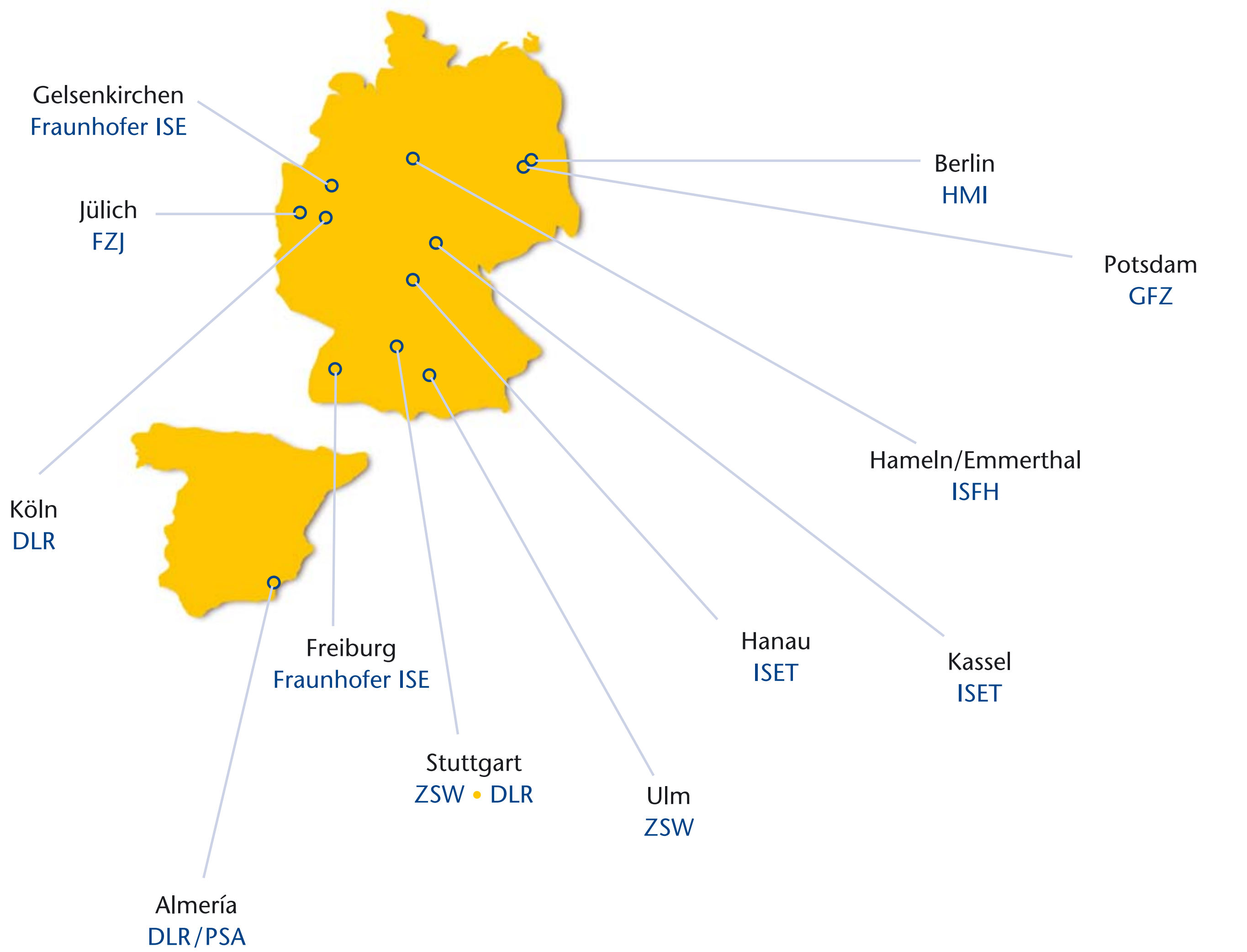

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