



WBGU

GERMAN ADVISORY COUNCIL ON GLOBAL CHANGE

policy paper

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**Renewable energies
for sustainable
development: Impulses
for *renewables 2004***

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1 Introduction

Energy is a key theme for future world development. Worldwide energy demand is mounting rapidly, particularly in the developing and newly industrializing countries, which seek to catch up with the economic development attained by industrialized countries. The great challenge now is to meet this energy demand in a sustainable manner. Sustainable development will be inconceivable without a deep-seated reconfiguration of worldwide energy systems. One goal must be to protect natural life-support systems and, in particular, to prevent dangerous anthropogenic interference with the climate system. If the present path continues and rising energy demand is met mainly from fossil sources, this would trigger intolerable global climate change with high consequential costs, and would thus also jeopardize economic development. A second necessary goal is to overcome energy poverty in developing countries in order that these countries can make use of development opportunities. It is essential that 2.4 billion people gain access to modern forms of energy so that they can shake off the yoke of energy poverty.

To attain these two goals, energy systems need to be turned towards sustainability. To that end, efficiency must be improved at all levels of the energy system, and fossil energy sources must be substituted by renewable ones. The potential of renewable energies, above all solar energy, is almost unlimited and can be harnessed sustainably. Energy system transformation towards sustainability is thus the first step into the solar age. However, without rapid and resolute international policy support, the expansion of renewable energy sources will not be able to develop the necessary dynamics in time.

The international community recognized this challenge, putting renewable energies on the agenda of the World Summit on Sustainable Development (WSSD) held in Johannesburg in 2002. Unfortunately the Summit fell short of expectations with regard to sustainable energy system transformation. In particular, states were unable to agree upon concrete expansion targets for renewables. Consequently, upon Germany's initiative, during the conference a group of states formed the Johannesburg Renewable Energy Coalition (JREC) with the aim of taking joint action to move beyond the WSSD resolutions. The

International Conference for Renewable Energies (*renewables 2004*) due to take place in Bonn in June 2004 is a milestone of this process.

The conference holds out a unique opportunity to amplify and coordinate at the international level the necessary political support for renewable energies. This opportunity must be grasped, for the window of opportunity to prevent dangerous climate change is closing rapidly. Only if the right strategic decisions are taken now will it be possible to finance and implement energy system transformation towards sustainability without severe interventions in the socio-economic systems of industrialized and transition countries alike.

In its two most recent reports – 'Kyoto and Beyond' and 'Towards Sustainable Energy Systems' (WBGU, 2003, 2004) – the German Advisory Council on Global Change (WBGU) has shown that the transformation of energy systems will require major effort even if it is launched immediately. However, the Council has also made it clear that this transformation is both technologically and financially feasible. It has further illustrated which technologies and instruments can be harnessed, and has signposted a roadmap towards a sustainable energy future. The present policy paper sets out the Council's recommendations in a condensed and targeted form as input to *renewables 2004*.

2 Guard rails for sustainability

To operationalize sustainability requirements for energy systems, the Council has developed 'guard rails for sustainability'. Guard rails are quantifiable limits to damage whose transgression would entail intolerable consequences today or in the future. They thus mark out thresholds to the realm of non-sustainable development trajectories. Policies need to be shaped in such a way that energy systems are returned to the realm of sustainability, or in such a way that guard rails are not breached in the first place.

Preserving natural life-support systems

To preserve natural life-support systems, the Council has developed ecological guard rails:

- *Climate protection*: A mean global temperature change of more than 2°C relative to pre-industrial levels and a mean long-term rate of global temperature change exceeding 0.2°C per decade are intolerable parameters of global climate change. It will only be possible to remain within this climate window if energy systems are converted from the present use of fossil fuels (delivering approx. 85% of consumption worldwide) to climate-neutral energy sources. Renewable energies will need to play the main role in this context.
- *Sustainable land use*: 10–20% of the global land surface should be reserved for nature conservation. As a fundamental matter of principle, natural ecosystems should not be converted to bioenergy cultivation. Where conflicts arise between different types of land use, food security must have priority. Consequently not more than 3% of the global land surface should be used to cultivate bioenergy crops and establish plantations for carbon sequestration. This places limits upon the expansion of modern bioenergy.
- *Protection of rivers and their catchment areas*: In the same vein as terrestrial areas, about 10–20% of riverine ecosystems, including their catchment areas, should be reserved for nature conservation. This is one reason why hydroelectricity – after necessary preconditions have been met – can only be further expanded to a limited extent.
- *Protection of marine ecosystems*: In the view of the Council it is not tolerable to use the oceans to

sequester carbon, because knowledge about biological consequences is very fragmentary and ecological damage could be severe. Carbon sequestration must therefore be limited to depleted oil, gas and salt caverns.

- *Prevention of atmospheric air pollution*: Critical levels of air pollution are not tolerable. As a preliminary quantitative guard rail, it could be determined that pollution levels should nowhere be higher than they are today in the European Union, even though the situation there is not yet satisfactory for all types of pollutant. A final guard rail would need to be defined and implemented by multilateral environmental agreements and national environmental standards.

Overcoming energy poverty

To concretize the general objective of 'overcoming energy poverty', the Council has defined socio-economic guard rails:

- *Access to modern energy for all*: It is essential to ensure that everyone has access to modern energy, particularly electricity.
- *Meeting the individual minimum requirement for modern energy*: The Council considers the following final energy quantities to be the minimum requirement for elementary individual needs: By the year 2020 at the latest, everyone should have at least 500 kWh final energy per person and year (of which approx. 20% in the form of electrical energy) and by 2050 at least 700 kWh. By 2100 the level should rise to 1,000 kWh (whereby the relative proportion of electrical energy will increase significantly).
- *Limiting the proportion of income expended for energy*: Poor households should not need to spend more than one tenth of their income to meet elementary individual energy requirements.
- *Minimum requirement for macroeconomic development*: As a minimum energy requirement for macroeconomic development, all countries should command over at least that quantity of energy needed to achieve a per-capita gross domestic product of about US\$ 3,000, in 1999 values.

- *Keeping risks within a normal range:* A sustainable energy system needs to build upon technologies whose operation remains within the 'normal range' of environmental risk. Present production of energy by nuclear fission fails to meet this requirement, particularly because of its high accident risks and unresolved waste management, but also because of the risks of proliferation and terrorism.
- *Preventing disease caused by energy use:* Indoor air pollution resulting from the burning of biomass and urban air pollution resulting from the use of fossil fuels cause severe health damage worldwide. The overall health impact caused by this should not exceed 0.5% of the total health impact (measured in DALYs, disability adjusted life years) in each WHO region.

Compliance with these socio-economic guard rails assigns a key role to renewable energies. For only renewables can provide a broad-based additional energy supply without excessive health or environmental impairment.

The guard rail approach provides an excellent benchmark by which to test the degree of sustainability of energy systems. It would be important to achieve agreement on the guard rails at international level. To this end, the Council recommends that *renewables 2004* advances the process of adopting a World Energy Charter that includes guard rails as a key element (Section 7).

RECOMMENDATIONS

- Agree ecological and socio-economic guard rails.
- Enshrine guard rails within the World Energy Charter.

3 Global strategies for the expansion of renewable energies

In the process of energy system transformation towards sustainability, the use of renewable energy sources will play a key role. Their expansion must develop dynamically and without delay. This calls for consistent and long-term strategies, as well as vigorous political action. Because long-term perspectives are a critical basis for investment decisions in the industrial sector, international agreements are an essential element. Agreements on expansion targets for renewables need to be based upon analysis of what is necessary and what is possible.

Potentials and scenarios

In its two recent reports – ‘Towards Sustainable Energy Systems’ and ‘Kyoto and Beyond’ – the Council elaborated scenarios for a global transformation of energy systems. That work was founded upon an analysis of the global potentials available for each of the different energy sources. For these analyses, the Council introduced the concept of ‘sustainable potential’ which, besides technological restrictions, also integrates dimensions of sustainability as potential limitations (see Section 2 above). As a quantitative context for the following estimates, it may be noted that in the year 2000 the primary energy consumption of the whole of humanity figured 420 exajoules (420×10^{18} joules). The Council’s analyses found the sustainable potential of wind power to be approx. 140 exajoules per year, that of geothermal energy to be approx. 30 exajoules per year and that of bioenergy to be approx. 100 exajoules per year. In that analysis, the sustainable long-term potential of bioenergy concentrated upon modern forms of use because traditional uses (e.g. burning biomass in three-stone hearths) entail, among other problems, major health hazards. With a view to the – quite rightly – tightened requirements upon environmental and social acceptability, the Council estimates the sustainable potential of hydropower cautiously at 15 exajoules per year. The use of solar energy to generate e.g. power, heat or hydrogen is the only energy source for which, in relation to all projections of human energy requirements, no limitation is seen

according to present knowledge. The sustainable potential of solar energy is thus virtually unlimited in relation to human energy requirements.

To derive schedules for the expansion of renewable energies building upon this analysis of potentials, the Council examined timelines of global primary energy portfolios guided by ambitious CO₂ stabilization targets. This work proceeded from a range of scenarios developed by the International Institute for Applied Systems Analysis (IIASA) in Laxenburg, Austria, which permit analysis of a very broad range of potential global trajectories. In its report ‘Towards Sustainable Energy Systems’, the Council selected a model world characterized by very high economic growth and high energy demand. The aim of this exercise was to verify the technological and financial feasibility of a future energy system which, even under these extreme conditions, obeys the Council’s guard rails of sustainable energy policy. Figure 1 shows the resulting ‘exemplary transformation path’, in which renewables play a key role.

Strategies for expanding renewables

The following discussion of strategies for expanding different types of renewable energies distinguishes between two categories of renewables. One class (Group A) is already in large part (almost) competitive today, but is subject to two limitations upon expansion: One reason is that its sustainable potentials are limited (e.g. wind, biomass, hydro). Another is that if energy systems are restructured with efficiency improvement as a guiding principle, then within a few decades the demand for thermal energy in the buildings sector will no longer grow substantially. This particularly limits over the medium term the demand for thermal energy from solar sources and from biomass and geothermal sources.

A second class (Group B; e.g. solar electricity or solar-generated hydrogen) is still comparatively expensive today, but even extreme projections of human energy requirements do not approach the limits of its sustainable potential for expansion or deployment. The Council proceeds from the assump-

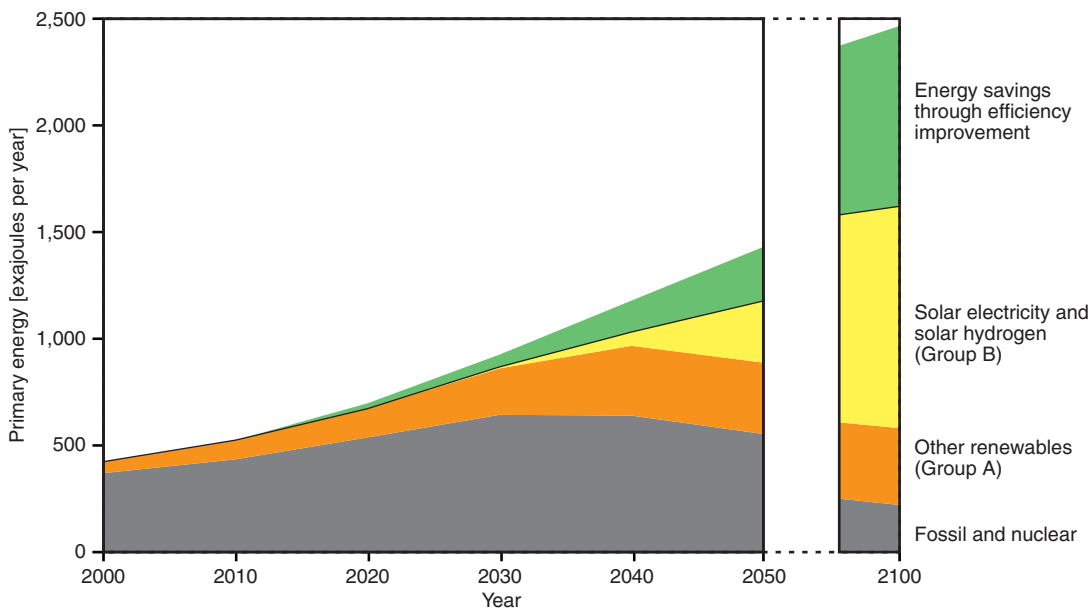


Figure 1: Global primary energy portfolio in the Council's exemplary transformation path. Primary energy is inventoried using the 'direct equivalent method'. If ambitious growth rates are applied, the expansion of renewable energy sources excluding solar power generation and solar hydrogen (Group A) reaches the limits of its sustainable potential around mid-century. Exponential expansion of the effectively unlimited energy carriers gained from solar energy sources – solar electricity and solar hydrogen (Group B) – can only then deliver the growth in renewables that will continue to be necessary in the second half of the century if, as assumed in the figure, an expansion rate of about 26% annually is achieved throughout the coming four decades. This corresponds roughly to the present rate of expansion, which, however, is essentially taking place only in Japan, Germany and the USA. Energy intensity (energy input per unit gross domestic product generated thereby) has improved globally in a historical perspective by about 1% per year. The Council recommends implementing ambitious efficiency strategies to raise the annual rate of energy intensity improvement over the medium term to 1.6% per year in a step-by-step process. The upper band in the Figure shows the primary energy savings compared to the business-as-usual 1% rate of energy intensity improvement. Source: after WBGU, 2003.

tion that the costs of supply will decline continuously and considerably with growing market volume for Group B energy sources.

Proceeding from these studies, the Council recommends the following global strategy for expansion: All Group A energy sources should be expanded swiftly up to their maximum sustainable potentials. Overall, an annual growth of about 5% over several decades is considered possible and necessary in this group. Group B energy sources presently only make a very small contribution to global energy requirements. This group should continue to be expanded over several decades at growth rates that, while high, correspond to rates currently already achieved. Ten-fold growth per decade, corresponding to 26% annual growth, is needed for Group B to be capable over the long term to deliver further continuous growth in renewable energies after Group A energy sources have reached their maximum potential. For

the global transformation of energy systems towards sustainability to succeed, these expansion rates need to be sustained at least until the year 2040.

This global strategy must be concretized by long-term, regionally disaggregated expansion roadmaps (Section 4). It is crucial to specify these roadmaps according to energy sources (wind, solar electricity etc.), and not to focus exclusively upon expansion of those options that are most cost-effective at a given point in time (e.g. Group A options), as this would prevent the critically important growth of Group B options. Figure 1 makes clear the need to persevere over many decades if global energy system transformation towards sustainability is to succeed.

The European Union, for instance, has set the target of raising its proportion of renewables in electricity production from 14% (1997) to 22% by 2010. The Council recommends that the EU meets at least 50% of its primary energy demand from renewable

sources by 2050, whereby the share of renewables in power supply should then have reached at least 60%.

Electricity-hydrogen economy

In the view of the Council, more intensive use of renewables will amplify the trend towards an electricity-hydrogen economy. Here, too, the transformation process must be launched in time. This includes, for instance, reinforcing electricity networks for the large-scale deployment of renewable sources and for worldwide interconnection (global link), as well as building an infrastructure for hydrogen and developing energy storage technologies, particularly for the transport sector.

Energy efficiency

Intensified efforts to improve efficiency are an indispensable element of global energy system transformation at all levels. Energy intensity, meaning the energy input per unit gross domestic product generated thereby, is a good indicator of energy efficiency.

In a historical perspective, this has improved globally by about 1% annually. The Council recommends implementing ambitious efficiency strategies that raise the rate of energy intensity improvement over the medium term to 1.6% annually. In view of the long service life of energy sector facilities (power plants, buildings, vehicles etc.), this can only be achieved in a step-by-step process (Fig. 1).

In the EU, energy efficiency strategies should be agreed in binding form, targeting particularly the transport and building sectors. In new building construction, an EU-wide standard should be implemented by 2010 according to which the external primary energy input per square metre floor space and year for heating, cooling, lighting and building services does not exceed an average of 60 kWh. This target can be achieved by applying solar and energy-efficient construction methods. By 2020, 40% of the entire building stock in the EU should achieve a performance of 100 kWh per square metre and year or better.

RECOMMENDATIONS

- Continue, as an ongoing, long-term process, the committed expansion of solar electricity and solar-generated hydrogen, increasing global capacity by about one-quarter each year.
- Tap, over the medium term, all sustainably utilizable potentials of wind energy, bioenergy, hydropower, geothermal and solar thermal energy.
- Initiate early enough the process of transformation towards a highly interconnected electricity-hydrogen economy.
- Improve efficiency at all levels of the global energy system.
- Adopt binding expansion targets for renewable energies and energy efficiency in the EU.

4 Implementing expansion strategies for renewables

Commitment to national expansion targets

In order to implement the expansion strategies for renewables on a differentiated basis for each energy carrier, as discussed in Section 3, it is desirable for those states which are willing to proceed to commit themselves to expanding renewables at national level first. Achieving such commitments to progressive expansion targets for renewable energies should be a key objective of *renewables 2004* and the follow-up process.

National contributions to global expansion targets should take account of countries' individual potential and be based on the sustainable potential of the various energy sources available in the country concerned. Such commitments could, for example, take the form of a quota (e.g. as a minimum percentage of electricity production or of fuels from renewable energies); alternatively, they could be formulated as absolute values (e.g. as installed energy generation capacity or an energy tax). It should also be possible, within a foreseeable period, for countries to meet a proportion of their expansion commitment by purchasing 'certificates' from countries exceeding their expansion target. This type of system of internationally tradeable quotas for renewable energy shares as a proportion of the total energy system could keep the costs of a global expansion of renewables low, while promoting international technology transfer at the same time.

Instruments for the expansion of renewables

Compared with conventional energy carriers, renewables are not yet competitive in some cases (Section 3). This is due, not least, to the failure to internalize the external costs of rival energy carriers. The ambitious expansion of renewables therefore requires targeted market launch strategies and measures to increase the price of other energy carriers, especially fossil fuels. However, there is no 'right' approach to implementing national expansion strategies. Methods which should be considered include price-based

instruments (e.g. subsidizing renewables, taxing fossil fuels) and quantitative instruments (e.g. minimum quotas and competitive tenders for renewable energies).

Energy supply experience in several countries shows that fixed rates for power sold to the grid (i.e. coupling an obligation to purchase with fixed payments) can achieve a rapid expansion of renewables. Once the market share of each energy carrier has been substantially expanded, the transition to a system of tradeable quotas may be beneficial in the medium to long term. In this way, the allocation, selection and innovation function of the market can be utilized more intensively in respect of renewables. In this context, the Council recommends the adoption of the 'Green Energy Certificates' concept, which is discussed in its report on energy. Here, the production certificates for electricity from renewables, for example, would be traded on a market which is separate from the electricity market itself.

Comprehensive ecological financial reforms would also promote the use of renewables. The ecological restructuring of the tax system, for example, would raise the price of fossil fuels and thus boost the competitiveness of renewable energies. As a 'go-it-alone' approach at national level would be difficult to enforce, especially in reducing environmentally harmful subsidies on energies, the Council recommends that negotiations be commenced on a Multilateral Energy Subsidization Agreement (MESA). The purpose of such an agreement would be to progressively dismantle subsidies on fossil and nuclear fuels.

Ultimately, it is a matter for the individual countries to decide which instruments they should use to expand their renewables; this cannot and should not be regulated, or indeed standardized, through international agreements. Nonetheless, with a view to establishing a system of internationally tradeable quotas and especially with the increasing liberalization of the energy markets, some degree of compatibility between national instruments at global level is desirable. The expansion of renewables can only suc-

ceed if far more resources are pumped into research and development (Section 6).

Renewable energies in development cooperation

To overcome energy poverty, energy policy aspects should be given greater priority in development cooperation. The World Bank, which is explicitly committed to sustainable development, should implement its theoretical findings more rigorously at operational level. The German federal government should push to ensure that the promotion of renewables is integrated into the Country Assistance Strategies (CAS). Moreover, energy poverty is currently not a topic for negotiation in the context of the Poverty Reduction Strategy Papers (PRSP). Indeed, environmental issues are generally not given sufficient priority. As the World Bank exerts great influence over the preparation of the PRSPs, the discussion process launched in 2003 to take greater account of renew-

ables in the PRSPs and the CAS should be accelerated.

The Council also notes, once again, that the funds provided through official development assistance (ODA) must be increased to at least 0.5% of GDP by 2010. Furthermore, far more resources than at present should flow into sustainable energy projects, especially the promotion of renewables (see model projects, Section 5). In this context, the Council welcomes the 'Sustainable Energy for Development' programme announced by the German federal government at the WSSD in 2002, which aims to develop strategic energy partnerships; however, the Council recommends an increase in the envisaged funds. More intensive cooperation between public institutions and business (public-private partnership) in the field of renewables could help increase the funds deployed and encourage the efficient use of these resources. In contrast, direct subsidization of non-sustainable energy projects through development cooperation and public-private partnerships should cease. The same applies to indirect subsidization of non-sustainable energies through export credit agencies.

In order to ensure that special priority is given to renewables in international climate policy, the use of renewable energy carriers in developing countries should be included on a priority list for CDM projects. However, the CDM alone will certainly not be enough to fund the global transformation of energy systems towards sustainability. For that reason, the GEF, which has emerged as an important funding institution for global environmental protection in recent years, should be upgraded and endowed with additional financial resources. A dedicated GEF window for renewables as well as for efficiency technologies is recommendable ('window for sustainable energy systems'). The global warming emissions of international aviation are not yet subject to any satisfactory regulatory regime – the user charges on international aviation recommended by the Council (WBGU, 2002) could contribute to financing the GEF window.

RECOMMENDATIONS

- Establish binding national expansion targets for renewables.
- Seek to create an international system of tradeable expansion commitments for renewables in the medium term (internationally tradeable quotas).
- Commence negotiations on a Multilateral Energy Subsidization Agreement (MESA).
- Promote renewable energies through the World Bank's policies.
- Allocate far more funding to the promotion of renewables within the context of development cooperation.
- Include the use of renewable energy carriers on a CDM priority list.
- Establish GEF window for sustainable energy projects.

5 Model projects in international cooperation

The Council recommends deploying a small number of large-scale model projects to provide strategic leverage for the global transformation of energy systems towards sustainability. Successful lighthouse projects undertaken in international cooperation help to remove barriers, demonstrate what is already technologically feasible today and generate positive incentives for investors. The projects proposed here centre on lynchpins of a sustainable transformation strategy: grid-connected power supply, distributed electrification of rural regions, provision of energy for food preparation in developing countries and, finally, solar and energy-efficient building concepts. All model projects should be accompanied by research programmes in the spheres of monitoring and project analysis, in order to generate learning effects and disseminate the experience gained in an effective manner.

Sahara power for North Africa and Europe

The Council recommends establishing a strategic energy partnership between the European Union and North Africa. For Europe, this would not only be an important further step on the path towards rapidly deploying a climate-relevant volume of renewable energies; it would also be a major step towards more intensive economic and foreign policy cooperation with North Africa. For North Africa, this partnership would present an opportunity to link climate protection with industrial and social development, and to do so already over the medium term. The energy partnership could be a driving force for development in the region. The establishment of such a partnership should be launched through the following concrete initiatives:

- Planning and putting out to tender a large-scale photovoltaic power plant as well as a large-scale solar thermal power plant, in cooperation with one or several North African countries;
- Planning and putting out to tender a large-scale wind farm, in cooperation with one or several North African countries;

- Planning and putting out to tender a North African interconnected transmission line, as well as a transmission line from North Africa to Europe;
- Establishing a European liaison office for North African project partners and European investors.

As far as is compatible with competition law, the EU should ensure that the project package is sufficiently economically attractive by signing time-limited electricity purchase agreements at guaranteed prices in order to secure private-sector support for the project's implementation. Similar lighthouse projects could be initiated in various regions across the world.

Biogenic liquefied gas for cooking

In developing countries, the traditional use of biomass often poses major problems (health impairment caused by fumes, over-exploitation of local timber resources), which could be reduced by progressively replacing e.g. three-stone hearths with liquefied gas cookers. However, for reasons of climate protection, the large-scale use of liquefied gas from fossil sources cannot be viewed as sustainable in the long term. Via gasification or fermentation with a subsequent reforming process, synthesis gas (CO/H₂ gas mixture) can be produced from biomass, from which in turn liquefiable hydrocarbons can be produced that are easier to transport. This allows for producing biogenic liquefied gas. Moreover, in many cases the chemical processes involved can be supported through the use of solar thermal energy. The Council recommends:

- Stepping up the substitution of traditional three-stone hearths with liquefied gas cookers within the context of development cooperation activities;
- Developing, through research cooperation with one or more developing countries, facilities for the environmentally sound synthesis of liquefied gas from biomass that are adapted to local conditions.

Energy-efficient minimum-cost buildings

In order to improve the living conditions of disadvantaged population groups in developing and newly industrializing countries, state programmes are erecting many new housing units. These, however, largely neglect aspects of sustainable construction. The Council recommends carrying out, within the context of development cooperation activities and in cooperation with partners in newly industrializing and developing countries, large-scale demonstration projects (involving many thousands of housing units) in the field of solar and energy-efficient minimum-cost construction.

Improving power quality in rural regions

When bringing electricity to rural regions in developing countries, a frequent problem is that due to low user density, large distances have to be bridged in weak electricity grids. This reduces electricity quality greatly, especially for users in more remote areas. The technologies developed in a number of industrialized countries to integrate distributed renewable energy sources into the grid could be utilized profitably and cost-effectively to improve this situation, but they are still sometimes unfamiliar to the local grid operators. The Council recommends that within the framework of technical and financial cooperation a selected rural region be electrified in cooperation with a larger

regional energy supplier and using these novel technologies. Within this project, power should be fed into the grid from distributed renewable sources to a major degree. Cooperation with a local grid operator is essential, particularly in order to produce a multiplier effect.

'One Million Huts' electrification programme

As part of the process of electrifying rural regions in developing countries, distributed approaches such as individual photovoltaic systems and microgrids are essential – alongside intelligent grid expansion and reinforcement – as a response to low population density. Until now, this type of project has taken place on too small a scale to develop the necessary momentum. Moreover, in many cases social and technological settings have not been taken into account adequately. The Council therefore recommends launching a 'One Million Huts' electrification programme on the required scale and with the necessary duration, which must also include a new dimension of in-process technological and socio-economic support. For the project to have a sustained impact, it should draw on the expertise of leading companies from industrialized countries, be accompanied by regional training programmes, and involve the development of local financing structures and supply industries.

RECOMMENDATIONS

Initiate large-scale model projects in international cooperation:

- Sahara power for North Africa and Europe.
- Biogenic liquefied gas for cooking.
- Energy-efficient minimum-cost buildings.
- Improving power quality in weak grids of rural regions, involving the deployment of renewable sources.
- 'One Million Huts' electrification programme for rural areas in developing countries.

6 Research and development

The large-scale expansion of renewable energies is a major technological and social challenge which can only be mastered if substantial resources are pumped into research and development worldwide. This applies to research in science and technology as well as in the social sciences.

Social sciences

The aim must be to identify the obstacles to the rapid expansion of renewables and develop strategies to overcome them. At the same time, research is needed on acceptance and proliferation strategies in both industrialized and developing countries. In this context, priority should be given to:

- Researching instruments for the direct promotion of renewables (e.g. fixed rates for power sold to the grid, and quotas/certificate schemes for grid-connected renewables, fee-for-service schemes and microcredits for off-grid applications);
- Devising strategies for the more intensive development of local capacities in developing countries and more effective dissemination of information on renewables and their benefits;
- Researching the targeted use and development of flexible climate instruments (Clean Development Mechanism, Joint Implementation) for the promotion of renewables.

Science and technology

The task of transforming energy systems towards sustainability cannot be restricted to a few technologies. The underlying technology portfolio must be broad-based. To this end, priority must be given to the following areas:

- Researching technologies which are essential for the long-term development of energy systems (e.g. photovoltaic technology, energy efficiency);
- Working on technologies which require only minimal further development to open up major new markets (e.g. solar thermal power plants and wind power in developing countries, biogenic synthesis gas);
- Improving and adapting those technologies which in many cases can already be deployed cost-effectively (e.g. solar and energy-efficient

buildings, photovoltaic electricity supply for off-grid applications, modern methods of biomass use).

Funding for research and development

The expectations made of research into the transformation of energy systems towards sustainability cannot be met within the current financial framework. For example, the OECD's spending on research and development in the energy sector has more than halved since 1980. For this reason,

- in the industrialized countries to 2020, direct public spending on research and development in the energy sector should increase at least tenfold, e.g. through reallocations. There should be a rapid shift away from the prioritization of fossil energy and energy from nuclear fission towards renewables and efficiency measures.
- In order to maintain and expand the positions achieved in research and technology development, a focussed research and development campaign should be launched in Germany which covers both the technical use of renewable energy sources and greater energy efficiency. To this end,
- German resources for research and development in renewables and energy efficiency should at least be doubled in the next five years.

Research coordination

In order to ensure that these more intensive research efforts impact effectively at global level, better coordination of research at international level is also required. To this end,

- a World Energy Research Coordination Programme (WERCP) should be established under the auspices of the UN, responsible for strategic coordination and the provision of advice on national energy research activities.

Energy research benefits if different research projects work on the same topic to some extent, thus promoting innovation and development on the basis of competition. The Council therefore endorses pluralism and diversity in the international research landscape, both on the implementing and on the funding

side. This pluralism could be structured efficiently through WERCPC.

Based on continuous monitoring and analysis of the international research landscape, WERCPC should provide advice and coordination to countries and relevant institutions in order to align and optimize their international research and development strategies. It should also manage a global strategic fund for research and development. Here, projects designed for developing countries should focus in particular on adapting the modern energy technologies existing in the industrialized countries to local needs. In this context, WERCPC should also organize an intensive international exchange of scientists working in the energy sector.

Scientific policy advice

The political implementation of a transformation of energy systems towards sustainability should be continuously underpinned by independent research analyses. By promoting awareness of scientific research and the various options for action, the basis can be established for policy-making bodies to adopt preventive strategies and bring existing policies into line with new requirements. The Intergovernmental Panel on Climate Change (IPCC) can serve as a model here, since it demonstrates how, through the

broad-based participation of researchers from around the world, a recognized scientific basis for climate policy decisions can be established. In the energy sector too, the aim should therefore be to report regularly – at least every five years – on the successes and failures in implementing the global transformation of energy systems towards sustainability. The Council therefore recommends,

- the establishment of an Intergovernmental Panel on Sustainable Energy (IPSE).

The aim should be to achieve the greatest possible regional presence, so that, as with the IPCC, the participation of scientists from developing countries can be supported through targeted funding.

RECOMMENDATIONS

- Increase direct public spending on research and development in the energy sector in the industrialized countries tenfold by 2020.
- Shift energy research and development priorities rapidly away from fossil energy and energy from nuclear fission towards renewables and efficiency.
- Establish a World Energy Research Coordination Programme (WERCPC) under the auspices of the UN.
- Establish an Intergovernmental Panel on Sustainable Energy (IPSE).

7 Adopting a World Energy Charter

To establish a common substantive foundation for the activities of relevant international players, the Council recommends developing a global strategic framework in the form of a World Energy Charter. The Charter could initially be adopted in non-binding form at intergovernmental level, retaining the option for long-term further development into a legally binding convention with verifiable targets and timetables. It would remain the task of states and international institutions to implement the Charter. The World Energy Charter should enshrine key elements of international policy for energy system transformation towards sustainability.

Agreeing guard rails for sustainability

To conceptualize and operationalize energy system transformation towards sustainability, quantifiable limits to damage must be defined. Here the concept of guard rails for sustainability, as developed by the Council, offers a useful approach (Section 2). For the energy sector the Council has proposed concrete guard rails designed to safeguard both the preservation of natural life-support systems (ecological guard rails) and the eradication of energy poverty (socio-economic guard rails). Guard rails should be agreed at international level.

Principles of global energy system transformation

Present energy systems harm the natural environment in many ways, jeopardize human health and pose major security risks. Their global transformation is therefore essential in order to preserve the natural life-support systems on which humanity depends, and to overcome energy poverty in developing countries. This can only succeed through a fundamental transformation of energy systems. The Charter signatories should establish the following principles:

- Substantially improving energy productivity (e.g. through energy conservation);
- Significantly expanding renewables, while reducing the share of fossil sources in the energy mix;
- Phasing out nuclear power;

- Securing access to modern energy forms and attaining a minimum level of supply worldwide;
- Combining regulatory and private-sector elements;
- Enhancing developing countries' capabilities.

International cooperation

Bi- and multilateral cooperation is the key to energy system transformation. Without international political support, this transformation will not succeed in time. To promote international cooperation, the following elements are essential:

- Aligning the activities of relevant players at international level (e.g. World Bank, UN organizations) with energy system transformation;
- Pooling and strengthening global energy policy activities at institutional level;
- Improving scientific policy advice at international level;
- Organizing information and technology transfer;
- Using model projects for strategic leverage, and engaging in energy partnerships;
- Removing subsidies for fossil and nuclear energies, and multilaterally agreeing promotion measures for renewables;
- Mobilizing financial resources for global energy system transformation.

Research and development

For renewable energy technologies and energy efficiency measures to come into widespread use over the medium to long term at low cost, there is a need for sustained and high investment in research and development (Section 6) by:

- Drastically increasing technological and non-technological research efforts in the renewable energy sector;
- Increasing tenfold the direct state expenditure for research and development in the energy sector in industrialized countries by 2020.

Renewables 2004 is the ideal forum to initiate adoption of the World Energy Charter within a circle of like-minded, advanced states. At present it would

appear that the international community will need to develop such a sustainable global energy strategy even without the initial participation of a number of important countries. Nonetheless, it may be expected that the dynamics of technology development in the renewable energy sector and the long-term superiority of renewable technologies over fossil and nuclear development paths will lead nations still hesitant today to change course over the medium term.

RECOMMENDATIONS

Develop a World Energy Charter containing the following elements:

- Guard rails for sustainable energy policy.
- Principles for the global transformation of energy systems towards sustainability.
- Alignment of international cooperation with sustainable energy policies.
- Targeted strengthening of research and development in the energy sector.

8 Follow-up process

Renewables 2004 will give fresh impetus to the dynamic process towards global expansion of renewable energies initiated in Johannesburg. However, the conference should not remain a singular event, but should rather provide the starting point for resolute international action. To move ahead vigorously with efforts to expand the share of renewables in the energy mix, as well as to improve energy efficiency worldwide, a strong follow-up process should

- Institutionalize the coordination and steering of sustainable energy policies;
- Ensure the monitoring of targets and measures;
- Facilitate linkages with other international processes.

Coordinating and steering the follow-up process

To advance the conference follow-up process, a coordinating and steering body is essential. The Council doubts that the Johannesburg Renewable Energy Coalition (JREC; Section 1) can perform this function, as this is steered by the EU and attached institutionally to the European Commission. This will make it difficult to elicit participation of further states in the Coalition. The Council therefore does not recommend expanding the JREC Secretariat.

The positive experience gained with the global environmental forum held at ministerial level rather suggests establishing a Global Ministerial Forum for Sustainable Energy. Supported by a secretariat, the task of this new body would be to support and coordinate the activities of the participating countries, to ensure communication and the exchange of experience, and to generate political consensus. Furthermore, it should be responsible for coordinating, reviewing and advancing the step-by-step institutional strengthening of global energy policy upon the basis of a World Energy Charter (Fig. 2). The secretariat of the forum would facilitate the monitoring of national expansion targets and strategies, and would e.g. collate and evaluate progress reports. The secretariat would also perform an important clearing-house function, drawing attention to best practices and promoting lighthouse projects. If it does not prove possible to set up such a ministerial forum, an

informal working group on the follow-up process should be established in its place.

Over the medium term, these and further tasks could be performed by a new International Sustainable Energy Agency (ISEA). The greatest additional value of the ISEA would be that this could, for the first time, integrate at global level energy, environment and development issues and could address these in an institutionally concentrated manner. The agency would not only perform a key function in promoting renewables, but would also integrate the entirety of energy systems in the process of reform.

Germany, as conference host and as a country that has adopted a leading position in the process of implementing energy system transformation, has a special responsibility. The Council recommends to the German federal government that, as a part of its efforts to live up to this commitment, it makes a substantial contribution to the institutional safeguarding of the follow-up process, for instance by providing time-limited basic funding for a secretariat of the ministerial forum or of the informal working group.

It will further be exceedingly important to expand the group of like-minded countries after the conference. To this end, states will need to be convinced that a mix of sustainable energies with efficiency improvements in the energy system is a development path holding great promise for the future. Developing countries should be able to reckon with financial support. The momentum generated by *renewables 2004* needs to be maintained by follow-up conferences, held above all in developing countries.

The Council further notes the importance of promoting networks linked closely to the goals of *renewables 2004*, e.g. the EU poverty reduction initiative (EUEI), the Global Network on Energy for Sustainable Development initiated by UNEP, or the Global Village Energy Partnership. Networks are particularly important to build technological, scientific and economic capacity in developing countries. This can be done by promoting regional cooperation between industrialized and developing countries (North-South cooperation) and among developing countries (South-South cooperation). On the demand side in particular, i.e. the awareness and behaviour of con-

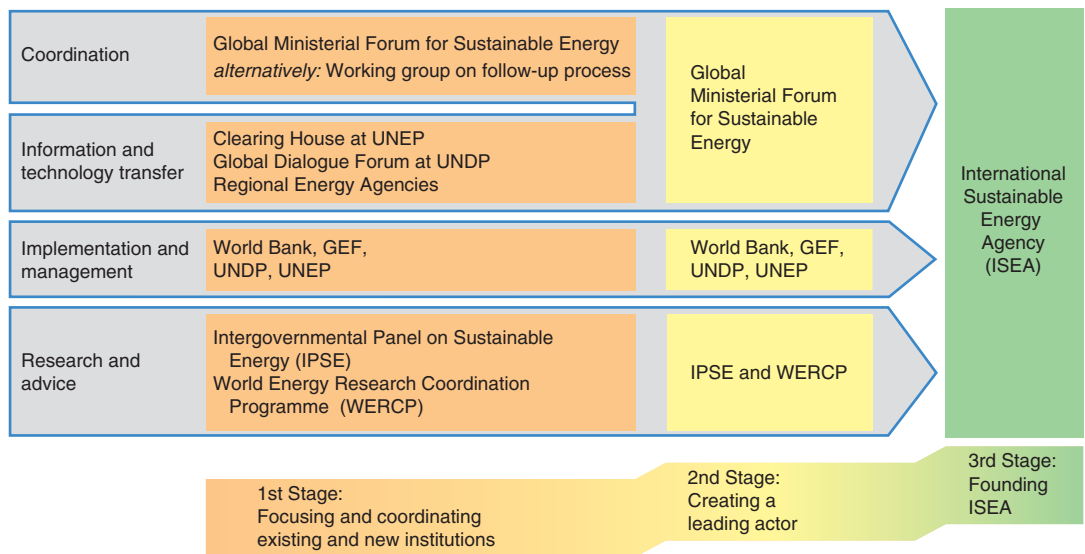


Figure 2: The Council's scheme for a step-by-step strengthening of the institutional architecture for global energy policy. In a 1st Stage, the activities of existing and new organizations should be coordinated. Building upon that stage, the institutional foundations of global energy policy should be further strengthened by channelling and building competencies (2nd Stage). Finally, if appropriate, the establishment of a new overarching institution should be considered (International Sustainable Energy Agency – ISEA; 3rd Stage). Source: after WBGU, 2003.

sumers, but also in relation to the implementation of structural change in the political and social realms, civil society networks perform key functions for energy system transformation. A global dialogue forum – for instance in the form of the already established UNDP Global Round Table on Energy for Sustainable Development – could improve exchange among all actors in society on objectives, measures and new partnerships.

The public sector will not be able to muster on its own the financial resources required for energy system transformation. In the opinion of the Council, great importance will therefore attach in the coming years to the establishment of new (public-private) partnerships among state, civil society and private sector actors.

Monitoring

In the opinion of the Council, it will be key to the success of both international and national objectives and measures that governments prepare regular progress reports. These reports should be oriented to criteria that can be derived from the principal goals of the conference, such as: measurable progress in energy efficiency, expansion of new renewable energies, assessment of poverty and equity impacts, progress towards attainment of the United Nations Millennium Development Goals, and alignment with long-

term environmental protection goals. The conference should resolve to launch a process for the definition of these criteria. Governments should be under an obligation to report to both the international community and their own national parliaments. The process of preparing these progress reports should involve private-sector, scientific and civil-society interest groups. They should also be submitted to the UN Commission on Sustainable Development (CSD) at its energy session due in 2006/07.

Taking up the conference outcomes in international processes

In the opinion of the Council, development policies that dovetail closely with global environmental policies can act as a catalyst for the transformation of energy systems. Besides the re-orientation of multi- and bilateral donors called for in Section 4 above, steps to promote sustainable energy policies should also be made a key component of coherent poverty reduction strategies on the part of the international community. Programmatic calls for a re-orientation of international policy towards globally sustainable development are numerous, but only the first tentative steps have been taken in actual practice. This re-orientation needs to be advanced vigorously in order to accelerate renewable energy expansion in developing countries. For energy system transformation to

proceed successfully, energy policy measures will also need support at national level in other sectors, notably in climate, transport and agricultural policy.

The CSD will take up energy policy as a focal theme again in 2006/07. That session should follow on from the impulses generated by *renewables 2004*. To improve the integration of environmental aspects into energy policy, as well as into other policy spheres, it will be important to ensure that further departments, above all the ministers of economics and of energy, are involved in the Commission in addition to environment and development ministers.

The United Nations Framework Convention on Climate Change (UNFCCC) has a key function for international energy policy. Whether the positive influence of international climate policy upon energy policy can emerge as a pacemaker of change hinges on the ratification of the Kyoto Protocol and on the development of climate negotiations over the next years. Here the main issue will be to tighten industrialized country targets in an appropriate manner and to involve developing countries in the process in a fashion that gives them leeway for development while at the same time helping them to embark early upon a path which is sustainable in energy policy terms.

RECOMMENDATIONS

- Agree upon regular country progress reports, and upon a process for defining criteria for these reports.
- Establish a Global Ministerial Forum for Sustainable Energy with its own secretariat, or, alternatively, an informal working group on the follow-up process.
- Organize follow-up conferences, particularly in developing countries.
- Promote existing global networks and public-private partnerships in the energy sector, and establish a global forum for dialogue.
- Take up the conference outcomes in international processes such as the CSD and the UNFCCC, and support energy policy measures in other sectors at national level.

CONCLUSION – IMPULSES FOR *RENEWABLES 2004*

The Council recommends to the German federal government that it works towards the following goals within the context of the International Conference for Renewable Energies – *renewables 2004*:

- *Adopting binding expansion targets*: Countries willing to proceed should commit themselves at the conference to quantitative targets for the expansion of renewable energies at national level. It is crucial in this context to harness and further develop a broad range of technologies for the utilization of renewable energy sources and for the improvement of energy efficiency. Agreements on targets must take into account the sustainable potentials of the individual energy sources. According to present technological knowledge, solar electricity generation should be expanded with ambitious targets over a period of several decades, as a sustainable global energy supply does not appear achievable without large-scale use of solar energy (Sections 3 and 4).
- *Adopting a World Energy Charter*: A global energy strategy in the form of a World Energy Charter should be a key outcome of *renewables 2004*. This Charter should set out the essential elements of a sustainable global energy policy, and should provide relevant players at international level a joint platform for action (Section 7).
- *Strengthening and concentrating the institutional architecture of global energy policy*: The Council urges that *renewables 2004* decides upon – or better still establishes – a Global Ministerial Forum for Sustainable Energy with the remit to coordinate and orient relevant actors and programmes. Over the medium term, the Council argues for the establishment of an International Sustainable Energy Agency (ISEA; Section 8). At the same time, policy advice and research activities need to be enhanced at an international level: To achieve this the Council recommends, first, setting up an Intergovernmental Panel on Sustainable Energy (IPSE) charged with analysing and assessing global energy trends and identifying options for action, and, second, initiating a World Energy Research Coordination Programme (WERCP) with the task of coordinating and optimizing at the international level national research and development strategies (Section 6).

- *Using model projects in international cooperation for strategic leverage:* The Council recommends developing a small number of large-scale model projects in international cooperation, which have the potential to set in motion the transformation of energy systems in many parts of the world (Section 5). These projects could be agreed upon and communicated to a wider public at *renewables 2004*.
- *Stepping up research and development through targeted support:* The Council recommends that direct state expenditure in industrialized countries for research and development in the energy sector be increased at least tenfold by 2020. The thematic focus of R&D should be shifted swiftly from fossil energy and energy from nuclear fission to renewable energies as well as efficiency improvement. For Germany, the Council recommends launching a focussed research and development drive; this should be underpinned by doubling the funding available for renewables and energy efficiency within the next five years (Section 6). The German federal government could present at *renewables 2004* a comprehensive research and development programme on renewables and energy efficiency, including a budget.
- *Expanding the European Union's pioneering role:* The Council recommends setting ambitious targets for the expansion of renewables by 2050 within the EU. Within the individual member states, binding country-specific expansion targets should be oriented to national capacities and to the sustainable potentials of the various energy sources available in each country. Moreover, EU-wide energy efficiency strategies should be adopted as soon as possible. These must target in particular the transport and building sectors (Section 3).

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