

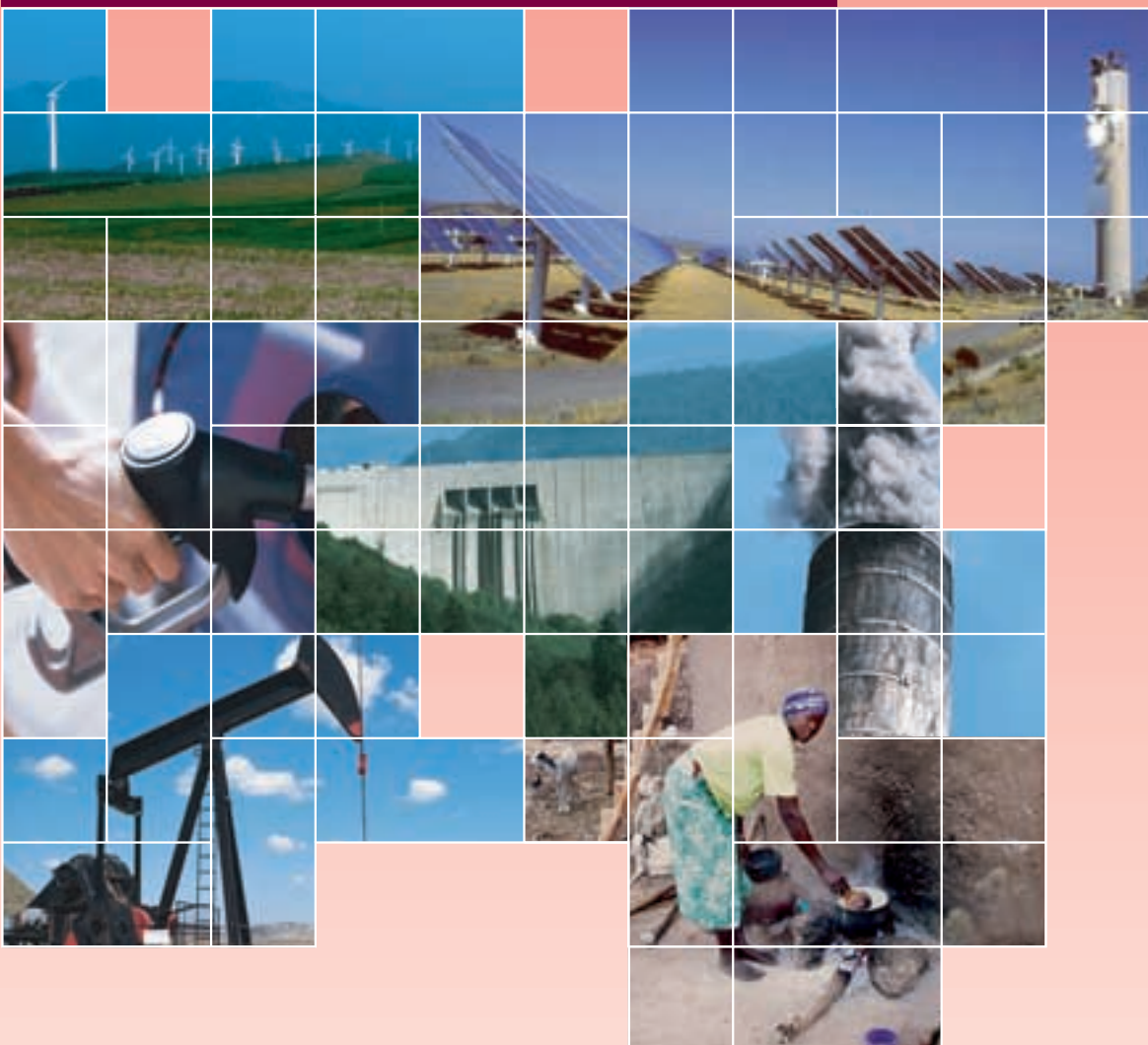
World in Transition



German Advisory Council
on Global Change
(WBGU)

Towards Sustainable Energy Systems

Summary for
Policy-Makers



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(as on 21.03.2003)

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German Advisory Council on Global Change

Summary for policy-makers

World in Transition:

Turning Energy Systems Towards Sustainability

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Summary for policy-makers

The first section of this summary for policy-makers presents in brief the prime concerns surrounding today's energy systems, while the second proposes the criteria that need to be met to turn energy systems towards sustainability. The third section, building upon an exemplary scenario, sets out a possible path for transforming the global energy system within the 21st century; this will require a substantial redirection of energy policies over the coming decades. On that basis, the fourth section proposes a roadmap with concrete goals and policy options for action by which to implement this global transformation.

1 **Why it is essential to transform energy systems worldwide**

The German Advisory Council on Global Change (WBGU) illustrates in the present report that it is essential to turn energy systems towards sustainability worldwide – both in order to protect the natural life-support systems on which humanity depends, and to eradicate energy poverty in developing countries. Nothing less than a fundamental transformation of energy systems will be needed to return development trajectories to sustainable corridors. A further important aspect is that such a global reconfiguration of energy systems would promote peace by reducing dependency upon regionally concentrated oil reserves.

1.1 **The use of fossil energy sources jeopardizes natural life-support systems**

Today, 80 per cent of worldwide energy use is based on fossil energy sources, and this share is rising. Burning these fuels releases emissions to the environment, where they cause climatic changes, air pollution and human disease. The effects of emissions can be local (in the case of grit, benzene or soot), regional

(aerosols, short-lived gases) or global (persistent greenhouse gases). Global climate protection is the supreme challenge presenting an urgent need to transform energy systems.

Emissions of persistent greenhouse gases – above all carbon dioxide, but also methane and nitrous oxide – contributed substantially over the past 100 years to a 0.6°C increase in the mean ground-level air temperature. For the next 100 years, the Intergovernmental Panel on Climate Change (IPCC) forecasts a rise in mean temperature ranging between 1.4 and 5.8°C, depending upon humanity's behaviour and without taking climate protection measures into consideration. The Council considers a mean global temperature change of more than 2°C compared to pre-industrial levels to be intolerable. The predicted shift in climatic regions, in combination with more frequent weather extremes such as floods and drought, has the potential to impair severely, for millions of people, the natural basis of human existence. Developing countries are particularly threatened. Damage to sensitive ecosystems is already evident today. The risk of irreversible ecosystem damage grows in line with the level and rate of warming.

Besides carbon dioxide, the burning of fossil fuels generates benzene and soot emissions with numerous damaging effects on health and ecosystems. It also generates nitrogen oxides, hydrocarbons and carbon monoxide, which promote the formation of ground-level ozone and reduce the self-purifying capacity of the atmosphere. Nitrogen and sulphur oxides, as well as ammonia, are converted chemically in the atmosphere and enter soils through acid deposition. Present energy systems damage the natural environment in many and diverse ways, jeopardize human health and exert massive influences upon biogeochemical cycles.

1.2 Two billion people lack access to modern forms of energy

Improving access to advanced energy in developing countries is a fundamental contribution to poverty reduction and key to attaining the United Nations Millennium Development Goals. For some 2.4 billion people, notably in rural parts of Asia and Africa, energy supply depends largely or entirely upon biomass use (firewood, charcoal or dung) for cooking and heating. On average, 35 per cent of energy consumed in developing countries derives from biomass; in parts of Africa this share reaches 90 per cent. According to the World Health Organization, emissions from the burning of biomass and coal indoors

cause the death of 1.6 million people every year. This is substantially more than the one million deaths caused by malaria. A transformation of energy systems towards sustainability is therefore essential in order to overcome development problems.

2 A corridor for sustainable energy policy: Guard rails for a global transformation

Sustainable transformation paths are bounded by so called “guard rails”. The Council defines these guard rails as those levels of damage which can only be crossed at intolerable cost, so that even short-term utility gains cannot compensate for such damage (Box 1). For instance, if, in the interests of short-term

Box 1

Guard rails for sustainable energy policy

Ecological guard rails

CLIMATE PROTECTION

A rate of temperature change exceeding 0.2°C per decade and a mean global temperature rise of more than 2°C compared to pre-industrial levels are intolerable parameters of global climate change.

SUSTAINABLE LAND USE

10–20 per cent of the global land surface should be reserved for nature conservation. Not more than 3 per cent should be used for bioenergy crops or terrestrial CO₂ sequestration. 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.

PROTECTION OF RIVERS AND THEIR CATCHMENT AREAS

In the same vein as terrestrial areas, about 10–20 per cent of riverine ecosystems, including their catchment areas, should be reserved for nature conservation. This is one reason why hydroelectricity – after necessary framework conditions have been met (investment in research, institutions, capacity building etc.) – can only be expanded to a limited extent.

PROTECTION OF MARINE ECOSYSTEMS

It is the view of the Council that the use of the oceans to sequester carbon is not tolerable, because the ecological damage can be major and knowledge about biological consequences is too fragmentary.

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 pollutants. A final guard rail would need to be defined and implemented by national environmental standards and multilateral environmental agreements.

Socio-economic guard rails

ACCESS TO ADVANCED ENERGY FOR ALL

It is essential to ensure that everyone has access to advanced energy. This involves ensuring access to electricity, and substituting health-endangering biomass use by advanced fuels.

MEETING THE INDIVIDUAL MINIMUM REQUIREMENT FOR ADVANCED 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 and by 2050 at least 700 kWh. By 2100 the level should reach 1,000 kWh.

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 MACROECONOMIC DEVELOPMENT

To meet the macroeconomic minimum per-capita energy requirement (for energy services utilized indirectly) all countries should be able to deploy a per-capita gross domestic product of at least about US-\$ 3000, 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. Nuclear energy fails to meet this requirement, particularly because of its intolerable 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 air pollution in towns and cities resulting from the use of fossil energy sources causes severe health damage worldwide. The overall health impact caused by this should, in all WHO regions, not exceed 0.5 per cent of the total health impact in each region (measured in DALYs, disability adjusted life years).

economic gains, the energy sector is transformed too late, global warming will be driven to the point at which the costs of inaction would be much higher over the long term due to the economic and social upheaval that is then to be expected. Guard rails are not goals: They are not desirable values or states, but minimum requirements that need to be met if the principle of sustainability is to be adhered to.

3 Turning energy systems towards sustainability is feasible: A test run for system transformation

The sustainability of scenarios for energy futures can be tested against the guard rails set out in the previous section. In principle, many developments are conceivable that would turn today's worldwide energy systems towards sustainability. Insofar, the scenario created in this report should be viewed as one example (Fig. 1). Building upon scenarios for the stabilization of CO₂ concentrations in the atmosphere at a maximum of 450 ppm, this report shows that the global transformation of energy systems over the next 100 years is in principle technologically and economically feasible.

The exemplary path charted by the Council embraces four key components:

1. Major reduction in the use of fossil energy sources;
2. Phase-out of the use of nuclear energy;
3. Substantial development and expansion of new renewable energy sources, notably solar;
4. Improvement of energy productivity far beyond historical rates.

Analysis of this path yields the following key findings:

- Worldwide cooperation and approximation of living conditions facilitate rapid technology development and dissemination. High economic growth can then, in conjunction with a strong increase in energy productivity, lead to sustainable energy supply.
- It will only be possible to meet minimum climate protection requirements if binding CO₂ reduction requirements are in place.
- Energy policy activities need to be supported by further measures to reduce greenhouse gas emissions from other sectors (for instance nitrous oxide and methane from agriculture) and to preserve natural carbon stocks.
- While the exemplary path developed here is based upon a stabilization of atmospheric CO₂ concen-

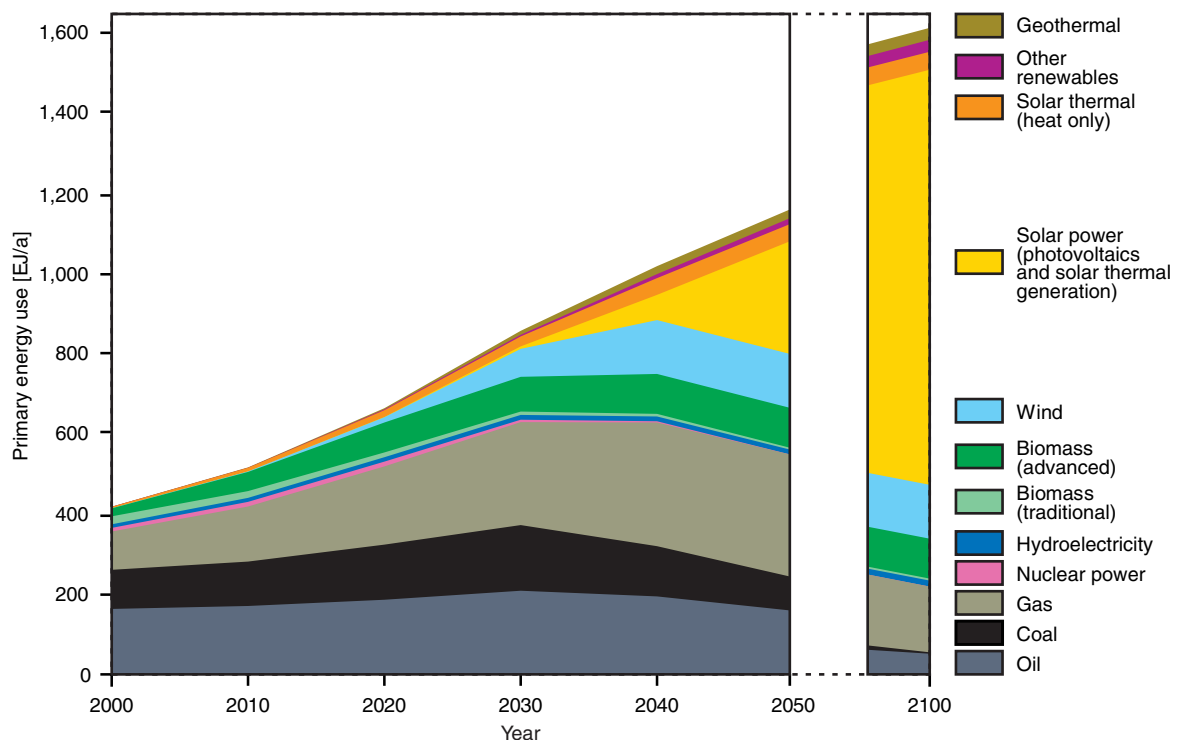


Figure 1
Transforming the global energy mix: The exemplary path until 2050/2100.
Source: WBGU

trations at 450 ppm, due to uncertainties attaching to climate system behaviour this can by no means be taken as a safe stabilization level. The Council recommends retaining options by which to achieve lower stabilization concentrations.

- Even if climate protection goals are met, a fossil-nuclear path entails substantially larger risks, as well as much higher environmental impacts. Moreover, it is significantly more expensive over the medium to long term than a path relying upon promoting renewables and improving energy efficiency, mainly due to the costs of CO₂ sequestration.
- Due to the long time lags, the next 10–20 years are the decisive window of opportunity for transforming energy systems. If this transformation is initiated later, disproportionately high costs must be expected.
- The transformation will only succeed if the transfer of capital and technology from industrialized to developing countries is intensified. To this end, industrialized countries will need to strengthen technology development significantly in the fields of energy efficiency and renewable energy sources, for instance by raising and redirecting research and development expenditure, implementing market penetration strategies, providing price incentives and developing appropriate infrastructure. This can reduce the initially high costs of the new technologies and can accelerate attainment of market maturity, thus in turn facilitating transfer to developing countries.
- Over the short and medium term, it is essential to swiftly tap those renewable energy sources which are already technologically manageable and relatively cost-effective today. These are in particular wind and biomass. Over the long term, the rising primary energy requirement can only be met through vigorous utilization of solar energy – this holds by far the largest sustainable potential. To tap this potential in time, installed capacity will need to grow ten-fold every decade – now and over the long term.
- The utilization of fossil energy sources will continue to be necessary over the next decades. Wherever possible, this needs to be done in such a fashion that the efficiency potential is tapped and both the infrastructure and generating technology can be converted readily to renewable sources. In particular, the efficient use of gas, for instance in combined heat and power generation and in fuel cells, can perform an important bridging function on the path towards a hydrogen economy.
- A certain volume of carbon sequestration in appropriate geological formations (e.g. depleted oil and gas caverns) will be necessary as a transi-

tional technology during this century in order to remain within the climate guard rails. For ecological reasons, the Council rejects use of the oceans for carbon sequestration.

4 Milestones on the WBGU transformation roadmap: Targets, time tables and policies

4.1 Protecting natural life-support systems

To keep global warming within tolerable limits, global carbon dioxide emissions need to be reduced by at least 30 per cent from 1990 levels by the year 2050 (overview: Fig. 2). For industrialized countries, this means a reduction by some 80 per cent, while the emissions of developing and newly industrializing countries are allowed to rise by at most 30 per cent. Without a fundamental transformation of energy systems, emissions must be expected to double or even quadruple in developing and newly industrializing countries over that period. This is why in these countries, too, a rapid redirection of energy production and utilization is essential. The focus of such activities needs to be placed on promoting renewables and enhancing efficiency. In view of the considerable uncertainties, e.g. regarding the behaviour of the climate system, these emissions reduction goals are minimum requirements.

4.1.1 Improving energy productivity

In order to minimize resource consumption, global energy productivity (the ratio of gross domestic product to energy input) needs to be improved by 1.4 per cent every year initially, and then by at least 1.6 per cent as soon as possible. At that rate, energy productivity would treble by 2050 from 1990 levels. Moreover, minimum efficiencies of more than 60 per cent should be aimed at by 2050 for large fossil-fuelled power plants. To this end, the Council recommends

- establishing international standards prescribing minimum efficiencies for fossil-fuelled power plants in a stepwise process from 2005 onwards, based on the corresponding European Union (EU) directive.
- generating, by 2012, 20 per cent of electricity in the EU through combined heat and power (CHP) production. There is a particular need to harness

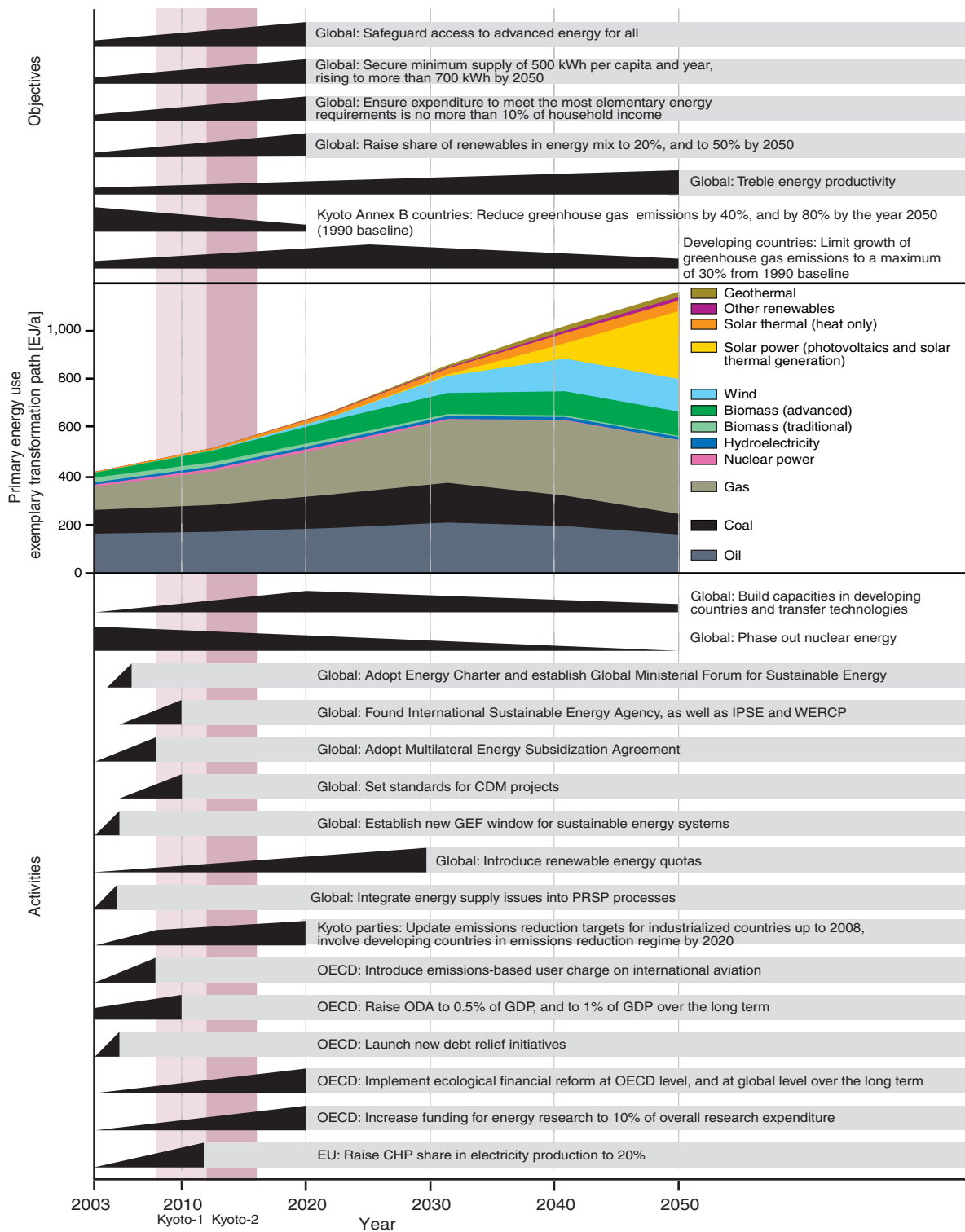


Figure 2
 Overview of the transformation roadmap proposed by the German Advisory Council on Global Change (WBGU).
 CDM=Clean Development Mechanism, CHP=combined heat and power, GDP=gross domestic product, GEF=Global Environment Facility, IPSE=Intergovernmental Panel on Sustainable Energy, ODA=Official Development Assistance, OECD=Organisation for Economic Co-operation and Development, PRSP=Poverty Reduction Strategy Papers, WERCPC=World Energy Research Coordination Programme
 Source: WBGU

the potential offered by distributed production. To promote this, the German federal government should argue within the EU for the swift setting of binding national CHP quotas.

- initiating ecological financial reforms as a key tool for creating incentives for more efficiency. This includes measures to internalize external costs (e.g. CO₂ taxation, emissions trading) and the removal of subsidies for fossil and nuclear energy.
- improving the information provided to end users in order to promote energy efficiency, e.g. by means of mandatory labelling for all energy-intensive goods, buildings and services. In the case of goods traded internationally, cross-national harmonization of efficiency standards and labels is recommendable.
- exploiting the major efficiency potentials in the use of energy for heating and cooling through instruments of regulatory law targeting the primary energy requirement of buildings.

4.1.2

Expanding renewables substantially

The proportion of renewable energies in the global energy mix should be raised from its current level of 12.7 per cent to 20 per cent by 2020, with the long-term goal of more than 50 per cent by 2050. Ecological financial reforms will make fossil and nuclear sources more expensive and will thus reduce their share in the global energy mix. Consequently, the proportion of renewables will rise. As this rise will remain well below the envisaged increase to 20 per cent and, respectively, 50 per cent, the Council recommends that renewables be expanded actively. In particular, it recommends

- that countries agree upon national renewable energy quotas. In order to minimize costs within such a scheme, a worldwide system of internationally tradable renewable energy credits should be aimed at by 2030. Its flexibility notwithstanding, such a system should commit each country to meet a substantial part of its quota through domestic generation.
- continuing and broadening market penetration strategies (e.g. subsidy schemes over limited periods, guaranteed feed-in tariffs, renewable energy quota schemes). Until significant market volume has been achieved, guaranteed feed-in tariffs under which payments decline over time are amongst the particularly expedient options. When a sufficiently large market volume of individual energy sources has been reached, assistance should be transformed into a system of tradable

renewable energy credits or green energy certificates.

- upgrading energy systems to permit the large-scale deployment of fluctuating renewable sources. This includes in particular enhancing grid control, implementing appropriate control strategies for distributed generators, upgrading grids to permit strong penetration by distributed generators as well as expanding grids to form a global link. This should be followed later by the establishment of an infrastructure for hydrogen storage and distribution, using natural gas as a bridging technology.
- providing vigorous support to disseminate and further develop the technologies involved in solar and energy-efficient construction.
- building and strengthening human-resource and institutional capacities in developing countries and intensifying technology transfer in order to improve the framework conditions for the establishment of sustainable energy systems.
- setting within export credit systems, from 2005 onwards, progressive minimum requirements for the permissible carbon intensity of energy production projects.

4.1.3

Phasing out nuclear power

No new nuclear power plants should be given planning permission. The use of nuclear power should be terminated worldwide by 2050. To this end, the Council recommends

- seeking to launch international negotiations on the phase-out of nuclear power. This process could begin with an amendment to the statutes of the International Atomic Energy Agency (IAEA).
- establishing by 2005 new, stricter IAEA safety standards for all sites at which nuclear material is stored, as well as expanded monitoring and action-taking competencies of the IAEA in the field of safeguards relating to terrorism and proliferation.

4.2

Eradicating energy poverty and seeking minimum levels of supply worldwide

Access to advanced energy is a vital element for poverty reduction and development. The Council therefore recommends adopting as an international target that access to advanced energy is safeguarded for the entire world population from 2020, and that, from that time onwards, all individuals have access to at least 500 kWh per person and year to meet ele-

mentary final energy requirements (Fig. 2). In this endeavour, care needs to be taken that socio-economic disparities are reduced in connection with all measures seeking to transform energy systems. The proportion of household income spent on energy should not exceed 10 per cent. Access to advanced energy is also a key contribution to achieving the United Nations Millennium Development Goals.

- Germany, in connection with its involvement in these banks and within the EU context, works towards the promotion of energy supply in developing countries through the regional development funds;
- the EU makes targeted use of the European Development Fund to promote renewables in the ACP (African, Caribbean, Pacific) states.

4.2.1

Focussing international cooperation on sustainable development

IMPLEMENTING NEW WORLD BANK POLICY IN ASSISTANCE DELIVERY PRACTICE

The Council takes the view that the World Bank, which supports countries in expanding their energy systems, should also promote sustainable energy in order to facilitate the leapfrogging of unsustainable development stages. In efforts to promote the transformation of energy systems, the World Bank has not yet moved sufficiently from the conceptual to the operational level. An urgent need thus remains to redirect its assistance delivery procedures, which until now have predominantly financed fossil fuels according to the least-cost principle. The Council recommends that

- the new assistance delivery approach of the World Bank is implemented in practice, starting immediately. The German federal government should use its membership on the Board of Governors of the World Bank to work towards this.

INTEGRATING SUSTAINABLE ENERGY SUPPLY WITHIN POVERTY REDUCTION STRATEGIES

In late 1999, the International Monetary Fund (IMF) and the World Bank began focussing their policies vis-à-vis least developed countries primarily on poverty reduction. Poverty Reduction Strategy Papers (PRSPs) serve to steer the medium-term development of countries and provide a basis for eliciting international support. The Council recommends

- integrating sustainable energy supply within PRSP processes in order to raise the profile of energy-related issues in development cooperation.

STRENGTHENING THE ROLE OF REGIONAL DEVELOPMENT BANKS

The role of regional development banks should be strengthened. These have good regional connections and more intimate knowledge of local problems than global institutions do. The Council recommends that

4.2.2

Strengthening the capabilities of developing countries

PROMOTING ECONOMIC AND SOCIAL DEVELOPMENT IN LOW-INCOME COUNTRIES

To turn energy systems towards sustainability, a minimum degree of economic development is a precondition. Many countries fall far short of the per-capita income required for this. The Council therefore recommends not only intensifying development cooperation in the field of basic services and sustainable energy supply, but also intensifying cooperation with low-income countries in particular, in both quantitative and qualitative terms. Furthermore, within the context of the WTO "Development Round", improved access for goods from all low-income countries to the markets of industrialized and newly industrializing countries should be urged.

LAUNCHING NEW DEBT RELIEF INITIATIVES

In general, heavily indebted developing countries have little scope to cope with price fluctuations on world energy markets. Their ability to finance improvements to the efficiency of their energy supply systems and to advance the deployment of renewable energy technologies is similarly limited. To embark on transformation, wide-ranging debt relief is needed. The Council recommends that

- the German federal government argues for new debt relief initiatives within the G7/G8 context.

4.2.3

Combining regulatory and private-sector elements

It is essential to take measures on both the supply and demand side in order to improve access to advanced low-emission energy forms and to renewable energy sources, and to improve the energy efficiency in developing, newly industrializing and transition countries.

SUPPLY SIDE: COMBINING LIBERALIZATION AND PRIVATIZATION WITH REGULATORY INTERVENTIONS
On the supply side, privatization and liberalization need to be combined with regulatory interventions undertaken by the state. The mix of these three spheres will need to vary depending upon the specific circumstances of a region. Liberalization and privatization require an attractive environment for private-sector investors and the tapping of international sources of capital. Stronger state intervention requires the setting of standards, and also an expansion of public-private partnerships, possibly supported by bilateral and multilateral development cooperation activities.

DEMAND SIDE: INCREASING THE PURCHASING POWER OF THE POOR

On the demand side, the aim must be to increase purchasing power in relation to energy, particularly of the poor. This can be done by target-group specific subsidies, or by expanding micro-finance systems. To also increase the willingness to use energy more sustainably, measures taken on the demand side need to give consideration to culture-specific and gender-specific framework conditions.

4.3 Mobilizing financial resources for the global transformation of energy systems

To finance the global transformation of energy systems towards sustainability, there is an urgent need to mobilize additional financial resources, as well as to create new transfer mechanisms or strengthen existing ones in order to support economically weaker countries in this transformation process. The Council welcomes the programme on “Sustainable energy for development” geared to establishing strategic partnerships which the German government announced at the World Summit on Sustainable Development. Over the next five years, a total of € 1000 million will be budgeted for this programme.

MOBILIZING PRIVATE-SECTOR CAPITAL

To mobilize private-sector capital for the global transformation of energy systems, the Council recommends

- facilitating access to developing country markets for small and medium-sized suppliers of renewable energy technologies within the context of public-private partnerships;
- establishing by 2010 a German and, if possible, EU standard for the Clean Development Mechanism. This standard should permit exclusively, with exceptions to be substantiated in each case, pro-

jects that promote renewables (excluding large hydroelectric dams due to currently unresolved sustainability problems), improve the energy efficiency of existing facilities or engage in demand-side management.

BOOSTING DEVELOPMENT COOPERATION FUNDING
At 0.27 per cent of gross domestic product (GDP) in 2001, German official development assistance (ODA) funding is far from the internationally agreed target of 0.7 per cent. However, Germany has committed itself to increasing ODA funding to a level of 0.33 per cent of GDP by 2006. Even an increase to some 1 per cent of GDP would be commensurate to the severity of the problems prevailing. The Council recommends

- as a matter of urgency, raising ODA funding beyond the level of 0.33 per cent announced for 2006, and proposes allocating, as a first step, at least 0.5 per cent of GDP by 2010.

HARNESSING INNOVATIVE FINANCING TOOLS

To implement the global transformation of energy systems, it will be essential to tap new sources of finance. Specially, the potential of raising charges for the use of global commons deserves examination. The Council recommends

- raising from 2008 onwards an emissions-based user charge on international aviation, provided that this sector is not yet subject by then to international emissions reduction commitments.

STRENGTHENING THE GLOBAL ENVIRONMENT FACILITY AS AN INTERNATIONAL FINANCING INSTITUTION

The Global Environment Facility (GEF), operated jointly by UNDP, UNEP and the World Bank, should be used as a catalyst for global environmental protection measures. The Council recommends

- concentrating by 2005 the financial assistance provided for efficiency technologies and renewable resources in a newly created GEF “window for sustainable energy systems”. In order to be able to give greater consideration to development policy aspects in the deployment of funds, a simplification of the incremental costs approach should be considered. With a view to the high levels of funding required to promote the global transformation of energy systems, GEF resources need to be expanded considerably.

4.4

Using model projects for strategic leverage, and engaging in energy partnerships

SENDING OUT SIGNALS THROUGH MODEL PROJECTS

The Council argues in favour of using model projects for the introduction of new renewables on a large scale to deliver strategic leverage for a global transformation of energy systems towards sustainability. Such model projects could have global knock-on effects. They would showcase how technology leaps can be implemented in energy projects. The Council recommends initiating the following model projects:

- A strategic energy partnership between the European Union and North Africa, integrating into European power supply the potential of solar energy use in a manner profitable for both sides;
- Developing the infrastructure needed to substitute traditional biomass use by biogenic bottled gas;
- Energy-efficient buildings in the low-cost sector, piloted by South African townships;
- Improving the power quality in weak electric grids in rural African regions;
- “1 million huts electrification programme” for developing countries, generating the necessary internal dynamics for off-grid rural electrification.

FORMING STRATEGIC PARTNERSHIPS TO TURN ENERGY SYSTEMS TOWARDS SUSTAINABILITY

Existing or emergent policy initiatives promoting a global transformation of energy systems towards sustainability provide a framework for action. The Council recommends that, in addition to the World Conference for Renewable Energy due to take place in 2004, the following policy processes in particular are used as catalysts to promote this transformation:

- The international initiatives adopted at the World Summit on Sustainable Development
 - Energy Initiative for Poverty Eradication and Sustainable Development,
 - Global Village Energy Partnership,
 - Global Network on Energy for Sustainable Development.
- The economic partnership agreement currently being negotiated between the EU and the ACP states.

4.5

Advancing research and development

Turning energy systems towards sustainability is a major technological and social challenge on a scale comparable to that of a new industrial revolution. For it to succeed, a major research and development

effort is necessary. This concerns renewable energy sources, infrastructure, end-use efficiency technologies as well as the provision of knowledge on the conservation and expansion of natural carbon stocks and sinks. The social sciences also need to contribute, by analysing the individual and institutional barriers to this transformation process and developing strategies to overcome these barriers.

However, for many years now expenditure for research and development in the energy sector has been declining. At present, across the OECD only some 0.5 per cent of turnover in the energy sector is devoted to research and development activities, and the percentage is dropping. Only if there is sustained, high investment in research and development can there be a prospect of renewable-energy technologies and efficiency-enhancing measures coming into widespread use over the medium and long term at low cost. The Council recommends

- increasing at least ten-fold, above all through re-allocation of resources from other areas, by 2020 the direct state expenditure in industrialized countries for research and development in the energy sector from its current level of about US-\$ 1300 million annually (average across the OECD for the 1990–1995 period). The focus needs to be shifted rapidly away from fossil and nuclear energy towards renewables and efficiency.
- establishing within the UN system a World Energy Research Coordination Programme (WERCP) to draw together the various strands of national-level energy research activities, in analogy to the World Climate Research Programme.

4.6

Drawing together and strengthening global energy policy institutions

ESTABLISHING COORDINATING BODIES AND NEGOTIATING A WORLD ENERGY CHARTER

To promote a global transformation of energy systems towards sustainability, it is essential to coordinate activities at global level and consequently to draw together international institutions and actors. The Council recommends strengthening and expanding the institutional architecture of global energy policy in a stepwise process, building upon existing organizations:

- As a first step, a World Energy Charter should be negotiated at the planned World Conference for Renewable Energy to be held in Germany in 2004. This should contain the key elements of sustainable, global energy policy and provide a joint basis for action at global level.

- Moreover, this conference should decide upon – or better still establish – a Global Ministerial Forum for Sustainable Energy responsible for coordinating and determining the strategic direction of the relevant actors and programmes.
- In parallel, a Multilateral Energy Subsidies Agreement (MESA) should be negotiated by 2008. This agreement could provide for the stepwise removal of subsidies for fossil and nuclear energy, and could establish rules for subsidizing renewable energy and energy efficiency technologies.
- At least the OECD states should commit themselves to national renewable energy quotas of at least 20 per cent by 2015. It would be important in this context to agree to negotiate the globalization and flexibilization of this system, such negotiations leading by 2030 at the latest to a worldwide system of tradable renewable energy credits.
- In support of these activities, a group of like-minded, advanced states should adopt a pioneering role on the path towards sustainable energy policies. The European Union would be a suitable candidate for such a leadership role.
- Building upon the steps above, the institutional foundations of sustainable energy policy could be further strengthened by concentrating competencies at global level. To this end, the role of the Ministerial Forum could be further expanded.
- Using the experience gained until that date, by about 2010 the establishment of an International Sustainable Energy Agency (ISEA) should be examined.

ENHANCING POLICY ADVICE AT THE INTERNATIONAL LEVEL

It is important that the political implementation of a global transformation of energy systems towards sustainability receives continuous support through independent scientific input, as is currently the case in climate protection policy. To this end, the Council recommends

- establishing an Intergovernmental Panel on Sustainable Energy (IPSE) charged with analysing and evaluating global energy trends and identifying options for action.

5 Conclusion: Political action is needed now

To protect natural life-support systems and eradicate energy poverty alike, there is an urgent need to transform energy systems. This transformation will be feasible without severe adverse effects upon societal and economic systems if policy-makers grasp the opportunity to shape this process over the next two decades. The intended effects can only be expected to

emerge after a certain time lag. This lag makes swift action all the more important. The costs of inaction would be much higher over the long term than the costs of initiating this transformation. Every delay will make it more difficult to change course.

The direction of transformation is clear: The energy efficiency must be increased, and massive support for renewables must be provided. It will be particularly important in this endeavour to reduce dependency on fossil fuels. The long-term objective is to break the ground for a solar age.

In the view of the Council, the transformation is feasible. It is also financeable if, in addition to intensified use of existing mechanisms (e.g. GEF, ODA, World Bank and regional development bank loans) and enhanced incentives for private-sector investors (e.g. through public-private partnerships), innovative financing avenues (such as user charges for global commons) are pursued. The present report highlights the key opportunities for steering energy systems towards sustainability, guided by a transformation roadmap.

For the worldwide transformation of energy systems to succeed, it will need to be shaped in a stepwise and dynamic manner, for no one can predict today with sufficient certainty the technological, economic and social developments over the next 50–100 years. Long-term energy policy is thus a searching process. It is the task of policy-makers to rise to this challenge. The World Conference for Renewable Energy announced by the German chancellor at the Johannesburg World Summit on Sustainable Development offers an excellent opportunity to take action.

Publications of the German Advisory Council on Global Change (WBGU)

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