

WBGU

German Advisory Council on Global Change

Summary for
Policy-Makers

World in Transition A Social Contract for Sustainability



The Council Members

Prof. Dr. Hans Joachim Schellnhuber CBE (chair)

Director of the Potsdam Institute for Climate Impact Research, external professor at the Santa Fe Institute and chair of the Governing Board of the Climate-KIC of the European Institute of Innovation and Technology

Prof. Dr. Dirk Messner (vice chair)

Director of the German Development Institute, Bonn

Prof. Dr. Claus Leggewie

Director of the Institute for Advanced Study in the Humanities, Essen, Institute for Advanced Study of the University Alliance Metropolis Ruhr

Prof. Dr. Reinhold Leinfelder

Geologist and palaeontologist, focus on geobiology, integrative biodiversity and science communication; Professor at the Institute of Biology, Humboldt-University, Berlin

Prof. Dr. Nebojsa Nakicenovic

Vienna University of Technology and Deputy Director, International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria

Prof. Dr. Stefan Rahmstorf

Professor of Physics of the Oceans, Potsdam University and head of the Climate System department at the Potsdam Institute for Climate Impact Research

Prof. Dr. Sabine Schlacke

Professor of Public Law, specializing German, European and International Environmental and administrative Law, Bremen University

Prof. Dr. Jürgen Schmid

Director of the Fraunhofer Institute for Wind Energy and Energy System Technology, IWES

Prof. Dr. Renate Schubert

Professor for economics at the Swiss Federal Institute for Technology and director of the Institute for Environmental Decisions, ETH Zurich (Switzerland)

Scientific staff at the Secretariat: Dr. Inge Paulini (Secretary-General); Dr. Carsten Loose (Deputy Secretary-General); Dr. Karin Boschert; Rüdiger Haum, Ph.D.; Dr. Benno Pilardeaux (Media and Public Relations); Dr. Astrid Schulz; Dr. Birgit Soete

Scientific Staff to the Council Members: Dr. Steffen Bauer; Dipl.-Phys. Christoph Bertram; Dipl.-Volksw. Julia E. Blasch; Daniel Klingefeld, M.Sc., MPP; Dr. Susanna Much; Olivia Serdeczny, M.A.; Alexander Schülke, M.Sc., MPP; Dr. Niels B. Schulz; Dr. Bernd Sommer; Dr. Michael Sterner; Dipl.-Phys. Amany von Oehsen

Layout, Editorial work, Secretariat: Mario Rinn, B.Sc.; Martina Schneider-Kremer, M.A.; Margot Weiß



German Advisory Council on Global Change

World in Transition

A Social Contract for Sustainability

Summary for Policy-Makers

This publication summarises the report „World in Transition: A Social Contract for Sustainability“ which will be published in the autumn of 2011 and will be available free of charge at the Secretariat.

German Advisory Council on Global Change (WBGU)

WBGU Secretariat
Luisenstraße 46
D-10117 Berlin
Phone.: +49 30 263948 0
Fax: +49 30 263948 50
Email: wbg@wbg.de
Web: <http://www.wbg.de>

Copy deadline: 17.03.2011

Bibliographic information published by the Deutsche Nationalbibliothek
The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie;
detailed bibliographic data are available in the Internet at <http://dnb.d-nb.de>.

ISBN 978-3-936191-47-9

WBGU Berlin 2011

Translation: KERN AG, Global Language Services, Berlin (www.e-kern.com)

The R&D project that generated this report was conducted on behalf of the German Federal Ministry of Education and Research and the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety under grant number 01RI0708AA. Responsibility for the content of this publication rests with the author.

Designed by WERNERWERKE GbR, Berlin
Cover photo © Erhard Dauber, Photographer Bochum

Produced by WBGU
Typesetting by WBGU
Printed and bound by AZ Druck und Datentechnik Berlin

WBGU used certified eco-friendly paper for this publication.

This work is published under a Creative Commons License.



Summary for Policy-Makers

It's not because things are difficult that we dare not venture. It's because we dare not venture that they are difficult.
Seneca (1 BC–AD 65)

A new Social Contract

In recent history, the ongoing pro-democracy movements in a number of Arab states and the fall of the Berlin Wall have served as proof of the power and dynamics of transformative processes. There are several lessons to be learned from these upheavals for the transition to sustainability: firstly, unsustainable situations can lead to dramatic collapse. Moreover, transformative forces often remain hidden below the surface for quite some time. This is evident today not least in the quantifiable global change in values to embrace sustainability. After all, the downfall of dictatorships whose mainstay has been the extraction of crude oil and natural gas (Soviet Union, Libya) also reveals the formerly hidden costs of a 'fossil' industrial metabolism.

Normatively, the carbon-based economic model is also an unsustainable situation, as it endangers the climate system's stability, and therefore the natural life-support system for future generations. The transformation towards a low-carbon society is therefore as much an ethical imperative as the abolition of slavery and the condemnation of child labour.

For quite some time now, the fossil economic system has been changing all over the world. The WBGU views this structural transition as the start of a 'Great Transformation' into a sustainable society, which must inevitably proceed within the planetary guard rails of sustainability. Long-term studies show clearly that worldwide, an ever-increasing number of people desire this move towards sustainability and a long-term approach. Moreover, the nuclear disaster in Japan makes it clear that we must choose the fast lane towards a low-carbon future without nuclear energy.

Now, it is first and foremost a political task to overcome the barriers of such a transformation, and to

accelerate the change. In the WBGU's view, a long-term oriented regulatory framework must be developed for this to ensure that prosperity, democracy and security are achieved with the natural boundaries of the Earth system in mind. Above all, development paths must be pursued which are compatible with the 2°C climate protection guard rail agreed upon by the global community at Cancún in 2010. This drastic change in direction must be accomplished before the end of the current decade in order to reduce global greenhouse gas emissions to a minimum by 2050, and thereby to maintain the possibility of avoiding dangerous climate change. Hence, time is of the essence here.

In its flagship report, the WBGU elaborates explicitly on the fact that the technological potential for comprehensive decarbonisation is available, outlines business and financing models for the transition, and points out that the political instruments needed for a climate-friendly transformation are widely known. The council also describes how the requisite transformation encompasses profound changes to infrastructures, production processes, regulation systems and lifestyles, and extends to a new kind of interaction between politics, society, science and the economy. Various multi-level path dependencies and obstacles must be overcome. Furthermore, the transformation can only succeed if nation states put global cooperation mechanisms before their own short-term oriented interests, in order to make a trend reversal, particularly as far as the global economy is concerned, towards climate-friendliness and sustainability possible. And not least, from a global perspective, this is also about issues of fairness – issues that need resolving.

This 'Great Transformation', then, is by no means an automatism. It very much depends on 'organising the unplannable' if it is to succeed within the available tight timeframe. This is unique in history, as the 'world's great transformations' (Jürgen Osterhammel) of the past were the result of gradual evolutionary change.

Adding together all of these challenges involved in the transformation to come, it becomes clear that the upcoming changes go far beyond technological and

technocratic reforms: the business of society must be founded on a new 'business basis'. *This is, in fact, all about a new global social contract for a low-carbon and sustainable global economic system.* It is based on the central concept that individuals and civil societies, states and the global community of states, as well as the economy and science, carry the joint responsibility for the avoidance of dangerous climate change, and the aversion of other threats to humankind as part of the Earth system. The social contract consolidates a culture of attentiveness (born of a sense of ecological responsibility), a culture of participation (as a democratic responsibility), and a culture of obligation towards future generations (future responsibility).

One key element of such a social contract is the 'proactive state', a state that actively sets priorities for the transformation, at the same time increasing the number of ways in which its citizens can participate, and offering the economy choices when it comes to acting with sustainability in mind. The social contract also encompasses new forms of global political will formation and cooperation. The establishment of a 'UN Council for Sustainable Development', on par with the UN Security Council, and the forming of international alliances of climate pioneers between states, international organisations, cities, corporations, science and civic organisations, would be examples of this.

The WBGU has developed the concept of a new social contract for the transformation towards sustainability – not so much on paper, but rather in people's consciousness – as an analogy to the emergence of the industrialised societies during the course of the 19th century. Karl Polanyi (1944) referred to this process, too, as a 'Great Transformation', and showed that stabilisation and acceptance of the 'modern industrialised societies' were only successful through the embedding of uncontrolled market dynamics and innovation processes into a constitutional state, democracy and the creation of the welfare state – i.e. through the emergence of a new social contract.

The WBGU, by highlighting the technical and economic feasibility of the transformation, by describing the change agents, by identifying barriers, and by developing political and institutional approaches to overcome these, illustrates the transition to climate-friendliness and sustainability's 'conditions of possibility' (Immanuel Kant). In doing so, the WBGU wants to encourage policy-makers, but also the economy and the social protagonists, to dare to make the change.

..... Low-Carbon Challenge

Climate protection plays a particularly important part in the transformation towards sustainability, as it is a *conditio sine qua non* for sustainable development: although climate protection alone cannot guarantee the conservation of the natural life-support systems on which humanity depends, it is nevertheless foreseeable that without effective climate protection, mankind will soon have to do without some essential development opportunities.

During the past few years, anthropogenic climate change has become a central topic of social discourse. There is a global political consensus that rapid global warming by more than 2°C would overtax our societies' ability to adapt. The consequences would be environmental crises with major social, economic and security-political risks. The avoidance of dangerous climate change has therefore become one of the biggest challenges facing humankind.

If restricting global warming to a mean temperature change of 2°C is to succeed with a probability of at least two-thirds, then, by the middle of this century, no more than around 750 Gt of CO₂ from fossil sources may still be released into the atmosphere (WBGU, 2009). This global CO₂ budget would already be exhausted in around 25 years' time if emissions were to be frozen at current levels. We therefore need fast, transformative counteraction. By the middle of the century, the global energy systems must largely be decarbonised.

Search processes going in this direction can be observed in many countries worldwide. Europe, South Korea, China, Indonesia, India and some of the USA's federal states, amongst others, are endeavouring to decouple prosperity growth from greenhouse gas emissions. Many companies realise that in an increasingly prosperous world with soon-to-be 9 billion people, the next global innovation cycle must be low-carbon and resource friendly. Long-term investments, particularly in renewable energy sources as well as in energy and resource efficiency, not only serve atmosphere protection, but also reduce the numerous dependencies on the import of fossil fuels, at the same time determining future innovation centres and the reordering of global economic hierarchies. The remodelling process will open up new prospects, including for European societies whose strength lies in innovation.

A Future without Nuclear Energy

The WBGU's analyses in this report show that ambitious global climate protection is possible even without

using nuclear energy. At the centre of any decarbonisation strategy must be the massive extension of the renewable energies, and the infrastructure they need. However, the move towards sustainable energy systems can only succeed if, concurrently, the huge potentials for efficiency increase are fully tapped, and changing our wasteful lifestyles is no longer a taboo subject, particularly in the industrialised and industrialising countries.

Several countries are currently planning to increase their use of nuclear energy. The WBGU urgently advises against this, above all because of the not negligible risk of serious damages, the still unresolved issues concerning final storage, and the danger of uncontrolled proliferation. Existing plants should be replaced by sustainable energy technologies as soon as possible, and, in the case of evident safety deficiencies, be closed down immediately. However, the phase-out of nuclear energy must not be compensated by renewed or intensified brown or black coal based energy generation.

Climate Protection in Three Key Transformation Fields

The transition to climate-friendliness within the scope of sustainable development mainly concerns the following three key supporting pillars of contemporary global society. These pillars should be the starting point for any political agenda: *firstly*, the energy systems, including the transport sector, which the entire economy depends on, and which are currently facing a new wave of growth due to the fast-paced dynamics of the development of the industrialising countries. The energy sector causes around two-thirds of today's long-lived greenhouse gas emissions. *Secondly*, the urban areas, currently responsible for three-quarters of global final energy demand, and whose population will double to 6 billion by 2050. *Thirdly*, the land-use systems (agriculture and forestry, including deforestation), which are currently responsible for almost a quarter of global greenhouse gas emissions. Land-use does not just have to provide enough food for a world population that continues to grow, and becomes more demanding, but also has to deal with a growth in demand due to the increasing use of bioenergy and bio-based raw materials.

In all three of the fields described, the world is still far away from setting a clear course towards sustainability. The mitigation actions announced by the majority of governments within the scope of the international climate negotiations so far will certainly not be enough to comply with the 2°C guard rail. Neverthe-

less, the dynamics of a transformation that is already in progress should not be underestimated. The debate on the limits to growth, ongoing since the 1970s, and the quest for low-carbon development paths have now taken central stage in our societies. This opens up opportunities for extending the low-carbon experiments, industries, niches and efficiency islands that already exist in many countries, and gives us the chance to speed up the change in economic strategy, from dependence on the use of fossil energy carriers to a low-carbon way of doing business. Measures which, taken on their own, appear not to be particularly ambitious can, in such a dynamic situation of change, develop significant impact as a whole, and trigger the tipping points of development. Nevertheless, the transition to climate-friendliness in all three fields is a great challenge.

➤ The *transformation field 'energy'* is so significant because the world is still continuing down a 'high-carbon growth path' with rapidly increasing CO₂ emissions. If the 2°C guard rail is to be observed, though, the global emissions trend must be reversed by 2020 at the latest, as the drastic reduction rates which would otherwise be necessary later would overtax societies. A global energy turnaround that also takes global development dynamics into account is what is required. More than 80% of the worldwide energy supply is still based on environment and climate damaging fossil energy carriers, whilst around 3 billion people still do not have access to essential modern energy services. The challenge lies in giving these people access to modern energy services as soon as possible, whilst at the same time significantly reducing global CO₂ emissions from the use of fossil energy carriers. This can only succeed if energy efficiency is drastically increased and lifestyle changes are triggered, leading to a limitation of the overall energy demand. The requisite decarbonisation of energy systems means that the pressure is on to act, not just in the industrialised countries, but also in the dynamically growing newly industrialising and developing countries. Even the poorer developing countries must veer towards a low-emission development path in the medium-term. The era of fossil energy carrier reliant economic growth must be brought to an end.

➤ The *transformation field 'urbanisation'* is so significant because the urbanisation process is the major driving force behind energy demand. Urban expansion creates new, long-lived infrastructures that are going to impact on the energy demand for a long time to come. Currently, already around half of the world's population lives in cities. In Asia, the urban population will double to 3 billion people within the

next couple of decades. It is likely that by 2050, as many people will be living in cities as there are on Earth today. The current urbanisation wave must therefore be redirected towards low-carbon urban development very quickly indeed – and that in a situation where we do not have one single, functioning, low-carbon model city that we might learn from. The modification of existing urban structures is also very important; it needs a lot of time, and therefore a determined approach.

- › In the *transformation field 'land-use'*, the conversion of natural ecosystems (forests, grasslands, wetlands) into agricultural land is one of the major sources of greenhouse gas emissions. The main focus must therefore be on stopping deforestation and forest degradation as quickly as possible. Worldwide, forest areas are currently being reduced at a rate of about 13 million hectares per year. According to projections by the Food and Agriculture Organisation of the United Nations (FAO), in order to secure the food supply for a growing world population, global food output must increase by up to 70% by 2050. Agriculture's challenge is covering the strong growth in demand for agricultural produce in a sustainable way, including biodiversity protection, and, at the same time, to mitigate emissions along the whole life cycle, from field to consumer. One particular challenge here is the change in eating habits in favour of animal products in many regions of the world.

Conducive and Impeding Factors

One positive aspect is that many of the alternatives for putting sustainable progress in the three transformation fields as described into action are already available. The respective technologies are already in use or under development. Thanks to modern communication technologies and worldwide knowledge networks, climate-friendly innovation and learning processes can be shared fast, even with countries where this is not politically wanted. The policy and economic steering instruments are also well-known and could, assuming a corresponding public willingness to create the framework conditions, soon be adapted to decarbonisation.

The financial challenges of the transformation are significant, but controllable. Globally, the additional investment required for transformation into a low-carbon society, compared with the cost of 'just carrying on as we are', probably lies somewhere in the region of at least US\$ 200 to up to 1,000 billion per year by 2030, and would significantly exceed this amount between 2030 and 2050. These investments will be offset by later savings of a similar size, and the avoidance of the

immense costs of dangerous climate change. Through innovative business models and financing concepts, we can resolve these issues.

Not least, a positive fact in the WBGU's view is that an ever-growing part of the world population is developing value systems that include focusing on the protection of the natural environment, or that this aspect is at least gaining in significance. Policy-making should acknowledge this trend, and show much more courage when it comes to making pro-climate protection decisions.

However, this positive development is hindered by factors that impede a transformation.

Political, institutional and economic path dependencies, interest structures and veto players make the change into a sustainable society more difficult. Annual consumption subsidies for fossil-based energies are estimated to range between US\$ 300 to over 500 billion worldwide. However, this is not just about a lot of money and the corresponding interests of the established high-carbon sectors of the economy. The economic model of the past 250 years, with its rules and regulations, research environments, training and qualification systems and social role models, and its foreign, security, development, transport, economic and innovation policies, was almost without exception geared towards the use of fossil energy carriers. This complex system must now be fundamentally modified with a view to the decarbonisation of energy systems and radical increases in energy efficiency. John Maynard Keynes put it in a nutshell when describing one of the key challenges of this kind of profound system change: 'The difficulty lies not so much in developing new ideas as in escaping from old ones.'

Moreover, the transformation must be achieved within a very tight timeframe, which, for complex societies, particularly in the context of international negotiation systems, poses a significant challenge. At the same time, our societies must be willing to act in an anticipatory manner, on the basis of scientific findings. For this to happen, politics, economy and society must wholeheartedly embrace long-term orientation.

The urbanisation waves in the developing regions, a significant proportion of which are caused by high-carbon growth in many parts of the world, are a further huge challenge for the transformation process, but also a great opportunity. Particularly in the rapidly growing economies of the newly industrialising countries, the change into low-carbon cities has to be effected within a very short period of time. On the one hand, this is asking a lot in terms of the transformation and learning capacities of those countries. On the other hand, in most of those countries, the prevailing tenet is that climate change has primarily been caused, and continues

to be caused, by the OECD countries, and that therefore, the presumably costly investments into climate protection measures must, for the most part, be made in the established industrialised countries. This issue has so far not been resolved by a global burden sharing agreement. The situation is made more difficult by the availability of cheap coal in many of the newly industrialising countries.

The WBGU analysis also shows that current global governance institutions are not very well prepared for the transformation. This applies in particular to the three key transformation fields energy, urbanisation and land-use. Furthermore, no truly assertive climate pioneer alliances exist to accelerate the establishment of post-fossil, transnational structures.

Overall, though, the WBGU's central message is that the transformation into a low-carbon global society is essential, and achievable. In some sectors, regions and countries, it has already begun. Above all, we must now refrain from preventing the transformation, and instead forge ahead with initiatives that serve its acceleration.

Transformation Concept and Implementation Strategy

Characteristics of Great Transformations

The WBGU views this worldwide remodelling of economy and society towards sustainability as a 'Great Transformation'. Production, consumption patterns and lifestyles in all of the three key transformation fields must be changed in such a way that global greenhouse gas emissions are reduced to an absolute minimum over the coming decades, and low-carbon societies can develop. The extent of the transformation ahead of us can barely be overestimated. In terms of profound impact, it is comparable to the two fundamental transformations in the world's history: the Neolithic Revolution, i.e. the invention and spreading of farming and animal husbandry, and the Industrial Revolution, which Karl Polanyi (1944) called the 'Great Transformation', meaning the transition from agricultural to industrialised society.

The WBGU's Transformation Strategy

The great transformations the human race has so far experienced were, for the most part, the uncontrolled results of evolutionary change. The challenge, unique in history, with regard to the upcoming transformation into a climate-friendly society is advancing a *compre-*

hensive change for reasons of understanding, prudence and providence. The transformation must be anticipated, based on scientific insights regarding the risks of continuing on high-carbon development paths, in order to avoid the 'standard historic reaction', a change of direction in response to crises and disasters. The quest for suitable strategies has gained hugely in importance for corporations, in politics, in science and for society as a whole.

Figure 1 illustrates a possible course the transformation could take. To achieve decarbonisation, misguided incentives must be abolished, and the number of obstacles must be diminished. Figure 2 illustrates the temporal dynamics of the transformation into a low-carbon society, possible paths leading to failure to achieve the transformation, and the different levels of action.

Europe and the whole world currently stand at a crossroads. By now, there are change agents in all areas of society; in many countries, they even hold positions that can claim acceptance by the majority. The German federal government, the EU, the governments of the People's Republic of China, India, the USA, South Korea, Japan and Indonesia are all pro sustainable development, and have presented corresponding strategies, 'green growth' models or energy sector remodeling plans. In addition, all over the world, a number of low-emission technologies have seen dynamic development over the past few years. Renewable energies have become an important economic and employment factor. Globally, many cities have already implemented climate-friendly future concepts, in some major corporations, formerly small departments for corporate social responsibility have grown into 'innovation centres for sustainable markets', and in science, research alliances dealing with the transformation into a climate-friendly society have been formed.

So there is a lot of movement, and in the right direction. Nevertheless, there is a very real danger that the dynamics between change and dogged insistence on the established will lead into a lock-in (fig. 2); the transformation into a low-carbon society could also fail. For example, the increasing energy efficiency of vehicles could be overcompensated by a rebound effect, e.g. the more rapid growth in their number. Or states could agree on mitigating their greenhouse gas emissions, but these could nevertheless be far below the required ambition level. Renewable energies could gain in significance, but they might only be an addition to the still dominating fossil energy carriers, rather than replacing them. If the transformation were to be implemented in this kind of half-hearted and slow manner, it could lead to a '3-4°C world' with the respective, almost uncontrollable consequences for nature and society. The important thing now is to set the course in such a way

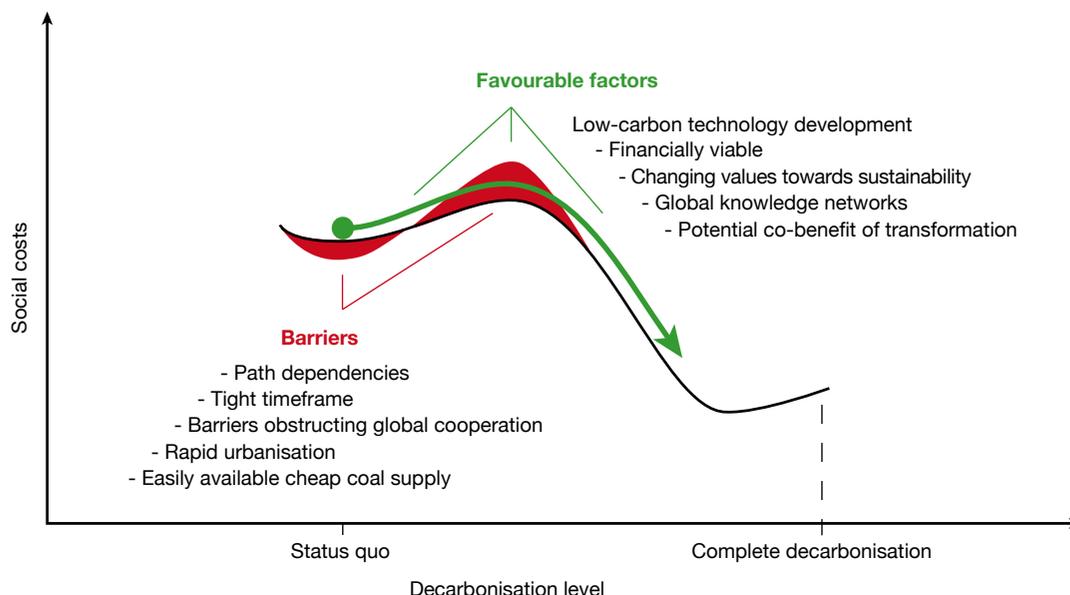


Figure 1

Topography of the transformation: the first step towards turning the global society’s status quo into low-carbon (complete decarbonisation) is the overcoming of obstacles, shown here as an increase in social costs. This increase is currently intensified through barriers (red): the social costs of the status quo appear to be lower than appropriate, due to, for example, misguided incentives such as subsidies for fossil energy carriers, or environmental costs that are not internalised. At the same time, the barriers to be overcome appear to be higher than they actually are: although overcoming various barriers requires a high degree of effort, for example, the costly overcoming of path dependencies, this is compensated by favourable factors: many low-carbon technologies are already available, and their deployment is financially viable. Aided by the favourable factors, barriers can be diminished to pave the way for the transformation. Once the decisive barriers have been overcome, the move towards low-carbon can be expected to develop its own dynamics.

Source: WBGU

that a result like this becomes improbable.

Historical analyses show that a ‘concurrency of multiple change’ (Osterhammel, 2009) can trigger historic waves and comprehensive transformations. The social dynamics for a change in the direction of climate protection must therefore be created through a combination of measures at different levels:

- It is knowledge-based, based on a joint vision, and guided by the precautionary principle.
- It relies heavily on the change agents, who can test and advance the options for leaving behind an economy reliant on the use of fossil resources, thus helping to develop new leitmotifs, or new visions, to serve as guiding principles for social transition. Initially, the change agents are involved as marginalised protagonists; they could, however, develop into an effective force, greatly advancing the transformation (fig. 2).
- It needs a proactive state to allow the transformation process to develop into a certain direction by providing the relevant framework, by setting the course for structural change, and by guaranteeing the implementation of climate-friendly innovations. The proactive state gives the change agents leeway, and supports them actively.

- It also counts on the cooperation of the international community and the establishment of global governance structures as the indispensable driving force for the intended transformation momentum.

The Decarbonisation of Energy Systems is Achievable

The most important starting point for the transformation towards sustainability is the reduction of CO₂ emissions from the use of fossil energy carriers. Apart from decarbonisation, a second major goal of a remodelling of the energy systems is overcoming global energy poverty.

The WBGU shows explicitly that the decarbonisation of energy systems on a global level is feasible, both from a technical and an economic point of view. The long-term economic costs of such a transformation amount to just a few percent of the global GDP. For the transformation to succeed, it is imperative that the reduction of the carbon dioxide intensity of the global GDP is greatly accelerated. Assuming an economic growth of 2–3%, if a development path were to be followed that would lead to not more than 750 Gt CO₂

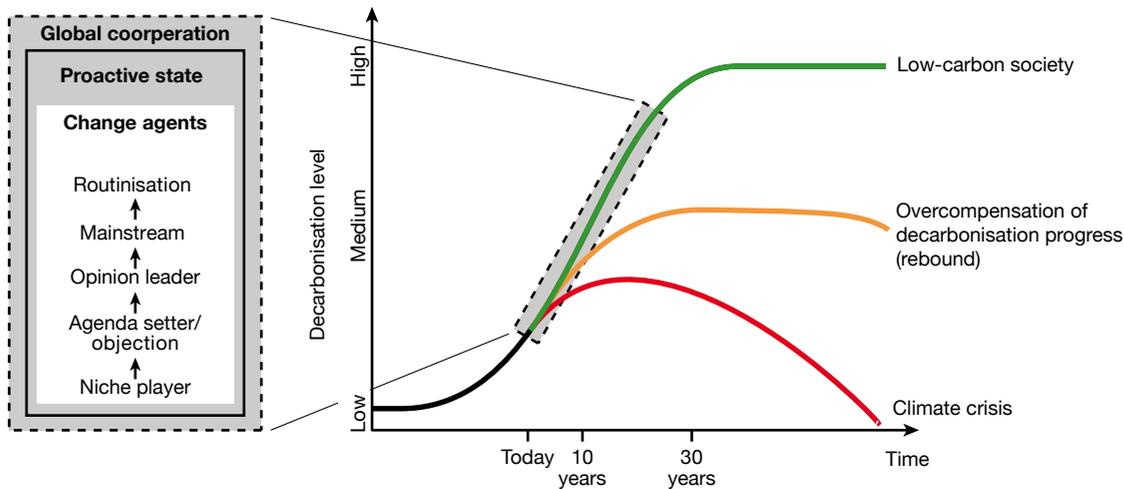


Figure 2

The transformation's temporal dynamics and action levels. The goal of the transformation is a low-carbon society. Central to the transformation is the decarbonisation of energy systems. Left: The proactive state and the change agents are the key players. As far as the change agents are concerned, they must move away from a marginalised existence and increase their impact through widespread inclusion in social routines. Right: Decisive action for a change of course towards transformation must be taken within the next decade if the conversion is to succeed within the next 30 years. The sustainable path (green) manages the transition from high-carbon to low-carbon society in time. Overcompensation for decarbonisation advances (for example through rebound effects) could lead to rendering climate protection measures ineffective, so that the transformation fails (yellow). Moderate endeavours only carry the risk of path dependencies that will lead to a global climate crisis (red).

Source: WBGU, modified acc. to Grin et al., 2010

emissions from fossil sources by 2050, then, over the next few years, the speed at which the CO₂ intensity of the global economic output is reduced would have to be at least twice as fast as it has been in the past.

However, there is more than one way to transform energy systems in the direction of climate protection. The actual energy paths followed will differ between states and regions, depending on political, technological and cultural circumstances and preferences, and individual geographical features. The use of nuclear power and the relevance of carbon capture and storage (CCS) in particular could develop in very different directions, both regionally and nationally – especially through policy decisions. The WBGU advises against the use of nuclear power. CCS, on the other hand, is a necessary climate protection measure for countries that continue to use fossil energies. In combination with the use of bioenergy, CCS could also turn out to be an important option for actively withdrawing CO₂ from the atmosphere during the second half of the 21st century. In its recommendations, however, the WBGU focuses on development paths where these two technologies play only a marginal role. Rather, the WBGU recommends a strategy that relies primarily on an accelerated use of renewable energies, with a medium-term prospect of covering 100% of demand. This goal requires a simultaneous pursuit of drastic improvements in energy efficiency.

In the WBGU's opinion, a look at the various trans-

formative scenarios suggests that the global final energy demand should not rise to more than 400–500 EJ per year by 2050; it currently amounts to approx. 350 EJ per year. Without a change in political direction, though, the final energy demand could more than double. Hence, downsizing this demand in the industrialised and the economically fast growing newly industrialising countries is a crucial task.

Utilise Changing Values

Creating the relevant attitudes and preferences is an indispensable premise for a successful transformation to a low-carbon society. Politicians must make the intended transition agreeable to the vast majority (acceptance), obtain their consent (legitimation), and invite cooperation (participation). There is ample evidence, such as the results of the international World Values Survey, which has been conducted since 1981, or the debate on alternatives to GDP as a prosperity indicator, to suggest that the core values of a large part of the world population include the protection of the natural environment. There is a relatively broad, cross-cultural consensus to transform the predominant economic strategy so that it becomes embedded in sustainable environmental management. Political options that pick up on post-materialistic values and sustainability-oriented attitudes are therefore not antitheses to

the majority view in industrialised societies. They are also popular amongst opinion leaders in the newly industrialising countries, seeking to catch-up in terms of economic development. For all of the reasons mentioned, it is clear that policy-makers can certainly be more courageous when it comes to making pro climate protection decisions. People are far more willing to tackle this issue than generally thought.

A New Global Social Contract

The idea of a new social contract refers to the necessity of humankind taking collective responsibility for the avoidance of dangerous climate change and other dangers to the planet. For one thing, this needs a voluntary capping of the usual options for economic growth in favour of giving the people in those parts of the world already suffering the consequences of our irresponsible behaviour, and particularly future generations, room to manoeuvre. For another, the transformation needs a powerful state, counterbalanced by extended participation on the part of its citizens.

The idea of a social contract takes the original concept found in the natural law theories of early modern history one step further, and today's revised edition must address four major challenges:

1. Because of progressive economic and cultural globalisation, the nation state can no longer be considered the sole basis for the contractual relationship. Its inhabitants must responsibly take transnational risks and natural dangers, and the legitimate interests of 'third parties', i. e. other members of the world community, into account.
2. Traditional contract philosophy presupposed the fictitious belief that all members of a society are equal. Considering the disproportionate distribution of resources and capabilities in today's international community, we must have effective, fair global compensation mechanisms in place.
3. The natural environment should be given increased consideration when revising the social contract.
4. The contract has to bring two important new protagonists into the equation: the self-organised civil society and the community of scientific experts.

The new social contract is an agreement to change: the global citizenship consents to expecting innovations that have a normative link to the sustainability postulate, and, in exchange, agrees to surrender the instinct to hang on to the established. The guarantor in this virtual contract is a proactive state that involves its citizens in future decisions requisite to the agreement of sustainability targets. This in turn is linked to a culture of attentiveness (born of a sense of ecological respon-

sibility), a culture of participation (as a democratic responsibility), and a culture of obligation towards future generations (future responsibility). It is by no means the case that the contract calls for a merely superficial or even resigned acceptance on the part of civil society: rather, the civil society is acknowledged as an active partner with shared responsibility for the success of the transformation process, and mobilised, thereby legitimising the process. The concept of a proactive state is therefore indelibly intertwined with the acknowledgment of civil society, and the innovative forces in the economy, in science and in administration.

Ten Measure Bundles with Major Strategic Leverage: Recommendations for Action

Strategic Perspectives

The transformation into a low-carbon society means nothing less than a paradigm shift from fossil to post-fossil society that must take place in the form of a societal search process. Although specific sustainability objectives can be defined (like restricting anthropogenic global warming to a temperature rise of 2°C, or stopping deforestation globally), it is not possible to provide an exact description of the ultimate desired state of economy and society. However, the objectives and direction of global economic development can take their lead from globally established and, for the most part, universally accepted standards (Human Rights, UN Conventions, Rio Declaration, Millennium Development Goals etc.). Widely accepted, above all, is also the imperative, voiced by Hans Jonas, amongst others, that current actions should not result in irreparable damages for coming generations to deal with, i. e. that we should not leave them worse basic conditions for survival, but rather improved conditions for survival, if at all possible.

The global perspective also dictates that despite all our differences and unique cultural characteristics, the global societies' development opportunities should not diverge too much. The principle of common but differentiated responsibilities set down in the Rio Declaration and the UN Framework Convention on Climate Change (UNFCCC) means that for the time being, the developing countries shall be given more leeway with regards to the transformation than the newly industrialising or industrialised countries. The agreed parameters allow plenty of room for a range of different strategies. In accordance with each country's specific conditions, every sector and society should develop and follow its own individual transformation path. The

WBGU sees two ideal, typical transformation options for this:

1. *Polycentric strategy*: The current climate protection endeavours in the different sectors and at different levels are bundled and considerably stepped up. The WBGU is convinced that this strategy can be implemented soon, and with the existing means, and is reasonably realistic. Measures which, taken on their own, have little transformative impact can, through clever mixing and skilful combination, have a far greater impact and generate unexpected movement, far more than a simple addition might lead us to believe. Taken in total, a societal tipping point can be reached, beyond which resistance to the transformation significantly decreases, the requisite political willingness grows, and the acceleration gains considerable momentum.
2. *Focused strategy*: Here, the focus is on concentrating on just a few major course changes that can have high transformative impact – but which a great number of the protagonists currently view as unrealistic, because they would need to be pushed through in the face of powerful forces insistent on preserving the status quo. Some of these major course changes are however necessary to achieve the scale and speed the transformation into a low-carbon society needs to reach.

Both polycentric and focused transformation strategy are aiming for a ‘Great Transformation’, though, hence both differ from the incremental politics of short-term crisis management and the ever-procrastinating negotiation of compromises.

In this report, the WBGU advocates an intelligent combination of both strategies. There are concrete recommendations for the intensification of current climate protection endeavours with regards to the three transformation fields of energy, urbanisation and land-use. The more small-scale measures show results, and the more change agents become actively involved, start networking, and start to initiate changes on different levels, all working towards a transformation, the sooner decision-makers will be encouraged to tackle the major, supposedly unpopular course changes. In a societal environment as dynamic as this, measures which are still viewed as unrealistic today could certainly become realisable tomorrow. The WBGU has therefore ranked its recommendations according to ambition level, i.e. according to their transformative impact *and* political achievability. This provides for explicitly including major course changes in our recommendations which may still seem unrealistic from today’s point of view, but which may well turn out to be inevitable in the long term.

Practical Recommendations for Action: Ten Transformative Measure Bundles

The scale and speed of the current transformation endeavours are by far not enough to avoid a dangerous climate change, and the risk of an irreversibly unsustainable global development. We are still a long way away from reaching the tipping point with regards to sustainable global resource conservation and value generation. In the following, the WBGU therefore outlines ten measure bundles with major transformative impact to accelerate and spread the transformation to sustainability.

Bundle 1: Improve the Proactive State with Extended Participation Opportunities

A central element in a social contract for transformation is the proactive state with extended participation in a multilevel system of global cooperation. It entails two aspects, frequently thought of as separate or contradicting: on the one hand empowering the state, which actively determines priorities and underlines them with clear signals (for example with bonus/malus solutions), and on the other hand, giving citizens more extensive opportunities to have a voice, to get involved in decision-making and to take a more active role in politics. A powerful (eco-)state is often thought of as restricting the autonomy of the ‘man in the street’, whilst at the same time, any meddling on the part of the citizen is viewed with misgivings as a disturbance factor to political-administrative rationality and routines. A precondition for a successful transformation policy, though, is the simultaneous empowerment of state and citizens with regard to the common goal of sustainable policy objectives.

The proactive state is firmly anchored in the tradition of a liberal and constitutional democracy, but it develops this democracy further with a view towards the future sustainability of democratic communities and liberal civil societies, and takes into account the boundaries imposed on economic and social development by a finite planet. Whereas climate protection is often regarded as a restriction and unreasonable deprivation, a proactive and enabling form of government has the explicit task of preserving available choices and the current room to manoeuvre for future generations and even, if possible, to extend these.

The WBGU recommends the approach of these goals on four interconnected levels: substantive through provision of climate protection targets in climate protection legislation; constitutionally, through the setting of a respective national objective regarding climate protection; procedurally, through extending the opportu-

nities for citizens and civil society organisations for public participation in decision-making, access to information and legal protection; and institutionally through mainstreaming the climate policies of government institutions (for example, by way of the establishment of a joint ministry for environment, climate and energy).

The level of ambition, and therefore the transformative impact of these elements, increases through combination, and a corresponding definition of content with regard to the following elements: as a central measure, the WBGU suggests climate protection legislation with ambitious mitigation targets, to be reached by 2050 (bundle 9), along the lines of the WBGU's budget approach. Another important legislative measure would be the introduction of a comprehensive, obligatory climate impact assessment scheme for any legislative proposal. Contrary to the existing planning and approval procedures, the public should be informed at the earliest opportunity about projects that have a major impact on climate protection and the transition to sustainable energy systems, and be given the chance to become actively involved in the planning and approval process. Further avenues for legal redress in the form of supra-individual collective actions should be opened up, in addition to the existing legal remedies, to allow judicial examination of planning and approval decisions. The use of ombudsmen and ombudswomen with a 'right to remonstrance' and a 'right to monitor', as well as prompt, iterative deliberation proceedings with the corresponding inclusion of scientific expert knowledge and non-professional expertise would, in the WBGU's view, complete the procedural system for climate protection relevant decisions by administrative and legislative authorities.

The federal German administrative bodies should undergo a climate mainstreaming at federal, state and local level. All of the measures described above that are of a material, legal, procedural-legislative and institutional nature (extended participation, climate mainstreaming, climate protection legislation, climate impact assessment, extended legal remedies) stand for, and concretise, the national goal of climate protection. Legislative, executive and judiciary bodies are legally bound to act.

National policies have reached their limits, both in terms of time and scope. We must therefore discuss how the (supposed) interests of future generations can be taken into account in contemporary elections and polls, and how people beyond national borders can be included, in accordance with transnational democracy. The WBGU proposes an extension to parliamentary legislative procedure in the form of a deliberative 'future chamber' to provide an institutional anchor for future-oriented interests. To avoid interest and party

political interference, chamber membership could, for example, be decided by drawing lots.

Statehood transcends national borders and sovereignties, particularly as far as climate, energy and the environment are concerned; this aspect also requires new supra- and transnational institutions. One prime example for such improvement, in the opinion of the WBGU, is the European Union's network of institutions, as the EU, after all, will also benefit from impulses for a deepening of its integration through joint, citizen-friendly climate, environment and energy policies (bundle 3). Although it does not have a central legal act on climate protection, it has set material targets as far as renewable energies, energy efficiency and climate protection are concerned. Further harmonisation is required with respect to energy policy. The EU obliges its member states to give its citizens access to information on environmental issues, to give them the chance to participate, and to make legal remedies available to them. The recently established Directorate General for Energy could be a first step towards future climate mainstreaming, although so far, this directorate has not been sufficiently committed to a transformative energy policy. Constitutionally, climate protection is anchored in the Treaty on the Functioning of the European Union; it could, however, certainly be codified as an explicit goal.

On an international level, central arenas for global governance of energy, urbanisation and land-use would have to be established for the transformation (bundle 10). Exemplary for mobilisation of the global community is the Aarhus Convention, so far limited to Europe, which obliges its member states to advise their citizens of environment-relevant projects, and provides them with ways in which to participate, obtain information, and legal recourse.

Bundle 2: Advance Carbon Pricing Globally

The WBGU believes that carbon pricing is the most important political measure for decarbonisation, and a necessary element of any regulatory framework for the transformation into a climate-friendly society. However, the price of carbon has to be at a level that is high enough to achieve the transformative impact called for, i.e. it must be substantially higher than the current European emissions trading price level. Price is a signal which can be given either through taxation, or through the introduction of a cap and trade system. Assuming that the institutional capacities are given, and that stringency can be guaranteed, the WBGU considers cap and trade to be the more effective instrument.

The WBGU proposes the following steps, with progressive ambition levels:

- *Refine the European Emissions Trading System (EU ETS) and reach a G20 agreement on carbon pricing (low ambition level):* The EU ETS should be continued, simplified in terms of administration, and supported by ambitious caps on emissions. The EU-wide goal for emissions reduction should be increased to at least 30% below 1990 levels by 2020, not least to regain EU credibility in international climate politics. A carbon price should also be introduced for sources of diffuse emissions, such as transport, which so far have not been included. At the same time, the EU should lobby for the introduction of carbon pricing policies in all G20 states.
- *Pursue the linking of emissions trading systems (medium ambition level):* Parallel to this, linking of current emissions trading systems should be encouraged. The more countries join a linked system, the higher the chances that other countries will follow their example. For countries that have not introduced national emissions restrictions, sectoral approaches should be considered. In countries that are currently unable to introduce emissions trading systems due to a lack of institutional capacity, the introduction of a CO₂ tax would be a reasonable measure.
- *Establish an emissions trading scheme that is as global as possible, with joint emissions restrictions (high ambition level):* The speedy and comprehensive integration of the major high-emission countries in a global emissions trading scheme would ensure that significant global emissions reductions can be achieved. To send a price signal both for investments and consumption, emissions trading should take place at corporate level. Such an emissions trading scheme requires a high level of international cooperation and must therefore be based on principles of fair distribution, as, for example, suggested in the WBGU's budget approach (2009).

Bundle 3: Promote a Common European Energy Policy

Goal of a common European energy policy should be the decarbonisation of the energy systems by the middle of the century. To achieve this, the WBGU recommends consistent and strong support for renewable energies, a coordinated, speedy extension of grid infrastructures, grid access, as well as storage facilities, and strong foreign and development EU policies on energy to promote the integration of neighbouring states, such as Norway or the North African countries. Such a common European energy policy would have a

great symbolic effect, and would underscore Europe's commitment to joint action in key future-oriented fields, strengthen the Union's competitiveness, and serve as an inspiration to the global economy. The WBGU proposes the following three steps, with progressive ambition levels:

- *Strengthening of the objective 'climate protection', and elaborating existing energy political measures (low ambition level):* To guarantee all-encompassing consideration of decarbonisation in all areas influenced by EU policies, climate protection should be given symbolic and constitutional support by being explicitly defined as an EU goal. Ambitious goals that go further than the EU renewable energy directive, which defines the targets to be reached by 2020, should be set, to be reached by 2050: climate protection objectives must be elaborated, and binding energy efficiency targets must be agreed. The financial support given to renewable energy carriers should be better coordinated on an EU-wide level, and, in the long-term, harmonised (bundle 4). These material provisions should be procedurally accompanied by extending monitoring scope, such as, for example, the introduction of collective European legal action.
- *Realisation of a single European energy market (medium ambition level):* To ensure a continent-wide sustainable energy supply, the WBGU strongly recommends pushing ahead with the realisation of a single European energy market to provide better support for renewable energies. Independent network operators would guarantee unrestricted grid access. Unrestricted grid access and cross-border networks are indispensable for the efficient integration of renewable energies into the existing grid, and for a guaranteed reliable supply. This is the only way that allows the development of a single European market for energy and gas with uniform prices.
- *Europe-wide energy strategy on union basis (high ambition level):* The EU should pool its continent-wide renewable energy potentials and, taking the differing geographical and economic conditions for the production and storage of renewable energies into account, drive ahead their cost-efficient extension. Apart from the harmonisation of existing promotion schemes, this requires joint planning of grid expansion, including the securing of the requisite funds. The WBGU advises the German federal government to support augmentation of EU legislative authority to allow for the definition and implementation of a European energy strategy, including the determination of the respective energy carriers, and the extension and rebuilding of cross-border infrastructures, to achieve a decarbonised, EU-wide

energy system by 2050 based on the largest possible share of renewables.

Procedurally, we recommend a division of labour between the EU and its member states: the EU provides the legal framework for the energy mix and the extension and rebuilding of infrastructural projects. The actual legal form and the implementation of planning and application procedures for infrastructure-related projects should be the member states' tasks.

Bundle 4: Accelerate Promotion of Renewable Energies on a Global Level through Feed-In Tariffs

The transformation speed that needs to be reached to protect the climate and avoid the imminent risk of path dependencies on fossil energy technologies can only be achieved by accelerating and increasing the use of renewable energies. The WBGU therefore advises the German federal government to strongly support, both at EU and global level, the widespread use of feed-in tariffs as a useful instrument. The most important accompanying measure, as it creates the one vital precondition an accelerated expansion of renewable energies depends on, is extension of the infrastructure, above all the construction of high-capacity transmission grids and storage facilities. Simultaneously, subsidies for fossil energy carriers should gradually be phased-out, as they are currently several times higher than the subsidies for renewable energy carriers. This ratio must be reversed as soon as possible.

➤ *Harmonise EU feed-in tariffs step by step:* Initially, the EU should strive for a binding EU-internal agreement for the introduction of feed-in tariffs in all member states, and for gradual harmonisation of the various national feed-in tariffs. However, complete harmonisation cannot be implemented immediately, as the transport capacities of Europe's electric power grids are as yet far away from being capable of allowing a limiting of the extension of renewable energies to ideally suited locations only. A harmonised, EU-wide feed-in tariff would be a sensible option once the grids are in place, and should already be prepared in advance. Renewable energies should also enjoy a Europe-wide feed-in priority status. The tariff should degress gradually to take into account changing market conditions, in line with the cumulative performance of each technology used. At an early stage, the potential integration of North Africa into this Europe-wide feed-in tariff system should be explored.

➤ *Drive ahead worldwide acceptance of feed-in tariffs:* Germany should, both as a pioneer of the feed-in tariff system and on the basis of having already gained practical experience, step up the knowledge transfer with regards to a system implementation. The International Feed-in Cooperation (IFIC) should receive more support, both financially and in terms of staffing, to allow further development into a centre of excellence that attracts international interest. In addition, the German federal government should suggest the founding of an initiative to encourage global adoption of the feed-in tariff system. The UN Conference for Sustainable Development (Rio+20 Conference) in 2012 would be a suitable occasion for the launch. The UN General Assembly has declared 2012 the 'International Year for Sustainable Energy for All'. Within the scope of this initiative, bilateral partnerships between industrialised and developing countries could be proposed, including support in terms of capacity and financing. An international financing mechanism should also be established to provide the (co-)funding needed for financing feed-in tariff systems in developing countries. The funding required for the extension of the necessary infrastructure, like grids and storage facilities, should also be taken into consideration here. The International Organisation for Renewable Energies (IRENA) could function as a platform for initiative administration and coordination. The initiatives and systems supporting feed-in tariffs should gradually be phased out towards the middle of the century, as in all probability, renewable energy carriers will be competitive by then, even without subsidies.

Bundle 5: Promote Sustainable Energy Supply Services in Developing and Newly Industrialising Countries

If the 2°C guard rail is to be complied with, there is very little room for manoeuvre left for greenhouse gas emissions intensive development paths in developing and newly industrialising countries. These countries need support with guaranteeing all of their people access to the basic essentials of a modern energy supply by 2030. They need support that allows them to establish a sustainable energy infrastructure (AGECC, 2010). If they do not succeed, there is a risk of path dependencies on high-carbon energy systems that would be very difficult and costly to overcome, and it would take decades to do so. The WBGU proposes the following steps, with progressive ambition levels:

- › *Adapt concepts and strategies (low ambition level):* The goal of overcoming energy poverty should be anchored more firmly in all developmental policy planning processes. The WBGU also proposes that the World Bank should develop a measurable, sophisticated strategy for low-carbon transformation, with the requirements of the 2°C guard rail as the benchmark. During the implementation of a global decarbonisation strategy, and in supporting the establishment of a low-carbon infrastructure, the regional development banks should also play a more prominent role. Development cooperation should set concrete energy political targets on this basis.
- › *Extend the use of modern energy in rural areas (medium ambition level):* Stepping up the use of existing technologies is one way to quickly and inexpensively improve the quality of life for many hundreds of millions of people. Efficiency optimisation in bioenergy use and switching to electricity and gas are crucial for overcoming energy poverty. Beyond poverty reduction, the European Development Cooperation should be guided systematically by the goal of low-carbon growth. Particularly in sub-Saharan least developed countries and in southern Asia, it should contribute to the establishment of low-carbon infrastructures, thereby supporting climate-friendly growth in these countries, too.
- › *Commence large-scale implementation soon, and accelerate it (high ambition level):* The EU should offer strategic ‘decarbonisation partnerships’ to developing and newly industrialising countries for low-carbon energy system establishment that go far beyond the scope of current EU climate-related cooperative partnerships. The WBGU recommends rapid large-scale expansion of existing model projects, and improvement of the preconditions for expansion, acceleration and multiplication of further pilot projects. One concrete measure is the major extension of the Africa-Europe Energy Partnership, and the potential expansion of Desertec further south. The G20 should use the Rio+20 Conference to set a clear signal for this.

Bundle 6: Steering the World’s Rapid Urbanisation towards Sustainability

Cities have a key function in the transformation process, not least because around three-quarters of global primary energy is used in urban areas – a rising trend. For currently rapidly growing urban structures, for example in Asia, high-carbon path dependencies must be prevented, as they would hinder low-carbon development for many decades. The issue of low-carbon

urbanisation should therefore be as high up as possible on the international political agenda. The following recommendations are important steps, but hardly enough to overcome this challenge. The WBGU proposes the following measures, with progressive ambition levels:

- › *Improve global communication and information (low ambition level):* Initially, scientific and methodical foundations should be laid through the generation of regular progress reports on global urbanisation trends. Verifiable methods and standardised illustrations of greenhouse gas intensity in cities, including all of the relevant protagonists and sectors, as well as direct and indirect emissions, should be developed. On the strength of these, UN Habitat should be upgraded, its current role with regard to the setting of standards should be expanded, and its staff significantly increased, ultimately leading to further development into a central organisation for issues concerning sustainable urban development.
- › *Develop and implement technologies and planning for low-carbon cities (medium ambition level):* Technologies and different ways of using renewable energies that are particularly suitable for use in urban areas should enjoy strong support in the form of special programmes (for example UN, World Bank or bilateral governmental cooperation), within the scope of an ‘emergency plan for sustainable urbanisation’. Germany should become increasingly involved in international technology cooperation. In addition, the network of existing initiatives, cooperating cities, town twinning and protagonist associations should be improved. The adaptation to the unavoidable aspects of climate change should be one of the priorities here. Sustainable urban and regional planning are key issues that have so far been neglected in transformation management; they should play a bigger role in development cooperation and development bank programmes (global training initiative, capacity increase). Moreover, the World Commission on Dams might be a role model for establishing a ‘World Commission on Low-Carbon Urban Planning’. At this ambition level, the WBGU proposes the creation of a UN Specialised Agency for sustainable urbanisation, with a strong mandate, which UN Habitat would then become part of (bundle 10).
- › *Large-scale launch of beacon projects and initiatives (high ambition level):* The World Bank should support the implementation of particularly ambitious mitigation strategies that address the goal of ‘climate-neutral mega-cities’ to make investment sums in the region of two-digit billions possible. The WBGU also believes that Germany should call for a bundled European initiative for the development of

actions with signal effect to promote low-carbon urbanisation in Asia. In Europe and in Germany, too, model regions and niches for change agents should be created to test ambitious concepts for low-carbon mobility and urban development. A model region could be the Berlin metropolitan area, in particular the area within the Berlin urban rail system (S-Bahn) circle line or within the scope of the International Building Exhibition 2020 (IBA).

Bundle 7: Advance Climate-Friendly Land-Use

Priority of any globally sustainable land-use policy must be securing the food supply for just under a billion mal- and undernourished people. Furthermore, demand for agricultural produce is going to rise because of the growing share of animal products and the increase in biomass production for energy and industry. At the same time, competition for arable land, by now a rare commodity, will become even fiercer due to soil degradation, water shortages and increasing climate impacts. The necessary mitigation of greenhouse gas emissions from land-use is an additional challenge. For these reasons, the transformation of global land-use is one of the central tasks for the future.

➤ *Establish a 'Global Commission for Sustainable Land-Use' (medium ambition level):* Land-use must be given a significantly higher priority on the international political agenda, and given a firmer institutional footing. The WBGU reaffirms its previous recommendation of establishing a new 'Global Commission for Sustainable Land-Use' for this purpose, with extensive authority regarding integrated land-use, that would have to go far beyond issues concerning agriculture or food security (WBGU, 2010a). Amongst others, it should have the following responsibilities: determination of the current state of scientific knowledge regarding global land-use, setting objectives and launching initiatives to encourage climate-friendly eating habits, developing a minimum sustainability standard for all biomass products, and exploring options for global land management.

Around a quarter of world-wide greenhouse gas emissions can be attributed directly to agriculture and land-use change. These emissions can be mitigated, but land-use systems cannot become completely emissions-free, not least because of the nitrous oxide resulting from the use of nitrogen fertilisers. Without a significant contribution from land-use, climate stabilisation cannot succeed. Mitigation of greenhouse gas emissions should therefore become another core element of new strategies for global, integrated land-use management. The

most important starting points for this are forest management, agricultural production, and eating habits. In each of these three categories, the respective ambition level of the recommendations are noted:

➤ *Stop deforestation and transition towards sustainable forest management:* A central goal of climate-friendly land-use is stopping deforestation and destructive forest-use. As an important platform for international dialogue, the REDD-plus Interim Partnership should be used for advancing the application of ecological and social minimum standards (low ambition level). In addition, the WBGU reaffirms its previous recommendation to extend the cooperation in the field of forest management with the major 'forest countries' with a view to forming strategic alliances (WBGU, 2010b) for joint development and testing of the technical and administrative framework conditions for sustainable forest management, and for REDD-plus-projects (medium ambition level). Particular attention should be paid to the protection and renaturation of (frequently forested) peatlands. The multilateral negotiations on a REDD-plus regime within the scope of the UNFCCC should be intensified to create the global framework for a legally binding mechanism, and to provide the required long-term planning security (medium ambition level).

➤ *Support climate-friendly agriculture:* Global agriculture must cover the expected rapid growth in demand for food, bioenergy and biomass as an industrial feedstock in a sustainable manner, and at the same time significantly reduce greenhouse gas emissions. Development policy should address this challenge, and encourage investment and incentive structures aiming for a sustainable, climate-friendly intensification of agriculture. One goal should also be the halving of agricultural post-harvest losses by the middle of the century. Equally, an international consensus on a minimum standard for sustainable bioenergy production should soon be reached (medium ambition level; WBGU, 2010a). The WBGU again emphasises not least the major significance of a rapid and more extensive liberalisation of global agricultural trade under the World Trade Organisation (WTO). The agricultural subsidies in the EU and the other OECD countries should soon be reduced further, and market access for developing countries should be improved. Negative impacts of liberalisation on poorer developing countries should be offset by international financial support (high ambition level).

➤ *Promote climate-friendly eating habits:* One priority that demands critical attention, apart from food wasted in households, are the changing eating habits

in favour of animal products. In total, around three-quarters of agricultural land is already dedicated to livestock production, seen as the most dynamic factor in land-use alongside population growth. Successfully steering demand away from this would have a major transformative impact, and is therefore considered 'high ambition level'. The WBGU recommends stepping up education, together with food labelling identifying the environmental impact, as measures to be speedily implemented. Canteens run by public authorities should schedule one or two meat-free days a week by way of setting an example. EU subsidies supporting livestock production should be phased out as quickly as possible. Due to the substantial leverage of these impacts, the option of including the emissions intensity of foodstuffs as a criterion in the taxation of agricultural products within the scope of a tax reform should be examined.

Bundle 8: Encourage and Accelerate Investments into a Low-Carbon Future

The transformation into a climate-friendly society needs substantial additional investments in sustainable energy and land-use systems (several hundred billion US\$ per year). State policies must therefore aim to make investment into low-carbon technologies more attractive, and to abolish current misguided incentives and investment barriers. The ambition levels of the recommendations in the following four areas depend on the level of development of the respective countries (industrialised, newly industrialising, or developing), and on the stringency of their political implementation, so ambition levels are not explicitly identified:

- *Provide stable framework conditions for climate-friendly investments:* The most important precondition for investments into low-carbon technologies and infrastructures are long-term, stable climate and energy policy framework conditions with ambitious targets, for example within the scope of climate protection legislation or a decarbonisation strategy. Apart from carbon pricing and phasing out of subsidies for fossil energy carriers (bundle 2), technology-specific funding should be granted, and binding efficiency standards for buildings, vehicles and energy consuming products should be introduced, or become more stringent. In the interim, tax incentives, for example for investments in sustainability and sustainable assets, should be an additional measure for a certain period of time.
- *Open up new financing sources at state level:* Ambitious carbon pricing and the phasing out of subsidies are important financing sources for the transforma-

tion. Of further relevance for developing and newly industrialising countries are financial transfers within the scope of the UN Framework Convention on Climate Change (UNFCCC). To make these available, the Green Climate Fund should immediately be turned into a binding mechanism, which offers grants without repayment. The fund should finance mitigation measures in developing and newly industrialising countries which are strategically integrated into decarbonisation road maps. Grants for mitigation projects in developing countries funded by existing multilateral funds should also be increased. The funds for mitigation, adaptation, technology transfer and capacity-building that have already been agreed by the industrialised countries as available from 2020 onwards should be in addition to Official Development Assistance, and exceed US\$ 100 billion per year. Levies on international shipping and aviation and the introduction of a tax on international financial transactions could generate further funds. Potentially, a global emissions trading system (bundle 2) could become an international financing instrument for the transformation.

- *Strengthen mechanisms to encourage private investment:* A large part of the investments will have to come from non-governmental sources. For many countries, we can assume that, due to historically low net investments but high private profits, considerable private capital exists; for Germany, empirically sound data is available to prove this. The release of these funds should be stimulated through suitable framework conditions and government measures to raise the rate of return for investments (for example low-interest loans), and to minimise the risks (for example credit guarantees). At national or EU level, the WBGU advocates the establishment of national Green Investment Banks to consolidate existing grants. For institutional investors with a long-term investment horizon (for example pension funds and insurance companies) the Green Investment Banks should offer attractive terms. To strengthen venture and equity capital markets, favourable taxation could be introduced, or the Green Investment Banks could establish new Venture Capital Funds. The development banks should extend their regular lending in the field of renewable energies and energy efficiency, and expand it through the jointly financed climate investment fund, not least in order to encourage additional, private investment through leverage. Existing microfinancing approaches in German development cooperation to promote decentralised energy generation from renewable sources should be increased. Concerning the Clean Development Mechanism (CDM), the WBGU recommends the

future limiting of this mechanism to the Least Developed Countries, enhancing the development aspect, and the inclusion of programme-based and sectoral measures.

- *Encourage new business models:* The high initial investment burden for individual investors could be shared if traditional seller-buyer business models were turned into business models with new financing and ownership structures. These would allow businesses to offer their customers combined packages in certain areas (for example mobility, housing, production and consumption) that include services as well as real assets, instead of just tangible goods. Car sharing and energy contracting provided by energy service companies are examples of this. Cooperative societies are also suitable for financing larger investments. To have a major transformative impact, new business models such as these must become more widely accepted, and more widely established.

Bundle 9: International Climate and Energy Policy

As infrastructures for energy generation, transport and production have a long lifetime, any current conversion and extension projects must already be geared towards climate protection. As most of the additional energy infrastructures are expected to be built in developing and newly industrialising countries, a climate protection scheme that is limited to the more prosperous countries cannot solve the problem. Global cooperation is therefore necessary to ensure that the requisite funds for climate-friendly development are also available to poorer countries, and that all countries have access to climate protection technologies and the respective expert knowledge. International climate and energy policy is the forum for achieving a global consensus on transformation targets and ambitions. There is also no better alternative for negotiations on balancing global equity than the UN level. Although some operative goals like the sharing of climate protection related knowledge and technologies can be advanced on a sub-global level, the strengthening and institutionalisation of the fragmented international energy policy, and a convergence of climate policies, should nevertheless be systematically pursued to accelerate the technological shift.

International Climate Policy

The gap between the claims and the reality of international climate policy is widening. In the agreements of

the Cancún Climate Conference, a restriction of global warming to less than 2°C above the pre-industrial level is recognized as the long-term goal, the urgent need for action is identified, and a review process is initiated. An effective regime with internationally binding obligations on emissions targets, on the other hand, seems to have been put on the back-burner. Currently, climate protection depends on the voluntary pledges for limiting emissions on the part of the states. These pledges altogether are currently not enough to achieve compliance with the 2°C guard rail. The WBGU proposes the following steps for an international climate policy, each with progressive ambition levels:

- *Ambitious unilateral targets within a pledge and review system (low ambition level):* An absolute minimum should be higher mitigation target ambitions on the part of the states within the scope of a pledge and review system (voluntary, internationally verified climate protection measures and payments) to a level that is compatible with observing the 2°C guard rail. The WBGU recommends that German and EU mitigation levels should be more or less in line with the budget approach proposed by the WBGU (2009). Compliance with the 2°C guard rail requires global greenhouse gas emissions of no more than 44 Gt CO₂ eq per year by 2020. By 2020, in accordance with its share of the global population figures, Germany would have to reduce its emissions by 56% compared to 1990. It could meet this demand through a reduction of its own emissions, stocked up with transferred funds. For example, domestic emissions could be reduced by around 40%, offsets or CDM could also play a small part in this, the remainder would be covered by finance and technology transfers amounting to at least € 4–8 billion annually, which would allow an additional mitigation of 0.2 Gt CO₂ eq annually in other countries. The level of reduction the whole of the EU is responsible for would be around 40%, around 30% of which could be realised within the region, plus annual financing and technology transfers worth around € 11–22 billion for mitigation measures in other countries. These amounts do not include finance and technology transfers for adaptation to climate change or compensation for climate damages. On the other hand, to allow the global climate protection goal to be met, countries where emissions are still low, but which are currently on a dynamic growth path, would have to aim for development paths with emissions levels significantly lower than they would be if the global budget were to be applied equally per-capita, by as early as 2020. They should be supported in this in the form of the above mentioned finance and technology transfers from high emission

countries. During this process, the physically achieved emission reductions should always be in line with the respective countries' mitigation potentials. The development of appropriate decarbonisation road maps should be a precondition for access to the Green Climate Fund. The technology mechanism agreed in Cancun offers a very good starting point for a global offensive to promote the spread of climate-friendly technologies, and should be put into operation as soon as possible. All of the described aspects of international technology transfers should be taken into account here. Parallel to this, Germany and the EU should become actively involved in determining the vital long-term global emissions target.

- *Pioneer coalitions for mandatory climate protection (medium ambition level):* Many states are prepared to go beyond pledge and review. Through coalitions, both within the framework of the UN negotiation process and independent of it, the EU should contribute to reaching ambitious partial agreements on climate protection. These kinds of sub-global alliances could, for example, play an important role in forest protection, the establishment of climate-friendly infrastructures, or help to establish acceptance of emissions trading systems. Beyond these alliances, however, the EU should also increasingly seek coalitions for a binding treaty within the scope of the UNFCCC. Apart from unconditionally and stringently raising its own mitigation targets, the EU should also show a clear commitment to continuation and further development of the Kyoto Protocol.
- *Comprehensive mandatory global climate protection regime (high ambition level):* The ultimate goal of international climate policy should be a comprehensive, binding agreement for global emissions restriction. In its budget approach, the WBGU (2009) outlined the basic elements of such a treaty: a 2°C guard rail compatible maximum global budget for CO₂ emissions from fossil sources would be allocated across all countries on an equal per-capita basis. All countries should agree to present internationally verifiable decarbonisation road maps that clearly state the planned national emissions path up to 2050. In the WBGU's view, CO₂ from non-fossil sources and other greenhouse gases should be governed by separate regulations to achieve a more direct impact. The WBGU has repeatedly proposed an independent international agreement for the protection of terrestrial carbon stocks (WBGU, 2004). Priority should here be given to the stopping of deforestation in the developing countries (bundle 7). Mitigation of fluorinated greenhouse gases could be accelerated and simplified through a special agree-

ment along the lines of the Montreal Protocol (WBGU, 2009). As far as the as yet unregulated, short-lived radiative forcing substances such as soot particles and ozone-forming gases are concerned, there could be separate agreements directly related to national air pollution control.

International Energy Policy

The most important objectives of the transformation of global energy use towards climate-friendliness are (1) limiting final energy demand whilst at the same time ensuring access to modern, sustainable energy services for all people, (2) the decarbonisation of the energy supply, and (3) the introduction of new, low-carbon technologies in the transport sector, in buildings technology, and in industry. One important starting point for the relevant international energy and technology policies is the agreement of norms and the setting of standards. Beyond this, international cooperation can also accelerate the development of key technologies for the transformation. Ultimately, cooperation plays an important role in breaking down the barriers obstructing a global diffusion of technologies for a low-carbon development. Currently, there is a lack of legal and institutional foundations for an effective international energy policy for the transformation. The WBGU recommends building upon existing organisations to gradually establish global sustainable energy governance, and proposes the following steps, with progressive ambition levels:

- *Open up IEA, consolidate and strengthen IRENA (low ambition level):* The International Energy Agency (IEA) is an influential, international energy institution. However, membership, role and energy political objectives regarding a sustainable energy policy have so far been restricted. The IEA's policies should focus more on sustainable energy use and sustainable energy systems, methods should be made more transparent, and access for non-OECD countries should be accelerated. The International Renewable Energies Agency (IRENA), established in 2009, can take on the important task of acting as the global voice for the diffusion of renewable energies and the requisite industries in all country groups in future. The WBGU recommends continuing to actively support the establishment of IRENA. In future, IRENA should play a major role worldwide with regards to energy issues to advance the increased use of renewable energies, on par and in cooperation with existing organisations in the field and the civil society.
- *Upgrade UN-Energy and strengthen sustainable energy policies within the UN system (medium ambition level):* The link between energy policies and

development assistance policies on a global level has long been neglected. The WBGU therefore recommends to upgrade UN-Energy to the level of official UN programme. The UN general assembly has declared 2012 the 'International Year for Sustainable Energy for All'. This should be utilised to agree access to modern energy services by 2030 for all people as an additional Millennium Development Goal.

- *Make IRENA the central organisation for global sustainable energy policies (high ambition level):* IRENA's mandate should be extended to encompass all energy systems and low-carbon energy options, including issues regarding system integration and energy efficiency on the demand side. Step by step, IRENA could then be developed further into an International Sustainable Energy Agency (WBGU, 2004). The federal government should actively support turning IRENA into one of the central organisations for energy policy in the long-term, that can effectively advance the global transformation of energy systems.
- *Use the G20 as the driving force for a sustainable global energy and climate policy (high ambition level):* Considering the urgency of the global energy shift, political willingness to act must significantly increase, and political leaders must be mobilised. As an alliance of the economically and politically leading industrialised and newly industrialising countries, which together cause approx. 80% of global greenhouse gas emissions, the G20 occupies a prominent position. The German federal government should encourage the G20 in their determined pursuit of a sustainable energy political agenda, and the creation of the institutional foundations required for effective global cooperation.

Bundle 10: Pursue a Revolution in International Cooperation

The world desperately needs a higher level of international cooperation if climate- and environmentally-friendly global development is to be achieved in the long-term. Considering this aspect, the WBGU recommends:

1. Using the Rio+20 Conference as a chance for setting the course of international environmental and developmental policy towards improved cooperation and climate-friendliness.
2. The conference should therefore pave the way for a comprehensive cooperative global governance architecture, without which a worldwide transformation to sustainability cannot succeed.

International Environmental and Developmental Policy in Context with the Rio+20 Conference

The UN Conference on Sustainable Development (Rio+20 Conference) scheduled for 2012 provides an excellent opportunity for elaborating international environmental and developmental policies. In view of the background provided by the two key issues defined for the conference, 'Green Economy in the Context of Sustainable Development and Poverty Eradication', and 'Institutional Framework for Sustainable Development', the least the WBGU would expect is the adoption of a global 'Green Economy Roadmap', and profound institutional reforms within the scope of the UN.

- *Green Economy Roadmap and institutional reforms (low ambition level):* With the 'Green Economy Report' presented by UNEP in 2011, the international community gathering in Rio has been provided with a suitable and timely basis for discussion and decision-making with regards to binding agreements. The WBGU believes that a binding 'UN Green Economy Roadmap' with specific targets in terms of both content and timing should be decided in Rio, to be implemented within the framework of national Green Economy Strategies that include verifiable indicators by 2030. The focus should be on low-carbon oriented, quantifiable targets and secondary targets, as these have proven successful in the context of the Millennium Development Goals for the conversion of energy systems, and on issues of urban development and sustainable land-use. Concurrently, poverty eradication strategies and especially the further implementation of the MDGs should be integrated into the higher-ranking Green Economy Roadmap in a way that explicitly allows direct focusing on the demands of the transformation. Key starting points for this are the securing of access to modern forms of energy for all people, and an improved food supply through the sustainable intensification of agriculture. As of now, the multi-lateral institutions involved in developmental policy-making should be coherently guided in their operative strategies by the target systems serving poverty reduction and low-carbon development. The implementation of the UN Green Economy Roadmap should also be supported by long overdue institutional reforms. The WBGU reaffirms its recommendation that UNEP should be politically upgraded and expanded to a UN Specialised Agency under particular consideration of the developmental dimension of international environmental policy. The Rio+20 Conference is also an opportunity to lay the groundwork for more fundamental reforms of the UN's development assistance political architecture.

- › *Fundamental reform of multilateral environmental and developmental policy (medium ambition level):* An ambitious summit result would be a comprehensive modification of the multilateral environmental and developmental architecture in line with the transformation. In the context of the Rio+20 Conference, both the German federal government and the EU should initiate a process aimed at prompt transformation of the major operative international development agencies (such as the World Bank, regional banks, UNDP, UNIDO) into change agents for low-carbon transformation. The WBGU takes its inspiration here from the 2006 reform proposals presented by the High-Level Panel on System-wide Coherence, and also recommends that these are geared explicitly towards an environment- and climate-friendly developmental policy.

In addition, system-wide coherence, taking the transformation into account, demands closure of the huge governance gaps in the key transformation fields of energy, urbanisation and land-use on an international level (bundles 6, 7 and 9), and the gradual abolition of transformation impeding and expensive parallel structures. The Rio+20 Conference should task the standard multilateral organisations with the drafting of concrete restructuring plans, to be presented to the member states by 2014 for decision-making. The benchmark guiding all these actions should be compliance with the international climate policy's 2°C guard rail. New organisations would only be established if the demand for global regulation in the three transformation fields could not be satisfied within the foreseeable future through the reorganisation of already existing structures.

- › *United Nations 2.0 (high ambition level):* Considering the scale of the described challenges of the transformation, the WBGU believes that there are plenty of arguments for an even more radical approach that would go beyond the existing UN architecture, a fundamental restructuring of the organisation. Currently, this does not seem feasible in political terms, as it would need a political leadership that is guided by a profound realisation of vital global necessities, for example, in the UN Security Council as well as other industrialised and newly industrialising countries. If this were the case, a reform should start with a review of the UN Charter, and aim for a completely restructured United Nations organisation. Its purpose would be to take the planetary guard rails into account as a guiding principle that governs UN actions, and the pursuit of which would guarantee protection of climate and environment as much as peace, security and development.

The Rio+20 Conference should at least admit to this kind of vision, and initiate an intergovernmental consultation process aimed at substantially extending the UN Charter. The drawing up of a 'Charter for Sustainable Development' that codifies the joint responsibilities and duties of all states and their (global) citizens regarding the protection of the Earth system would be a significant step towards a global social contract. This could form the basis for a contemporary review of the UN – for example the establishment of a 'Council for Sustainable Development', on par with the Security Council, reflecting a 21st century world of states – which would be a formal expression of the normative need for a global we-identity.

Extensive Global Governance Architecture for the Transformation

A generally high level of international cooperation, global coordination and political pro-activeness are central conditions for the success of the transformation. The global development dynamics trend reversal that is needed will therefore not be achievable without comprehensive, long-term oriented international regulatory policies with an equitable world order as its goal. In the following, the WBGU outlines three steps with progressive ambition levels on the path towards the necessary 'revolution in global cooperation'.

- › *Revitalised multilateralism (low ambition level):* Inevitably, non-cooperation regarding central issues of global environmental and climate change leads to an escalation of conflicting interests and distributional conflicts. To prevent this, the key actors of world politics must find a new mode of international diplomacy as soon as possible. In the view of the WBGU, the G20 are generally suitable for handling this task, as they not only carry a high level of climate political responsibility, but also have correspondingly high potentials for transformation. The WBGU therefore recommends working towards the goal of a global transformation road map within the scope of the G20, or a comparable sub-global constellation. The benchmark for the practical decisions this kind of plan might include should at the very least be a G20 crisis management in the context of the global financial crisis. The interests of smaller and poorer developing countries would have to be taken into account in a plausible way to allow for a gradual pro-transformation mobilisation across the international community as a whole. The German federal government and the European Union should, through credible leadership, also aim for a high level of ambition as far as this joint cause is concerned, and meet the other

states with a committed and mediating attitude. The G20 could then even become the driving force behind modernising the entire UN system.

- › *Transformative global infrastructure development (medium ambition level)*: The transformation focuses on three fundamental national and global economy 'infrastructures': the energy systems, urban areas, and land-use systems. Compliance with the 2°C guard rail is only possible if we have changed our course towards low-carbon in all three of these transformation fields by 2020. However, all three fields lack problem-adequate global governance mechanisms to coordinate global and national transformation goals, develop the corresponding indicators and routes for transformation, and define suitable incentive systems.

Accordingly, the WBGU recommends that suitably capable international organisations are either authorised to act, or newly established and provided with adequate resources. One important point of reference is provided by the UNFCCC, particularly in view of the emissions restrictions that have been negotiated there. The mechanisms that were additionally agreed upon, for example on the transfer of technology or forest protection, should be developed and implemented quickly (bundles 7 and 9). In the transformation field of energy, the German federal government should actively support a shift in the objectives of the IEA towards sustainable energy policies, the improvement of organisation accessibility for developing countries, the strengthening of IRENA as the driving force behind the international diffusion of regenerative energies, and the upgrading of the status of UN-Energy (bundle 9). Regarding urbanisation (bundle 6) and global land-use (bundle 7), the WBGU initially recommends the establishment of a 'World Commission for Low-Carbon Urban Development' and a 'Global Commission for Sustainable Land-Use'. On the strength of the findings of the latter commission, the FAO should then develop a suitable range of instruments to ensure the climate friendliness of national and global land-use paths. Due to the impact of the rapid urbanisation on climate protection, and the fact that the UN-Habitat programme is not adequately equipped to deal with this aspect, the WBGU also recommends the establishment of a UN Specialised Agency for sustainable urbanisation with a strong mandate (bundle 6).

- › *Equitable new global system (high ambition level)*: In accordance with the global social contract for sustainability, the ultimate goal of a revised global governance architecture must be the creation of a new, equitable global system. Its institutions must put the international community in a position that leaves

them capable of appreciating the complex interdependencies of the global society within the scope determined by the limits imposed by our planet, as soon as within the first half of the 21st century, to allow for timely and adequate response. This demanding process is comparable with the embedding of market dynamics in constitutional states, democracies and welfare states during the last great transformation into an industrialised society, which led to the stabilisation and acceptance of this new form of society in the first place.

Politically, this requires a historically unprecedented transcending of established sovereignty concepts and purely power-driven global politics in favour of ensuring the long-term availability of global commons. Sustainable strategies and concepts must be developed for this in order to embed sustainable global development in transnational democratic structures, to formulate answers to the 21st century questions regarding global equity and distribution of resources, and, not least, to be able to claim world-wide legitimacy.

This means concrete academic search processes, for example by global governance theoreticians, international law experts, cosmopolitans, transnationalists and philosophers of justice to formulate legitimate and realisable norms, rules and procedures which, all together, could form the basis of an ideal global social contract. This would be something of a quantum leap for civilisation, on par for example with the transition of the feudal systems to constitutional states and democracy. Comparably to the Universal Declaration of Human Rights, however, it should in principle also be possible to reach a universal consensus regarding human civilisation's ability to survive within the natural boundaries imposed by planet Earth. This necessarily presupposes an extensive 'Global Enlightenment', which must be aimed towards promoting cooperative behaviour and accelerating the formation of relevant global social standards and debate. The WBGU strongly advises the use of the coming Rio+20 Conference as a historic chance for such an enlightenment process. A corresponding summit declaration could serve as a future reference framework and point of reference for global enlightenment, and help to initiate an effective, long-term paradigm shift.

Synthesis of Measures

In the face of the imminent challenge, policy-making should pave the way for several of the steps with a high level of ambition, even if these currently still appear to

be of a rather visionary nature. For example, a climate policy that focuses primarily on measures with the lowest level of ambition is hardly likely to comply with the 2°C guard rail. Ultimately, a great number of demanding measures will be required to make it possible for the transformation to succeed.

The bundles of measures must also be put together wisely. The combination possibilities describe a continuum across different operating levels: at one end, there are polycentric transformation approaches at different levels of ambition, with an initially limited geographical or sectoral extent, that rely on a ‘concurrence of multiple change’ to create an irreversible general momentum. At the other end are strategies aimed at the highest level of ambition, and ultimately at the establishment of a comprehensive global architecture for the transition into a low-carbon society. In particular, the global approach is aimed at the enforcement of a legally binding world climate agreement to establish an upper limit for global emissions and instruments for global emissions trading, and at multilateral mechanisms for the climate-friendly transformation of urbanisation, land-use, and the energy systems. Along this continuum, there is a wide range of choices. Particularly ambitious, polycentric transformation policies can work in different ways:

- *Geopolitics – forming sub-global alliances:* To accelerate the transformation, the forging of intergovernmental alliances between climate pioneers should be increased. For Germany and the EU, the major newly industrialising countries China, India and Brazil are particularly important in this respect. Suitable topics would be the promotion of renewable energies or emissions trading, areas in which pioneer partnerships could set standards and establish structures that should gradually be ‘globalised’. These alliances should also serve the discussion on a fair burden-sharing of decarbonisation measures.
- *Establish incentive systems for dynamic protagonists in the transformation fields:* In the transformation fields, positive incentive systems for dynamic protagonists could speed up the low-carbon transformation. Thus, generously funded programmes for low-carbon investment projects by the World Bank and by regional development banks could provide considerable incentives for leaving the established fossil development path. Substantial loan programmes for a competition to identify and support the 10 or 20 most visionary models for the building of low-carbon cities in developing or industrialising countries could initiate or accelerate search processes in that direction. This path could be followed independent of the progress of geopolitical alliances.

- *Focus on transformation barriers:* One particularly difficult obstacle the transformation must overcome is presented by the global annual subsidies for fossil energy carriers in the region of three-digit billion figure amounts. A politically supported international alliance of change agents in economy, civil society and science could contribute to breaking down this barrier impeding progress towards sustainability.

This outline of polycentric transformation strategies clearly shows the extensive scope of options for innovative paths. The ten bundles of measures presented by the WBGU are representative of the wide spectrum of strategies available to us. The 2°C guard rail is the most important benchmark any measures have to consider. To stay credible, the European Union should, as far as emissions reductions are concerned, agree on the raising of its own reduction target to at least 30% for the year 2020, complemented by substantial, legally binding international climate protection financing commitments.

.....

The Role of the Knowledge Society in the Transformation Process: Recommendations for Research and Education

Social Renewal by Comprehension

Research and education are going to play a central role during the requisite transformation process, as the realisation of the necessity for restructuring the world economy has been triggered mainly by scientific knowledge. Society should therefore decide on actions that are not a direct response to recently experienced events, but motivated by foresight and precaution. For this purpose, the debate between science, politics and society should be far more structured, more obligatory, and livelier, to ensure a constructive discourse about the best ways to achieve sustainability. Research and education that assume participation can make a decisive contribution to this.

The transformation is a societal search process that should be supported by experts. In collaboration with politics, the economy, and society, research and education are tasked with developing visions for a low-carbon society, exploring different development paths, and developing sustainable technological and social innovations. Concurrently, the social framework for a culture of participation should be strengthened. To this end, education should enable people to develop an awareness of current problems, to learn systemic thinking, and to act responsibly. Promoting research and education is therefore a key task for the modern, proac-

tive state, which should provide targeted support for the integration of the scientific expert community into the social contract.

The Four Transformative Pillars of the Knowledge Society

To clarify the different roles research and education play in the transformation process, the WBGU suggests differentiation between ‘transformation research’ and ‘transformation education’ on the one hand, and ‘transformative research’ and ‘transformative education’ on the other hand. The subject of transformation research or transformation education is the transformation as such, and the conditions needed for realising it. Transformative research or transformative education is tasked with advancing the transformation process with the aid of specific information, methods and technologies (fig. 3).

Transformation Research

The WBGU proposes the establishment of a new scientific discipline, ‘transformation research’ (Tr), which specifically addresses the future challenge of transformation realisation. This discipline explores transitory processes in order to come to conclusions on the factors and causal relations of transformation processes. Examples from history could provide the basis for analysing observed transformative moments. One such example would be the integration of the steam engine into the mechanisation of cotton processing around 1785. This one, seemingly innocuous step led to a rapid rise in textile production efficiency, which in turn led to a rise in the demand for raw materials, thus (co-)triggering the Industrial Revolution. It was, though, embedded in a complex causal network of further factors and historically evolved framework conditions. This equally applies to transformations at another level, for example the normatively motivated abolition of slavery. Transformation research should draw conclusions for the transformation to sustainability based on an understanding of the decisive dynamics of such processes, their conditions and interdependencies. It is important here to learn how to anticipate acceleration moments in order to create the relevant favourable framework conditions. One particular challenge for transformation research is the creation of a network of social, natural and engineering sciences in order to understand the interaction between society, the Earth system, and technological development.

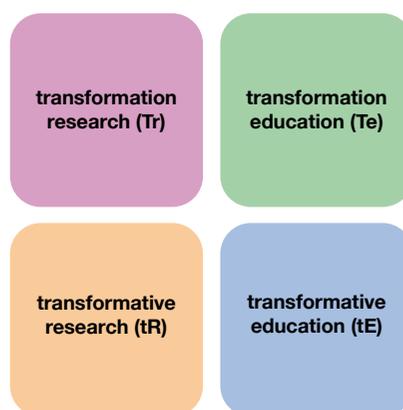


Figure 3

Typification of transformation research and education. Source: WBGU

Transformative Research

The WBGU uses the expression transformative research (tR) to describe research that actively advances the transformation. Transformative research supports transformation processes with specific innovations in the relevant sectors. It encompasses, for example, consumer research, which is needed for the development of new business models such as the shared use of resource-intensive infrastructures, and research for technological innovations like efficiency technologies. Transformative research can have a wider transformative impact if, as of a certain development stage, development activities for low-carbon innovations are embedded into a systemic context, their impact on climate and sustainability is verified, and they reflect the conditions required for transformative impact. So although achieving higher degrees of efficiency in photovoltaics – for example through development of new, different material combinations – is necessary, the aspect of global usability should also be taken into account at the earliest possible stage. This also applies to the development of new investment models for energy efficient technologies. Their intercultural transferability should also be considered at an early stage, yet equally, attention should be paid to measures against rebound effects and potential path dependencies. Transformative research therefore encompasses a spectrum that reaches from purely discipline-based to system-based research. This means that the application-oriented exploration of highly-efficient storage technologies can have as much of a transformative impact as an interdisciplinary project for the development and implementation of SuperSmart Grids.

The ongoing exchange of information between both types of research leads to ‘cross-fertilisation’, and in turn with society, the economy, and politics, thus offe-

ring the best possible support to the transformation. Absolutely crucial for this is a higher level of science communication, including the targeted utilisation of the new media. This provides a wide range of opportunities for interactive, participative shaping of the social dialogue.

In this context, the education sector must also take on more responsibility. As an important channel of knowledge communication, education provides the foundations for each individual's knowledge-based self-concept, thereby creating the social preconditions needed for the transformation. Transformation research should be linked closely to transformation education. Categories and interaction are described in the following.

Transformation Education

Transformation education (Te) makes the scientific findings of transformation research available to society. As 'education for participation', it critically reflects on the requisite basic requirements – like a thorough understanding of the pressure to act, and a global sense of responsibility – and generates a systemic awareness of the different action paths. It is especially about communication of knowledge at the interface of engineering, social and Earth system sciences. Suitable narratives of change should be developed, so that these can be fed into everyday discourse through creative forms of knowledge communication, and develop further scope there. Through a focus on change agents, an awareness of the preconditions for the transformation can be firmly ensconced in education. Change can only be imagined through a dynamic view of the world. In view of this, educational institutes should increasingly teach sustainability-oriented knowledge, and the skills necessary for lifelong learning and systemic thinking. This also includes a better understanding of the scientific research process, its possibilities, and its limits.

Transformative Education

Transformative education (tE) generates an understanding of action paths and possible solutions. Related educational content would, for example, be innovations that are likely to have transformative impact, or that have already had a transformative impact. The current stage of research should be made understandable, and should be actively shared with society. To facilitate this, education should, if possible, attempt to establish a relation to the key factors of the transformation. For example, renewable energies could be a topic in physics lessons, whilst concurrently, international energy partnerships are discussed in the social science subjects.

Geography lessons might be about, for example, low-carbon cities. Transformative education should also be responsible for creating a basic general problem awareness, which is also reflected in theme-specific educational opportunities. In accordance with this, the boundaries between the different disciplines should be less strict, and comprehension of the broader, interdisciplinary and global contexts should be strived for. In economics, for example, global material flows, from resources to waste products such as CO₂, could be analysed. So the lesson would be about embedding the economy into the planetary boundaries.

Both types of education should regard society as a stakeholder in the transformation process, with the aim of also allowing participation in the education process itself in the future. People can only comprehend the transformative power of their actions if they see themselves as an active factor. Respective educational structures are an essential precondition for this.

Current Research Programmes

Currently, a number of programmes with implicit transformation relevance are running both at German federal republic and EU level. The WBGU analyses relevant programmes in its report. Certain criteria are applied, such as, for example, 'international scope' and 'interdisciplinarity', to show the positive trends apparent in the different research programmes, but also to identify their weaknesses. On the basis of this analysis, the WBGU concludes that research policy in the individual areas, like urbanisation and land-use, is already addressing the challenges posed by the transformation through innovative research agendas and programmes, frequently in a low-carbon context, even though funding is inadequate. In many cases, interdisciplinarity, too, has already been admitted into research programmes, although overall, incentive structures to encourage interdisciplinarity are as yet insufficient. As far as the factors that are needed for transformation acceleration are concerned, many research grants are already focusing on innovation, which is a very welcome sign. Nevertheless, the emphasis is too much on the purely technical side, in comparison with social conditions and the corresponding systemic approaches, which is also why too much attention is paid to supply rather than demand.

Recommendations

Considering the identified challenges for research and education and the analyses carried out, the WBGU has

reached the following conclusions in terms of recommendations.

Research

- › Science and research should dedicate themselves even more to the low-carbon transformation within the context of sustainability. Research should focus more on transformation-relevant issues and subjects and the new field of transformation research. At the same time, it should increasingly meet a number of structural demands, such as, for example, a systemic, long-term, cross- and transdisciplinary direction. It should develop technological and social low-carbon innovations, evaluate these, and assess the required conditions for their global diffusion. This also includes the development, evaluation, and public discussion of strategies and policy options. Accordingly, research programmes should reflect these demands.
- › The WBGU calls for the establishment of a new field of studies, ‘transformation research’, which examines transformation processes and the social preconditions within the scope of planetary boundaries. To develop this new field of inquiry, the WBGU proposes a joint societal search and discussion process. This process could be overseen by The Alliance of Scientific Organizations in Germany.
- › Overall, in order to face the current challenges successfully and accelerate the transformation, substantial additional research and development funding is required. Concurrently, research should be consolidated both at EU and international level, as no country can develop all the solutions required on its own.
- › Funding for the central transformation field energy should be substantially increased. The WBGU emphasises its 2003 recommendation to increase direct public spending in the industrialised countries on research and development in the energy field tenfold, largely through reallocation. Grants for energy generation through nuclear fusion could be stretched across a longer term to release funds for higher priority tasks.
- › The current funds for the German Federal Ministry of Education and Research (BMBF) sustainability research, particularly the framework programme ‘Research for Sustainable Development’, and ‘Socio-Ecological Research’ (SÖF) should be significantly increased, and SÖF’s global perspectives should be considerably extended.
- › Interdisciplinary research should be supported by concrete measures. This requires changing the existing incentive systems, and introducing new ones. The WBGU proposes that the German Rectors’ Con-

ference, the Joint Science Conference, the German Research Foundation and the Academies of Sciences meet to consult on recommendations and directives for the implementation and rating of interdisciplinary transformation research.

- › In the course of drawing up the 8th EU Framework Programme for Research, the German federal government should lobby for a stronger focus on the transformation; environment and energy research should be given particular weight.
- › Internationally, Germany and the EU should forge stronger research alliances with research centres in emerging economies. In the scope of its development cooperation, Germany should step up the promotion and support of education, science and research capacities in the less developed countries.
- › The WBGU suggests that a coming Initiative for Excellence should focus thematically wholly on the subject of research in the context of the transformation for a resource friendly, sustainable and liveable society.
- › The current evaluation of the Consultative Group on International Agricultural Research (CGIAR) is an opportunity to direct their activities towards climate friendliness and sustainability.

Education

- › Transformation education should be given a higher priority in the German sustainability strategy. It should also be integrated into school and university curricula, vocational qualification, and further studies. This encompasses exchange programmes, new combinations of bachelor and masters courses, teacher training modules for transformation-relevant systemic education, and degree programmes for transformation sciences.
- › Through coherent policies, subject-relevant education and vocational qualification systems should be redesigned in such a way that they can dedicate themselves to the demands of sustainable development. At the same time, opportunities for life-long on-the-job learning should be extended through publicly funded further education courses and post-graduate qualifications, for example in the form of a ‘sabbatical’ with regard to transformation for employees.
- › The WBGU also suggests the establishment of low-carbon business schools and interdisciplinary faculties for low-carbon land-use, energy science, urbanisation and transformation-specific management in order to support the transformation process.
- › During the UN ‘Decade of Education for Sustainable Development’, institutional mechanisms should be

developed to ensure that sustainable development education continues once the decade has passed. The UNESCO could initiate a process that could be designed similar to the continuation of the International Decade for Natural Disaster Reduction (IDNDR). That way, successful activities could be continued through local and national institutions.

Therefore, the social contract addresses future generations in two ways, as it is they who will participate in bringing about the change in future. Above all, however, it is also in our young citizens' interest to rapidly accelerate the transformation and to stop impeding it – now.

Field of Interaction Education–Research

- › In view of the overriding importance of the issue, the WBGU further suggests the establishment of a German federal university with a research and education profile that focuses on the transformation towards sustainability. Research and teaching should be inter- and transdisciplinary.
- › The WBGU proposes an extensive education and research programme 'Participation in the Science for Transformation', aimed at education and knowledge for the benefit of the environment and sustainability, achieved through participation of non-scientists.
- › Science policy and science should initiate interdisciplinary and society-wide dialogues on subjects such as visions for a 'decarbonised society', requirements for transformation research, stepping up inter- and transdisciplinary research, or priority research issues. The dialogue could also be stimulated in a cultural and artistic form, for example in museums, at future exhibitions or music and film festivals.
- › To increase the involvement of social actors, the establishment of participative formats should be promoted. Appropriate would be, for example, networked biodiversity, environmental and climate 'stations', or participation in model participation projects on subjects such as electromobility, alternative agriculture, or new forms of housing.
- › The WBGU suggests the introduction of a voluntary social year in 'education and research'.

A reform of research and education towards sustainability not only paves the way to a knowledge-based social contract for this 'Great Transformation', but also opens up specific future opportunities for those who participate. In accordance with the social contract, educative opportunities that encompass the communication of a sense of responsibility, a sense of justice and the skills needed for proactiveness should be encouraged. School education should also not just endeavour to instigate cross- and transdisciplinary approaches, but also an understanding of the scientific process as a whole.

Science and research policy can serve as a role model on an international level if it continues to expand in the direction it is in part already heading, towards systemic, transformation-relevant research.

Conclusion

The 'fossil-nuclear metabolism' of the industrialised society has no future. The longer we cling to it, the higher the price will be for future generations. However, there are alternatives which would at least give all people access to the chance of a good life within the boundaries of the natural environment. Without a global agreement to actually dare to experiment with these alternatives, we will not manage to find our way out of the crisis of late modernity. So nothing less than a new social contract must be agreed to. Science will play a decisive, although subservient, role here. Ultimately, sustainability is a question of imagination.

'Imagination is everything. It is the preview of life's coming attractions.' (Albert Einstein)

References

- AGECC – Advisory Group on Energy and Climate Change (2010): Energy for a Sustainable Future. The Secretary-General's Advisory Group on Energy and Climate Change (AGECC) Summary Report and Recommendations. New York: AGECC.
- Grin, J., Rotmans, J. and Schot, J. (2010): Transitions to Sustainable Development. New Directions in the Study of Long Term Transformative Change. London: Routledge.
- Osterhammel, J. (2009): Die Verwandlung der Welt. Eine Geschichte des 19. Jahrhunderts. Munich: Beck.
- Polanyi, K. (1944): The Great Transformation: The Political and Economic Origins of Our Time. Boston, MA: Beacon Press.
- WBGU – German Advisory Council on Global Change (2004): World in Transition: Towards Sustainable Energy Systems. London: Earthscan.
- WBGU – German Advisory Council on Global Change (2009): Solving the climate dilemma: The budget approach. Berlin: WBGU.
- WBGU – German Advisory Council on Global Change (2010a): Future Bioenergy and Sustainable Land Use. London: Earthscan
- WBGU – German Advisory Council on Global Change (2010b): Climate Policy Post-Copenhagen. A Three-Level Strategy for Success. Policy Paper 6. Berlin: WBGU.

Current Reports of the WBGU

Climate Policy Post-Copenhagen. A Three-Level Strategy for Success.
Berlin: WBGU © 2010, 19 pages, ISBN 978-3-936191-35-6

Future Bioenergy and Sustainable Land Use. Flagship Report.
London: Earthscan © 2010, 365 pages, ISBN 978-1-84407-841-7.

Solving the climate dilemma: The budget approach. Special Report.
Berlin: WBGU © 2009, 58 pages, ISBN 978-3-936191-27-1.

Climate Change as a Security Risk. Flagship Report.
London: Earthscan © 2008, 248 pages, ISBN 978-1-84407-536-2.

The Future Oceans – Warming Up, Rising High, Turning Sour. Special Report.
Berlin: WBGU © 2006, 110 pages, ISBN 3-936191-14-X.

World in Transition: Fighting Poverty through Environmental Policy. Flagship Report.
London: Earthscan © 2005, 289 pages, ISBN 1-85383-883-7.

Climate Protection Strategies for the 21st Century: Kyoto and beyond. Special Report.
Berlin: WBGU © 2003, 77 pages, ISBN 3-936191-04-2.

World in Transition: Towards Sustainable Energy Systems. Flagship Report.
London: Earthscan © 2004, 242 pages, ISBN 1-85383-882-9.

Charging the Use of Global Commons. Special Report.
Berlin: WBGU © 2002, 48 pages, ISBN 3-9807589-8-2.

World in Transition: New Structures for Global Environmental Policy. Flagship Report.
London: Earthscan © 2001, 231 pages, ISBN 1-85383-852-7.

The German Advisory Council on Global Change

(Wissenschaftlicher Beirat der Bundesregierung Globale Umweltveränderungen – WBGU)

The WBGU is an independent, scientific advisory body to the German Federal Government set up in 1992 in the run-up to the Rio Earth Summit. The Council has nine members, appointed for a term of four years by the federal cabinet. The Council is supported by an interministerial committee of the federal government comprising representatives of all ministries and of the federal chancellery. The Council's principal task is to provide scientifically-based policy advice on global change issues to the German Federal Government. The Council:

- › analyses global environment and development problems and reports on these,
- › reviews and evaluates national and international research in the field of global change,
- › provides early warning of new issue areas,
- › identifies gaps in research and initiates new research,
- › monitors and assesses national and international policies for the achievement of sustainable development,
- › elaborates recommendations for action, and
- › raises public awareness and heightens the media profile of global change issues.

The WBGU publishes flagship reports every two years, making its own choice of focal themes. In addition, the German government can commission the Council to prepare special reports and policy papers.

More at: www.wbgu.de