

Policy Paper

**Financing the
Global Energy-System
Transformation**

7

Contents

Summary	3
Global Transformation of Energy Systems: Necessity and Opportunities	5
The Opportunities of an Energy-System Transformation towards Sustainability	5
Sustainable Energy Technologies	6
Investment Activity, Investment Requirements, Agents and the Availability of Capital	8
Status Quo of Capital Spending in the Energy Sector	8
Investment Requirements	8
Agents and Available Capital	8
Barriers to Investment in the Energy-System Transformation	13
Goals and Prices	13
Barriers in the Capital and Energy Markets	14
Specific Problems in Developing Countries	17
Recommendations on how to Mobilise Capital for the Energy-System Transformation	20
Develop a Transformative Regulatory Policy	20
Create Incentives for Investment in the Energy-System Transformation	22
Reduce Barriers in the Capital Markets	26
Promote the Energy-System Transformation in Developing Countries	29
Link International Policies on Energy, Climate and Development	30

Summary

The world faces the challenge of a global transformation to sustainable energy systems. Substantial up-front investments are needed to improve energy efficiency and switch to renewable energies. At the same time, these investments offer great opportunities, because strategic innovations can be triggered and new markets can develop in the course of the transformation process. Savings on the cost of fossil fuels in conventional technologies could completely offset the investment in renewable energy technologies and energy efficiency by as early as 2040. The private capital needed for the transformation is available and can be mobilised if a suitable political framework is put into place. A corresponding regulatory policy should be introduced to make such investment more attractive for the private sector. The WBGU advocates a *proactive state* that integrates energy, environmental and climate policy; this could reduce existing investment risks by developing a stable, long-term transformative regulatory framework. At the same time, policy makers should expand the opportunities for participation. Germany is currently leading this transformation, both in terms of technological innovations and in the creation of a suitable policy framework. Our country is able to give the world an example of how the *Energiewende* (energy-system transformation) can generate more, not less prosperity.

Both private and public-sector agents must get involved to finance the global transformation of energy systems towards sustainability. This can only succeed with a policy framework that reduces barriers to low-carbon investments and creates stable, long-term conditions for transformative investment, thus generating incentives for businesses and households to finance the corresponding private investments.

Up to now, however, private financiers have been rather reluctant to invest in the transformation of energy systems. The private sector's propensity to invest is obstructed by such barriers as inadequate political objectives, subsidies for fossil-based and nuclear forms of energy, unfavourable risk-return ratios, highly regulated electricity and capital markets, underdeveloped markets and administrative structures in many developing countries, and fragmented international financing mechanisms.

A large proportion of investments in the global energy-system transformation towards sustainability will have to be made in the newly industrialising countries. China in particular has sufficient public financial resources and considerable foreign exchange reserves that could be used for initial funding. Compared to the heavily indebted industrialised countries, these emerging economies are at an advantage in starting the transformation of energy systems. Yet even here, investments in renewable energy technologies are frequently discriminated against, are risky or not yet competitive in the short term.

To overcome these disadvantages, the WBGU recommends, among other things, creating a transformative policy framework for investments in the energy-system transformation and taking concrete measures in the electricity and capital markets. International cooperation in energy policy should also be intensified.

The WBGU's recommendations can be summarised as follows:

Develop a Transformative Regulatory Policy

The WBGU recommends integrating national energy, climate and environmental policies and consistently gearing them towards the transformation of energy systems. This is a crucial prerequisite for breaking down barriers and making private investment in the transformation more attractive. The proactive state is called upon in all countries to introduce a regulatory framework for gearing the energy and capital markets to the energy-system transformation. At the same time its citizens should be offered enhanced participation opportunities to get them involved and to increase social acceptance of the transformation. This also includes suitably cushioning of temporary income disadvantages among private households by appropriate social policies. An important element of this national policy framework is an ambitious, mandatory and long-term national energy strategy with measurable targets. It should aim to internalise the social costs of fossil and nuclear energy technologies, e.g. via a CO₂ price, thus making renewable energies more price-competitive. In addition, it will be necessary to phase out the subsidies on fossil fuels that still exist in many countries as quickly as possible.

Create Incentives for Investment in the Energy-System Transformation

The WBGU regards temporary support schemes for renewable energies as indispensable. For this purpose, it recommends feed-in tariffs combined with feed-in or purchase guarantees during the renewable-energy roll-out phase. The power market and grid regulation in Germany and Europe should be designed in such a way that electricity from renewable sources is increasingly integrated into the market and sold directly. Public-sector support of research and development in the field of sustainable energy technologies is essential, especially in electricity transmission and storage. Energy efficiency should be improved – following the top-runner approach – by introducing dynamic efficiency standards for production facilities, buildings, vehicles, etc.

Reduce Barriers in the Capital Markets

To ensure a sufficient supply of financial resources, the WBGU recommends increasing the funds available to national development banks, gradually giving them the functions of *green investment banks*, and gearing institutions more strongly towards long-term and sustainability criteria in financial-market regulation and international accounting standards. Private households and small and medium-sized enterprises can be supported in the financing of transformative

energy investments by promoting energy cooperatives and new business models and by enabling better access to venture capital.

Promote the Energy-System Transformation in Developing Countries

In developing countries, additional measures are needed to reduce transaction costs, e.g. establishing market facilitation organisations; developing strategic energy partnerships between industrialised or newly industrialising countries on the one hand and developing countries on the other; improving access to national and international capital; and providing risk hedging for investments. In developing countries, too, new financing and business models can help reduce liquidity barriers obstructing investment in energy generation and energy efficiency.

Extend International Energy Policy

International cooperation in the field of energy policy should be improved by strengthening UN-Energy and IRENA. These two organizations should coordinate the global expansion of renewable energies, the diffusion of efficiency technologies and the reduction of energy poverty. The Energy Charter Treaty should be extended and transformation partnerships created between the OECD and newly industrializing countries.

Link International Policies on Climate and Development

International development-policy and climate-financing institutions should strengthen the links between policies on energy, climate and development, both financially and in terms of goals. Corresponding institutions should be strengthened and provided with sufficient funding.

Global Transformation of Energy Systems: Necessity and Opportunities

The world faces the challenge of transforming its energy systems to make them sustainable and, in particular, climate-friendly. Substantial investments in energy systems are needed in many countries – on the one hand to secure the supply of energy, given the advanced age of existing power plants and infrastructures, and on the other to develop them to meet the rising demand for energy (IEA, 2011a). The increasing demand for energy-related services due to rising prosperity has to be satisfied in an environmental-friendly and efficient way. It will only be possible to guarantee quantitative and qualitative welfare provision in future if the energy systems are sustainable.

In its flagship report *World in Transition – A Social Contract for Sustainability* (WBGU, 2011), the WBGU has examined the need for, and the possibilities of, a transformation towards sustainability in general and a global transformation of energy systems (*Energiewende*) in particular. This means that profound changes in production processes and infrastructures will have to be initiated in the coming decade. Maintaining and expanding the supply of energy while simultaneously making systems more sustainable will require a great deal of investment; but at the same time it also involves great opportunities.

The Opportunities of an Energy-System Transformation towards Sustainability

Many countries, including newly industrialising countries like China, are already investing heavily in their energy systems. This trend will intensify in the future. One reason is that much of the existing power-generation and transmission capacity needs to be modernised or replaced. Another is that the demand for energy is growing worldwide, because population figures are rising, the population's age structure is changing in many

countries and, not least, per-capita incomes are growing, leading to additional consumer desires and possibilities. It is therefore important to quickly initiate or accelerate the transformation and development of the energy systems in a sustainable manner. Although such a transformation of energy systems involves additional investment in the short and medium term, it offers the economy as a whole considerable long-term cost reductions and additional social benefits compared to maintaining the current structure of energy systems (IEA, 2010; GEA, 2012; WWF et al., 2011).

The investment required for the energy system transformation towards sustainability, or *Energiewende*, will generate many new stimuli for the economy and open up opportunities that are especially important during the current economic crises, e.g. in the EU, the USA and Japan. Innovations can be strengthened, opening up new economic fields of activity with good future prospects (OECD, 2011). These can include such fields as information and communication technologies, offshore wind power plants or the development of smart cars and home appliances. The development of new sectors enhances the international competitiveness of individual countries and companies and can also generate new jobs. This will also create significant opportunities in Europe, an important location for innovations in the fields of renewable energy, energy systems and energy efficiency (Bierenbaum et al., 2012).

Further advantages of the transformation of energy systems are that the dependence of individual countries or regions on fossil-fuel imports is reduced and the security of energy supplies is strengthened. The smaller the shares of fossil and nuclear energies in a country's energy mix, the lower the social costs of corresponding environmental and health problems (IEA, 2011a; GEA, 2012). Furthermore, fuel costs can be expected to fall in sustainable energy systems. Fuel-cost savings alone could completely offset the cost of additional invest-

ment in the sustainability of energy systems in the period up to 2040 (IEA, 2010; WWF et al., 2011).

A transformation of energy systems towards sustainability also represents an opportunity for many developing and some newly industrialising countries – by giving growing populations universal access to modern energy and expanding energy supplies without excessively depleting the resources of future generations. The world's present energy-supply structure, which is primarily based on fossil fuels, is failing to provide nearly three billion people with adequate or, in many cases, any access to modern energy-related services (Zerriffi, 2011; AGECC, 2010). The sustainable conversion and development of energy systems could improve these people's living conditions and development prospects. Improvements in per-capita incomes and better opportunities in education and healthcare would be the most important benefits of such action.

Substantial additional investment will be necessary – in addition to the replacement and expansion investments already planned in the energy sector – in order to benefit from the many advantages of a transformation of energy systems. Overall, global investment in the energy sector will need to double between now and 2030, and triple by 2050 (GEA, 2012). In absolute terms this means that initially a total of about US\$1,100 billion a year needs to be invested today in sustainably developing and converting the energy systems; the total amount of annual investment required will increase to as much as US\$3,500 billion by around 2050. In other words, investment in this field will have to rise significantly by the middle of the century.

The involvement of both government and private agents will be needed to fund the investments needed to transform the energy systems. The aim must be to create an economic framework that encourages climate-friendly investment and mobilises private capital. What is primarily needed is not more public money, but a transformative regulatory policy.

The decisive factor will be to put into place a wise overall government policy for businesses and households – many of whom already have a preference for sustainable energy systems (WBGU, 2011; IIGCC, 2010; Initiative 2°, 2010) – offering incentives that are strong enough to ensure that corresponding investments really are made and financed. Improvements in the specific risk-return profile of these investments are a crucial aspect here. Another essential element is the need to offer enough opportunities for stakeholders to participate (WBGU, 2011). In addition to regulatory policy and participation, it is also important to quickly and intelligently resolve any distributional conflicts that may arise. If, for example, fossil-based or nuclear forms of energy are no longer subsidised or given preferential

treatment, and renewable energies and grid expansion are actively promoted, this will mean that households and companies will have to pay more for power during a transitional period. This could lead to energy poverty in individual households in developing, newly industrialising and industrialised countries, and its social effects must be cushioned. In the long term, however, energy and environmental costs will fall markedly in energy systems that have been sustainably expanded and converted. The *green path* for the development and conversion of the global energy systems will therefore be beneficial in the long term.

Sustainable Energy Technologies

A transformation of energy systems, or *Energiewende*, is closely linked to the development and market launch of sustainable technologies, especially in the field of renewable energies and efficiency technologies. The future sustainable design of energy systems will depend on a number of factors that impact on the overall policy framework: apart from the choice of technologies, these include economic and population growth, the demand for energy, the energy resources and the future costs and performance of energy-supplying and energy-consuming technologies. Scenarios modelling the transformation of energy systems under given climate protection targets make it possible to assess future sustainable technological options and the available room for manoeuvre (WBGU, 2011; Krey and Clarke, 2011). These scenarios seem to indicate that the transformation can be accomplished most quickly in the electricity sector, followed by heating and transport. Furthermore, a shift in end-use energy applications towards electricity is foreseeable, since electricity is easiest to provide on a large scale from renewable energy sources. Accordingly, in the following this paper will relate primarily to the electricity sector and the field of energy efficiency.

Importance of the Electricity Sector

There is a wide range of low-emission energy-supply technologies in the electricity sector (WBGU, 2011). Increasing the use of solar and wind energy is an excellent way of boosting renewable energy's share of the electricity system. These energy sources are globally available, have great long-term potential, and also open up opportunities for rural electrification and reducing energy poverty in developing countries. The large-scale integration of corresponding technologies into electricity systems requires additional infrastructures such as storage facilities and smart grids. These make it possible to find a balance between the time-related and geographical fluctuations in solar and wind power on

the one hand, and the similarly fluctuating demand for energy on the other (WBGU, 2011). This will be especially important if decentralised power generation is expanded in the course of a transformation of energy systems.

In the electricity sector, nuclear power and fossil energies using carbon capture and storage (CCS) would also be technological options from the perspective of climate policy. However, the WBGU advises against the use of nuclear power because of high external costs and, in particular, the risk of nuclear disasters, the unresolved issues of final waste storage, and the danger of uncontrolled proliferation. CCS is relevant for countries that will continue to use fossil energy carriers for a transitional period. In the WBGU's view, however, CCS should be used as little as possible, since the risks of this technology have not yet been reliably assessed (WBGU, 2011).

Energy Efficiency and the Demand for Energy

There are many technological options for improving energy efficiency, both in the field of conversion and in end use. Many of these involve using improved techniques and optimised processes. In addition, structural changes can effectively reduce primary energy demand. Among other things, these include the use of combined heat and power generation, the introduction of electromobility, and the use of thermal insulation to reduce the amount of energy consumed by buildings. The implementation of energy-efficiency measures has a fundamentally restraining effect on the global trend towards rising energy consumption and increases the number of choices available in the technology mix (WBGU, 2011). Care should be taken, however, to shape the overall policy framework in such a way that the successes of efficiency measures are not cancelled out by rebound effects, i.e. by additional energy consumption in response either to reductions in consumption or to associated cost savings (Sorrell, 2007).

The creation of sustainable structures in the fields of energy efficiency and electricity requires investments over and above the volume of investment that has been budgeted for to cover currently planned replacement and expansion investments. The following section will now roughly estimate the amount of investment required for the sustainable development and conversion of energy systems worldwide and compare the result with the status-quo investments.

Investment Activity, Investment Requirements, Agents and the Availability of Capital

Status Quo of Capital Spending in the Energy Sector

Current global investment in the energy sector is estimated to be approx. US\$1,300 billion a year, which corresponds to about 2% of global gross domestic product (GEA, 2012). The supply side – i.e. capital spending on extraction and the generation, conversion, transmission and distribution of energy – accounted for about US\$960 billion of this total in 2010. Present investment on the demand side (industry, transport, buildings, households) can only be roughly quantified. If only the energy component of this investment is taken into account (e.g. the engine in an energy-efficient vehicle), it is estimated at about US\$300 billion per annum (GEA, 2012).

The share of investment in renewable energies has increased in recent years and amounted to US\$210 billion in 2010, of which about US\$190 billion went into the construction of generating capacity. The remainder was capital spending on technology development and the production of plants, equipment and components. Global investment in renewable energy in 2010 was thus roughly comparable to – or even slightly higher than – investment in new capacity for fossil energy carriers (BNEF and UNEP, 2011; GEA, 2012).

Approx. US\$50 billion is currently spent on research and development (R&D) in the entire energy sector (public and private R&D); about half of this relates to fossil-based energies and nuclear energy (GEA, 2012). According to BNEF and UNEP (2011), R&D expenditure on renewable energies reached only about US\$9 billion in 2010, although this represented an increase of 40% over the previous year. Slightly less than US\$10 billion was invested in the research and development of end-use technologies and energy efficiency (GEA, 2012). About US\$9 billion per annum is currently being invested worldwide in universal access to modern energies (IEA, 2011a).

Investment Requirements

A considerable amount of investment will be required if the world sets itself the target of supplying electricity exclusively from renewable energies by mid-century – without using nuclear power and assuming a substantial increase in energy efficiency. Total annual investment would be between approx. US\$1,100 billion (today), US\$2,000 billion in 2030 and US\$3,500 billion in 2050 (GEA, 2012; Box 1). This means that present investment in the energy sector would initially have to be shifted to renewable energies and energy efficiency, then approximately doubled by 2030 and tripled by the middle of the century. Under a scenario aiming at using exclusively renewable energies to supply all electricity worldwide, investment in renewable-energy generating capacity would have to rise by a factor of four by 2030 compared to today – to up to US\$600 billion a year. Overall, about US\$68,000 billion would have to be invested over the period from today until 2050 under this scenario (GEA, 2012).

Figure 1 compares the current structure of investment in the energy sector (excluding R&D investment) with the necessary investments in 2050 (based on an illustrative scenario assuming a greatly expanded use of renewable energies, enhanced energy efficiency and no use of nuclear energy).

Agents and Available Capital

The investment in the sustainable transformation of the world's energy systems must be made by a wide range of agents. In the case of investment in renewable energy generation capacity, these are mainly energy-producing companies or project developers. In decentralised generating capacity, industrial companies and households are also among the potential investors. When it comes

Box 1**Regional and Sectoral Distribution of Investment Requirements**

China, North America and the EU will account for about 60% of estimated total investment requirements up to 2030. North America and the EU will each have to shoulder about 22% of global investment requirements up to 2015, and about 17% by 2030, while China's percentage of global investment requirements will rise from approx. 18% to about 26% between 2015 and 2030 (IEA, 2010). The investment requirements in the developing and newly industrialising countries will be between about US\$260 and US\$560 billion per annum up to 2030 (World Bank, 2010b; Project Catalyst, 2010). In some cases this also includes investment to achieve universal access to modern energy in developing and newly industrialising countries, for which about US\$36 to US\$48 billion a

year will have to be made available up to 2030 (GEA, 2012; IEA, 2011a).

Taking a sectoral view, the building and transport sector will account for about half of the total investment requirements (IEA, 2010, 2011a). In the electricity sector, in a scenario depending on renewable energy about US\$500 billion must initially be invested every year worldwide on the supply side, followed by approx. US\$700-800 billion per annum up until 2030 and about US\$1,000 billion per annum by mid-century (IEA, 2010; IPCC, 2011; GEA, 2012). These investments include both generating capacity and the expansion of grids and storage facilities. Investment in grid and storage technologies and capacity alone will have to reach about US\$300-500 billion a year by the middle of the century, i.e. it must be twice the status-quo figure (US\$260 billion). According to a special report by the World Bank, R&D expenditure on renewable energies and energy efficiency would have to be increased as much as fivefold by 2030 (World Bank, 2011a).

to investment in grids and storage infrastructures, the situation varies from country to country: in the liberalised electricity markets of industrialised countries, the private grid operators and local providers are usually responsible; in newly industrialising and developing countries it is mostly state-owned companies that provide the grid infrastructure. Measures to increase energy efficiency will need to be taken by private and public enterprises, public institutions and private households.

Most of these investors use the capital markets to finance their investments. Since many households and companies do not have enough capital resources, they are dependent on external finance. Providers of capital include the public sector, venture-capital and private-equity investors, institutional investors such as sovereign wealth funds, pension funds, insurance or investment companies, foundations, family offices (which administer large private fortunes), as well as industry and smaller private investors. As lenders, banks have the function of intermediaries in the capital markets.

Two factors are important to ensure that the investments required for the transformation of energy systems, or *Energiewende*, are actually carried out: first, potential investors must have sufficient incentives to actually realise the projects; second, financiers must consider these investments attractive enough to actually commit the necessary financial resources. In this context, different players in the financial markets vary in terms of their capital resources, risk propensity and return expectations.

Private Capital

Private capital can play a key role in the transformation of energy systems. Unlike many heavily indebted countries, many private companies and households have considerable financial assets at their disposal

which could, in principle, be invested in the transformation of energy systems. Global private financial assets have recently been estimated at US\$179,400 billion (McKinsey, 2011).

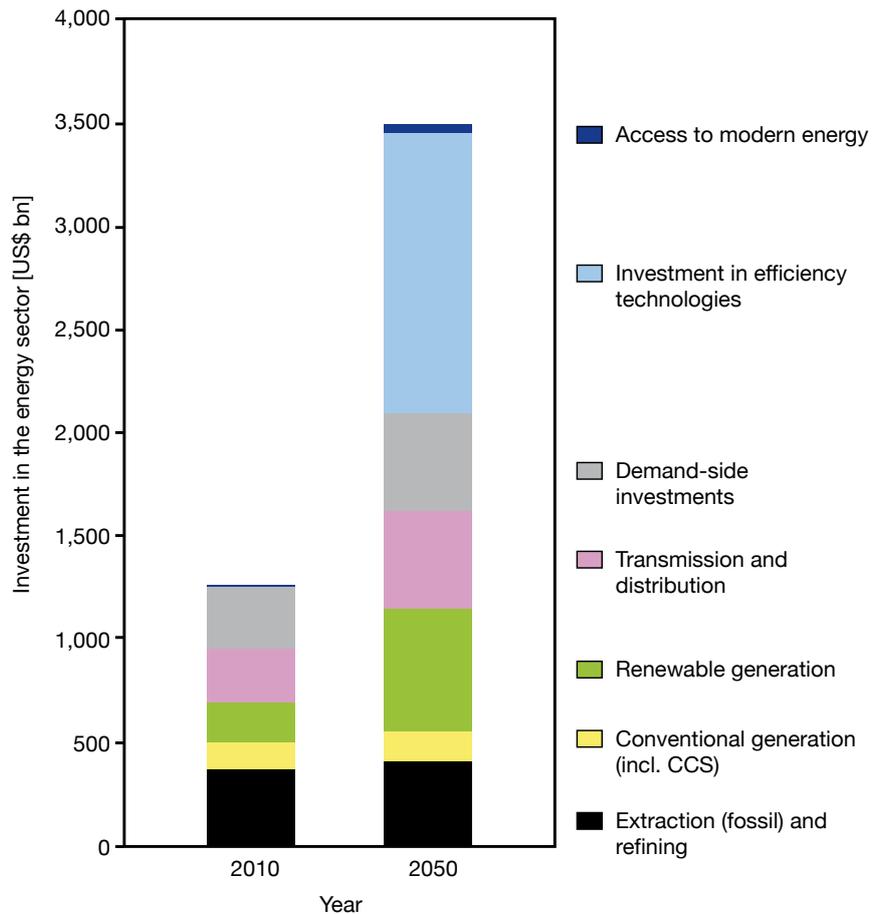
Private capital is generally provided in the form of equity capital or loans. Equity capital can be either a company's own capital and shareholders' equity or venture or private-equity capital. While new technologies tend to depend on venture capital in the initial stages, more developed technologies at the market-entry and diffusion phase can be financed by private equity or bank loans.

Venture capitalists usually have a relatively short investment horizon of 4 to 7 years and expect returns of more than 50% per annum. Providers of equity capital usually have an investment horizon of 3 to 5 years and expect an average annual return in excess of 25%. These financial investors are usually interested in large projects or project portfolios with a volume in the three-digit million range (UNEP-SEFI, 2009a; Thumfart, 2011).

Institutional investors such as insurance companies, pension funds and infrastructure funds have a more long-term investment horizon of usually 10 to 25 years, not least because of the regulation they are subject to. Pension funds and insurance companies expect relatively low returns of 7 to 15%; infrastructure funds expect between 10 and 20%. The amounts invested by infrastructure funds are usually in the two- to three-digit million range; in the case of insurers and pension funds the volumes start at US\$10 million (UNEP-SEFI, 2009a; Thumfart, 2011). Finally, family offices, foundations, charitable institutions or even small investors can provide funds via closed-end renewable-energy funds, citizens' funds or energy cooperatives. Here, the expected returns are usually around 6 to 10% (Thumfart, 2011; FAZ, 2011).

Figure 1

Worldwide investment in the entire energy sector in 2010 (excluding expenditure on research and development; demand-side energy investment only includes the energy components) compared to the global investment requirements of the entire energy sector in 2050 (scenario assumptions: no nuclear energy, universal access to modern energy-related services by 2030, improved energy security, reduced air pollution and compliance with the 2°C guard rail). Source: WBGU, based on GEA, 2012; BNEF and UNEP, 2011



Because of their long-term investment profiles, insurance companies, pension funds, foundations and family offices in particular are in a good position to invest in renewable energies and energy efficiency. Pension funds have capital amounting to US\$28,300 billion and insurance companies of over US\$23,000 billion at their disposal worldwide (McKinsey, 2011). A large proportion of private financial assets is thus managed by institutional investors, so that corresponding investment decisions by insurance companies and pension funds are particularly important if the transformation of energy systems is to be successful. However, insurance companies also invest quite a large proportion of their assets in the short to medium term because they need to have liquidity available to cover (unexpected) insurance claims (WEF, 2011).

Public Funds

Unlike private financiers, the public sector is often active in the capital market with a significantly longer-term investment horizon and lower return expectations. According to estimates by McKinsey (2011), nation states worldwide currently have financial assets of approx US\$18,700 billion – in total, therefore, about

a tenth of estimated private capital. So-called sovereign wealth funds represent a special category of state assets; they are mainly fed by revenue from oil extraction or the mining of other commodities. Sovereign wealth funds exist, for example, in the United Arab Emirates, Singapore, Norway, China, Saudi Arabia and Russia. They manage assets totalling approx. US\$4,000 billion worldwide (McKinsey, 2011; Prequin, 2011) and are interested in long investment periods; however, their expected returns are relatively high at 15 to 25%; investment volumes are in excess of US\$100 million (Thumfart, 2011).

Public resources can flow into investment in energy-system transformation either directly – e.g. in connection with infrastructure construction – or indirectly, for instance by subsidising private investors or hedging private financiers' risks. Such financing operations are usually handled by state-owned development banks. According to an estimate by Bloomberg New Energy Finance (BNEF), national and regional development banks provided about US\$13.5 billion for renewable energy projects worldwide in 2010 (BNEF and UNEP, 2011).

In addition to pure public funding, mixed forms of private and public funding are also relevant, e.g. for

Box 2**Public Climate Financing and Development Assistance and the Energy-System Transformation**

The agreements of the Climate Conference in Cancún in 2010 contain two important elements that are relevant to the transformation of energy systems. First, it was agreed that the developing countries should carry out mitigation measures in the context of sustainable development and be supported in this by the industrialised countries with technology transfer, finance and capacity building (UNFCCC, 2011). The aim of these measures, so-called NAMAs (Nationally Appropriate Mitigation Actions), is to reduce the emissions of developing countries below the level of business-as-usual (BAU) by 2020. To date, however, there has been neither a more detailed definition of the NAMAs, nor a concept on how they can be supported by the industrialised countries (van Renssen, 2012). Second, the industrialised countries were urged to provide *new and additional* funds to support developing countries with mitigation and adaptation. The Cancún Agreements specify

that these funds should reach US\$100 billion per annum by 2020 and – at least in the field of adaptation – be largely channelled via the newly created Green Climate Fund. One concern on the part of the developing countries is that they want to be sure this money really is in addition to development assistance and as far as possible is public and not private money.

Two aspects remain open in this context: first, what should be regarded as the baseline for Official Development Assistance in order to be able to tell whether the public climate financing is really additional; second, up to now there is no uniform, universally accepted method of recording the cash flows (Buchner et al., 2011).

There is currently no definition of public climate financing that includes a clear distinction from Official Development Assistance. A strict separation of the two areas of funding does not appear appropriate with a view to the necessary transformation of energy systems. Climate protection must ultimately become an integral part of energy and development policies if the decarbonisation and transformation of energy systems towards sustainability worldwide is to succeed.

climate-change mitigation in developing countries in structured funds such as the KfW and BMU's Global Climate Partnership Fund (which has US\$500 million at its disposal over 5 years). However, only a relatively small amount of finance has been made available in this way to date.

International Funding

At the international level, financial flows between countries in the context of international development assistance and climate financing are relevant for funding the transformation of energy systems. In these cases, multilateral funding agencies like the World Bank and the Global Environment Facility (GEF) usually act as intermediaries in the disbursement of funds. Furthermore, regional development banks with their own financing mechanisms (ADB, AfDB, EBRD, etc.), as well as bilateral funds for financing climate and energy projects, are relevant at the international level.

An average of US\$6.9 billion flowed into the energy sector in the 2007/2008 financial year in the context of Official Development Assistance (ODA). This amounts to approx. 7% of total ODA provided in that year (OECD-DAC, 2010, 2011). With the rise in oil prices since 2005 and the ratification of the Kyoto Protocol in 2005, bilateral ODA has risen in the energy field, particularly for renewable energies (Michaelowa and Michaelowa, 2010; OECD-DAC, 2010). Public funds paid for mitigation purposes by industrialised countries to developing countries under the umbrella of the Framework Convention on Climate Change (UNFCCC) or in the context of climate-related ODA (plus export credits) totalled between US\$8 and 12 billion per annum in 2008 (World Bank, 2010a,b; Buchner et al., 2011). However, these

funds went to a number of different sectors, not necessarily to the energy sector (Buchner et al., 2011).

Investment in renewable energies and energy efficiency in developing and newly industrialising countries can also be financed via the Clean Development Mechanism (CDM). The 2,400 projects registered within the CDM framework in the field of renewable energies and energy efficiency led to a total investment volume of approx. US\$101 billion in the energy sector in developing and newly industrialising countries between 2004 and 2011; the largest sums were invested in China (Bazilian et al., 2011). In the last four years (2008–2011), the World Bank Group has spent an average of US\$9.25 billion per annum (World Bank, 2011b) to finance the energy sector including climate finance (Global Environment Facility, GEF; Clean Technology Fund, CTF).

Green foreign direct investment (FDI) was estimated at US\$37 billion in 2008 and *low-carbon* FDI (i.e. renewable energies, recycling, production of wind turbines and solar panels) at just under US\$90 billion in 2009 (Buchner et al., 2011; UNCTAD, 2010).

At the 2010 Conference of the Parties to the UNFCCC in Cancún (Box 2), the industrialised countries promised to provide funds amounting to US\$30 billion for financial transfers in the period from 2010 to 2012, although only roughly half of the pledges made so far focus on mitigation, and only a certain percentage of these on energy investment (own estimate based on WRI, 2011). The commitments have evidently not yet been fully met up to now. According to BNEF (2011), in many cases the funds are moreover not new, additional amounts, but re-declared funds that had already been pledged. It was also agreed in Cancún that industrialised countries will mobilise new and additional funds for adaptation and

mitigation in developing countries reaching US\$100 billion per annum by 2020. Part of this is to be channelled via the newly created Green Climate Fund.

The international public financial flows made or pledged to date are still well below the level of investment required for a transformation of energy systems in developing and newly industrialising countries. However, if public funds are used specifically to support private investment via national and international public financing mechanisms, they can trigger a considerable leverage effect on private capital. In this way they can mobilise private investment amounting to many times the funds originally spent. The IFC Partial Credit Guarantee for energy efficiency, for example, achieved an extremely high leverage ratio of 15:1, so that 15 million of private capital was mobilised by each million of public funds. A ratio of 8:1 was observed for the World Bank's Clean Technology Fund, and 4:1 for the World Bank's Carbon Partnership Facility (Norad, 2010; World Bank, 2010a). The leverage effect of public funds increases at the rate at which they reduce the risk for private investors or financiers (Neuhoff et al, 2010). Public and private capital can thus complement each other in a meaningful way.

Overall, it should be noted that a great amount of investment is required for the global transformation of energy systems towards sustainability and that this cannot be covered solely by public funding. At the same time, enough private capital seems to be available, in principle, to finance the required investments. The annual investment requirements for the sustainable development and conversion of energy systems currently amount to less than 0.5% of global private capital assets. Since capital assets can be expected to increase over time (McKinsey, 2011), this percentage is unlikely to rise significantly over the years, despite higher capital requirements in 2050. However, there appears to be little willingness to invest sufficient quantities of private capital in the transformation of energy systems. The reasons for this are described in the following.

Barriers to Investment in the Energy-System Transformation

Up to now, there has not been enough (private) investment in the sustainable development and conversion of energy systems. The main causes lie in the following areas:

- (Energy-)Policy objectives are inadequate, leading to insufficient transparency and planning certainty for investors.
- The prices of fossil-based and nuclear energies are kept artificially low, making the costs of renewable energies look high and potential gains of saving energy unattractive.
- Risk-return ratios are unfavourable; this is caused by the long periods of capital lock-up, the use of novel technologies and other investment risks.
- The relevant markets are highly regulated (electricity and capital markets).

These causes can be identified in industrialised, newly industrialising and developing countries. In addition, the necessary investments are obstructed in many developing and some newly industrialising countries by poorly designed markets and administrative structures as well as fragmented international financing mechanisms.

Goals and Prices

Lack of Energy Strategies

Climate and energy policies in many countries offer few incentives and little in the way of long-term legal and planning certainty for investments in renewable energies, energy infrastructure and energy efficiency. Investors not only expect attractive risk-adjusted returns, they also need transparency as well as legal and planning certainty. This can be summarised by the abbreviation TLC: transparency, longevity, certainty (DB Climate Change Advisors, 2009). In many cases, TLC is even directly undermined or hindered by public policy – for example in Spain, where feed-in tariffs were retroactively cut, leading to the collapse of investment in the solar industry (Gillman, 2011). Similarly, uncertainty in the USA on the continuation of production tax credits

(offered per unit of renewable energy generated) caused a decline in investment in wind energy (Kalamova et al., 2011). Many countries lack ambitious, long-term and (legally) binding climate- and energy-policy targets, so that the conducive market environment needed for investment in the transformation of energy systems, or *Energiewende*, has not yet been created in many places. Numerous companies would definitely be interested in making sustainable investments, but are waiting for policy makers to create an ambitious, long-term and (legally) binding policy framework (IIGCC, 2010; Initiative 2°, 2010).

Distorted Relative Prices

Up to now, only *mature* renewable energies such as biomass, hydroelectric power or onshore wind energy have been able to compete with conventional power generation (RREEF, 2009). This is partly because the social costs of fossil-based and nuclear energy carriers are not – or not sufficiently – internalised. In the case of fossil energies, social costs are caused mainly by CO₂ emissions, particulate-matter pollution and external effects in the extraction of energy carriers. In the case of nuclear power, the social costs stem from the extensive socialisation of liability for damage caused by nuclear accidents, and from the costs of the interim and final storage of radioactive waste. These social costs are not reflected in the prices of fossil-based and nuclear energies; the relative prices of fossil and nuclear forms of energy are therefore distorted. From a microeconomic perspective, this means that investing in renewable energies, the energy infrastructure and energy efficiency often seems unprofitable (Beck and Martinot, 2004; UNEP-SEFI, 2009b). The resultant costs of the corresponding technologies are then excessive in relative terms, and fuel-cost savings achieved by increased efficiency have little economical weight. Even if some savings are made, in view of the low prices of fossil and nuclear energies these savings are (partially) cancelled out by the so-called rebound effect: i.e. increased consumption either directly in the same field or indirectly in other fields (Sorrell, 2007).

Furthermore, subsidies for fossil-based energy carriers make renewable energies less competitive (Beck and Martinot, 2004; UNEP-SEFI, 2009b). The IEA has estimated the annual global subsidies for fossil fuels in 2010 at US\$410 billion on the demand side and US\$100 billion on the supply side (IEA, 2011a; GSI and IISD, 2011). By comparison, renewable energies were only subsidised by an amount of US\$66 billion worldwide in 2010 (IEA, 2011a).

Barriers in the Capital and Energy Markets

Investment in plants and systems for generating, distributing and storing electricity from renewable energies – and in energy-efficiency measures – is also impeded by other barriers on the capital and energy markets.

Initial Capital Requirements and Payback Periods

As a rule, a lot of upfront investment is required in order to build power-generating plants, as well as grid and storage infrastructure, or to implement energy-efficiency measures (e.g. making buildings more energy-efficient). Energy-generating companies, project developers or private households wishing to make the corresponding investments rely on external finance from banks and other financiers because they lack enough capital of their own. Since investments in the transformation of energy systems are commonly infrastructure investments, or relate to durable consumer goods, the capital is tied up for periods of 10 to 40 years. Investments in which relatively large amounts of capital are tied up for a relatively long time are comparably unattractive and fraught with risks for the providers of capital. As a result, there is often a lack of funding for such investments. This phenomenon is not fundamentally new in the conversion of energy systems. Similar problems were observed in the 1970s relating to investment in nuclear energy (OECD-NEA, 2009).

Another reason why long payback periods for investments are a problem is because few financiers and investors have the kind of long-term investment horizon that would be necessary to invest in the transformation towards sustainable energy systems. From the perspective of a typical company, an investment should amortise in 3 to 5 years, and banks expect their loans to be repaid in the same period. Only established utilities and a few institutional investors have an investment horizon of more than 10 years.

The short-term orientation of most financiers and investors is also partially due to institutions and regulations in the capital market (De Larosière et al, 2009; LTIC, 2010; WEF, 2011). For example, the salaries of many financial and asset managers are based on an

assessment made over very short time periods; this primarily gives them an incentive to maximise the returns on their investment portfolios in short-term. Moreover, international accounting standards (e.g. IFRS) often rate long-term investments lower than short-term ones, because the balance-sheet items are valued at a given moment in time, rather than over the entire investment period (De Larosière, 2010; WEF, 2011). Regulations on the capital markets also have the potential to put investments in the transformation of energy systems at a disadvantage compared to other investments – albeit unintentionally (Box 3).

Risks and Returns

The risks connected with new technologies and new markets are a major hurdle. Institutional investors in particular usually have a fiduciary obligation to invest their capital soundly and profitably. Under current market conditions, investments in the transformation of energy systems frequently do not meet these requirements.

The risks of investing in renewable energies and efficiency improvements are to be found in many different areas. There are technical risks (because some technologies are little-tested), project-management risks (delays, cost overruns), market risks (relating to market, price and demand trends), regulatory risks (relating to the stability of current regulations), interest-rate and currency-exposure risks, resource risks (e.g. wind speeds, number of sunshine hours), and political or country risks (e.g. political and economic stability, lack of legal certainty) (Goldman et al., 2005; UNEP-SEFI, 2009a; Inderst, 2009). Especially the technical and market risks of renewable-energy projects are frequently overrated by the financiers, who are generally risk-averse, due to their lack of experience with these technologies. Furthermore, the necessary data and empirical results (e.g. historical data on wind speeds in the case of wind farms, or the number of hours of sunshine in the case of solar power plants) needed to assess the risks are not available in many cases when projects are appraised (Sonntag-O'Brien and Usher, 2004). This complicates risk assessment by the financiers and often has the effect that risks are perceived as being much higher – for lack of better information.

Suitable risk-management instruments already exist for many of the risks faced during the construction and operational phases by the companies that manufacture and operate such plants. For example, there are insurance policies that cover bad-debt losses or technical risks: e.g. transport insurance, contractor's all-risk insurance, business-interruption insurance, liability insurance, loss-of-revenue insurance and performance guarantees for solar panels (UNEP and GEF, 2008; Danelutti and Pazur, 2011; Munich Re, 2012).

Box 3**Effects of Basel III and Solvency II on the Financing of Renewable Energies**

Some new regulations on the capital markets – e.g. for banks (Basel III) and for European insurance companies (Solvency II) – have an indirect impact on the financing of projects in the field of renewable energies and energy efficiency. On the one hand, they require banks to back up long-term loans with a longer-term refinancing scheme in future, and this has become more expensive since the financial crisis (Bundesverband Deutscher Banken, 2011). On the other hand, they increase the opportunity costs of long-term and risky investments by banks and insurance companies, since these investments will need to be backed up by more own funds in future (Zähres, 2011). In future this will put at a disadvantage all riskier and long-term investments in new, as yet unproven technologies (including renewable energies). At the same time they create

advantages for investments in technologies for tried-and-tested renewable energies such as onshore wind power. In risk assessments, such technologies are classified in a relatively low risk category; in future, therefore, they will not need to be backed by as much own funds as investments in shares, which are classified as riskier (Bloomberg, 2010).

Basel III will enter into force in 2013, and the EU's Solvency II framework directive will be transposed into national law in the same year. On the one hand, with the introduction of Solvency II insurance companies will be expected to redeploy their portfolios away from shares and towards the less risky bonds – and often to investments in tried-and-tested renewable energies such as onshore wind energy or hydroelectric power (Bloomberg, 2010; Zähres, 2011). On the other hand, banks and insurance companies can be expected to be even more reluctant to invest in the *Energiewende* using technologies that are little-tested and therefore classified as more risky, e.g. offshore wind energy.

Furthermore, forward exchange transactions, foreign-exchange swaps and interest-rate swaps can be used to hedge against interest-rate and currency-exposure risks (Goldman et al., 2005). Wind derivatives or solar performance guarantees can in principle be used to hedge against weather risks in the generation of wind and solar energy, although these instruments are relatively new and have not yet become widely established in the market (Danelutti and Pazur, 2011; The Economist, 2012). Regulatory and political risks, however, are not covered by commercial insurance companies on principle (Danelutti and Pazur, 2011). Similarly, some technical risks – especially in the case of renewable energy technologies in the early stages of development – are regarded as uninsurable for lack of experience (Mitchell et al, 2011; Sonntag-O'Brien and Usher, 2004; Munich Re, 2004). An insurance gap therefore remains, since in the case of investments in renewable energies the focus of attention is often on technical risks, uncertain market and technology developments, and regulatory risks.

Risks can also arise as a result of administrative barriers in the form of statutory requirements or after-the-fact licensing requirements and orders, e.g. in the case of wind turbines as regards their height, noise emissions, safety and aesthetics (De Jager et al., 2011). Lack of experience on the part of the responsible licensing authorities can lead to delays or the rejection of investment projects; this represents a risk for investors and financiers (Beck and Martinot, 2004).

Acceptance problems, too, are an important risk factor in investments in renewable energies, energy-infrastructure projects and efficiency improvements. Although large sections of the population welcome the transformation towards sustainable energy systems in

principle, they often reject the idea of new plants being built in their immediate neighbourhood. This so-called NIMBY (not in my back yard) problem is also observed when renewable energies or the energy infrastructure are to be expanded, despite a general acceptance of sustainable energy systems (Devine-Wright, 2010). When there is local resistance in the population, resulting objections and lawsuits can delay the realisation of projects. This increases the management costs of the investment, thereby jeopardising its funding (Ball, 2009). This is particularly serious in the case of energy-sector infrastructure projects because of so-called *delay cascades*: if one part of a project is delayed, subsequent projects often also have to be postponed, placing in jeopardy the realisation of an entire major infrastructure project.

In the eyes of investors and financiers, high risks could be offset by high rates of return. Yet precisely this is frequently not the case in the energy sector. Because the energy prices of fossil-based and nuclear energies are relatively low, the average returns on investment in renewable energies or energy efficiency are lower than those in the field of conventional infrastructure investments and also below the expected returns of investors and financiers (Inderst, 2009; AGF, 2010). After calculating the returns and risks, many providers of capital therefore prefer other forms of capital investment, so that investment in the transformation of energy systems often goes unfunded. However, the higher the expected inflation rates and the greater the overall uncertainty in the stock markets, the more attractive the investments in renewable energies become, particularly in established technologies. A fundamental advantage of investments in renewable energies is their low correl-

ation with traditional asset classes. However, this effect has not been dominant up to now because there are so many other barriers to this kind of investment.

Information and Transaction Costs

Information and transaction costs are often very high in the case of investments in renewable energies, energy infrastructure and energy efficiency. On the one hand, this is because lenders have little experience or expertise and therefore need a relatively large amount of information beforehand about locations, resource potential, permits, planning, financing and feed-in options (Roland Berger, 2011). On the other hand, those who intend to make the real investments often also lack the relevant financial knowledge. This is especially true in the case of smaller investment projects. This causes high pre-investment costs, e.g. costs for legal and technical reports, other expertises, consulting services and administrative fees. Finally, many potential investors also lack knowledge of the various possibilities – as well as the advantages and disadvantages – of investing in renewable energies and energy efficiency. This applies in particular to investments by private households.

Projects in the field of renewable energies and energy efficiency are frequently on a smaller scale than, say, in the field of conventional power generation. The transaction costs in small-scale projects are often so high that they make the investment unattractive to providers of capital (Goldman et al., 2005; Kalamova et al., 2011). This applies especially often to renewable-energy and energy-efficiency projects (Beck and Martinot, 2004; UNEP-SEFI, 2009b; Kalamova et al., 2011).

In energy-efficiency projects, information asymmetries often also prove to be an investment barrier. Investors usually have more knowledge than the potential financiers, who are often both unaware of the savings the measures can achieve and unable to monitor the savings that are actually made. To date, there is a lack of generally accepted standards for measuring and verifying the savings made – or else the existing measurement and verification methods are often not trusted due to a lack of transparency and standardisation. Moreover, there are often no trained experts with the skills to measure and verify savings (IEA, 2011b).

Grids and Storage Facilities

The electricity grids are regulated as natural monopolies, irrespective of their ownership structure. However, in many countries the current form of regulation does not provide sufficient incentives to invest in expanding the grids. Without such investment there is rising network congestion, and the transformation of the overall system is hampered (Schütz and Klusmann, 2011). Since investments in grids are usually irreversible and

therefore represent sunk costs, and because of the risk of arbitrary changes in price regulation by governments, private grid operators lack guaranteed long-term financial returns (Helm, 2010). This explains why grid operators are still highly unwilling to take on the necessary development and conversion of the grids or to provide the necessary funding.

Furthermore, the network charges of grid operators are usually fixed according to national objectives and not aligned to cross-border electricity grids. Up to now no rules have been created for cross-border grid development, above all in the EU (European Commission, 2010). This makes investments in this field insecure and unattractive.

Investments in grid infrastructures are also made more difficult by the fact that they cause network externalities (Griffin and Puller, 2005). The more participants there are in a grid, the lower the net costs for each individual user. At the same time, however, costs rise in a given physical grid infrastructure due to congestion effects (Erber and Hagemann, 2002). Under the current incentive regulation in many European countries, there are not enough opportunities to pass on the costs, which keeps the willingness to invest low.

Lock-in effects also slow down investment. Tried-and-tested standard technologies are frequently not replaced by new technologies because the latter are more expensive as a result of research and development costs. Furthermore, changing the technology path – e.g. by introducing direct-current transmission or expanding underground transmission networks – also requires additional transaction costs which are not usually rewarded by higher returns (Erber and Hagemann, 2002).

Finally, grid development faces funding problems because – e.g. in Europe – either grid operators are state-owned or the government is a principal shareholder. Such companies do not always have the necessary own funds to finance grid development. At the same time there are legal restrictions on having investment funded by external providers of capital such as international financial institutions (e.g. European Investment Bank, European Bank for Reconstruction and Development), commercial banks or companies (Roland Berger, 2011).

The current design of electricity markets does not offer adequate incentives to invest in either grid development or storage technologies or demand-side management. Given the high volatility of the supply, this would be essential for the transformation of energy systems, or *Energiewende*, if there is to be more integration of renewable energies into the market. One reason why investment in the development of storage facilities is very hesitant is that the technological developments are still unsatisfactory and at a pre-commercial stage. There is little private investment in such research

– among other things due to knowledge spill-over (positive externalities). But public-funded research, too, has only been making small contributions in this field up to now (Witte, 2009).

Energy Efficiency

Investments in the field of energy efficiency should be carried out by businesses, but also by general government and private households. In the household field, investments in efficient electrical appliances or the energy efficiency of buildings are particularly important. Investments in sustainable, efficient electrical appliances are often not made because private households are not well enough informed about the various technical options and their advantages and disadvantages. Another reason is that the higher investment cost of energy-efficient appliances is hardly worth it in view of the relatively low current prices of fossil and nuclear forms of energy. Non-monetary incentives for investments in energy efficiency are often lacking.

A look at the field of energy efficiency in buildings also reveals unfavourable incentive structures. One important example is the landlord-tenant structure: landlords typically bear the costs of efficiency measures in buildings, yet it is the tenants who benefit from the savings. Such structures reduce the chances of such efficiency-improving investments being implemented and financed.

In buildings with several owners (e.g. condominiums), disagreements between the parties can also be a barrier to investment. In the case of companies or public institutions, efficiency investments are also made more difficult by the fact that savings from efficiency measures are often posted under different budget items from the high initial investments. This makes it difficult to justify corresponding investments (Rezessy and Bartoldi, 2010).

Specific Problems in Developing Countries

The barriers to investment in the sustainable development and conversion of energy systems described above exist not only in industrialised countries, but also in developing and newly industrialising countries. While newly industrialising countries are more comparable to industrialised countries and are therefore affected by similar investment and financing barriers, developing countries and some emerging economies are affected by additional specific barriers.

Lacking Prerequisites for Foreign Direct Investment

Part of the investment in the development and transformation of energy systems in developing countries would have to be made in the form of foreign direct investment (FDI), since there is not enough capital or financially strong companies in the countries themselves (UNCTAD, 2010; Buchner et al., 2011). The existing instruments used by the World Bank Group, regional development banks and national export credit insurance in industrialised countries are, in principle, well suited to facilitating the financing of the transformation of energy systems via foreign direct investment (Kerste et al., 2011). The instruments are designed in such a way that the International Finance Corporation (IFC) and the Multilateral Investment Guarantee Agency (MIGA) provide security for private investment. However, international investors typically demand political stability, legal certainty, a banking and financial sector, sector policies and international investment agreements. Many developing countries, especially the Least Developed Countries, cannot offer this political environment (Delina, 2011; UNCTAD, 2010). As a result, the foreign direct investment needed for the transformation of energy systems is either not undertaken at all in these countries, or else not to the extent needed.

Many developing countries are characterised by political instability, currency fluctuations and high inflation risks (Hamilton, 2010; DB Climate Change Advisors, 2010; Stadelmann et al., 2011). When investments can only be made in the local currency, currency-exposure risks have a negative influence on investment decisions by foreign financiers and potential foreign investors and become an obstacle to investment. This is especially true of investment projects that cannot be transacted in US dollars or euros because there are hardly any ways of obtaining insurance cover (Kerste et al., 2011).

In addition, many investment projects in renewable energies and energy efficiency are on an even smaller scale than in industrialised countries, especially in rural areas of developing countries. The transaction costs are often prohibitive as a result (Hamilton, 2010; Kerste et al., 2011; UNEP-FI, 2012). If the aim is to overcome energy poverty in developing countries in the course of transforming the energy systems, rural electrification in particular has an important role to play. Most villages in poorer developing countries are not yet connected to a grid infrastructure, and connection costs are disproportionately high. In such cases, the use of renewable energies allows relatively inexpensive off-grid or small-grid solutions (Kerste et al., 2011). However, these energy projects offer relatively low returns to scale, since the population density is much lower in rural areas than in

cities. Consequently, the investment and maintenance costs have to be spread over a small number of users, and specific energy costs are higher (Zeriffi, 2011). This hinders the corresponding investments.

At the same time, rural households' lack of funds often limits their ability to pay for energy (IEA, 2011c). Consequently, investors in power-generating capacity or the grid infrastructure would only have a small number of solvent customers, which makes the corresponding investments unattractive. Opening up market potential among wealthier customers who are already consuming fossil energy involves high transaction costs and requires legally guaranteed market access, which is often lacking. Moreover, up until now the energy consumption patterns of private households and micro-enterprises in rural areas have often not been compatible with centralised power systems designed to provide continuous power (Kerste et al., 2011; Zeriffi, 2011; UNEP-FI, 2012; IEA, 2011c). This discourages many financiers and potential investors.

Problems of the Clean Development Mechanism

Investments in renewable energies and energy efficiency in developing and newly industrialising countries can also be financed via the Clean Development Mechanism (CDM). The idea behind this mechanism for environmental-friendly development, which is enshrined in the Kyoto Protocol, is to help the industrialised countries achieve their promised emission reductions while at the same time contributing to the sustainable development of developing and newly industrialising countries (Article 12, KP; UNFCCC, 1997). Under the CDM, documented CO₂-emission reductions can be securitised and traded. Industrialised countries can purchase the CDM emission-reduction allowances and offset them against their own emission-reduction commitments. This creates a monetary incentive to invest in reducing emissions in developing countries and newly industrialising countries. The prerequisite for securitisation is that the emission reductions achieved must be *in addition* to an imaginary baseline.

The additionality criterion of emission reductions raises problems in relation to the transformation of energy systems, which is indispensable for climate protection (WBGU, 2011). On the one hand, many investors shy away from the time-consuming licensing and certification processes for CDM projects – not least because it is unclear how the CDM will develop after the end of the current commitment period of the Kyoto Protocol (IEA, 2011b,c; Hosier et al., 2010; Buchner et al., 2011; UNCTAD, 2010). This means that the CDM does not represent a reliable financing instrument for potential investors (Kerste et al., 2011; UNEP-FI, 2012). Furthermore, up to now it has not been possible to finance any

infrastructure investments (e.g. in grids or storage facilities) using this mechanism because no direct, additional CO₂ savings are generated (Forum Umwelt und Entwicklung, et al., 2010; IEA, 2011c; Hamilton, 2010). From this perspective, a *softer* interpretation of additionality would be desirable. However, a strict interpretation of the CDM's additionality criterion is of great importance to climate protection because this is an offsetting mechanism in which the cash flows are linked to the countries that pledged emission reductions in the Kyoto Protocol being permitted higher emissions. For these structural reasons, the CDM will not be able to generate a major effect on investment in the transformation of energy systems – and indeed has not done so to date.

Lack of Coordination between Development Assistance and Climate Financing

It is possible to directly support renewable-energy or energy-efficiency technologies – or to initiate leverage effects in combination with private capital – in the context of Official Development Assistance (ODA) and public climate financing. However, the share of energy-related ODA has been rather low in recent years and fluctuates considerably, depending on the price of oil (Michaelowa and Michaelowa, 2010). Similarly, the instruments of climate financing – such as the GEF, the Climate Technology Fund (CTF), bilateral and multilateral funds and the CDM – have made up a small proportion of the funding provided for a transformation of energy systems up to now (IEA, 2011b,c; Hosier et al., 2010; UNEP-FI, 2012). On the whole, only small amounts of public funds have been available for the sustainable development and conversion of energy systems in developing countries.

In order to increase the use of ODA and climate financing for a transformation of energy systems towards sustainability, the developing countries would, among other things, need to have the administrative capacity to file the necessary applications, as well as financial resources of their own to be combined with the various instruments of the World Bank. This is not always the case.

Since the Paris Declaration (2005) and the Accra Agenda for Action (2008), another prerequisite for the use of ODA funds has been that each country must formulate its own development strategies and lay down its goals of energy and climate policy. In order to apply for funding from ODA, all projects and strategies should, as far as possible, be coordinated, combined into large-scale programmes and form an integral part of the respective development strategy. Energy-related projects or programmes, especially in many Least Developed Countries, generally tend to be too small to be able to meet these requirements (Hosier et al., 2010; IEA, 2011b,c; Glo-

bal Climate Network, 2010). As a result, corresponding funds are rarely assigned to energy-related projects.

Evaluations of the Paris Declaration and Accra Agenda for Action have shown that there are also problems on the side of the donor countries, which have shown little willingness to engage in coordinated, joint activities. This has led to an increase in the overall transaction costs of projects or programmes, although the partners in the developing countries have taken on greater individual responsibility, making it more difficult to realise such investments (Ashoff, 2011).

It should also be borne in mind that different financing instruments are subject to different rules on allocation; the allocation rules for climate-financing instruments are more stringent than those of Official Development Assistance due to the licensing and certification process in greenhouse-gas reduction (Hosier et al., 2010; Ritchie and Usher, 2011). Because the periods of time set aside for assessing applications for the individual instruments are not coordinated, there can be delays, which can cause friction (Hosier et al., 2010). Furthermore, the fragmentation of various existing bilateral and multilateral energy funds causes the recipient countries an enormous amount of coordination work (Hosier et al., 2010; Forum Umwelt und Entwicklung et al., 2010; IEA, 2011c).

Inadequate coordination between ODA and climate financing is therefore proving to be an important barrier to investment in the sustainable development and conversion of energy systems in developing countries.

It follows from the analysis of the barriers that, in particular, the terms of investment in developing countries should be improved, and ODA and climate financing well coordinated; there is also a need for reliable energy strategies, *correct* energy prices, and a general reduction of investment and financing barriers in capital and energy markets. The following section makes recommendations on stimulating funding for a global transformation of energy systems towards sustainability.

Recommendations on how to Mobilise Capital for the Energy-System Transformation

Despite the fact that private capital is, in principle, available, general willingness to invest in or finance the transformation of energy systems towards sustainability falls short of what is required. The WBGU recommends mobilising this private capital by pursuing a transformative regulatory policy. The “proactive state with extended participation opportunities” (WBGU, 2011) faces the challenge of changing the policy framework in such a way that private investment in the transformation of energy systems, or *Energiewende*, becomes more attractive. At the same time, policy-makers should create more openings for citizen participation – in order to address concerns, adjust planning where necessary, and thus boost acceptance of grid expansion.

Develop a Transformative Regulatory Policy

Willingness to invest in renewable energies, the energy infrastructure and efficiency technologies can be increased by reducing key investment risks. To do this, countries’ national energy, climate and environmental policies should be strongly focused on the transformation of energy systems towards sustainability.

Develop National Energy Strategies

Long-term, stable and binding targets and strategies in energy policy that give top priority to the development of renewable energies and improving energy efficiency form a crucial foundation for an energy-system transformation towards sustainability. Only if there are ambitious, long-term and mandatory energy strategies will it be possible to achieve the necessary legal and planning certainty and coordination between the various change agents involved in the transformation. Since we are currently entering a new cycle of investment in the energy infrastructure, investors and providers of capital urgently need forward-looking statements on which technologies will be politically promoted in the long term.

In this context, a number of countries – including Germany, Denmark, Sweden, the UK, Switzerland, New Zealand and Lithuania, as well as the European Union – have already submitted energy strategies and/or roadmaps up to 2050 targeting the expansion of renewable energies and improvements in energy efficiency. These should now be quickly implemented as legislation and concrete measures to ensure the necessary binding character – where this has not happened already. Legal certainty is key here, particularly the need to be able to rely on the long-term validity of support measures and on the protection of confidence. It is not sufficient to have a strategy; it must be followed up by ambitious and specific targets and implementation measures. Countries that have not yet developed such energy strategies are called upon to formulate and implement them as soon as possible. Suitable measures will be suggested in the following sections.

Recommendation 1

For all countries: quickly develop ambitious, long-term and mandatory national energy strategies with measurable targets; implement them by enacting suitable legislation and concrete measures.

Internalise the Social Costs of Fossil and Nuclear Energies

Long-term climate and environmental policy requires the internalisation of the external costs caused by fossil-

RECOMMENDATION ON “INTERNATIONAL INITIATIVE I”: Expand CO₂ Pricing by Emissions-Trading Systems

The WBGU recommends that Germany and the EU work to ensure that concepts on pricing CO₂ become a fixed pillar of all low-carbon development strategies. In particular the WBGU recommends the establishment of emissions-trading schemes in as many countries as possible. Many developing and some newly industrialising countries need international support here in the form of knowledge transfer and capacity building. There should be international financial transfers to this purpose, which could be institutionalised via the Green Climate Fund.

The next step should be to link existing or developing emissions-trading systems in order to enlarge the international carbon market. Such links could go as far as defining a common, cross-national emission cap; they can help reach reduction targets more efficiently and trigger private capital flows, especially in newly industrialising countries. Sectoral approaches in emis-

sions trading aim in a similar direction, e.g. in power generation. In this way, newly industrialising countries that have not yet introduced emission caps could initially be integrated into a linked emission-trading system through a sectoral or gradeable approach. The medium-term objective would be the complete integration of the newly industrialising countries into an international carbon market. Germany should advocate that the European Union commit itself to promoting cooperation opportunities in the sense of linking emissions-trading schemes with the European Emissions Trading Scheme (EU ETS).

However, the linking of emissions-trading systems will only bring about significant advantages if the individual systems are designed in a way that generates sufficiently high CO₂ prices and avoid excessively high price volatility. The EU ETS should set an example here.

based and nuclear energy technologies. If conventional forms of energy become more expensive as a result, this means that renewable forms of energy become relatively cheaper. These relative cost reductions make renewable energies more competitive and corresponding investment more attractive. When energy costs rise, investment in energy efficiency also becomes more attractive because households and companies can achieve significant savings in energy costs.

Internalising the externalities of fossil-based forms of energy means above all putting a price on CO₂ emissions. This can be done in principle either by introducing a tax or by a policy of cap and trade – i.e. restrictions on CO₂ emissions coupled with tradable emission rights (price control versus quantity control). With an eye on the European emissions-trading system, the WBGU (2009, 2010, 2011) recommends quantity control in the form of a cap-and-trade system. This makes it possible to combine ecological effectiveness with economic efficiency, thus creating incentives for all market players to invest in sustainable technologies. At the same time, it makes low-emission technologies more competitive compared to conventional fossil-based fuel technologies. If there is a (partial) auction for the initial allocation of emission allowances, the government will furthermore generate revenue that could be used to support the transformation of energy systems.

The WBGU recommends expanding the European emissions-trading system to all fossil CO₂ emission sources. In addition, subsequent adjustments of the amount of allowances during auctioning or the trading

period should be considered. In the WBGU’s opinion, a carbon tax should be introduced in countries that do not (yet) have the administrative structure and institutions needed for quantity control. To ensure that carbon markets are large enough, developing and newly industrialising countries should be encouraged to get involved in emissions-trading systems as soon as possible, and the various systems should be made mutually compatible. This should be coordinated internationally, e.g. under the auspices of the UNFCCC. Germany and the EU should play a pioneering role here (see the recommendation on “International Initiative I”).

The social costs of nuclear forms of energy could be internalised by a tax on nuclear fuels – like in Germany. In addition to raising the price of nuclear forms of energy, this would also generate public revenue which

Recommendation 2

Create planning certainty for investors: guarantee legal certainty for transformative investments, focusing particularly on the long-term validity of support measures and the protection of confidence.

could be used for the transformation of energy systems towards sustainability. Further ways of internalising the social costs of nuclear energy could include the compulsory retrofitting of existing power plants to minimise risks and extending the public liability of operators of new plants.

Phase out Subsidies on Fossil Energies

The social costs of fossil-based forms of energy can only be effectively internalised if the subsidies on fossil energy carriers which exist in many countries are phased out as quickly as possible. This could save an estimated US\$8 to 10 billion per annum in the industrialised countries of the G20 alone. Substantial savings could also be expected in Russia, Iran, China, Saudi Arabia, India, Indonesia, Ukraine and Egypt, where subsidies are currently particularly high (UNEP, 2008; IEA, 2011a). These savings could be used to support the transformation of energy systems, especially the expansion of renewable energies. The G20 understanding reached in Pittsburgh in 2009 to phase out subsidies on fossil energy carriers should be concretised and realised as soon as possible.

Cushion Undesired Distributional Effects

Price increases, particularly for electricity, will be the inevitable and intended consequence of internalising the social costs of fossil and nuclear forms of energy, extending grids and supporting renewable energies. It can be assumed that total expenditure on energy by households, companies and the public sector will fall again in the medium to long term, i.e. once progress has been made on the transformation of energy systems towards sustainability. However, energy expenditure must be expected to rise for a transition period. Whereas private companies can frequently pass these increases on to their customers in the form of higher product prices, many households are likely to be seriously affected in their daily lives. This will apply in particular to poorer households – and not only in developing and newly industrialising countries but also in industrialised countries (Kopatz et al., 2010; IEA, 2011a). According to estimates by the Federal Network Agency (Bundesnetzagentur), electricity prices for private households in Germany, for example, could increase by 7% over the next few years solely as a result of grid expansion (Bünder, 2012).

In order not to jeopardise social acceptance of a transformation of energy systems, the social effects of rising energy costs should be adequately cushioned. This could be done, for example, by means of direct income transfers to low-income households or voucher systems allowing the free use of a limited amount of power. The specific instrument by which the social effects are cush-

ioned should be suitably integrated into the respective national social-security systems.

The social compatibility of subsidies on renewable energies should also be given special attention. In Germany, the support scheme under the Renewable Energy Sources Act (EEG) tends to benefit better-off households, while low-income households are confronted by a higher burden – relative to their income – because the costs of renewables are shared out equally by means of a levy on all electricity consumers. Fiscal or other compensation measures could make a substantial contribution here (Ekardt, 2010).

Recommendation 3

Make renewable energy competitive: abolish the price distortion of fossil and nuclear energies caused by subsidies or ignoring social costs. Promote corresponding initiatives at the G20. Cushion the social effects of resulting increases in energy costs.

Create Incentives for Investment in the Energy-System Transformation

Ambitious, long-term and legally binding national energy strategies and the internalisation of the social costs of fossil and nuclear forms of energy are essential to ensuring that more is invested in the development and conversion of energy systems towards sustainability. Moreover, it would seem sensible to support energy efficiency and – for a limited period – the development and use of renewable energies. Finally, the regulation of electricity markets and grids ought to be changed in such a way that investment is promoted.

Introduce Support Schemes for Renewable Energies

The WBGU regards temporary support schemes for the use of renewable energies as indispensable for rapidly advancing their diffusion worldwide. The preferred options here are feed-in tariffs or quota systems (renewable portfolio standards) in which energy suppliers are required to have a certain percentage of electricity from renewable sources in their portfolio; they would also be

RECOMMENDATION ON “INTERNATIONAL INITIATIVE II”: Global Spread of Feed-in Tariffs

The WBGU recommends that, as a pioneer in the field of feed-in tariffs, Germany should not only intensify knowledge transfer, but also launch an international initiative to promote the spread of feed-in tariffs all over the world and create a mechanism for financing feed-in tariffs in developing countries. In a declaration of intent, the participating countries could commit themselves to the temporary introduction of feed-in tariffs in their countries or to improving existing tariff systems. International transfers will be necessary so that feed-in tariff schemes can also be implemented in developing countries. While feed-in tariffs in industrialised countries can be financed by end customers via the electricity prices, the majority of consumers in developing countries are unable to do this. Public or other grants should therefore be provided to support the feed-in of renewable energies, as well as funds for capacity building (knowledge transfer, training).

One conceivable method would be the establishment of an international financing mechanism based on the GET FiT (Global Energy Transfer Feed-in Tariffs) programme recommended by Deutsche Bank Climate Change Advisors (Fulton et al., 2011). GET FiT envisages an international public-private partnership in which sponsors act as provider of capital and as risk

hedgers, guaranteeing the payment of feed-in tariffs over the entire investment period. Such a framework could spur the supply of – and demand for – financing. Particularly in developing countries the existing funding potential could be mobilised in this way, with individual players participating in funding according to their capabilities. Independent mini-grid solutions could also be supported in a similar way (Moner-Girona, 2008).

Such a funding mechanism could be an integral part of UNFCCC commitments, according to which US\$100 billion per annum is supposed to be available for adaptation and mitigation measures in developing countries as from 2020. The expansion of the necessary energy infrastructure (grids, storage facilities) should definitely also be covered by the funding. Wherever possible, the financial support should be linked to market-based reforms of the energy markets (unbundling of energy-generating and grid-operating companies; independent regulatory agencies) to encourage competition and market efficiency. The phasing-out of subsidies for fossil energy carriers should be a prerequisite for support. Finally, there should be clear rules to ensure the medium-term expiry of the corresponding support schemes.

able to meet this requirement by buying green electricity certificates. The WBGU recommends feed-in tariffs (FiTs) combined with feed-in or purchase guarantees during the renewable-energy roll-out phase, since such a scheme has a faster impact than quota systems (IEA, 2008; IPCC, 2011). It is important to gradually reduce the level of subsidies over the years; their phase-out after a predetermined amount of installed capacity has been reached should also be announced well in advance.

Germany should make more use of the experience it has gained with the Renewable Energy Sources Act (EEG) to promote the international transfer of knowledge and the optimal design of feed-in tariff schemes. The International Feed-in Cooperation (IFIC) founded by Germany, Spain and Slovenia in 2005 lends itself to regular exchanges of knowledge and experience between countries with feed-in tariffs. This exchange of experience could be extended to include capacity building. In the future, the IFIC's role should be further strengthened to help coordinate the different support schemes in the member countries and reach a common and ambitious target for renewable energies. In this context, the WBGU recommends a second international ini-

tiative to be launched by Germany (recommendation on “International Initiative II”).

Feed-in tariffs can provide investment protection; they therefore represent a particularly effective instrument for encouraging investment in renewable energies. As electricity generation from renewable sources increases, it makes sense to develop the support schemes in such a way that renewable energies are successively integrated into the conventional power market. To do this, it is necessary to make the tariff for electricity generated from renewables increasingly market-based – to provide an incentive to focus on the electricity price and thus on demand. The WBGU therefore recommends increasing incentives to directly sell the power generated from renewable energies. Suitable schemes include market premium models in which companies that generate renewable energies and sell this electricity directly are paid the difference between the technology-specific feed-in tariff and the average exchange price for electricity. However, direct sale should not be an option until electricity from renewable energies has reached a significant proportion of total generated power as a result of feed-in tariffs.

Recommendation 4

For all countries: introduce temporary support schemes for renewable energies.

Reform Electricity-Market and Grid Regulation

Investment in the transformation of energy systems should be made more attractive by introducing suitable electricity-market regulation schemes. For example, private companies should be enabled to access the electricity market and end customers by means of supply contracts. End customers should be able to freely choose their electricity product and supplier, like in other product markets. At the same time, network access and market-oriented pricing should be guaranteed for electricity producers and suppliers. Negative distributional effects of energy-price increases should be offset not by price regulation, but by instruments of social policy.

Liberalised electricity markets require an independent regulator, particularly for the electrical grid as a natural monopoly. The growing importance of renewable energies makes it necessary to further develop the existing design of the power market – also in terms of pricing. The increasingly volatility of power from renewable energy sources leads to more grid congestion, because the current grid system is, for the most part, designed for controllable generation capacity. Experience from the USA shows that market-based congestion management is possible through regional price differentiation in the form of what is known as nodal pricing (Neuhoff and Boyd, 2011; Peter and Krampe, 2011). Nodal pricing can achieve sufficient transparency for grid-congestion management and system stability, because the system services and power trading are jointly evaluated in particular regions. However, as a rule it is necessary to have an independent overall system operator who integrates all the relevant parameters of the power that is generated and offered. The WBGU recommends reviewing the incentive effects of this market design – also from the competition point of view – since it can create incentives for investment in generating capacity, storage facilities and grid management.

The spatial distribution of generation and load is the most important factor influencing the future design of electricity grids. Therefore, as already described, a clear energy-policy framework and stable support policies are also essential for successful grid development.

The economic incentive for grid development is created by grid regulation. Since grid regulation is the responsibility of nation states, there is considerable heterogeneity in this field. Even so, the WBGU also recommends international cooperation in the context of national grid regulation schemes. In view of the large sums expected to be invested in grid development in the future, a high degree of transparency should be achieved in regulation in order also to be attractive to external financiers. International cooperation on identifying best-practice guidelines in grid regulation and disclosure requirements can make a contribution here.

An example worth mentioning here is the kind of incentive regulation that exists in many European countries. It encourages investment in the transformation of energy systems without neglecting quality assurance in the grids. Regulation must explicitly take into account both the quality of supply and innovations, as well as the environmental impact of electricity supply. A higher imputed interest rate on own funds or competitive tenders for grid construction measures could provide short-term incentives for grid investment. In the UK, for example, a new regulatory regime has been introduced which combines cost efficiency with innovation and quality. In Germany, the new grid regulation makes it possible to increase the revenues of grid operators by allowing them to apply for investment budgets (Bundesnetzagentur, 2011; BMWi, 2011). This also provides an incentive in the right direction.

The WBGU recommends the Europeanisation of energy policy – involving the consistent promotion of renewable energies – as well as the coordinated, rapid development of the grid infrastructure, including storage facilities and grid access, and a resolute EU energy foreign and development policy on the integration of North Africa (WBGU, 2011). A important first step is the implementation of the European Single Energy Market. Unrestricted grid access and the creation of

Recommendation 5

In Germany and Europe: design the power market and grid regulation in such a way that electricity from renewable sources is increasingly integrated into the liberalised energy market and, ultimately, sold directly.

cross-border grids are necessary for the efficient integration of renewable energies into the existing grid and for guaranteeing a reliable supply. The European Single Energy Market also requires a continent-wide networking of production, consumption and storage, and this means joint planning of energy-infrastructure development and guarantees for the necessary investments. The WBGU proposes that the German Federal Government should promote the creation of a climate-friendly Single Energy Market by the EU, because the latter has the power and authority to ensure the implementation of the measures planned in the Single Energy Market Package.

Introduce Dynamic Efficiency Standards

Incentives for improving energy efficiency can be created by introducing dynamic efficiency standards – that become more strict over time – for production facilities, buildings, vehicles and other durable consumer goods. In line with the top-runner approach, they should be geared to the most energy-efficient products on the market on a specific date. Corresponding standards should in particular be laid down for public buildings. Here, Germany could lead the way with a further international initiative (see the recommendation on “International Initiative III”).

Enhance Research and Development

Research efforts into the further development of sustainable energy technologies, particularly in energy transmission and storage, should be greatly enhanced and research policy designed accordingly. Public support has an important role to play here, since private companies do not have enough incentives to invest in basic research and fundamental new developments because of knowledge spill-over (positive externalities). However, the rapid development of storage technologies is an important prerequisite for a successful transformation of energy systems – specifically with regard to feeding electricity from renewable sources into electricity grids. In this context, government research-funding policy should primarily take the form of competitive project financing and providing direct support for pilot projects. The Federal Ministry of Research and Education’s Energy Storage Funding Initiative and the Federal Ministry of Economics’ 6th Energy Research Programme in Germany could be role models for other countries.

There is also a considerable need for research into the factors determining private households’ demand for energy and, consequently, their attitudes and behaviour in the field of energy efficiency. In particular, there should be more focused research into the importance of monetary factors compared to other, especially social factors (social networks, forms of social competi-

tion, social comparisons). Corresponding social-science research programmes should form an important part of future energy research, both in Germany and in other countries.

Moreover, decentralised solutions are likely to become more and more important in the future. There should also be more research into how centralised and decentralised energy generation and energy services can be efficiently combined.

Recommendation 6

Create incentives for innovation and research: lay down dynamic efficiency standards as an incentive for innovation. Focus research policy on energy-system transformation towards sustainability.

Improve Planning and Approval Processes

Investments in the sustainable development and conversion of energy systems become more feasible if there is a high level of social acceptance of concrete measures, and planning and approval procedures do not represent major hurdles. Infrastructure investments in particular (e.g. power lines, power stations) usually face high bureaucratic and acceptance barriers.

It is important to inform citizens about planned measures at an early stage and also to involve them early on and continuously in the planning and approval process. Clear and binding legislation must provide a framework for the participation and integration of citizens and for balancing interests – for example in the form of

Recommendation 7

To improve social acceptance: streamline and accelerate planning and approval processes for infrastructure projects and encourage participation.

RECOMMENDATION ON “INTERNATIONAL INITIATIVE III”: An International Agreement on Efficiency Standards in Public Buildings

The WBGU recommends a further international initiative within the G20 targeting an international agreement on efficiency standards in public buildings. This would be a powerful lever with considerable synergy potential. The building sector is responsible for a large proportion of final energy consumption. The Global Energy Assessment (GEA, 2012) estimates that the demand for energy can be reduced by up to 90% in industrialised countries with high building density by refurbishing the building envelopes. Governments and public institutions must have a fundamental interest in reducing building-operating costs. Since buildings are generally used for very long periods of

time, public building owners fundamentally have a long-term investment horizon within which efficiency investments are profitable.

An international agreement on building standards would furthermore open up a global market for energy-efficiency technologies in buildings and thus make a substantial contribution to cutting costs and accelerating market penetration by these technologies. Moreover, standards for public buildings can develop a role-model function for private-sector buildings and exert a positive influence on the market supply of efficiency technologies.

compensation for individual disadvantages (Koch, 2011; Uken, 2011; Pettersson and Söderholm, 2011). Citizens' funds and energy cooperatives enable the local population to participate in investment projects at an early stage. From the investors' perspective, furthermore, grid- and storage-infrastructure projects can be made significantly more attractive by streamlining and accelerating administrative planning and approval processes.

Reduce Barriers in the Capital Markets

Even if a large number of energy-transformation projects are in the planning pipeline, there is no guarantee that sufficient funding will be provided for these projects. Prospects could be improved by increasing the funds available to national development banks, gradually giving them the functions of *green investment banks*, and gearing institutions more strongly towards long-term and sustainability criteria.

Create Green Investment Banks

National development banks (i.e. government or public-sector banks that support government tasks) should be created to implement sustainable energy strategies; where such banks already exist they should be geared more to the transformation of energy systems. The aim would be for them to take over the functions of a green investment bank, following the example of the United Kingdom (UK-BIS, 2011). In Germany, such an institution already exists in the form of the KfW Bankengruppe; its range of services should be broadened in the course of the *Energiewende*. At the European level, the European Investment Bank (EIB) and the European Bank for Reconstruction and Development (EBRD)

could focus more on taking on corresponding functions.

In all countries, national and regional development banks should be permanently assigned more funds to stimulate investment in the transformation of energy systems; these resources can be used to provide low-interest loans and loan guarantees. The funds should be allocated as part of long-term strategies and programmes geared towards the goals of the transformation of energy systems.

National development banks operating as green investment banks could provide decisive support to investment in the transformation of energy systems in three areas that are crucial for investment:

1. *Information Provision and Capacity Building*: In order to help fill gaps in the knowledge of investors or financiers and reduce information asymmetries between lenders and investors, knowledge of – and experience with – specific technologies should be pooled in national green investment banks. These banks could pass on their knowledge directly to potential investors and lenders, or give the latter access to information databases. Furthermore, such institutions could offer services, such as specific risk assessments of individual investments.
2. *Capital Provision*: The hesitant nature of banks' lending for investment in the transformation of energy systems can be overcome by government providing low-interest capital and by means of credit-collateralization instruments (e.g. loan guarantees). Government funds could be allocated to investors through national green investment banks as part of promotion strategies and programmes. In addition to these public funds, green investment banks could raise private funds in the capital markets by issuing green bonds like those of the World Bank (World

Bank, 2012). Since national development banks frequently have a high credit rating, green bonds issued by these banks would also be interesting alternatives to investments in government and corporate bonds for the more risk-averse financial investors like insurance companies and pension funds (Kerste et al., 2011).

3. **Risk Hedging:** Green investment banks should launch structured funds pooling public and private funds in a form of public-private partnership, with the state underwriting part of the non-payment risks associated with the lending. Such partnerships are also particularly important in the field of venture capital. Examples include the UK Carbon Trust Venture Capital Fund and the CalCEF Clean Energy Angel Fund. Within such funds, the available resources can be divided into several tranches; the government would take on the riskiest shares respectively, thus reducing the risk of default for private lenders. In addition to banking services, green investment banks could also contribute to reducing risk by providing insurance solutions, should these not be available in sufficient quantities from private insurers. These solutions include (export) credit insurance policies and weather derivatives (e.g. wind derivatives) or solar performance guarantees which hedge against weather risks in the generation of wind and solar power. Another insurance product might be *energy savings insurances*, which can enable energy service companies to obtain better loan terms from banks.

Recommendation 8

Strengthen and focus the public promotion of investment: establish or strengthen national development banks and design them as green investment banks.

Adapt Financial Market Regulation

Banks, pension funds and insurance companies play an important role in financing the energy-system transformation. They are subject to varying forms of regulation, some of which tend to undermine the goal of sustainability in the transformation of energy systems. Political objectives beyond the financial sector should therefore be considered when developing further regulations in

the financial sector. Exchange and coordination processes between ministries, for example, would have to be strengthened to achieve this. In Germany, the new steering group at state secretary level on the implementation of the Germany's energy reforms (BMU, 2012) might be regarded as a first step in this direction.

Basically, when it comes to regulating financial markets in ways that promote a transformation of energy systems, the main issue is to make long-term investments more attractive than short-term ones in terms of return and risk (or at least not to put long-term investments at a disadvantage). A long-term investment horizon is characteristic of projects for transforming energy systems. Possible starting points for increasing the promotion of long-term investments include the accounting and publication requirements for financial and industrial companies; others are management and compensation systems, which up to now have focused on short-term evaluation periods (WEF and Wyman, 2011). In addition, special rules for investment in the transformation of energy systems would make sense in the context of risk-regulation requirements for banks and insurance companies (Basel III and Solvency II regulation packages, Box 3).

Strengthen Long-term and Sustainability Orientation

Reviews of sustainability criteria should be explicitly integrated into the decision-making processes of institutional investors. Many institutional investors have already committed themselves to sustainable investments and/or sustainability reporting, or else have signed voluntary commitments such as the UN Principles of Responsible Investment. Countries should promote such initiatives by campaigning – e.g. at the EU level and at international forums like the G20 – for such commitments to be signed by all major financial investors, especially pension funds, insurance companies, foundations and sovereign wealth funds with a long-term investment horizon. Organisations like the Institute of International Finance, the International Association of Insurance Supervisors and the Long-Term Investors Club should also focus more on sustainability issues and call for them to be a factor in investment decisions. With this in mind, the interpretation of the fiduciary duty of insurance companies and pension funds should be extended by an additional component and cover not only economic but also environmental and social sustainability aspects. Corresponding concepts have already been proposed (UNEP-FI, 2009a; Berry, 2011); they should be promoted and quickly implemented by governments. The G20 in particular has an important role to play here.

Recommendation 9

EU, G20, Long-Term Investors Club, Institute of International Finance and International Association of Insurance Supervisors: strengthen the influence of long-term and sustainability criteria on investment decisions, financial-market regulation and international accounting standards.

Encourage Energy Cooperatives and New Business Models

As technologies for decentralised power generation are important elements of the transformation of energy systems, citizens should be directly involved in the transformation of energy systems. Energy cooperatives are a highly promising model for financing renewable generating capacity, not least because they can boost public acceptance of energy-system transformation. Citizens, local (cooperative) banks and sometimes local utilities join together to form energy cooperatives in order to jointly operate a power-generating plant. They are financed by equity and borrowed capital, to which a cooperative is more likely to have access than private individuals (Holstenkamp und Ulbrich, 2010). In a cooperative organisation, citizens can participate democratically in the planning and further development of projects in their region (Brinkmann and Schulz, 2011). Energy cooperatives can turn passive consumers into producers of electricity and heat, i.e. into so-called *prosumers* (Toffler, 1980).

Although the first energy cooperatives were already set up in the early 20th century, they have been enjoying especial popularity in Germany since the 1990s. Between 2001 and 2011 the number of registered energy cooperatives in Germany rose from just over 50 to more than 400. Most of them are located in municipalities with populations smaller than 25,000 (Holstenkamp and Ulbrich, 2010; Maron, 2012). Energy cooperatives should be supported by local authorities' communication policy and, in certain circumstances, by equity contributions.

Energy contracting by Energy Service Companies (ESCOs) is an important business model for financing efficiency measures. ESCOs implement energy-saving measures in businesses and private households and thus reduce their information and transaction costs. Since

the initial investments are paid for by the ESCOs, and the repayments made by their clients usually come out of the resulting energy savings, ESCOs help to spread the financial burdens caused by major efficiency investments over time in a better way. This is a big advantage for households and companies with relatively low liquidity levels or credit ratings. Providers of such services also have knowledge of meaningful efficiency investments in companies and households and can combine large numbers of small efficiency projects. When pooled in this way, projects that would not have been funded separately often become financially feasible. Promoting ESCOs – e.g. by public loan guarantees or governmental support for energy-saving insurances – would thus also make it possible to leverage efficiency potential that is scattered and untapped. In addition, public-private partnerships (PPPs) involving financiers, utilities, local authorities and ESCOs also offer promising opportunities for coordination between the demand for and the funding of energy-efficiency services.

Increase Investment via Venture-Capital Markets

Venture-capital markets should be promoted by adapting the legal framework to create incentives to provide venture capital for the transformation of energy systems. One possibility in Germany would be to change the tax status of venture-capital companies. The EU Commission recently proposed harmonising legislation among the EU member states to give small and medium-sized enterprises better access to venture capital (European Commission, 2011). Public provision of venture capital would be useful in countries where a functioning venture-capital market has not yet become established (see recommendation on national green investment banks).

Recommendation 10

Reduce investment barriers for households and small and medium-sized enterprises (SMEs): support private households and SMEs in the financing of transformative energy investments by promoting energy cooperatives and new business models, and by enabling better access to venture capital.

Promote the Energy-System Transformation in Developing Countries

The measures recommended above can also provide stimuli for funding the development and conversion of energy systems towards sustainability in developing and newly industrialising countries. In these countries, too, legal certainty – especially the long-term validity of policy instruments and the protection of confidence – is a key prerequisite for investment in renewable energies and energy efficiency. When it comes to investment in sustainable energy systems, newly industrialising countries are similar to industrialised countries in terms of governance and their economic capabilities. By contrast, when it comes to developing countries there are several additional and specific recommendations that need to be mentioned.

Establish Market Facilitation Organisations

It would be expedient for developing countries to establish market facilitation organisations (MFOs), which can reduce the transaction costs of market development in new technologies. This can happen, for example, when MFOs help to find potential market partners and potential financiers, to conduct market analyses and provide advisory services for renewable-energy technologies on the spot, or to develop ideas for new business models that go beyond the sale of electricity alone. The public-private ownership structure of MFOs enables them to combine public goals like the introduction of renewable energy technologies with private business interests, e.g. providing services that are as cost-efficient as possible. Germany has already gathered experience in this field with project executing organisations and international companies in the field of location marketing. Based on this experience, the range of services provided by MFOs should be extended; Germany and other OECD countries could take on an advisory role here.

Enter into Strategic Energy Partnerships

Strategic energy partnerships between industrialised countries or large, newly industrialising countries on the one hand, and developing countries on the other, can help adapt renewable energy technologies to local conditions and support the development of a national production capacity. This speeds up learning curves, and cost reductions can be achieved more quickly. Successful examples of north-south partnerships in the energy field include the Africa-EU Energy Partnership (AEEP), the Euro-Mediterranean Partnership (EUROMED) and the US-China Clean Energy Cooperation (AEEP, 2011; US-DoE, 2011). Examples of south-south partnerships are the collaborations between Brazil, China or India with countries like Nigeria, Senegal, Indonesia and Mozambique (Biopact 2007a,b).

Improve Access to International Capital

Bilateral and multilateral financial institutions should be used to give grants, low-interest loans or public guarantees to regional and local banks in developing countries. This could create a more favourable risk-return ratio for potential investors. At the same time it would reduce the risk of default for local financiers, thus increasing the amount of liquidity in the local capital market. The involvement of international funds like the International Finance Corporation (IFC), the Multilateral Insurance Guarantee Agency (MIGA) or the Currency Exchange Fund could make it possible to offer investment-insurance solutions which are otherwise not commercially available in many developing countries.

International financial institutions should also support financing and business models that improve access to capital in developing countries while doing justice to specific local requirements. This would include the development of microfinance in the respective countries, focusing on the funding of renewable energy technologies and energy-efficiency investments. Furthermore, innovative and successful business models should be supported in these countries by Official Development Assistance. Such business models might involve leaving the power-generation technology and end-user devices in the ownership of the provider and only having private households pay for such services as light, television, radio or charging mobile phones (UNEP-FI, 2012, IEA, 2011b). Liquidity barriers for sustainable energy investments could be overcome in this way.

Reform the Clean Development Mechanism

A continuation of the Clean Development Mechanism (CDM) could also contribute to the transformation of energy systems towards sustainability in developing countries. The WBGU proposes limiting the CDM in future to Least Developed Countries and placing a focus on sectoral measures in the energy field, specifically on renewable energies and energy efficiency. Above all, a CDM reform should make it easier to pool a large number of small projects, making it less complicated and expensive for foreign investors to (co-)finance them. The existing Programmes of Activities (PoAs) or sectoral approaches are in principle suitable for such a pooling process. Both approaches involve high transaction costs, however. In order to reduce transaction costs, it is essential to develop standardised baselines and methodologies as well as simplified procedures for handling projects. Ultimately, these reforms of the CDM should prepare the ground for new market mechanisms, like the ones currently being discussed under the UNFCCC. If the industrialised countries set binding and much stricter emission caps in the future, it might be reasonable, as part of new market mechanisms, to also make it pos-

sible to offset measures at the national level against the reduction targets of industrialised countries. The baselines and methodologies from the programme-based CDM or sectoral approaches should therefore be easily scalable, but should definitely guarantee that emission reductions are verifiable. As long as industrialised countries lack binding and strict emission caps, the WBGU recommends that industrialised countries should rather enhance transformative investment by supporting the Nationally Appropriate Mitigation Actions (NAMAs), particularly in newly industrialising countries.

Recommendation 11

Developing countries and international development organisations: take additional measures to reduce transaction costs in developing countries, e.g. establish market facilitation organisations, enter into strategic energy partnerships and improve access to capital.

Link International Policies on Energy, Climate and Development

Additional international efforts are needed for a global transformation of energy systems towards sustainability. The main objective must be a better coordination of different policy areas at the international level.

Upgrade UN-Energy

The International Energy Agency (IEA) and the International Renewable Energy Agency (IRENA) are important institutional players in the field of international cooperation on the transformation of energy systems. However, the activities of the two organisations are hardly coordinated. Upgrading UN-Energy as a platform for an intergovernmental collaboration would generate synergies and strengthen these organisations. UN-Energy should make sure that the activities of international organisations have an integrated and systemic view on energy and ensure a link between energy policies and development-policy objectives. The WBGU recommends advocating the upgrading of UN-Energy as a coordinating platform within the UN system and raising it to the level of a programme.

Strengthen IRENA

An internationally coordinated and accelerated approach is expedient for the global development of renewable energies. IRENA, founded in 2009, has the task of advising and supporting industrialised and developing countries on the introduction of renewable energies. The purpose of IRENA is to offer practical and concrete advice to policy-makers, facilitate capacity building, technology transfer and financing, and promote the exchange of knowledge. The important thing now is to complete the start-up phase and get the substantive work fully operational. The WBGU recommends that the German Federal Government, a member state, should advocate permanent funding and a detailed medium- and long-term strategy for IRENA.

The global spread of temporary feed-in tariffs should be one of the organisation's programmatic objectives. IRENA could act as the secretariat and coordination platform for the WBGU-recommended „International Initiative II“ for disseminating feed-in tariffs. In order that IRENA can serve as a coordination platform for the introduction of feed-in tariffs, the German Federal Government should advocate giving IRENA a lot of attention and weight on energy issues worldwide, so that it can make progress with the expansion of renewable energies as an equal partner together with existing organisations.

In addition, IRENA could create databases on analyses of potential, support policies or the funding of renewable energies in order to make capacity building easier in developing countries in close cooperation with the International Feed-in Cooperation (IFIC). Furthermore, it could initiate partnerships between countries, which – like the energy partnership between the EU and North Africa – set common targets for expanding renewable energies and seek to meet these targets by means of jointly funded projects and by mutually offsetting new capacity.

Extend the Energy Charter Treaty

The Energy Charter Treaty was signed in 1994 between the European Union, its member countries and countries from central and eastern Europe as an investment-protection and trade agreement for the energy sector that is binding under international law. The treaty came into force in 1998. Many central and east Asian countries have signed up to it in the meantime. The Energy Charter Protocol on Energy Efficiency and Related Environmental Aspects came into force simultaneously. The Energy Charter Treaty contains substantive and institutional provisions aimed at promoting cooperation between member countries in the energy sector and, above all, creating legal certainty for investment in the energy sector and for trade in energy-related prod-

ucts. In line with the GATT and the WTO, it prohibits discrimination in relation to all products, services and capital movements in the energy sector. Nationalisation or expropriation are permitted only if appropriate compensation is paid. A dispute-resolution process is laid down in the treaty which applies to both investors and the treaty states. The Energy Charter Protocol on Energy Efficiency and Related Environmental Aspects furthermore supports the coordination of the parties' energy-efficiency policies.

The WBGU recommends that the Federal Government should campaign in the European Union to encourage more countries to join the Energy Charter Treaty and the Energy Charter Protocol. These agreements could secure international capital flows and strengthen international cooperation in the energy sector.

Expand Cooperation between Industrialised and Newly Industrialising Countries

The creation of a suitable regulatory framework can reduce barriers to investment in low-carbon technologies and create stable, long-term conditions for transformative investment. A large proportion of investments in the global energy-system transformation towards sustainability will be made in the newly industrialising countries in the future. Several emerging economies, especially China, have sufficient financial resources and considerable foreign-exchange reserves with which to finance the necessary initial investment. However, a suitable regulatory framework also needs to be developed in the newly industrialising countries in order to launch and accelerate the transformation.

Against this background, great importance should be assigned to cooperation on energy policy between Europe and the newly industrialising countries. In addition to technology partnerships and concerted investment in training the next generations of engineers, cross-national research programmes to improve energy efficiency should also be encouraged. Furthermore, common energy-policy learning processes should be made possible to develop transformative regulatory policies – to ensure that the transformation of energy systems can be financed. The real costs of financing will depend primarily on long-term policies and the type of instrument mix used. Joint search and learning processes are meaningful for OECD and newly industrialising countries. Elements of such cooperation might include high-level policy dialogues (e.g. at the G20 and B20 level), transnational cooperation between the ministries involved in the conversion of energy systems, or the joint development of international post-graduate master's degree programmes focusing on the energy-policy prerequisites and incentive systems for a low-carbon transformation of energy systems.

Recommendation 12

Extend international energy policy: strengthen UN-Energy and IRENA, create transformation partnerships between the OECD and newly industrialising countries, and extend the Energy Charter Treaty.

Strengthen the World Bank, Development Banks and the Green Climate Fund

An organisational coordination of energy-policy and development-policy institutions – like the World Bank, development banks and the Green Climate Fund (GCF) – would offer an opportunity to counter the unidimensional view of the United Nations as a service provider in multilateral development assistance by offering a broader perspective and emphasising the transformative leverage potential of multilateral organisations. Multilateral players and institutions involved in development policy making should coherently gear their operational strategies to the needs of environment-friendly and low-carbon development. In the energy sector they should pool their resources, particularly for a global transformation of energy systems towards sustainability. The promotion of conventional development programmes that maintain the status quo of the existing energy system should be scaled back and gradually phased out.

The WBGU recommends increasing the budgets of the World Bank, regional development banks and bilateral development assistance with the clear objective of developing sustainable energy systems and transforming existing non-sustainable energy systems. The additional funds should be spent on enabling the Least Developed Countries (LDCs) in particular to formulate energy policies in a participatory way and to recognise and exploit the available potential of renewable energies and energy efficiency.

The World Bank Group's International Development Association, bilateral Official Development Assistance and non-governmental organisations should use their resources in a targeted way to build up administrative and policy-making capacity in LDCs. This could enable these countries to formulate national development strategies, including their own energy- and climate-policy objectives. It would help create conditions that would enable these countries in future to apply for international funding as co-financing and simultaneously

be attractive for foreign direct investment. This helps increase a country's absorptive capacity for international finance. The national Poverty Reduction Strategy Papers (PRSPs) could be used for developing short-term national energy strategies in the 30 poorest developing countries. One of the objectives ought to be to improve access to modern energy services in these countries, which in turn contributes to poverty alleviation. For example, the World Bank could support the development of low-carbon energy infrastructures in the LDCs.

A facility for the private sector is provided for within the GCF. This facility gives private investors direct or indirect access to capital at the national and international level. The WBGU recommends that the GCF should apply, by analogy, the funding instruments recommended for national green investment banks at the international level. As already mentioned, the issues are information provision and capacity building, the provision of capital by means of low-interest loans and loan guarantees, and risk hedging by guarantees for non-payment risks. The instruments should take economic performance in the target country of the investment into account, enabling optimal support to be given to its economic development. National and local stakeholders should be incorporated into the process.

Promote the Convergence of Climate Financing and Development Policy

Public climate financing and Official Development Assistance (ODA) should converge more with a view to financing the global energy-system transformation towards sustainability. A strict separation between the two areas of financing seems inappropriate. Climate protection should become an integral part of energy and development policy. The challenge will then be to nevertheless ensure the additionality of funds for climate protection.

The WBGU recommends learning from development policy and adopting the Paris Declaration and the Accra Agenda for Action in international public climate financing in order to create more commitment for the donor and recipient countries on the one hand, and more confidence on the other. Furthermore, reporting on ODA should be used to create more transparency in public financial flows, also in the context of climate financing.

Moreover, investments in the energy sector should even be promoted internationally if their direct contribution to reducing emissions is small – if they make a contribution to the transformation of energy systems (e.g. grid development, storage systems). Corresponding indicators should be developed for measuring such a contribution.

Finally, the support of Nationally Appropriate Mitigation Actions (NAMAs) by the industrialised countries,

agreed under the UNFCCC, should not be regarded primarily as a contribution to their own climate-protection commitments (offsetting), but should have the character of financial transfers. Otherwise the industrialised countries' already unambitious mitigation targets would be further diluted.

Recommendation 13

International development-policy and climate-financing institutions: strengthen the links between policies on energy, climate and development, both financially and in terms of goals. Strengthen corresponding institutions and provide them with sufficient funding.

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Acknowledgments

The German Advisory Council on Global Change (WBGU) would like to thank all those who have contributed valuable suggestions and comments on the policy paper through conversations, comments and advice:

Felix Holz, Deutsche Bank, Vice President Team of Experts Greentech, Global Banking
Silvia Kreibiehl, Vice President Asset Finance and Leasing, Deutsche Bank; Lead Analyst GET FiT Program of Deutsche Bank; Investment Manager European Energy Efficiency Fund
Prof. Dr. Ulf Moslener, Professor of Sustainable Energy Finance, Frankfurt School of Finance and Management; Head of Research UNEP Centre for Climate & Sustainable Energy Finance (SEFI)
Dr. Armin Sandhövel, Chief Executive Officer, Allianz Climate Solutions GmbH
Heiko von Tschischwitz, Turina Holding GmbH & Co. KG/Lichtblick AG

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It would not have been possible to prepare this policy paper without the committed work of the WBGU's scientific staff:

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Copy deadline 01.06.2012

This policy paper is available online in German and English.

Translation: Bob Culverhouse, Berlin

© 2012, WBGU ISBN 978-3-936191-61-5

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