Renewable energies and the transformation of the global energy system

- Megatrends, challenges and strategies
- Significance of renewable energies and of energy efficiency in various global energy scenarios
- International energy policy

Megatrends, challenges and strategies

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Summary

Megatrends such as global population growth, the development of industrialised societies in developing and emerging countries, and the increased mobility of people, goods and knowledge are the main factors that will influence energy requirements in the future. The most important limitation on these developments is the durability of ecological systems.

A paradigm shift is necessary if a balance between growth and sustainability is to be found in the future. A wide range of challenges are associated with the transformation of the energy system and the emerging global markets for renewable energies; these challenges also have to be met by science and research policy if Germany is to retain its position as a technological leader in international comparison.

Introduction

Our world is changing at an increasing tempo. Industrialisation is proceeding in fast forward mode in certain parts of the world, and important markets are shifting from west to east and from north to south. Economic growth and the emergence of a global middle class with increasing urbanisation and uninterrupted population growth in developing countries are all resulting in a strong increase in demand for raw materials such as steel, cement and glass, and for capital items and long-life consumer goods. On the other hand, the reverse trends are taking place in western societies due to the ageing and shrinking of populations, an increasing focus on the consumption of sustainable products and, above all, the transformation of production economies into service and knowledge economies.

On an overall basis, these developments will nonetheless lead to a steep increase in energy requirements given current energy supply structures – the increase will be around 40% over the next twenty years alone [1]. The question thus arises as to how long this development can be sustained, particularly considering that a change in the trends in the fundamental data is not in sight. The availability and prices of non-renewable energies and the geopolitical risks alone demand that a decoupling of economic development and energy requirements take place. The task here is to keep the difference between energy consumption and the energy services actually needed – such as mechanical power, heat, light and communications – as low as possible. This is particularly necessary in view of the limited durability of ecological systems.

Challenges presented by climate change

The "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" [2] agreed at the climate conference in 1992 has now resulted in the specific requirement of limiting the increase in the average global temperature to 2 °C with respect to the pre-industrial age.

At their summit in L'Aquila, Italy, in July 2009, the G8 states recognised that it would be necessary to at least halve global greenhouse gas emissions by 2050 and reduce them by 80% in industrialised countries compared to 1990 levels in order to achieve this target [3]. Despite all the political difficulties, agreement among the international community of states on this matter appears to be a matter of "when" and "how" rather than "if" – particularly with regard to the fair distribution of burdens and opportunities between industrialised and developing countries.

After all, the reality of the progress of climate change will gradually increase the pressure to act and will ultimately force decisions to be made.

However, the risks of inaction are not the only issue here; the opportunities presented by the transformation of the global energy system are increasingly being recognised too. A paradigm shift can also clearly be identified in the World Energy Outlook 2009 from the International Energy Agency (IEA) [1]. In contrast with previous reports, which concentrated on what should be done in order to reduce greenhouse gas emissions, the focus has shifted to what will happen if we do not act decisively. In place of the business-as-usual development which has been classified as "not sustainable", a reference scenario has now been introduced that will achieve a stabilisation of the greenhouse gas concentration in the atmosphere at 450 ppm, which corresponds to the "2 °C rise scenario". As shown by the investigation carried out by Fraunhofer IWES in *Figure 1*, it is even possible from a technical and structural viewpoint to already achieve fully CO_2-free energy supply by 2050. To do so, the potentials for saving energy (mainly in the heating sector and in transport) and improving efficiency (e.g. cogeneration) need to be systematically harnessed to ensure that energy requirements do not further increase.

In parallel, fossil fuels and nuclear energy must be gradually replaced by a wide mix of renewable energies.

The main value of this type of scenario is that it demonstrates what is theoretically possible. But how realistic is this from today's perspective? Can renewable energies fulfil the role assigned to them in the IEA scenario and can they provide around 40% of the world's energy requirements by 2030? Currently, the figure is only 18%, and a not insignificant fraction of this is related to the non-sustainable use of firewood in developing countries. What are the key technologies, and what opportunities do they offer from Germany's perspective?

Development trend: Renewable energies

Practically all world energy scenarios assume that renewable power generation in particular needs to be expanded. After all, electricity con-

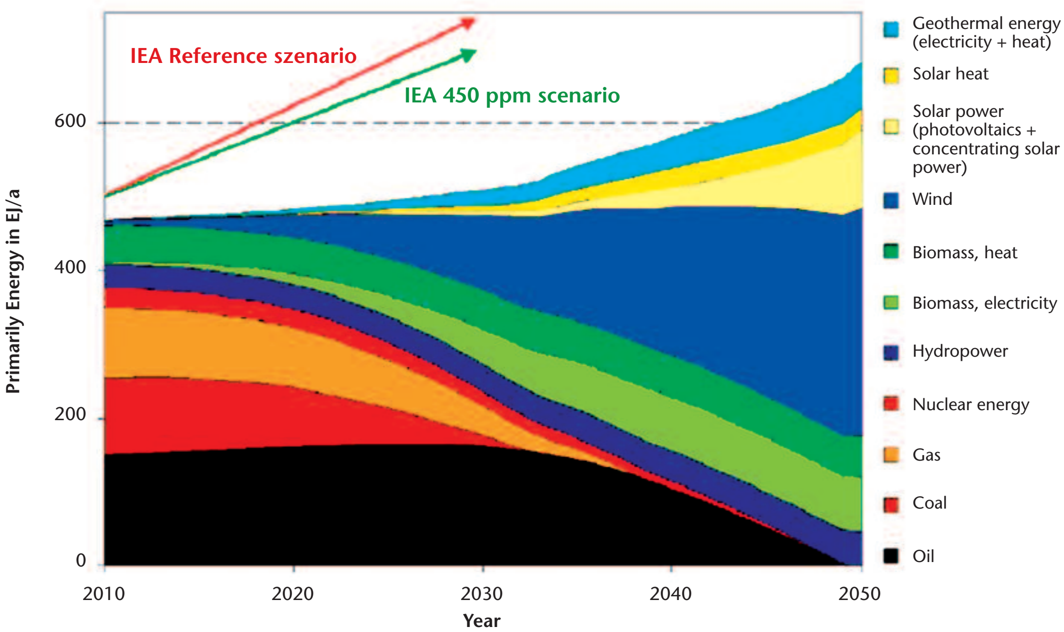

Figure 1
The Fraunhofer IWES's zero-emissions scenario by 2050 compared with the International Energy Agency's scenarios

sumption is rising in industry and in households, and new applications for electricity such as electromobility are also being added.

In addition, power supply is already responsible for over 40% of global CO_2 emissions today and is burdened with high specific CO_2 emission factors because of the fuels used (coal) and the poor efficiencies of power plants.

For this reason, the goal of the IEA's 450-ppm scenario is to more than halve specific CO_2 emissions from power generation from 603 gCO_2/kWh (2007) to 283 gCO_2/kWh by as early as 2030. In this scenario, nuclear energy and the introduction of CO_2 capture and storage (carbon capture and storage, CCS) technologies are to play a role. However, by far the greatest importance is attached to renewable energies, the capacity of which is to be significantly increased to almost 2,000 GW. In total, the share of renewables in power generation will increase from 18% to 37%, which will not only fully cover the increase in power consumption but will also contribute significantly to the replacement of conventional fuels before 2030.

The 10% criterion for key technologies

As the expansion of power generation from hydropower and conventional combustion of biomass is only possible to a limited extent, wind, photovoltaics, solar thermal power plants, geothermal energy, ocean energies and new biomass conversion processes will be the main pillars of this development. Thus the central question is whether these technologies are actually capable of this. The "10% criterion" theory can be forwarded as part of the empirical search for an answer to this question – in other words: a technology is capable of developing to become a key technology when a certain share of the market volume is exceeded.

The 10% criterion is already fulfilled by wind power at the moment, as around 10% of the growth in power requirements is being met by this technology worldwide. The wind market has been growing at an average of 30% per annum for ten years now, and is thus growing fifteen times faster than overall power consumption.

It is very likely that around three times as much capacity, i.e. around 340 GW of wind capacity, will be installed by 2013 as compared to 2008 [4], and around 10% of global power generation could be met by wind in 2020 if this trend continues.

This can also be expected to apply to photovoltaics with a certain time delay. However, photovoltaics currently have an installed capacity of 16 GW (2008, [5]) and are thus of the order of tenths of a percentage point worldwide. In addition, the amount of financial support necessary for grid-connected operation means that photovoltaics are only being used to a significant extent in certain countries such as Germany, Spain and Japan. In Germany, a 1% share of overall power generation is expected to be exceeded in 2009. The growth potential of photovoltaics has often been strongly underestimated up to now, as this supposedly expensive technology has seen cost reductions in recent years at a rate that nobody expected. Solar power can thus be generated for around 10 ct/kWh at locations with lots of sunshine, and this figure is falling all the time. This means that photovoltaics are at the threshold of major market penetration, and the sector has shown in the last ten years that it can deliver high growth rates.

For example, the European Photovoltaic Industry Association's scenarios assume that it will be possible to install photovoltaic capacity of more than one hundred gigawatts in Europe alone by as early as 2020 [6]. The IEA's expectations are admittedly significantly lower, with a worldwide installed capacity of around 130 GW [7], but it should be noted that this is based on very conservative development as regards power generation costs; these costs are an important factor in determining the rate of market penetration and, based on current trends, these assumptions can already be regarded as outdated. Nonetheless, the IEA scenario also implies that photovoltaics will be able to meet around 10% of the world increase in power consumption before 2030.

The development for the two technologies outlined here could also be repeated by other technologies – e.g.: solar thermal power, with numerous projects currently underway around the Mediterranean; the efficient conversion of biomass using innovative processes (e.g. thermo-chemical gasification of solid biomass); geothermal energy; ocean energies.

This applies analogously to numerous other application areas for renewable energies such as: solar building design; using solar energy to provide process heating and cooling; various energy storage technologies; renewable fuels; electromobility; fuel cells; renewable hydrogen. The achievement of CO_2-free energy supply is thus feasible both technically and economically from today's perspective.

Rate of growth of markets for renewable energies

Globalisation can already be clearly identified in various sectors. For example, *Figure 2* shows the development of markets for wind turbines based on the installed capacity for the years 1990, 1995, 2000 and 2008. The pace of development in Europe in the 1990s can clearly be seen, and major markets have also emerged in Asia and North America since 2000.

The second example indicates the production capacities for solar cells and modules, which have grown exceptionally quickly in a period of just three years in China and Taiwan above all (*Figure 3*).

Entirely new production and supplier structures have emerged as part of the globalisation of renewable energies. In the future, large multinational companies will also play a significant role in the sector; this is in contrast with the chronology of wind power in Europe, which began with regional and national markets and later led to exporting, and which often resulted in a great number of small companies. Multinational companies fulfil the financial and organisational prerequisites necessary to harness sophisticated technologies and implement increasingly larger projects. Examples of such projects include offshore wind farms, solar thermal power plants and the various production processes for renewable fuels. They can also benefit from numerous competitive advantages which result from these companies' comparatively high level of mobility and their international connections, for example.

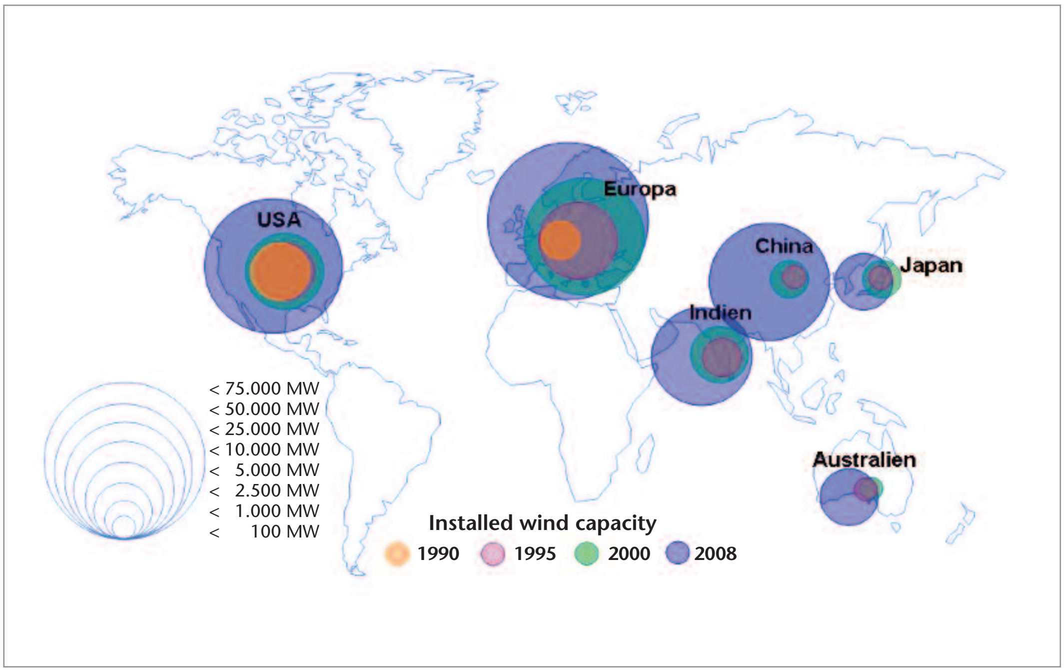

Figure 2
Development of installed wind capacity 1990-2008 [8], [9]

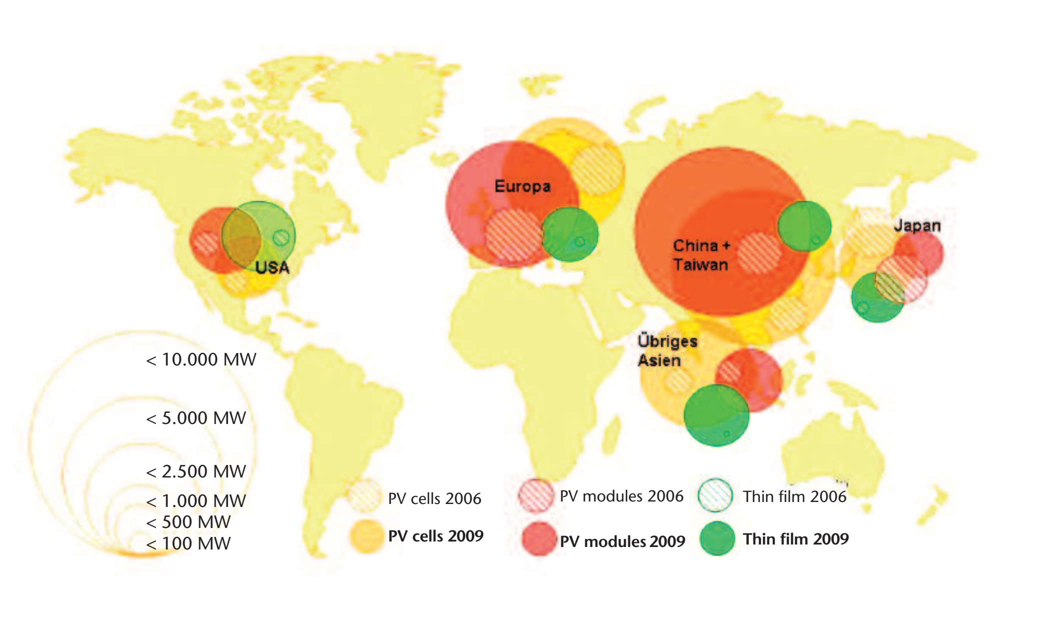

Figure 3
Production capacities for photovoltaic modules and cells as well as thin-film in 2006 and 2009 [10], [11]

Germany as a technological leader

What does this development mean for Germany as a business location? The broadly recognised leading role played by Germany in the growth of renewable energies and its leading technological position in many central areas is the result of very fruitful interplay between politics, science and business over the course of two decades at this stage.

The energy policy framework conditions in place established sufficient planning security and made it possible for industry to invest in the production and development of equipment in order to improve the performance and cost-effectiveness of this equipment. For example, the feed-in tariff (an indicator for power generation costs) for electricity from wind energy has fallen by over 60% since the German Electricity Feed Act came into force in 1991 [12]. A similar cost reduction has also taken place for solar power since the introduction of so-called cost-covering remuneration in the mid-1990s [13].

While science provided the impetus for the technological development in most cases, support instruments such as the so-called “100,000 Roof Programme” and the German Renewable Energy Sources Act helped to speed up innovation, as the existing markets meant that research results were quickly transferred from the laboratory to production.

As a result, a prospering renewable energy sector developed that is competitive internationally and currently employs around 300,000 people – around twice as many as in 2004. A good example here is the German wind industry, which had turnover of 8.5 billion euros in 2008 with exports representing 82% of this figure [14]. Worldwide, almost one in every three euros invested in renewable energies is spent on German-made wind power technology. This is of benefit not just to equipment manufacturers but also to suppliers from all sectors of the economy. This particularly applies to the mechanical engineering and machinery sectors, which are heavily involved in equipping photovoltaics factories worldwide.

In the future, the target countries for renewable energies will be establishing their own industries much more than has previously been the case. They will often be benefiting here from German expertise, which they can then build upon. However, there is also the risk that trade flows will be reversed; this can currently be observed in the case of Chinese photovoltaic modules, where the cost advantages are mainly due to major state subsidies for the construction of solar factories.

Even though this type of development cannot be ruled out in the future, no country will ultimately benefit from a "subsidy race". In the growing international competitive environment, it will be crucial for the industry in Germany that it establishes an advantage based on engineering performance in order to compensate for location-specific disadvantages such as the higher wage level. This is mainly the responsibility of the companies themselves, particularly in those areas of application where there is a sufficiently large market. However, this should not be misinterpreted as a generalisation for entire areas of technology, as engineering development is by no means already complete in wind power, photovoltaics, solar thermal energy, hydropower and the whole area of bioenergies.

Support for research and development of renewable energies

The state's task is to support not just fundamental research but also applied research so that new technologies, processes and strategies can be harnessed for energy supply in the future. The transition to industry-financed research is gradual, and should occur in the phase between demonstration and market introduction in the technology lifecycle.

State support for research should concentrate on areas of technology that will be relevant to the market in the medium term (in around 3 to 5 years) or long term (in over 10 years). The extent to which this should occur depends mainly on the amount of potential of the technologies as regards social and economic development. This is undoubtedly very much applicable to renewable energies, as the transformation of global energy supply is a central challenge for humankind in the 21st century. For this reason, international competition for the best technology will increase rapidly. This affects industry as well as research. In particular, multinational companies are in a position to procure research and development services from the "best in the world" at all times. This is the challenge that science and research policy in Germany have to face.

When German federal government expenditure for research is examined over a longer period, it can be seen that spending as a percentage of

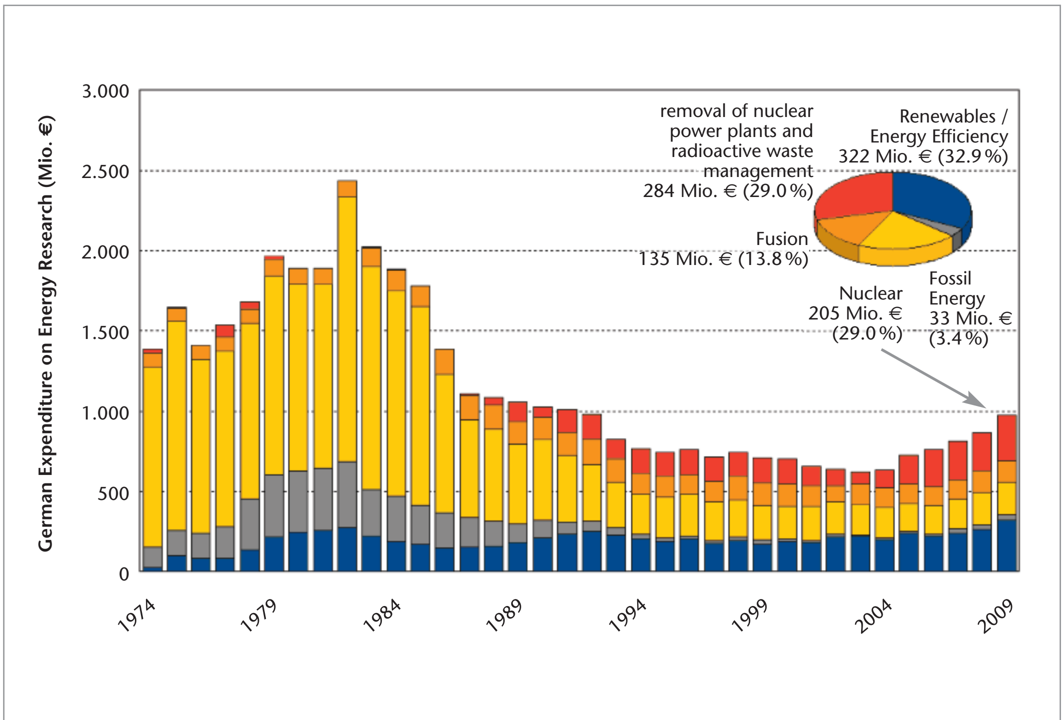

Figure 4
Amounts and structure of German federal government expenditure on energy research between 1974 and 2009 [16]

gross domestic product has always ranged between over 2% and just under 3% since the 1980s [15].

However, with a current figure of around 2.5%, Germany lies behind other industrial nations such as Japan (2005: 3.3%) or the USA (2005: 2.6%), although it should be noted for the USA in particular that its gross domestic product is almost four times greater.

Figure 4 shows that energy research spending in Germany in the mid-1980s was significantly above the current level [16]. Since then, the distribution of funding has shifted, but the fraction for renewable energies and energy efficiency is only around one-third in the targets for 2009 too. Germany must do much, much more in order to consolidate its position of technological leadership in this area in the light of the importance of renewable energies for global energy supply, the technological challenges and the growth that can be expected in research activities worldwide. The target markets must be kept in mind here, and technologies must be developed even if there is no or else very little potential for using them in Germany (e.g. high-temperature solar thermal energy, specialised processes for harnessing bioenergy, or the use of ocean energies). At the same time, we need more technology partnerships with industrialised countries outside of Europe and with emerging and developing countries.

It is indeed possible to identify positive trends, which are primarily associated with special programmes such as "Organic photovoltaics", "BioEnergy 2021" or "Lithium-ion battery LIB 2015" or with the National Electromobility Development Plan, the National Hydrogen and Fuel Cell Technology Innovation Plan (NIP) and the Leading Edge Cluster competition. The doubling of the research budget of the German Federal Ministry for the Environment for renewable energies since 2004 is also a contributing factor here.

However, this trend must be speeded up and must become permanent. The Renewable Energy Research Association recommends an annual increase in state research support in the area of renewable energies of 20 percent in order to double research expenditure to around 550 million euros by the end of the current legislative period [17].

Making Germany one of the world leaders in education, science and research, and making the transition to the era of regenerative energies – these two goals are highlighted in the foreword of the new German federal government's coalition agreement [18]. The government will have to be judged by how it meets these goals. The technological basis for achieving them is already in place. This is evidenced not least by the wide range of equipment and services represented at the Renewable Energy Research Association's 2009 annual conference on the topic of "Research for global markets for renewable energies".

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Significance of renewable energies and of energy efficiency in various global energy scenarios

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When one takes stock of the progress towards more sustainable development that the global energy supply has made in the last decade, the results are disappointing. Sustainability deficits in energy supply remain evident: the global warming that this energy supply causes; the very stark difference in energy consumption between industrialised and developing countries; the scarcity and higher prices of crude oil and natural gas that can be observed; the continuing risks of nuclear energy. These deficits have not become any smaller in the last ten years, as the demand for energy has grown rapidly due to the inadequacy of efforts to improve efficiency in "high-consumption countries" (industrialised countries) and the rapid growth in many emerging countries. Although renewable energies are expanding, they currently cannot (yet) keep up with this growth and thus cannot increase their respective shares of total energy supply.

On the other hand, a large number of energy scenarios that describe possible future developments in the global energy system clearly show that only significantly more efficient use of energy combined with a major expansion of renewable energies will be able to make a comprehensive contribution to solving the problems listed above. Numerous studies have concluded that this goal can be achieved technologically and that this approach is necessary from an economic viewpoint if economies wish to continue to enjoy a stable and affordable energy supply. On a global level, it is thus expected that renewable energies will be able to provide energy amounts of the order of the total current world energy consumption by 2050 (*Figure 1*).

Older scenarios (examples: Shell, WBGU, IEA 2003) generally assumed significantly increasing energy demand and thus expected significant contributions to come from renewable energies. The contributions of fossil and nuclear energies were also expected to rise strongly. However, the growing urgency of drastically reducing greenhouse gases combined with the increasing scarcity of fossil fuels has made it necessary to examine global efficiency potential more systematically in recent years.

For this reason, current scenarios assume lower consumption growths (examples: IEA 2008, WETO 2006), even in their reference or baseline cases. The predicted increase in global energy consumption by 2050 will then be only 700-900 EJ/a. A particularly systematic determination of efficiency potentials was carried out in the "Energy-(R)evolution" scenario. If these potentials can be tapped at an early enough stage, the global primary energy consumption could be returned to its current level of around 500 EJ/a after passing through a maximum of almost 550 EJ/a around 2020. With the simultaneous expansion of renewable energies to around 270 EJ/a (their contribution in 2007 was 64 EJ/a), it will be possible to reduce CO_2 emissions to 10 Gt CO_2/a by 2050, meaning that the maximum CO_2 concentration could be stabilised at 450 ppm ("2 °C target").

If potential efficiency increases are not realised to this extent, higher demand will also have to be met. The example of the BLUE-MAP scenario from the IEA quotes the following figures:

- Contribution of renewable energies 230 EJ/a
- Nuclear energy 90 EJ/a (currently 30 EJ/a)
- Fossil fuels 350 EJ/a (currently 412 EJ/a)

In order to achieve the climate protection target of 450 ppm, it is assumed that a considerable amount of CO_2 will be captured and stored underground. Assuming that efficiency improvements are very inadequate, the target of

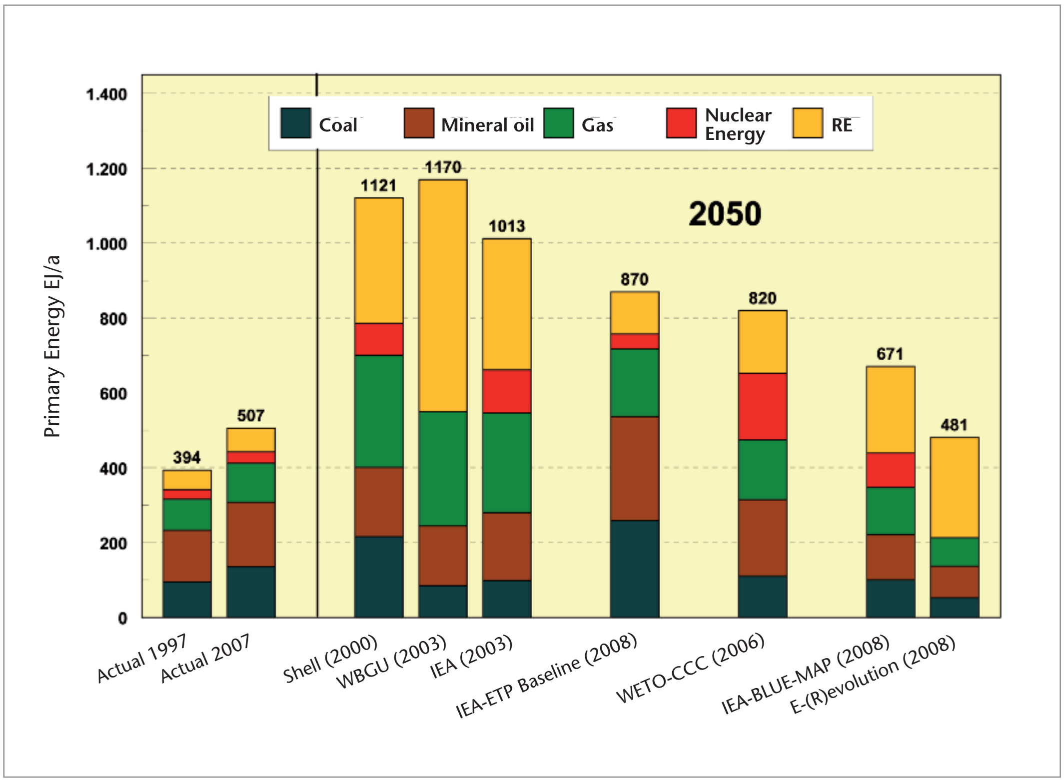


Figure 1

Selected scenarios for global energy supply in 2050

450 ppm will not be met even if the contributions of nuclear and fossil fuels are increased considerably. For example, the WETO-CCC scenario only achieves a stabilisation of the CO_2 concentration at 550 ppm. A very significant improvement in the efficiency of the conversion and use of energy in all regions worldwide is thus essential if climate change is to be kept to a manageable level. Secondary importance with regard to the potential for minimising greenhouse gases by 2050 is attached to renewable energies and to scenarios that also depend on nuclear energy and CCS technology.

The potential of the "solar technologies" already available today is large enough to be able to meet demand such as that in the "Energy (R)evolution" scenario, which provides for an increase of a factor of 4.2 relative to the current contribution. After around 30 years of systematic research, development and market introduction, a wide variety of high-quality technologies are now available.

The current state of research progress and the market launches also makes it possible to state that further significant technological improvements can be expected in the future. This and the ongoing rapid development of the market mean that costs will continue to fall significantly, accompanied by engineering improvements to equipment. Dynamic model calculations that take these factors into account show that useful energy from renewable energies will be less costly than energy from primary sources after 2020 at the latest.

The electricity sector is of particular interest because of its highly dynamic growth and its major economic importance (*Figure 2*). The contribution of renewable energies is currently 18% worldwide, with the dominant share from hydropower. However, because of the dramatic growth in demand for electricity in the last ten years, the share of renewables has fallen by one percent. In the IEA's "baseline" development, electricity demand will increase by a factor of 2.5 by 2050 relative to the 2007 level. Even in the case of significant improvements in efficiency of between 7,000 and 12,000 TWh/a of reduced electricity demand compared to the "baseline" development, electricity demand should still be between 1.8 and 2 times the current level, as shown in the two 450-ppm scenarios (*Figure 2*).

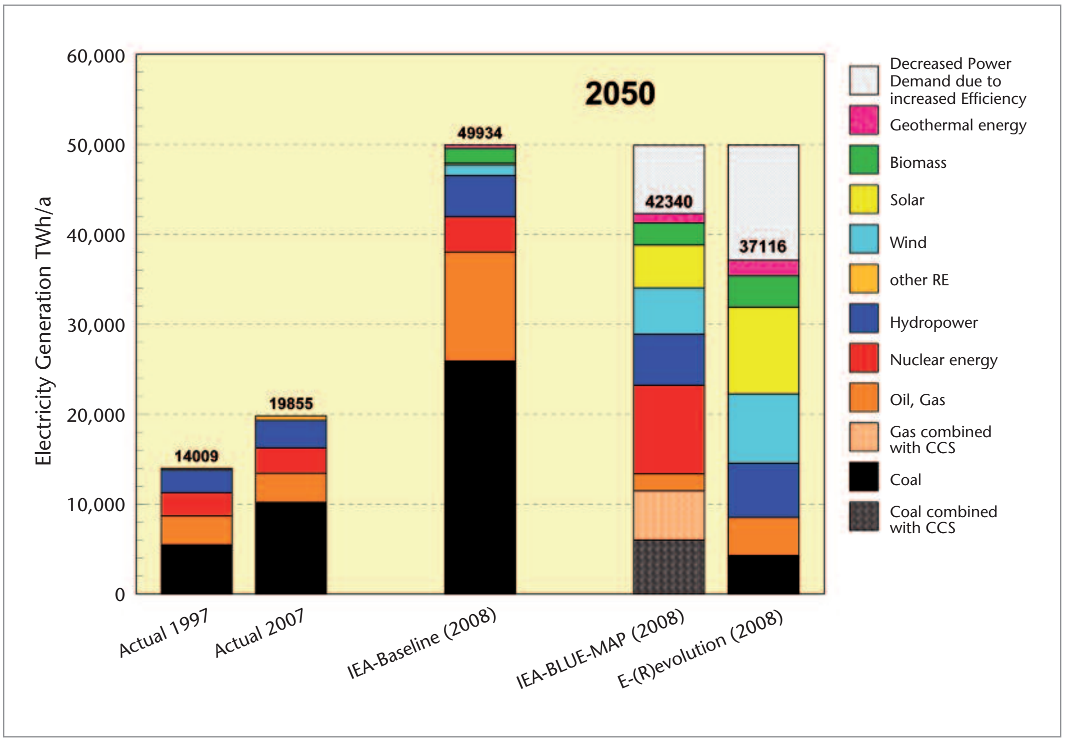


Figure 2
Structure of electricity supply in 2050 in two 450-ppm scenarios

This growth will demand that considerable efforts be made to promote power generation from renewable energies. In the "Energy-(R)evolution" scenario, their contribution increases from 3,600 TWh/a currently to around 29,000 TWh/a by 2050, which would then correspond to a share of 77%. In the BLUE-MAP scenario, it would increase to around 19,000 TWh/a (45%). As the additional contribution from hydropower – and also from biomass – is limited, this growth will mainly be provided by wind and solar energy. Lower rates of growth for these technologies in the BLUE-MAP scenario make a major expansion of nuclear power to almost 10,000 TWh/a necessary (currently 2,800 TWh/a). In this scenario, fossil fuels will even be used at around the same levels as today. The BLUE-MAP scenario assumes that CCS power plants are used for almost 85% of this amount of energy, corresponding to a total of 11,500 TWh/a of power.

Wind power currently has a capacity of 121 GW worldwide. The "Energy-(R)evolution" scenario assumes an increase to 2,700 GW by 2050, meaning that the annual market volume, currently at 27 GW/a, would "only" have to increase by a factor of five.

At the same time, the average electricity costs will sink by another 40%. In comparison, growth by a factor of 180 in photovoltaic capacity is necessary (currently 16 GW), and the annual market volume would have to increase by a factor of 35 to around 170 GW/a. In parallel, electricity costs would fall to around a quarter of today's levels on average. The market expansion of solar thermal power plants is only beginning. Their power share would be around 800 GW in 2050 according to the "Energy-(R)evolution" scenario, which corresponds to a market volume of approximately 40 GW/a. The generation costs should fall by around 60% compared to current power plants.

The market development proposed in the "Energy-(R)evolution" scenario shows that renewable energies will almost completely replace fossil fuel power plants in the marketplace over the next 40 years (*Figure 3*). At the moment, around 220 GW/a of new power plant capacity is being installed per annum, with over 65 GW/a of this coming from renewable energies (including 28 GW/a of hydropower and 27 GW/a of wind power). These technologies – supplemented by biomass, geothermal energy and, in the long term, wave energy and other sources –

will lead to a continuous growth in the market volume to around 260 GW/a in 2030 and 430 GW/a in 2050.

In total, the capacity to be installed annually will thus approximately double – due to the increasing demand for electricity and to the significantly lower numbers of full-load hours that apply to renewable energies.

Similar growth trends, which cannot be described in detail here, will also have to take place in the heating sector, with strong growth required in the solar collector market in particular.

By combining the resultant market volumes with the assumed cost trend for the individual technologies, the expected investment volumes for a growing global renewable energies market can then be derived (*Figure 4*). Around €170 billion per annum is already being invested in renewable energy technologies currently. However, (large-scale) hydropower is responsible for €65 billion per annum of this amount, with the wind industry accounting for a further €30 billion per annum. In the "Energy-(R)evolution" scenario, the annual investment volume will rise to almost €600 billion per annum by 2030 and almost €900 billion by 2050, with investments in hydropower remaining approximately constant.

Solar technologies will be responsible for a significant fraction of this with 55%, followed in turn by wind power. The considerable growth by a factor of almost five in the investment volume for renewable energies is a sign of the shift away from today's fuel-dependent energy supply with its totally uncertain price trends.

This shift is already well underway in the case of wind power, photovoltaics and the harnessing of biomass. Solar thermal power plants are currently undergoing something of a rebirth in southern Europe, northern Africa and the USA. Further technologies such as power generation from deep geothermal energy and wave energy are "in the starting blocks".

In the case of heat provision technologies, the existing market trends for the technologies already available need to be strengthened by

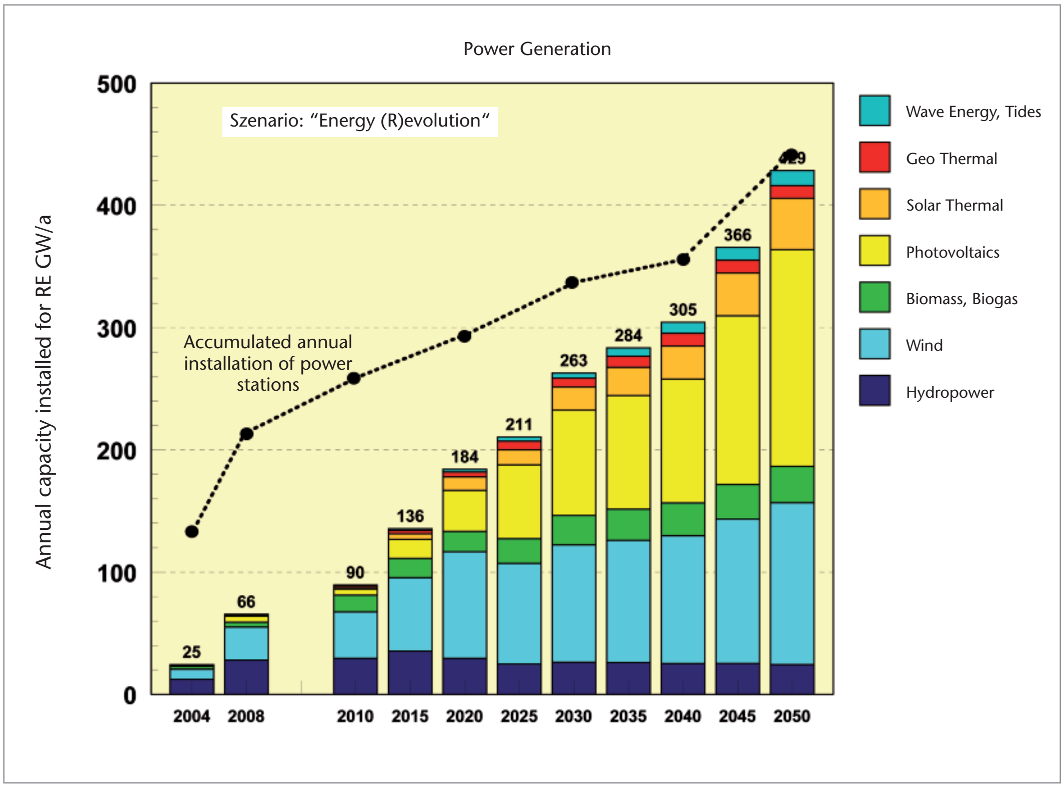
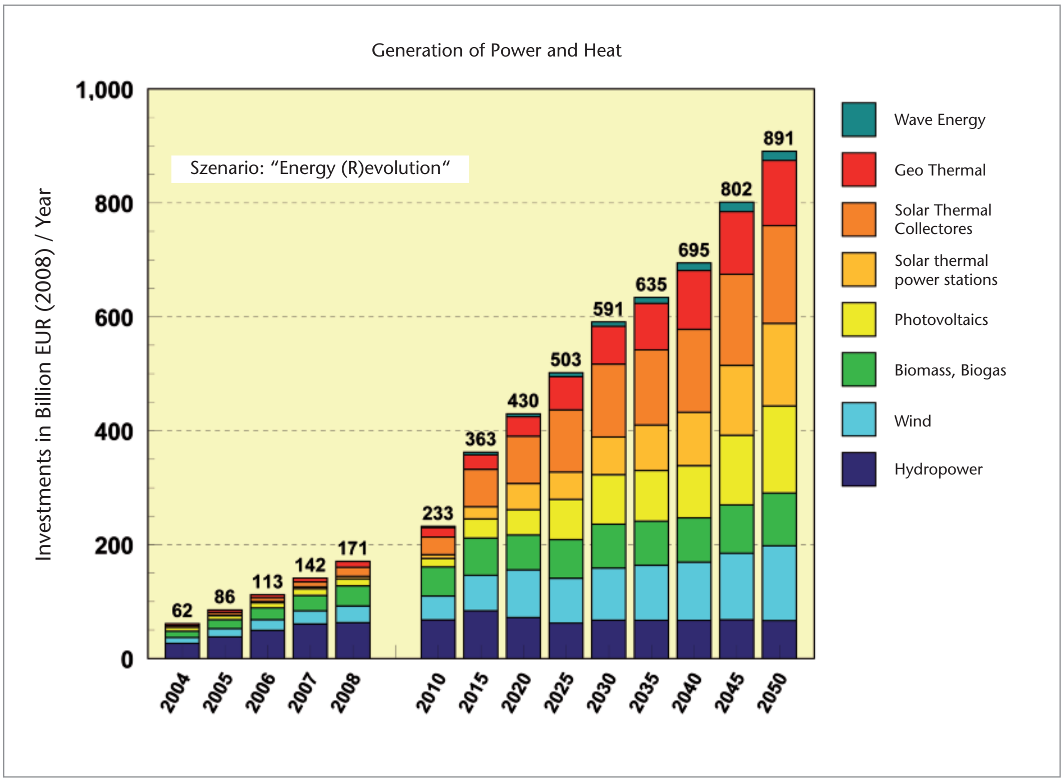


Figure 3
Annual capacity installed for renewable energies in the electricity sector

Figure 4
Global investments in renewable energies for electricity and heat by energy type



means of suitable support instruments. The variety of energy sources to be harnessed, the demanding technical standards with regard to efficient and cost-effective systems and the generally decentralised nature of renewable energy technologies result in a wide variety in terms of sectors and companies – ranging from large-scale series production with a global dimension through to regional and craft-industry structures.

These characteristics combined with the high level of public acceptance make it easier to raise capital and have also led to the involvement of a wide range of players.

In addition, the use of domestic renewable energy sources coupled with more efficient use of energy will make many countries less dependent on energy imports. Thanks to this combination of climate-related and economic advantages, stronger expansion of renewable energies (combined with improved efficiency of use) has all of the typical characteristics of a "win-win" strategy. All of these factors, when considered together, should be sufficient to ensure stable support from energy policy and to give rise to long-term growth.

Germany is at the forefront among industrialised nations in terms of the development, market growth and energy policy support for renewable energies. Investments of around €12 billion per annum are currently being made in the German domestic market (2008).

Based on the favourable initial conditions for German companies (current foreign turnover is around €8 billion per annum, which accounts for around 20% of the world market volume), foreign markets with a size of around €60-80 billion per annum should be created by 2030. According to the "Energy-(R)evolution" scenario, turnover of between €80 billion and €100 billion per annum is possible for the German renewable energy sector by 2050, which would correspond to an average share of between 12% and 15% of the world market.

Major stimuli for new sectors of the economy and for jobs will result from the widespread application of a large number of new energy technologies. By 2030, the gross number of jobs in the renewable energy sector could thus rise to between 500,000 and 600,000. A figure of the same order of magnitude can be expected for the increased use of technologies to improve energy efficiency.

However, to achieve these goals, ongoing and increasingly intensive efforts to maintain and consolidate the current favourable initial position on the world renewable energy market are necessary by the German renewable energy industry and also from the accompanying energy policy.

With a more pessimistic scenario that assumes that these efforts are not maintained, the turnover to be expected for the German renewable energy sector will not exceed €40 billion per annum, even with significant growth in the world markets.

Increased international cooperation will be necessary to provide the foundation for effective climate protection combined with global energy supply that is largely based on renewable energy sources. This trend is very much compatible with the liberalisation and globalisation of the energy markets, and it offers many opportunities for constructive political cooperation. The world's very great potential for renewable energies can only by harnessed to the extent necessary to meet the global demand for sustainable energy if joint international projects are implemented. This type of international "solar energy partnership" offers important geopolitical advantages. They are an ideal opportunity to reduce economic inequality between north and south and to create global markets for future-oriented energy technologies without the risk of conflicts for scarce resources. For example, the significance for global energy policy of the harnessing of the major potential of solar and wind power around the Mediterranean should not be underestimated in the context of the economic development and political stabilisation of this region and of its relationship with Europe.

There is no lack of solution approaches for the pressing problems of energy supply and climate protection. However, it is necessary that the efforts which have been successful up to now be expanded quickly and comprehensively and that the approach taken by just a few countries so far be expanded and implemented even more intensively. National egos should take a back seat here. The European Union, which rightly sees itself as having a leading role in the advancement of climate protection, can act to set an example here and would be economically and politically successful in doing so.

International energy policy

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Ladies and Gentlemen,

I would like to start by thanking the Renewable Energy Research Association for inviting me to this annual conference.

I am sure that most of you will be familiar from your day-to-day work with the German Federal Ministry of Economics, the Federal Ministry for the Environment and the Federal Ministry of Transport, Building and Urban Development as the main bodies that implement the federal government's energy policy. However, one thing is clear: Energy policy is no longer a national affair. It is very much a current issue that is debated very intensively both bilaterally between states and also in multilateral forums. The international political arena is increasingly getting involved; after all, the economic prosperity of humankind is dependent on this issue. In addition, this is an area of politics where individual states acting alone can achieve little. Only coordinated international efforts will lead to success. For this reason, German Federal Foreign Office provides intensive support for international debate on energy policy in close cooperation with other organs of the federal government.

After all, one thing is certain: Our national strategy for secure and climate-friendly energy supply can only be successful if we coordinate it with our international partners. In the areas of energy and climate protection, we cannot act alone. CO_2 emissions change the climate worldwide regardless of whether they come from a car in Germany or from a coal-fired power plant in China. German oil consumption influences the world market price via the oil markets and thus also affects consumption in other regions of the world. German investments in renewable energies and progress in research can reduce the prices for equipment – as can be currently observed in the case of photovoltaics – and thus stimulate further investment in sustainable energies worldwide. Successes and failures in energy research today will decisively shape the global energy system of tomorrow.

We have to think and act in an increasingly global manner as regards energy policy. Of course, we must also not lose sight of the development issues that are closely associated with the energy issue. There are still 1.6 billion people worldwide who have no electricity. They are waiting for energy supply methods that are decentralised and affordable. In order to create fair opportunities for development, we must structure access to energy reserves in a transparent manner and take new approaches to energy supply that do not threaten the common foundations for human life. The main issue here is to significantly reduce dependence on fossil fuels and, in turn, the emissions of greenhouse gases.

We are faced with a three-pronged challenge both nationally and internationally. We have to:

1. Prevent a climate catastrophe
2. Achieve a secure energy supply
3. Keep development opportunities open

If we fail to meet this triple challenge, the consequences for the international community and for German foreign-policy interests will be disastrous. On the other hand, if we succeed in finding the correct responses to these three challenges, this will contribute positively to our foreign-policy goal of achieving a stable and peaceful world order. This is why the success of renewable energies worldwide is so important for our foreign policy. Renewable energies are the only answer to all three of these questions at the same time. There are certain energy technologies that represent a partial response to one or two of these three challenges. The attraction of renewable energy sources is that a breakthrough for renewables will simultaneously prevent a climate catastrophe, create a long-term, secure energy supply and open up opportunities for development to all.

Based on this consideration, it is self-evident that responsible foreign policy must support and promote the breakthrough for these technologies in every way it can.

Coal and oil fuelled the first and second industrial revolutions, and the breakthrough for renewable energies will now spark off a veritable third industrial revolution. Germany has already undertaken major steps in starting off this revolution. We must now ensure that other states follow our lead. After all, Germany will not be able to achieve this energy revolution alone. I regard this as a central task for our foreign policy. We must explain the advantages of a switchover to renewable energy sources to our partners worldwide, and we have to show them the approaches necessary to implement this switchover. We also have to give them a helping hand so that we can all travel this path together.

We Germans are particularly credible partners for many states around the world because of the success of our policy up to now and because of our leading position in research.

Just how successful our support mechanisms in Germany have been is shown by a study by the International Energy Agency (IEA). It confirms that Germany and other states, including Denmark, Spain and Portugal, provide the most effective support for renewable energies. The IEA also notes that the certainty with regard to framework conditions provided by feed-in systems with fixed remuneration creates a stronger investment incentive than the amount of the tariffs alone.

The positive experience we have had with the German Renewable Energy Sources Act is one of our most convincing arguments. So far, over 40 states worldwide have passed similar acts or been guided by the German act in their promotion of renewable energies. Countless other states are interested in applying the act too. The Renewable Energy Sources Act is a German-made success story, and is also a stroke of luck for our foreign policy. In this way, we can actively offer our experience to other states. Flagship projects in Germany – I am thinking here of the second-biggest solar farm in the world in Lieberose and of the solar tower power plant in Jülich, which were both opened recently – also ensure that we continue to be prominent pioneers for renewable energies.

Our leading role in the area of renewables represents both an opportunity and a responsibility at the same time. It is a major opportunity for the German economy and for renewable energy technologies with the "Made in Germany" brand. However, it also leads to certain obligations: If we don't drum up enthusiasm for renewable energies on the international stage, who else will do so? For this reason, we are using our good reputation to promote renewable energies worldwide.

IRENA, Mediterranean Solar Plan and Desertec

Probably the greatest success of this policy so far has been the founding of IRENA, the new international organisation for renewable energies, in Bonn on 26 January 2009. The idea for IRENA originated in Germany, and Germany was also the driving force behind the process of setting up IRENA. IRENA will give renewable energies a voice worldwide and will advise governments how they can switch their national energy supply over to renewable energy sources as quickly as possible. IRENA, which probably would not exist without Germany's involvement, already has over 130 member states today and will help to pave the way for renewable energies in its role as one of many global institutions. Germany will continue to retain an important role in IRENA: The IRENA Innovation Centre in Bonn is to be the source of important stimuli for the ongoing development of renewable energies.

IRENA will contribute to the progress of the expansion of renewable energies worldwide. As Europeans, we have a particular interest in the progress of renewables in our own region and in our vicinity in particular. For example, there are major opportunities in the Mediterranean region for the harnessing of energy from renewable sources. Within the context of the Union for the Mediterranean, we are working together with our partners on the "Solar Plan", a solar energy programme for the Mediterranean region. Our main aim here is that the potential of renewable energies around the Mediterranean be harnessed.

We are also providing extensive accompanying support to the new “Desertec Industrial Initiative” consortium.

This consortium could provide new expertise and implementation opportunities for our solar energy programme. Within the context of German foreign policy, we wish to help in the creation of instruments and a framework that will allow this consortium to be successful.

One example here is that the German Federal Foreign Office is currently helping to pave the way for renewable energies in North Africa by financing the “UniSolar” programme being implemented by the DLR, which will support the expansion of solar power in North Africa.

What we need for the next step with the “Mediterranean Solar Plan” and – depending on the feasibility study yet to be completed – also for Desertec are equipment and grids. I do not regard direct investment as the task of the state. Our job is to create the political framework so that the existing potential for economic cooperation can be harnessed in a systematic manner. We are working to provide security for the necessary investments and to put in place sensible rules so that these investments can provide the best results for all participants.

Strategic energy partnerships

In addition to these specific initiatives, the Federal Foreign Office is also working on the integration of climate protection and energy policy issues into all areas of foreign policy, security policy, foreign trade policy and development policy. Nowadays, diplomacy also includes energy and climate diplomacy.

On the one hand, we will have to deal with governance issues in the future to a greater extent. We aim to create an international framework for energy relations that will provide dependability and thus greater security. Financing, production, trading and the respective shares of gas, oil and renewable energies in overall energy consumption are largely determined by a system of institutions and rules.

On the other hand, we will be building on strategic partnerships with individual countries. Here too, politics can open doors for business and vice versa.

We take advantage here of the opportunities offered by bilateral dialogue in all issues relating to energy relations, such as joint research or the exchanging of best practices. Dialogue on the matter of renewable energies also plays an important role in our strategic partnerships.

We have already set up a forum for dialogue on energy and climate matters with the USA in the form of the “Transatlantic Climate Bridge”. We aim to further intensify this dialogue in the coming months, particularly in the area of energy research. We have established energy partnerships not only with the west, but also with the north and south: I would like to highlight here our energy partnerships with Norway and Nigeria, and an energy partnership with Angola is currently being planned.

We are also working to increase the importance of energy issues in our foreign relations in a European context too. Russia will remain an important strategic partner in our external energy relations. I am convinced that we can integrate Russia even more strongly into European economic structures with a wide-based modernisation partnership. By doing so, we would also be improving European energy security significantly.

The role of energy research

What role does energy research play in these efforts by the Federal Foreign Office? One can do so much promotional work for a given product, but the product will only be successful if the quality is right. Germany enjoys a lot of credibility based on its successes with renewable energies up to now in terms of research, energy management and policy. However, we cannot allow ourselves to rest on our laurels in this regard. We must consolidate our credibility anew every day by continuing to push forward. We want to continue to increase renewable energies' share in the energy supply. We want to expand electricity grids in order to ensure supply security in the context of increased input from renewable energy sources and decentralised power plant structures. We want to increase our energy efficiency.

We want to find and implement better solutions for energy storage in order to be able to better integrate renewable energies into the grid. We need fossil-fuelled power plants that can be controlled more flexibly, along with energy storage systems and better load management.

Energy research plays a crucial role in all these challenges. After all, it determines the feasibility, security and costs of these measures and thus the degree to which they can be implemented politically, both nationally and worldwide. We must retain our position of world leadership in energy research and renewable energy technologies in order to remain credible as a promoter of renewable energies.

Partners that have followed our example also expect support from Germany in pressing matters such as the grid integration of renewable energies. The more German research makes us able to provide this support, the more credible our efforts will become.

German energy research and German foreign energy policy thus form a symbiotic relationship with one another. Each can benefit from the other. Excellent achievements in national energy research, productive international research cooperations and tangible results in renewable energy research are extremely strong arguments in the context of political dialogue with our partners. The growing political interest in issues relating to energy supply and renewable energies can and will in turn open up better framework conditions and new opportunities for research cooperation.

International research cooperation is also an area which is becoming more and more important in foreign policy. On the one hand, this is because a large fraction of global knowledge is of course not generated in Germany. Networking with science locations worldwide is in our interest so that we can benefit from this knowledge too. On the other hand, the major challenges facing the world can only be solved by acting together.

For this reason, the Federal Foreign Office strongly supports international research cooperation. I would like to mention just two examples here.

Around 20 German diplomatic missions abroad in locations with high potential for innovation have scientific officers. These include Moscow and Washington, along with Beijing, Tokyo and Brasilia. They maintain contact with the research ministries and institutions of their host countries, keep themselves informed of the latest developments in these countries and report on these. They also support politicians in the area of science, companies active in research, and scientists and researchers from Germany in their work abroad. The Federal Foreign Office intends to further expand this network of science officers next year.

Secondly, the Federal Foreign Office provided the impetus this year for the creation of "German Houses of Science and Innovation". A whole range of German research and science organisations are active abroad. They have excellent projects, offer very good stipends and contribute to Germany's good reputation. However, their contribution to our good reputation could be even stronger if they presented themselves in a joint, coordinated manner. For this reason, we have begun to establish "houses of science and innovation" in five pilot locations – São Paulo, Moscow, Tokyo, New Delhi and New York. The organisations will now present themselves under this single umbrella and provide their services in a coordinated manner. We intend to include further important locations after the pilot phase that will last around another two years. We would be delighted if the Renewable Energy Research Association were to show interest and participate in the "German Houses of Science and Innovation" initiative.

As you can see, diplomats and energy researchers can do a lot to help either in their work. With this in mind, I hope that this event will help to strengthen dialogue between the fields of diplomacy and energy research and that it will open up further opportunities for cooperation.