Franz-Josef Brüggemeier

Sun, Water, Wind: Development of the Energy Transition in Germany

good society – social democracy
2017 plus

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social democracy
#2017 plus

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2015 AND 2017

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– Democracy and democratic participation;
– New growth and a proactive economic and financial policy;
– Decent work and social progress.

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FOREWORD

On 11 May 2014, renewable energies briefly managed to meet 80 per cent of the demand for power – a record to date. Overall, 2014 was a record year for renewables. For the first time, more than 27 per cent of the demand for electricity was met by sun, wind, water, and biomass. Thus within 25 years the share of renewables in power generation grew from 3 per cent to more than a quarter. Furthermore, more than 370,000 people in Germany work in the renewable energy sector. The ambitious aim of the energy transition ("Energiewende") to phase out fossil fuels and energy production damaging to the climate thus appears to be in sight, at least as far as electricity generation is concerned. Moreover, there is continuous international interest in Germany's energy transition. The backbone of this project, the Renewable Energy Act, which regulates the development of renewable energy sources, has already been emulated in 65 countries.

Despite these achievements, the energy transition has not been a smooth process. It involves nothing less than converting the energy system of an industrial society. But a comprehensive explanation of the energy transition that goes beyond mere statistics and technology requires the consideration of the economic, societal, and political context in which the relevant decisions are made. How has the energy transition actually proceeded? What milestones have been reached? Who and what has driven the process? What interests have been pursued and how have they changed? Are there historical precedents?

These are the questions addressed by the author of the study, Franz-Josef Brüggemeier of the Albert Ludwig University, Freiburg. He explains that the energy transition not only has to reconcile the three key aspects of energy policy, namely supply security, cost-effectiveness, and environmental com-pa-tibility, but also to take into account a whole range of political, economic, and technological challenges, solutions, and interests. In his historical analysis, Brüggemeier shows that the implementation of the energy transition has always required a complex compromise that balances various interests.

He points to the leading role of social democracy as a social and political movement in shaping the energy transition. Unlike other political movements, it has not only been traditionally close to the energy sector, industry, and the workforce, but has also produced important visionaries and pioneers of the energy transition. In pursuing the complicated balance between the interests of winners and losers, a frustrating process for many of those involved, social democracy has given impetus to the energy transition as a process of social and economic modernization. In the future, this balance will be a crucial element in the development of the energy transition, and its achievement a key task for social democracy.

In the context of the Friedrich Ebert Stiftung's project "good society social democracy #2017plus," the 2017plus project team will be following developments in energy and climate politics and analysing their significance for social democracy.

I wish you an enjoyable read.

DR. PHILIPP FINK
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INTRODUCTION

There has been a worldwide discussion on an energy transition to reduce the emission of greenhouse gases and halt the feared rises in temperature. It involves replacing fossil fuels (coal, gas, lignite, oil) by renewable energies from wind, sun, water, and biomass. Efforts in this direction have been made in many countries. Progress has been particularly marked in Germany, which has shown that success can be achieved but also what problems have to be overcome. The German energy transition aims not only to reduce the use of fossil fuels but also to phase out nuclear energy with its risks and radioactive waste. These goals are ambitious, so that the German project has attracted a great deal of attention around the world.

The vital role played by civic action groups and environmental organizations in the energy transition has been stressed. Although such groups can lend impetus to the cause and exert pressure off their own bat, they cannot make the necessary decisions, let alone laws. They need the support of big political movements. In Germany, social democracy has assumed this role. It is particularly suitable, since traditionally it has had close links with the established industry and the workforce, and has repeatedly triggered modernization.

The Social Democratic Party of Germany has perforce not taken uniform action in tackling the energy transition; it has not only supported the project but has also subjected it to sceptical scrutiny. This is not surprising; for modern industrial societies the provision and use of energy is of such elemental importance that any effort to change things has far-reaching effects and produces many a contradiction. Even though environmental groups repeatedly lament these contradictions, there is no avoiding them. They must therefore be faced up to and politically acceptable solutions must be found. The SPD has made a greater contribution than other parties, not least because it can draw on its experience with earlier energy transitions. Past transitions pursued other goals, but they demonstrate how important it is when addressing this issue to continuously re-examine one's own ideas and if need be correct them. A good example is the transition to nuclear energy that raised such great hopes in the 1950s. It promised to overcome the age of dirty coal and provide almost unlimited, cheap, and clean energy – until in about 1980 it was realized that nuclear energy involved enormous risks. Renewable energies were already under discussion as an alternative, but they were not well developed at that time and were generally considered to offer at best a long-term perspective. It seemed more realistic to turn to coal, which experienced a comeback. As a consequence, many new coal-fired plants were built with a lifespan of several decades, which are hence still in operation and pose a major challenge for the present energy transition.

Looking back on earlier energy transitions and the problems involved is not to divert attention from the present situation. We need to understand our energy system and to be in a position to assess its adaptive capacity. Energy systems are like vast tankers that can change course only with difficulty. Decisions once made have a lasting impact, as building new coal-fired power stations has shown. Moreover, changes in course are made more difficult by the circumstance that our energy system is a tanker with not one but many captains, each responsible for a different field of energy supply and who differ on the course to be set: the operators of power stations, power grids, refineries, and lignite mines; suppliers of oil, coal, and gas; manufacturers of solar systems and wind turbines; and, not least, the people working in these sectors. Then there are politicians and parties who are also concerned about the energy supply and pursue specific goals such as protecting jobs.

Those hoping for a fast energy transition are often disappointed that so many groups and interests have a say in the issue and often even impede progress. Hence, there is good reason to lose patience. But the energy transition is not a purely technical project, where it is easy to decide what measures have to be taken. All three goals of energy policy have to be kept in mind: to supply energy reliably, with ecological sustainability, and at an affordable price. The attempt to achieve a turnabout is therefore a thoroughly political issue, which raises innumerable questions and necessarily requires reconciling a whole range of interests. This makes parties like the SPD all the more important in achieving the necessary consensus in society and taking both winners and losers into account.

If we are to understand the challenges facing the project, we need a precise picture of the many aspects and arguments involved. But this is not an easy task, since the debate has been heated and many participants unduly trenchant in their argumentation. Proponents of the energy transition have frequently been depicted as romantic "crackpots" who jeopardize the economic future and take all too optimistic a view of the potential offered by renewable energies. As a result, a multiplicity of comments, accounts, and expert opinions present widely differing and often contradictory conclusions, making it difficult to form a personal opinion.

The following offers orientation and discusses the various positions, problems, and possibilities associated with the energy transition. To understand it better we must pass earlier energy transitions in review; a particularly important one took place some two centuries ago. This might seem to be going too far back in time. However it is well worthwhile taking a look at this historical event. It took place in a society that was based almost entirely on the renewable energies that are so important today.

2

ENERGY TRANSITIONS IN HISTORY

2.1 COAL AND THE TRANSITION TO THE FOSSIL AGE

When some 200 years ago industrialization got under way, the economy and society relied almost entirely on renewable energies. Coal had long been used, but only in small quantities, whereas oil and gas played no role. For that period it is difficult to speak of energy in general terms. The main requirements were to produce heat (especially by burning wood) and to harness the motive power of wind, water, animals, and humans. There was no energy in a general sense, for example the conversion of heat into movement. This first came with the steam engine, which led to industrialization and to our notions about energy and dealing with it.

Wood, a renewable resource, offered by far the most important possibility for producing heat. Wind and water were also available to drive mills for grinding and hammering and to propel ships. Just as important was the physical strength of human beings and animals for transporting loads, operating tools, or doing other work. But of these sources of energy, only wood, water, and wind were sustainable. And it happened again and again that more wood and other resources were used up than were renewed. Long-term use therefore meant avoiding excesses to ensure a sustainable supply. Humans and animals, by contrast, did not provide their labour and thus energy in a sustainable fashion. They depended on food supplied by agriculture (Brüggemeier 2014: chaps.2, 3).

Generally speaking, agriculture and the produce of the soil were of decisive importance. They supplied not only food but also all the other raw materials that crafts, commerce, and the first factories depended on: hemp, flax, straw, and wood – taken directly from the soil – as well as wool, leather, candles, and other products of livestock farming and various forms of processing. Particularly important was wood, which has rightly been described as the key raw material of this period. It provided not only heat but also building material for houses, ships, wagons and other vehicles; and most objects in everyday use (tableware, tables, chairs, beds) and many sorts of tool were made of it, even the famous spinning jenny, long a symbol of industrialization.

Wood and the other raw materials depended fundamentally on the sun. Only the daily sun provided the energy to make these raw materials grow to meet the needs of human beings. Their use had to be sustainable. Year after year only so much of such raw materials could be used as was replaced by new growth. When harvests were poor, greater quantities were consumed and stocks depleted. But such overuse could not be kept up for long. If too much wood was consumed or too many animals slaughtered, if stocks ran out, this endangered people's subsistence. In handling raw materials, such societies were therefore necessarily sustainable and accordingly lived in considerable uncertainty, since harvests differed strongly from year to year.

This uncertainty was also nurtured by the difficulty of storing foodstuffs over a longer period and by the limits to storing the energy provided by sun, wind, and water and to transporting it over greater distances. It was stored in biomass, above all in wood, which, due to its great weight and low energy density, was very expensive and difficult to transport. Enterprises that used a great deal of energy were therefore located where wood or water power was available. Production was thus decentralized and had to cope with the natural fluctuations of the weather and the seasons, or even cease temporarily when water or wood was lacking. In other words, the demand for energy adapted largely to the supply.

The concomitant uncertainties increased where the population grew too fast. The yield of the soil could be increased only slowly, so that a rapid growth in the population led to crisis.

Nevertheless, very highly developed societies developed on the basis of renewable resources, which, long before industrialization, made impressive progress in science and technology and attained a remarkable standard of living. There were signs in about 1800, however, that the population was growing too fast and crisis threatened.

How serious the situation was and whether population growth did in fact create insurmountable problems is difficult to judge from the present-day perspective. Such difficulties often occurred, and the societies of the time had many ways of dealing with them. However, two things can be said with certainty. First, although these societies were sustainable through their use of energy and resources, this sustainability was accompanied by fluctuating harvests, frequent scarcity, early mortality, and many other uncertainties, so that they offer no model for emulation. Second, it was only industrialization and the use of coal that allowed these uncertainties to be overcome. Coal did not have to grow anew year after year, so that its use was not sustainable. Moreover, this source of energy appeared to be available in unlimited quantities, so that entirely new social and economic possibilities opened up.

Coal contained energy in stored form and, after the introduction of the railway, could be cheaply transported over long distances. Since then, vast amounts of energy have been available where needed – and without being subject to natural fluctuations. Innumerable machines and factories, more effective production processes, and technical inventions came into being, which, together with new scientific knowledge and many other factors, meant that productivity rapidly increased and modern industrial societies developed. After 1850, cities and industrial regions grew fast where the population, politics, administration, and economic activity were concentrated, and which depended on a constant supply of cheap energy.

Two further innovations gave impetus to this development: first the possibility of transporting energy in the form of electricity over long distances, and second – with this power as well as oil and gas – to operate not only large plants such as steam engines but also to run the smallest of motors. Huge power stations were consequently built to supply the electricity needed, which were largely instrumental in establishing industrial production as we know it. Such production is continuous, i.e., it is independent of natural fluctuations; it is based on the constant supply of energy, which follows demand; and it goes along with far-reaching centralization (Sieferle 2003).

The energy transition that took place some 200 years ago signalled the end of a type of economy that was sustainable through its use of resources and thus attained one of the goals to which we aspire with the present energy transition. At the same time, however, the societies of the time were at the mercy of fluctuations in the weather, the seasons, and nature in general and were plagued by great uncertainty. These conditions are not in keeping with our more developed understanding of sustainability. Not only resources but also politics and society are concerned. A sustainable society must safeguard political rights and participation and must display other characteristics that make it a good society to live in. In 1800 this was not the case.

At the same time, the transition then was not an abrupt one. It took decades before the new, industrial type of economy established itself. Many changes were needed in technology, the economy, society, and politics to adjust to and steer the industrial pursuit of economic affairs – which has not yet succeeded everywhere in the world. It is therefore not surprising that the current energy transition is not to be attained overnight; it will be a protracted and complex process.

2.2 OIL AND NUCLEAR POWER

Ever since the rise of coal there were repeated fears that reserves would soon run out. They were accompanied by criticism of the pollutants emitted during the use of this energy resource. Both concern about the depletion of reserves and criticism of pollution were the mark of the coal age, and persisted until after the Second World War when, in the mid-1950s, oil and above all nuclear energy promised a transition to clean and apparently unlimited sources of energy (Müller 1990; Radkau 1978).

Oil had been produced industrially already in the late nineteenth century, and was then to spread throughout the world. In West Germany, this resource gained key importance only after 1945 when it came to be used in the chemical industry, power stations, and private heating, and not least to fuel motor vehicles. From a chemical point of view, coal and oil have much in common, but oil is much easier to use in the fields mentioned. The modern chemical industry with its numerous (synthetic) products came into being, energy consumption grew markedly, and, not least, mobility increased to an unprecedented degree. One of the most important tasks in the current energy transition is therefore to maintain this mobility and/or to develop practicable alternatives.

The transition to oil was not nearly as great a public sensation as that to nuclear energy, which aroused almost unbounded expectations among the population and political parties. In 1955, the federal government set up a special department of nuclear power headed by Franz Josef Strauß, and in 1956 the SPD adopted a "nuclear plan," which proclaimed that "a new era has begun. Controlled nuclear fission and the nuclear power that can be obtained in this manner herald the beginning of a new age for humanity. ... the growth in prosperity that the new source of energy ... can bring must benefit all." Nuclear power could "help decisively to consolidate democracy at home and peace among nations. Then the nuclear age will be the age of peace and freedom for all" (Brüggemeier 2014: 228; Brandt 1957).

The federal government had to provide more funding for nuclear research to catch up technologically with other countries. Industry was criticized because it was neglecting the new technology for reasons of its "traditional attachment" to coal mining.

Such statements were common at the time. Nuclear reactors were to provide electricity and heat, desalinate sea water, and make deserts fertile, heat glasshouses in the cold north, and divert entire rivers to irrigate dry regions. In a smaller format they could drive ships, submarines, trains, and even cars – which would, however, pose safety problems. More detailed planning showed that a protective shield would be needed weighing some 100 tonnes.

Nuclear power promised not only clean and cheap but also inexhaustible energy, which would last for many centuries and eliminate almost all concerns. Innumerable journalists, writers, and politicians adopted this position. Nuclear energy also found support among the general public; even considerations of nature conservation and environmental protection spoke in its favour. According to the SPD Nuclear Plan, it would avoid "overmining" and the "damaging changes in the landscape caused by the extraction of lignite." Otto Kraus, the

Bavarian state commissioner for nature conservation, argued in similar vein in a 1960 paper on "Hydropower and Nature Conservation in the Nuclear Age." While admitting that "some scientists, some politicians, and some citizens" were worried about the associated dangers, he asserted that they were controllable and that dams were no less dangerous. Even their construction claimed many victims. What was more, dams could break owing technical errors or the forces of nature and cause disasters. By comparison, progress in nuclear engineering and the construction of nuclear power plants offered a useful alternative. This "defining moment," he declared, should be embraced (Kraus 1960: 34).

Reporting in the media was almost unanimously positive. But below official levels, the discussion was more controversial, not least because the use of nuclear energy recalled the menace of nuclear weapons. For this reason, the peace movement and the anti-nuclear movement were closely associated from the outset. When in 1951/52 sites for the first nuclear power plants were sought in Karlsruhe, Cologne, and Jülich, there were fierce disputes. In Karlsruhe, residents went to court, claiming that their constitutional right to life and physical integrity was at risk, and pointed to unresolved safety issues. Their suit attracted a great deal of attention and comment throughout the country, although most commentators were in favour of the new energy and described the plaintiffs as provincial troublemakers, who, as the Südkurier put it in November 1956 were: "attacking nuclear plants with flails" (Radkau 1978: 441).

The 1973 oil crises encouraged efforts to achieve an energy transition with nuclear power, since it demonstrated the great dependence of the country on Arab states. Since the demand for energy was also growing and oil was apparently running out, the then minister of finance Helmut Schmidt evoked the threat of an energy shortage. It was, he said, the biggest obstacle to "further economic growth, to the development of productivity, and, unfortunately, perhaps to job security." The nuclear industry agreed with him and offered to meet some 50 per cent of the demand for primary energy with nuclear power by the year 2000. To achieve this, they wanted to construct a further 35 nuclear power stations to ensure the power supply. These plants would not only generate electricity but also supply process heat for the chemical industry, as well as allowing petrol and other petroleum products to be extracted from domestic coal (Brüggemeier 2014: 316f.).

The coal mining corporation Ruhrkohle and the miners' union Industriegewerkschaft Bergbau reacted with enthusiasm to these proposals, which offered new prospects for their shrinking industry. The media that had previously been critical of nuclear energy now stressed its advantages. In 1973 the news magazine Der Spiegel pleaded in favor of doubling the number of nuclear power stations; for the Süddeutsche Zeitung and the Handelsblatt, only nuclear power could replace oil and secure the power supply (Schaaf 2002: 56). The Christian Democrat government of Baden-Württemberg was therefore acting in general consensus when in the summer of 1973 it decided to site a nuclear power station in Wyhl am Kaiserstuhl. But in so doing it triggered the anti-nuclear movement, which was ultimately to put an end to nuclear energy and give impetus to the search for alternatives.

2.3 NUCLEAR POWER AND DEPENDENCE ON OIL

In Wyhl the opponents of the nuclear plant were worried about local viticulture and their health, but initially did not fundamentally reject nuclear energy. The state government therefore found itself confronted by the usual reservations about industrial projects and stuck to its plans. But soon nuclear energy became the focus of attention, provoking increasing protest among local residents. Protesters included housewives, winegrowers, and farmers: people who usually played no prominent role in this sort of conflict, but who in Wyhl were to the forefront. They were supported by students from Freiburg and, increasingly, by scientists who contributed their knowledge to give a solid basis to the arguments against nuclear energy. Gradually, an unusually broad alliance developed, a constellation that contributed decisively to the success of the Wyhl protests. Just as important were politicians such as Erhard Eppler and the Baden-Württemberg SPD, who as early as 1975 expressed their reservations about the expansion of nuclear energy. The disputes became more radical, and opponents of the power station took spectacular action such as occupying the construction site. When the courts also put a temporary stop to construction and protest continued to grow, the national media, too, began to show interest in the conflict. But it was only in March 1975 that Der Spiegel reported in depth about Wyhl, almost two years after the conflict had begun (Rucht 2008).

In the meanwhile the issue of nuclear energy mobilized large sections of the population throughout the country. More and more individuals and groups joined in the protests, which in 1980 led to the founding of the Greens. Their rise owed a great deal to the rejection of nuclear power, which the SPD-led federal government continued to promote. The position of the Greens became increasingly popular, but the proportion of people in favor of nuclear energy remained just as large, even when on 26 April 1986 a reactor exploded in Chernobyl. For about half the West German population, the conclusion to be drawn from this disaster was obvious: they wanted to phase out nuclear power. At its party conference at Nuremberg in 1986, the SPD resolved to phase out nuclear energy within ten years, thus moving closer to the Greens, whereas CDU/CSU and FDP continued to support nuclear power, evoking the position taken by the other half of the population.

Against this backdrop, there were once again calls for an energy transition – a concept that for the first time gained broad usage. But more than the phasing out of nuclear energy was at stake. No less important were concerns that oil reserves would soon be running out. The much discussed 1972 Report to the Club of Rome had pointed to this, had warned against the limits to growth, and particularly about the dwindling reserves of oil. Many individuals and institutions took up these arguments, including the Freiburg Institute for Applied Ecology. A 1980 study identified the most important challenge as the imminent "exhaustion of the reserves of oil as a cheap source of energy" (Krause et al. 1980: 13) and called for a speedy energy transition. The authors proposed a number of ways to proceed, which have marked the debate to this day, including the more effective use of energy and the decoupling of economic growth from energy consumption. In addition, they wanted greater use to be made of renewable energies, which by 2030 should meet about half the demand for energy. The institute thus assessed the potential contribution of these energies more optimistically than was usual at the time, but also stressed that the rest of the demand for energy would have to be met by coal. According to the report, the future would be "self-sufficiency through coal and sun" (Krause et al. 1980: 39).

Many other studies, too, pleaded in favour of phasing out nuclear power, also pointing to the need to insulate buildings, develop new technologies, use energy more effectively, and decouple economic growth from energy consumption. All this was seen as offering major potential, but coal was ultimately expected to play a key role for the foreseeable future. A good and widely discussed example of these arguments is to be found in the 1986 book by Volker Hauff entitled "Energiewende" ("Energy Transition"). From 1978 to 1982, Hauff had been a minister under Schmidt and from 1983 onwards a member of the UN World Commission for the Environment and Development, which as Brundtland Commission had issued a report that is still one of the most important on the issue today. According to the subtitle of his book, Hauff wanted to show a way "from indignation to reform" and present practical steps for phasing out nuclear energy.

He described the most important source of all energy as its better use, but also clean coal as a source of energy with a future. He gave good reasons for this view. For although coal emitted considerable quantities of pollutants, including nitrogen oxide and sulphuric acid, which had long been criticized, and which in the mid-1980s had been strongly rejected as causing acid rain, there were effective technological possibilities for heavily reducing these and other emissions. This was what Hauff meant when he wrote of "clean coal" and attributed key importance to it (Hauff 1986: 95).

Erhard Eppler had adopted similar positions some years earlier. Eppler was among the first politicians in the SPD to demand the phasing out of nuclear power, and is regarded as a pioneer of the energy transition. As long ago as June 1979 he argued in a comprehensive paper that a phase-out of nuclear energy would raise no serious problems if the necessary adjustments and changes were made. Even a marked rise in the power supply was possible, he asserted, but could require doubling the amount of coal then consumed (Eppler 1979). This would bring problems with it; Eppler explicitly mentioned higher production rates of CO_2. But to reduce dependence on oil, which for Eppler was just as important as phasing out nuclear power, it was acceptable to use coal, especially since "clean cogeneration plants with fluidized-bed combustion on the basis of coal" were available. Eppler also set great store by decentralized gas-fired power plants, whereas, although he mentioned solar energy, he attributed little importance to it.

Generally in the 1980s there was repeated mention of the potential of solar energy. But even its proponents were cautious in their assessment of this alternative (Hauff 1986; Krause et al. 1980). It is therefore misleading to claim, as happens in the current debate, that a transition to renewable energies had been missed at the time. For the vast majority of contemporaries, the greater use of coal was a more realistic alternative, especially since technologies were available that could markedly reduce pollutant emissions. Then, as now, however, these technologies could not prevent CO_2 emissions. But the concomitant global warming was not yet seen as a key problem. The focus was rather on efforts to phase out nuclear energy and gain independence from diminishing oil reserves.

3

THE PRESENT ENERGY TRANSITION

3.1 AIMS

The aims of the present energy transition can be clearly and simply stated: it should phase out nuclear power, replace fossil fuels by renewable energies, and reduce emissions of gases harmful to the climate. For this reason the last nuclear power station is to be decommissioned in 2022. Furthermore, by 2050, renewable energies are planned to contribute 80 per cent of the electricity consumed, primary energy consumption is to fall by 50 per cent compared to the level for 2008, and the emission of greenhouse gases is to fall by 95 per cent compared to 1990 (BMWi 2014c).

These plans look ambitious, but they seem realistic, since remarkable success has already been achieved. Between 2000 and 2014 alone, the share of renewable energies in gross power consumption increased from 6.2 per cent to almost 26 per cent. If the use of renewable energies can continue to expand rapidly, they can replace first nuclear power stations and then fossil fuels. Since they emit only very low levels of CO_2, such emissions will fall considerably. Attaining the ambitious goal will therefore depend on continuing the developments of recent years (BMWi 2014b).

But this will not be simple. For these developments have led not only to remarkable success. They have also shown that the energy transition brings major challenges, contradictions, and conflicts. We shall be going into this in the sections to come. There is conflict not only with conventional power companies that fear for their influence but also between the various possibilities of obtaining renewable energies. The cost of solar energy, wind power, hydropower, and biomass differs, and they offer differing degrees of supply security, so that a decision must be made on how strongly each is to be expanded. But instead of further expansion, it would also be possible to use less energy or to develop new forms of economic growth.

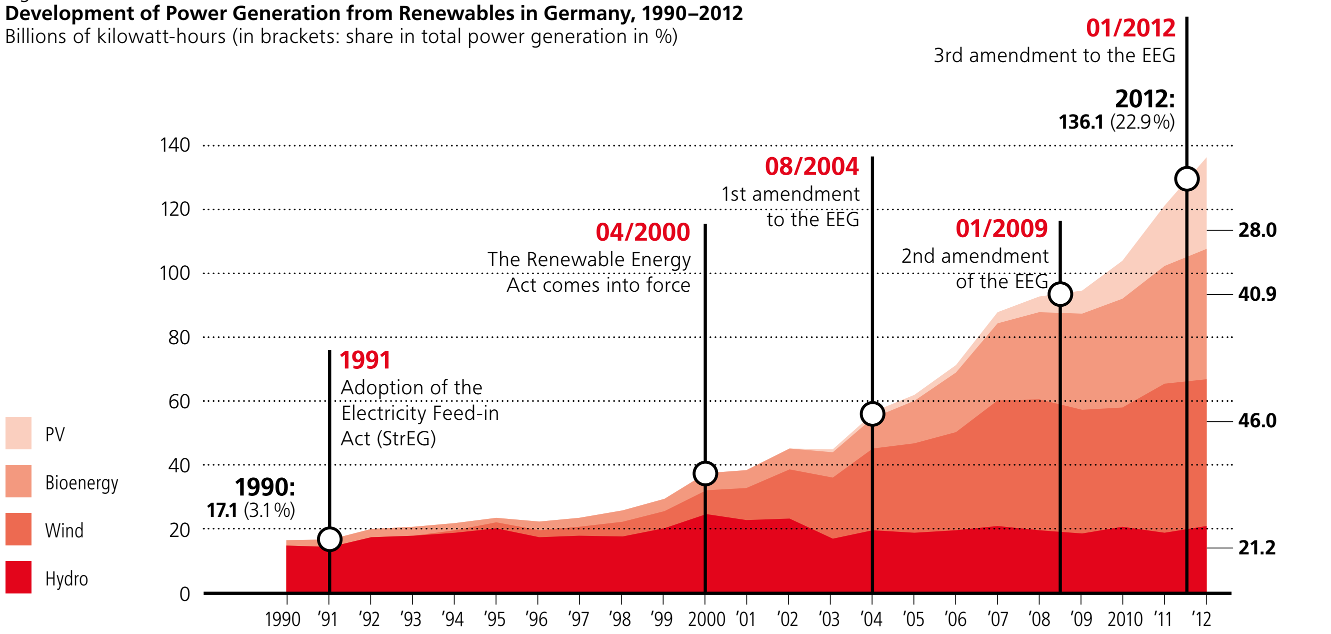
Basically, these possibilities can be combined and are not contradictory. In fact, however, decisions have to be made, if only to avoid unnecessary costs. Moreover, the energy transition has aroused far more expectations than those listed above. In addition to the above mentioned goals, it is also expected to reduce dependence on oil and gas imports; to create jobs; to promote structurally weak regions; to ensure greater efficiency in the use of energy; to contribute to ecological modernization and so on and so forth. It is obvious that these many expectations lead to conflicts, in which it is often difficult to discern the different interests and motives involved.

Some commentators go still further. Hermann Scheer, one of the pioneers of the energy transition, considers it “the most far-reaching economic structural change since the advent of the industrial age.” For him the energy transition has “significance in the history of civilization” and can be expected to fundamentally change how we live and conduct our economic affairs (Scheer 2010: 23, 28). Few see things quite so drastically. But even for those who do not share Scheer’s position it must be clear that the energy transition means more than installing wind turbines and solar plants. The aim is to completely reshape the existing energy system, which will require great effort and perseverance. The federal government talks of a task for generations, by which they mean a process with broadly set goals, each phase of which will have to be individually defined and corrected if need be. And it is a process with modest beginnings. Originally, the present energy transition was intended to expand the share of renewable energies, whose importance had been in steady decline since industrialization.

3.2 THE RENEWABLE ENERGY ACT: BACKGROUND AND HISTORY

In 1990, renewable energies still contributed no more than 3.1 per cent to the generation of electricity (see figure 1). This amounted to 17.1 billion kilowatt hours. By 2012 the level had risen by almost 800 per cent – to 136.1 billion kilowatt hours of electricity produced from renewable energies. By far the greatest amount in the 1990s was generated by hydroelectric power stations, whereas solar and wind energy were too expensive and played almost no role. Windmills, by contrast, had long since proved their worth. In 1895 there had been some 18,000 in Germany until small motors and the development of power grids superseded them. In the 1930s, however, wind power looked as it would enjoy a renaissance.

Figure 1
Development of Power Generation from Renewables in Germany, 1990–2012
Billions of kilowatt-hours (in brackets: share in total power generation in %)



Source: Renewable Energies Agency (AEE) 2013

Hermann Honnef, an inventor and pioneer in this sector, wanted to build gigantic tower plants to produce cheap electricity (Heymann 1990: chap. 6). The facilities were to be up to 430 metres in height and to have turbines with a diameter of between 60 and 160 metres, higher even than the Berlin Radio Tower with its 150 metres. Honnef believed they had to be so high to catch the upper wind for effective operation. He claimed that the costs would be so low that farmers would be able to install soil heating and bring in three to four harvests a year. Nowadays these proposals sound wildly extravagant, but they attracted a great deal of support until exact calculations showed how illusory his plans were. The vast towers presented insoluble static problems and the cost of their construction and operation was far too high.

Hydroelectric plants therefore remained the only competitive solution, but they were not popular among environmentalists because dams had a considerable impact on the landscape, an objection that has nowadays been levelled at pumped storage plants. Their contribution thus remained limited, but by 1990 they were nevertheless providing three per cent of electricity generated, whereas other renewable energy sources had hardly gotten off the ground. This was due not only to high costs but also to the behaviour of the power companies, who showed no interest in taking action themselves, and were also reluctant to buy the power thus generated. This obstacle was overcome in 1991 with the "Electricity Feed-in Act" (StrEG) which introduced two novelties: from then on electric utilities were obliged to buy power from renewable sources and also to pay fixed minimum prices for it. This benefited wind and hydropower, as well as biomass plants, which could generate electricity relatively cheaply. Solar energy, by contrast, was still far too costly and unable to escape from its niche; and, indeed, the share of renewable energies in the market as a whole grew only slowly.

3.3 NUCLEAR PHASE OUT I AND II

This situation changed only with the electoral victory of the SPD-Greens coalition in 1998, who considered the energy transition a key task involving two goals: to phase out nuclear power and expand the use of renewable energies. To achieve these objectives, the government adopted the Renewable Energy Sources Act (EEG) in 2000, which applied to wind power, photovoltaics, biomass, geothermal power, and hydropower, and which at first glance offered little that was new. This was because the act also provided for power purchase and price guarantees. But the guaranteed prices were much higher than in the past, especially for solar energy. Moreover, they applied for twenty years and hence offered long-term secure revenues, so that renewable energies experienced the hoped-for upswing.

At the same time, the government reached agreement with the power companies to phase out nuclear energy, amending the Nuclear Energy Act in 2002. This amendment limited the volume of electricity that nuclear power stations were permitted to generate and limited their operating life to the year 2021. This met major demands of the Greens and numerous environmental groups, but only because the SPD shared these objectives and ensured the required majority – until the CDU/CSU and FDP coalition electoral victory in October 2009 changed the situation. Although the new government continued to support the phase-out, it extended the operating life of nuclear power stations, provoking fierce protest among the public and the opposition. The SPD, the Left Party, and nine state governments announced they would take the issue to the constitutional court, but only a few months later this was no longer needed. The situation had once again changed, this time overnight, when on 11 March 2011 a nuclear accident occurred in Fukushima (Japan), the worst since Chernobyl 25 years earlier.

Figure 2
Current Status and Goals of the Energy Transition

Category	2010	2012	2020	2030	2040	2050
Greenhouse						
Greenhouse gas emissions (ref. 1990)	−25.6 %	−24.7 %	Min. −40.0 %	Min. −55.0 %	Min. −70.0 %	Min. −80.0 bis −95.0 %
Renewable energies						
Share of gross power consumption	20.4 %	23.6 %	Min. 35.0 %	Min. 50.0 % (2025: 40.0–45.0 %)	Min. 65.0 % (2035: 55.0–60.0 %)	Min. 80.0 %
Share of gross final power consumption	11.5 %	12.4 %	18.0 %	30.0 %	45.0 %	60.0 %
Efficiency						
Primary energy consumption (ref. 2008)	−5.4 %	−4.3 %	−20.0 %		−50.0 %	
Gross energy consumption (ref. 2008)	−1.8 %	−1.9 %	−10.0 %		−25.0 %	
Share of power generation by CHP	17.0 %	17.3 %	25.0 %			
Final energy productivity	17.0 % p. a. (2008–2011)	1.1 % p. a. (2008–2011)	2.1 % p. a. (2008–2011)			
Building						
Primary energy demand	–	–	–		In the order of −80.0 %	
Demand for heat	–	–	−20.0 %	–	–	–
Rehabilitation rate	ca. 1.0 %	ca. 1.0 %		Doubling to 2 per year		
Transport						
Final energy consumption (ref. 2005)	−0.7 %	−0.6 %	−10.0 %		In the order of −40.0 %	
Number of electric vehicles	6,547	10,078	1 million		6 million	

Source: BMWi 2014c: 11

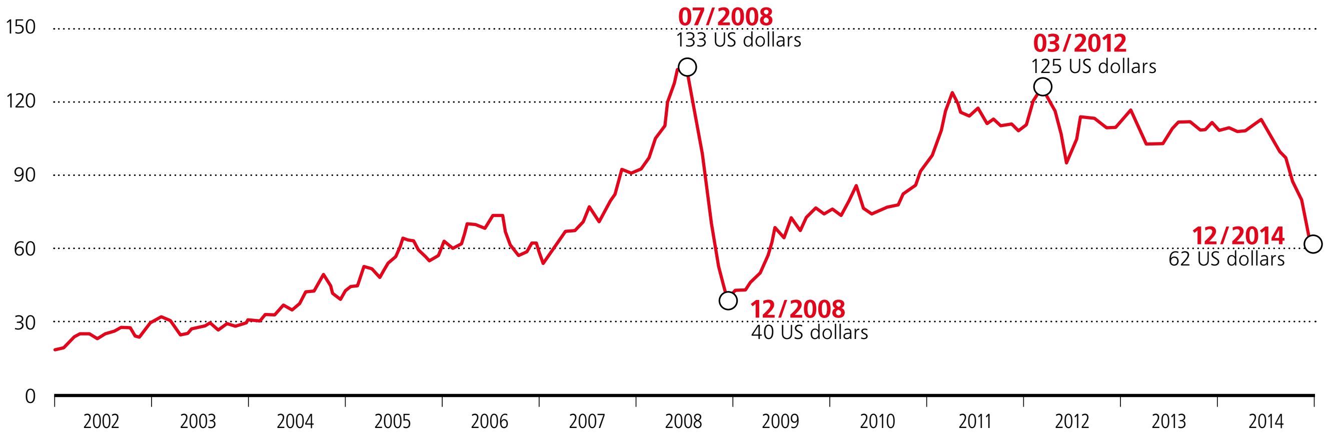
An earthquake and subsequent tsunami lead to core meltdowns at the nuclear plant there. Safety measures failed and large quantities of radioactive material escaped, entering the sea and threatening to spread around the globe. Fears were aroused worldwide, especially by the united impact of earthquake and tsunami that raised the spectre of a reactor explosion as in Chernobyl, which, however, did not take place. The number of victims was also considerably smaller, although no reliable forecasts could be made about the long-term effects. American scientists put the number of cancer deaths at between 15 and 1,300 (Süddeutsche Zeitung 2012). What is known, by contrast, is the toll of the tsunami, which had devastating consequences and claimed some 16,000 victims – which attracted far less comment in the German press.

At any rate, the shock was profound. The federal government reacted, notably in the person of Chancellor Angela Merkel. She announced a moratorium on nuclear power, which subjected all nuclear plants to safety assessment and immediately shut down the seven oldest for a period of three months. Subsequently, the government passed a new nuclear power act, which revoked the extensions that had previously been granted. For 8 of the 17 nuclear plants, the operating licence expired after a short time, and the others have to be taken off the grid by 2022 in accordance with a fixed timetable. The act resembled the arrangements introduced by the SPD-Greens coalition in 2002, but intervened more strongly in the energy industry, laid down detailed procedures for the phase-out, and set 2022 as the final date. Unlike under the SPD-Green act, the phase-out was not decided in consensus with the nuclear plant operators.

One of the two goals of the energy transition, the phasing out of nuclear energy, had thus been achieved. At the same time, the development of renewable energies was making great progress, which the conservative-liberal government continued to support. In 2013, renewables supplied 25.3 per cent of the electricity consumed in Germany, quadrupling the figure since adoption of the Renewable Energy Act and thus avoiding the emission of 145.8 million tonnes of CO_2 (BMWi 2014a: 32). The Federal Ministry of the Environment, the companies involved, environmental organizations, and political parties praised the act as the most successful tool worldwide for promoting renewable energies and initiating an energy transition. They had good reason to do so, as figure 1 shows. There was also broad popular approval. In a 2014 survey, 90 per cent of respondents described the greater expansion of renewable energies as 'important' or 'extremely important' (AEE 2014). And a number of countries around the world are planning to introduce similar legislations or have already done so, especially since electricity from these sources has fallen in price – at least on the power exchange. Power generated from renewables can be cheaper than that from conventional power stations, showing that this was the right track to be on.

And in principle this is the case, but in fact the situation is highly complicated. This is shown by the almost dirt-cheap exchange price, which is a consequence of the Renewable Energy Act and has caused innumerable problems for the entire

Figure 3
Development of Oil Prices 2002–2014
Monthly average price of Brent per barrel in US$



Sources: Federal Agency for Civic Education 2015

energy market. Other developments, too, were not foreseen, but caused no problems as long as renewable energies did not play a major role. In the meanwhile, however, since they have begun to supply considerable volumes of electricity, heat, gas, and petrol, many questions need clarification: which renewable energy sources in Germany are particularly suitable and deserve preferential support: solar energy, wind and hydropower, geothermal energy, or biomass? Should they serve primarily to produce electricity and heat or also gas and petrol? Should supply be as decentralized as possible, or do we need a nationwide, if not Europe-wide power system? How long should coal and lignite plants continue in operation? Should we continue to concentrate on developing renewable energies or would it make better sense to focus on greater efficiency in the use of energy and on better thermal insulation?

These are only some of the challenges that necessarily arise when an energy system undergoes fundamental changes. At the same time, there are efficient solutions available, which in recent years have been constantly improved. However, we also face problems that had existed even prior to industrialization and which are now back with us: first the dependence of renewable energies on the weather and the seasons, which makes the energy system vulnerable; second the difficulty of storing energy. Both aspects have far-reaching consequences, not least for the security of supply.

3.4 IMPLEMENTING THE RENEWABLE ENERGY ACT

3.4.1 SECURITY OF SUPPLY

Coal, Oil and Gas

Since the rise of coal and later oil, fears have repeatedly been expressed that reserves would soon be depleted. These fears intensified in the 1970s when the Report to the Club of Rome appeared, the then federal chancellor Helmut Schmidt warned of an imminent energy shortage, and the Freiburg Institute for Applied Ecology and many experts echoed this view. Such fears also play a major role in the present energy transition, so that the federal government describes the finiteness of oil and gas resources, as well as dependence on energy imports as key reasons for an energy transition.

Basically, these concerns have been justified. There can be no question that fossil energy resources will come to an end sooner or later. But this observation does not get us any further. What is more relevant is to establish the point in time when resources actually become scarce and expensive. And this is clearly a very difficult undertaking, as present developments have shown. When the Renewable Energy Act was passed in 2000, worldwide energy consumption and prices for oil and gas were rising sharply. Further rises were considered certain, and the transition to renewable energies appeared to be advisable even if only to guarantee supplies. Since the price of fossil fuels could also be expected to continue rising, renewable alternatives would prove first of all competitive and then even cheaper. Initially, this is what happened. But since 2011, prices for the so important oil have hardly increased at all and have even fallen markedly (see figure 3) – which has also been the case for coal. They will not remain at this low level in the long run, but it is difficult to predict when and to what degree they will rise again.

Around the world, politicians welcome lower energy prices and hope they will bring higher economic growth. For the environment, however, fossil energies can have undesirable consequences owing to their emissions, and, moreover, show that the real problem is not their scarcity. On the contrary, they are available in such vast quantities and so cheaply that for the foreseeable future supply is not only secure: the consumption of these resources and the volume of CO_2 they emit will continue to increase. In only a few years, the situation has radically changed. Whereas the finiteness of fossil energy sources has caused great concern, the problem now is to use the vast reserves of coal, oil, and gas as little as possible, to avoid the associated greenhouse gases, and instead to replace them by renewable energies.

In principle, this could also offer a secure supply. But natural fluctuations due to weather and seasonal changes, which are inevitable in generating renewable energies, pose serious problems. Pre-industrial societies could do little to counter these fluctuations. Today we have far better possibilities, but they require a great deal of effort and expense.

Fluctuations and Storage

Renewable energies depend essentially on wind and solar radiation, which are perforce subject to considerable fluctuation. Depending on duration and intensity, renewables generate varying volumes of electricity and are not always available. In 2013, solar systems operated on average for 867 hours (10 per cent of the time). Wind power plants in the country operated for an average 18 per cent of the time, a much better figure, which in particularly windy Schleswig-Holstein increased to 22 per cent (BDEW 2015: 25f.). So that if it can be said that their installed capacity or that of solar energy plants exceeds the capacity of nuclear power stations, this is in principle good news. But it is also misleading, because the installed capacity is basically available but can be used only to much smaller extent. Offshore, capacity utilization rates can reach 18 per cent and facilitate continuous supply, so that further marine wind farm development is planned. But considerable technical problems also present themselves and costs are much higher, so that offshore wind turbines currently contribute only one per cent to overall electricity generation (BDEW 2014: 11) and will play a bigger role only in the course of time.

Nature itself helps to balance out fluctuations. Thus photovoltaic installations perform best in summer and at noon, when energy demand is particularly high. In winter, by contrast, they often fail to deliver, but then strong winds are frequent and can help out. Anyway, wind and sun conditions always vary greatly at any point in time and from place to place, providing compensation but only limited security of supply. In 2012, sun and wind produced 22,121 megawatts of electricity on particularly good days, but little more than 5 per cent of this figure on bad days (Monopolkommission 2013: 185). Supplies from other countries where very stable sun or wind conditions prevail can help out.

One very ambitious project (Desertec) had planned to generate electricity in the Sahara and transport it from there to Europe. But numerous technical, economic, and political problems arose that forced postponement of the project to the distant future. But despite such setbacks, a successful energy transition needs European cooperation (see chapter 3.5).

Such considerations would not be necessary if heat and electricity could be stored. There are certain possibilities for storing heat, but they are limited, very costly, and involve losses. Losses always occur when energy is converted from one form into another, which in the case of storage is necessarily the case. The situation is particularly bad for electricity. The possibilities available are less effective and more costly and involve greater losses, so that the energy generated can be stored only in small volumes and for brief periods of time. There has been much discussion about pumped storage plants, which can release stored water to generate electricity when needed. But such plants have a considerable impact on nature and landscape, offer limited capacities and run dry after only a few hours. They can eliminate short bottlenecks but not provide a permanent supply.

Since effective storage is crucially important, a wide range of possibilities have been tested, some of which could be described as adventurous. They include experiments with disused mine shafts more than 1,000 metres deep. This difference in depth offers good conditions for using surface water reservoirs to drive underground turbines for generating electricity; but there are still major technical challenges to be met and cost problems to be solved. More progress has been made in producing efficient batteries, which are meanwhile used to drive electric cars. But here, too, it is still difficult to make batteries that are both affordable and effective. Once they are available, new possibilities will open up. Because electric cars, like all motor vehicles, do not run most of the time, their batteries could be linked up, resulting in a sort of mega-storage system.

Other projects are trying to convert electricity into heat. Sooner or later these and other plans will produce solutions. For the moment, however, batteries or comparable devices that can store such large volumes of energy that they can secure the power supply in general are not yet in prospect. However, there is one renewable that is not subject to fluctuation and, like coal or gas, also contains energy in stored form and is thus best suited to balancing out fluctuations: biomass.

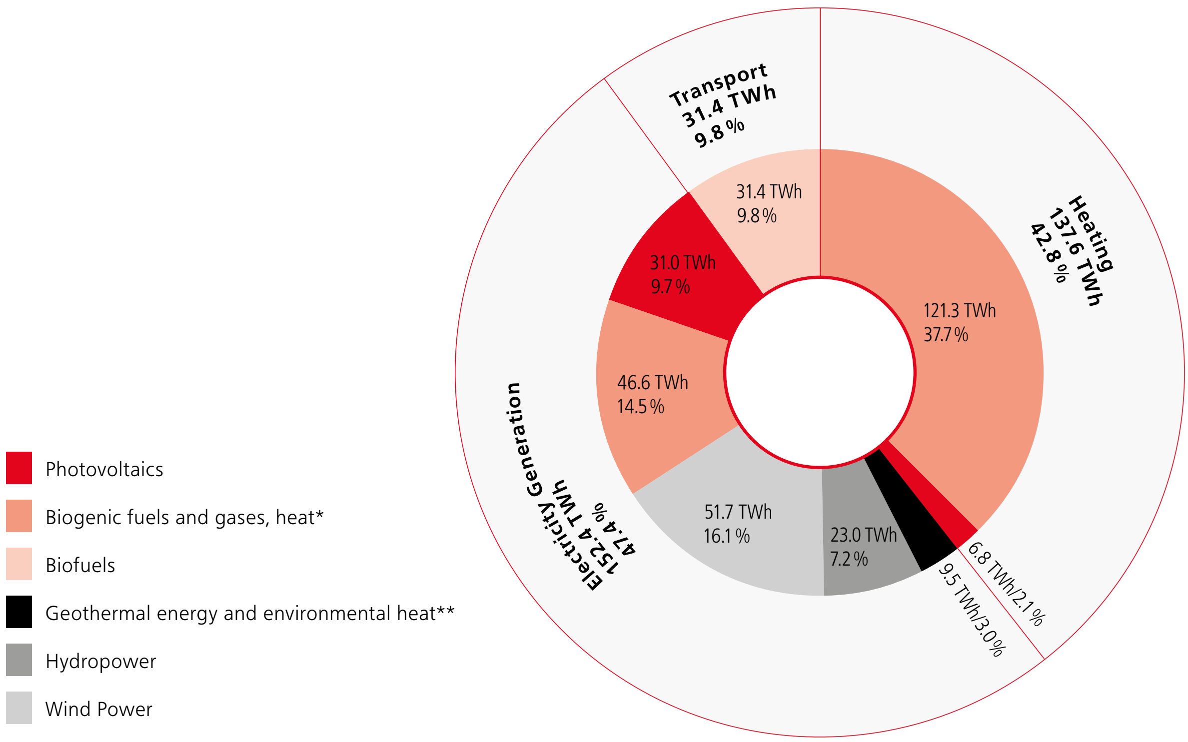
Biomass

Biomass includes a wide range of organic material, including animal excrements and many other sorts of waste. Intensive animal husbandry produces particularly large amounts of bio mass in the form of liquid manure, whose use as renewable energy source also solves a serious environmental problem. Then there is other waste from agriculture or abattoirs, organic and combustible refuse from households and industry, as well as gases from mines and landfills, although the last are strictly speaking not renewable energies. Apart from this, the various types of biomass characteristically make energy available in stored form, which can be used as the need arises.

Because of these properties, not only existing waste is used; biomass is also specially cultivated. This has long been the case for wood, which as heating material in the form of pellets is currently making a remarkable career. But trees grow slowly, so that they offer more of a long-term perspective. In the short term, maize, which is an especially good energy supplier, has in recent years been increasingly popular. This has been encouraged by high subsidies, for maize and biomass in general are an obvious choice for the energy transition. They grow anew year after year, and are thus renewable in the strict sense of the word, and not only provide electricity and heat but also serve as the basis for producing gases, petrol, and many raw materials.

In recent years, biomass has accordingly enjoyed a considerable boom, supplying a little over 60 per cent of all renewable energy. Lagging far behind are wind power (16.1 %), photovoltaics (9.7 %), and hydropower (7.2 %); other sources played no significant role (see figure 4). The development

Figure 4
Final Supply of Energy from Renewable Sources, 2013



* With biogenic part of waste
** Electricity generation from geothermal power about 0.1 TWh (not separately shown in figure)

Source: Federal Environmental Agency 2015

of biomass therefore presents an impressive success story, helping not only to offset fluctuations; since mostly small and medium-sized plants use biomass, it can also make an important contribution to decentralizing supply and to a local and/or regional mix of energy sources. Cogeneration units offer a good example, which provide both energy and heat, are highly efficient, and are above all suitable for generating smaller amounts of electricity or heat.

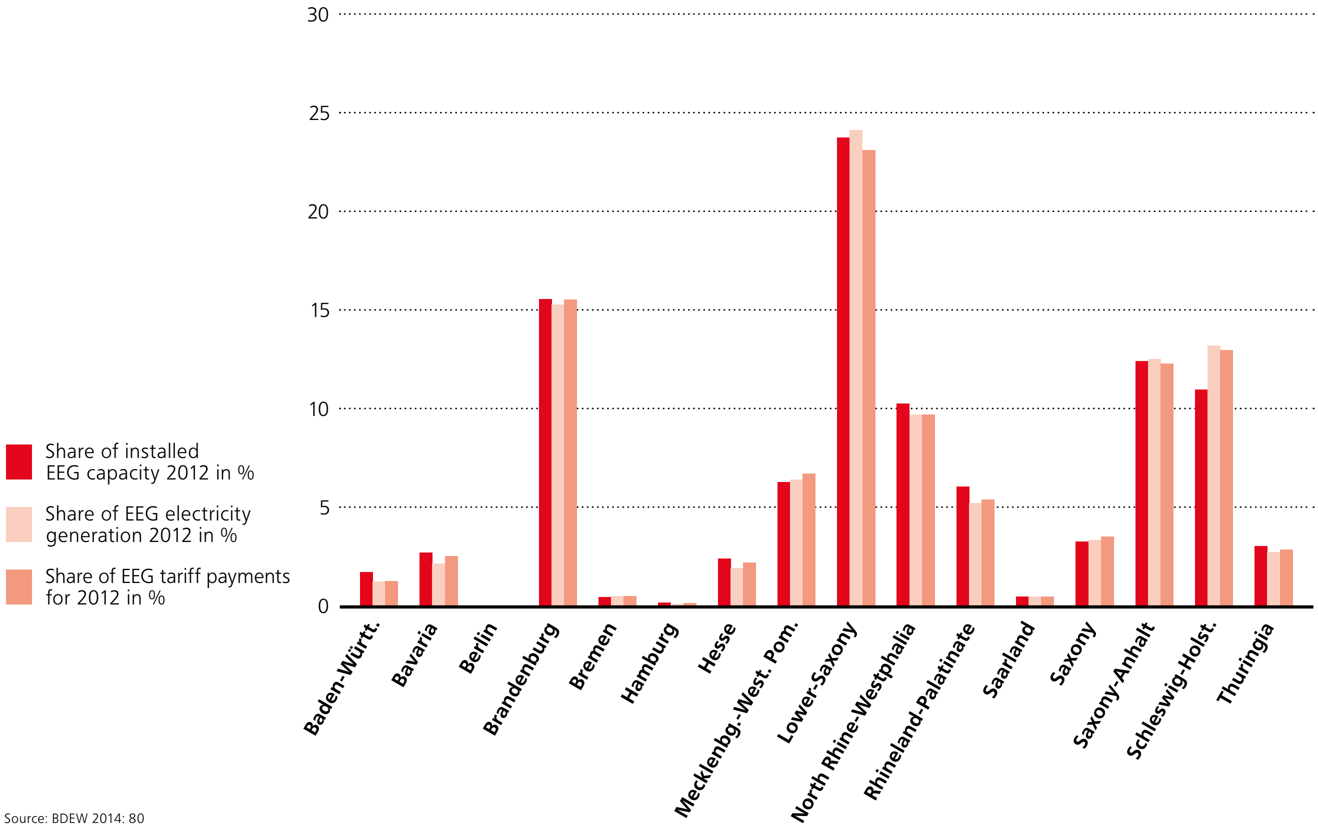
Despite these possibilities, stepping up biomass generation poses problems. First, it is expensive to use. Second, growing it takes a lot of land and hence competes with food crops. In well-supplied Europe, this competition is no problem. But in so-called Third World countries, food supplies suffer if large and often species-rich tracts of land are devoted to growing high-energy crops. In Europe, this development has also taken place, but in a different form. Since maize is a particularly suitable biomass crop, large monocultures have come into being, which require large quantities of fertilizer and pesticides, pollute the soil and water, and menace biodiversity. The promotion of biomass has therefore declined, while new ways have been sought to overcome these difficulties. They include concentrating on waste as a resource, to limit the cultivation of high-energy crops, to consistently apply ecological criteria, and, last but not least, to use algae, other plants and bacteria that do not compete with food.

In the long run, this could offer considerable possibilities. At present, however, additional solutions have to be found to balance out fluctuations, including efficient power transmission grids, which are crucially important. They are needed to link areas in which particularly large and particularly small volumes of electricity are generated from sun, wind, or water in order to achieve the necessary balance.

Grids

In power supply, three types of power station are to be distinguished: baseload, intermediate, and peaker plants. Baseload needs, i.e. almost constant basic demand, are met by nuclear and lignite-fired plants, which from a purely economic point of view generate electricity particularly cheaply. However, they can adjust their output only very slowly to fluctuations in demand; but this is not their job. This is the task of intermediate plants, which are brought on line at times when high demand can be expected. Using coal, gas, and steam, as well as hydropower, they can react faster. Finally, to meet high and short-term (peakload) demand, gas-fired plants are available, which can react very flexibly, but are more expensive to operate. These power plants are interconnected by grids, but which can be comparatively small, because conventional power stations use energy that is already stored in coal, oil, or gas. In simple terms, fossil fuels work like batteries that have been charged over millions of years and are now depleted in a very brief space of time. Since these fuels can also be easily transported, fossil-fuel plants are built wherever

Figure 5
Onshore Wind Power: Regional Distribution of Capacity, Electricity Generation and Tariffs, 2012
Shares in %



Source: BDEW 2014: 80

there is demand. Here, too, supply and demand can differ, single power stations can break down, and emergencies can arise. But major fluctuations are the exception and can quite easily be managed, since there are enough power plants within easy reach that can help out.

It is more difficult with renewable energies. Plants cannot simply be built where the demand is located, but require sufficient sun and strong enough winds. In other words, with renewable energies, generation and consumption are geographically separated. Since wind power plays a key role, it has been developed above all in the North and East, whereas the industrial centres in Germany are in the West and South, so that the electricity has to be transported there (see figure 5). It is in principle conceivable – as in pre-industrial times – to establish high-energy industries in places where renewable energies can be easily and reliably produced. Particularly good conditions are to be found in windy Northern Germany, and the structurally weak regions there would welcome such a development. But this would be at the cost of the Southern states and would cause considerable problems, so that relocation is at best a theoretical proposition. In the energy transition, by contrast, there is consensus that electricity is to be delivered to where there is a demand for it, and that it is to be supplied throughout the country at comparable prices. The consequence is obvious: transmission grids have to be correspondingly efficient.

Efficiency requires long lines and enough pylons, but also other approaches, including intelligent information systems (smart grids), which not only record and distribute supply and demand, but also control consumption and, for example, activate particularly energy-intensive processes when surplus energy is available (demand-side load management). This can mean running washing machines and dishwashers at night or at the weekend; appropriately insulated cold stores that can manage without power for a time, as well as aluminium smelters that step up production at times when the enormous volumes of energy they need is available.

In essence, a basic element of the existing energy system has to be modified. It has focused on providing energy where it was needed. This principle is to be maintained, but supplemented by efforts to adapt demand to supply. This endeavour recalls the pre-industrial world, where adaptation was absolutely necessary and involuntary. Today, by contrast, we have efficient systems that offer many possibilities for achieving a balance and which reduce the need for storage in proportion to how well it can adapt demand. There are no bounds to imagination in this field, but there are also difficulties to be dealt with, for steering consumption can involve large-scale data collection and the invasion of privacy.

Another possibility is to achieve greater self-supply at the regional or local levels or in individual households. Solar systems, wind turbines, and CHP plants are available in various sizes and can generate small amounts of power – for instance, for private consumption. This addresses one of the key elements of the energy transition: the decentralization of energy supply. Power has traditionally been supplied by large power stations, which are being replaced more and more by small units often supplying only individual households. Larger interconnected systems have also come into being, for example with large-surface solar energy plants or offshore wind farms. But even such farms do not reach the capacity of conventional power stations. Decentralized energy supply will therefore increase and requires a combination of different possibilities for obtaining renewable energy if greater security of supply is to be attained. They include heat pumps, cogeneration, biogas plants, battery storage, etc., which on a small and medium scale are highly efficient and facilitate decentralized supply.

These possibilities have so far been exploited only to a limited extent, and are suitable above all for small and medium-sized units. In large cities, by contrast, and everywhere where industrial plants and other consumers require a great deal of energy, large grids will continue to be needed to balance the inevitable fluctuations. This also applies for decentralized generation. Even if these highly ingenious systems for generating and storing power become established, bottlenecks can arise at times, especially since the effectiveness of the technical possibilities available will remain limited for the foreseeable future and involve substantial costs. With certain exceptions, it therefore makes little sense to play off decentralized supply against nationwide or Europe-wide energy networks. They must be complementary, which can naturally involve conflicts about what share each is to take. But decentralized supply that can make itself so independent of natural fluctuations and that supplies the required energy so reliably that it can do without larger networks will for the time being remain a rare and costly exception.

There is consensus about the need for these networks alone because profitable wind turbines are to be found above all in Northern Germany, whereas in Southern Germany photovoltaic installations predominate, which generate electricity less reliably. Moreover, it is in the South that the nuclear power plants are concentrated that will be in operation only until 2022. Since the Southern states are also home to major industries that consume a great deal of energy, electricity has to be transported there. But how much? How big do networks and above all power pylons need to be, and how are they to be routed? According to the Federal Network Agency, about 2,800 kilometres of new high voltage transmission lines have to be built in the years to come and 2,900 kilometres of existing lines renewed. In addition, new distribution networks of between 135,000 and 193,000 kilometres will have to be built and between 21,000 and 25,000 kilometres of such networks will need to be modified (German Energy Agency 2012: 7).

These figures are controversial and have provoked broad protest, not only because people do not want to see power pylons in front of their homes but also because is it difficult to assess actual needs. Demand would be lower and fewer new power lines would be required if decentralized generation were to increase or if energy were to be used more efficiently and therefore in smaller volumes. And it is also not clear what role fossil fuels, especially gas, will play in the longer term.

Fossil Fuels

The biggest change brought by the energy transition so far has been in power generation, where renewables currently (2014) meet one quarter of the demand for electricity (see figure 6). But this also means that fossil fuels continue to play a major role. In electricity generation, they produce almost 55 per cent of output, a figure that is expected to fall in the years to come if networks are better developed, supply and demand better coordinated, and if renewable energies in general gain in importance. But even if renewables attain the 80 per cent mark by 2050 as hoped, there will still be a gap, which will be smaller when the weather is favourable but much bigger when conditions are less favourable. Conventional power stations will therefore still be needed, both for basic supply and, above all, in reserve.

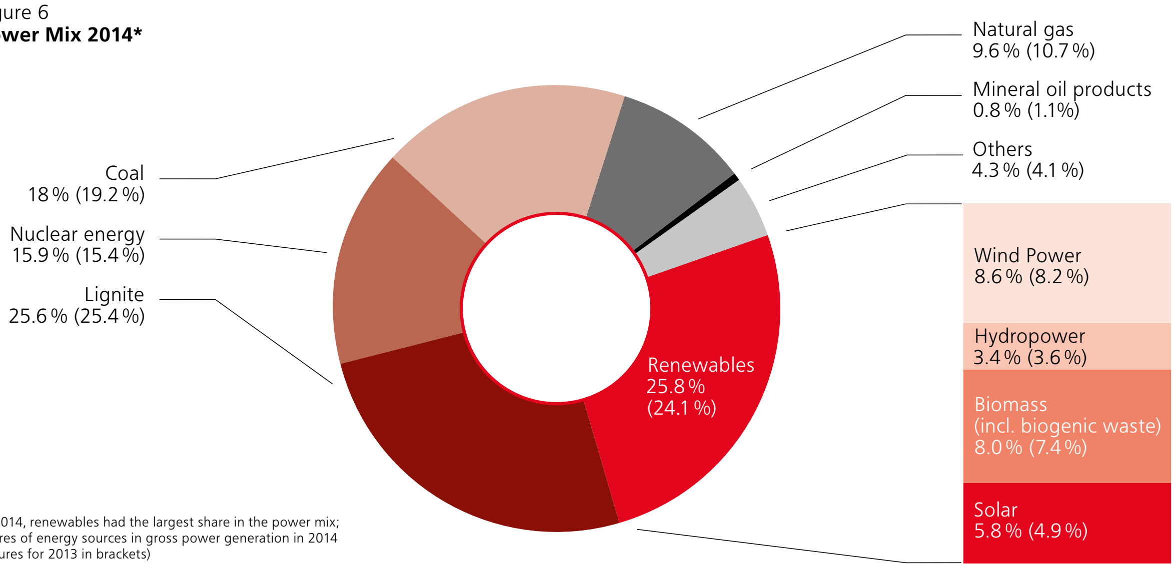
In future, conventional power plants are to be fired where possible by gas, a fuel that emits comparatively few pollutants, but which involves higher costs. At present, the share of gas is therefore declining and even very efficient and environmentally friendly stations like the Irsching power plant are to be shut down for cost reasons, so that coal and especially lignite is used for basic supply. Coal will remain important for the foreseeable future, also to compensate for the nuclear power stations that will be closing down in Southern Germany in the coming years. Thus when the new transmission lines have been built, they will initially transmit electricity not only from wind power plants but also from lignite-fired power stations.

Fossil fuels will be still more important for the foreseeable future in transport and in heat generation. Petrol as fuel and oil or gas for heating are difficult to replace. The government is therefore supporting many research projects looking for ways to convert electricity into heat or gas, and thus to replace fossil fuels. Great hopes have been placed in electric cars where electricity replaces petrol, and better thermal insulation for buildings is being promoted. In both cases, however, considerable costs arise, so that little progress has so far been made. This brings up the question of cost, which has not yet been addressed. The solutions discussed in this section are already technically feasible or will shortly be available. But the question of cost has been left aside – also by the Federal Environmental Agency study, which claims that it will be possible to achieve 100 per cent electricity generation from renewable energies by 2050 (Federal Environmental Agency 2010). This omission is understandable when the issue is to consider the multiplicity of solutions and stress that they are viable in principle. But whether they really will be implemented depends only partially on the fundamental possibilities. Just as important are the costs involved, as the heated debate on the rise in power prices in recent years has demonstrated.

3.5 EUROPE

The energy transition requires European cooperation, if only because little progress can be made in climate protection if only one country consumes less energy, reduces greenhouse gas emissions, or develops renewable energies. The other

Figure 6
Power Mix 2014*



* In 2014, renewables had the largest share in the power mix; shares of energy sources in gross power generation in 2014 (figures for 2013 in brackets)

Source: AG Energiebilanzen 2014

countries in Europe also have to pursue these goals if anything is really to be achieved. Moreover, in a European network it is easier to offset the inevitable fluctuations in renewable energy sources and to ensure security of supply. Finally, co-operation is also needed to share costs fairly. If individual countries press ahead and impose higher costs on their industry and on private consumers, this will sooner or later lead to considerable conflict.

As long ago as 1997, the then 15 member states of the European Union accordingly set themselves the target date of 2012 for reducing emissions of greenhouse gases by 8 per cent compared to 1990. In 2009, the enlarged EU adopted the 20-20-20 Climate-Energy Package. This provided for reducing emissions (see figure 7) and total energy consumption by 2020 by a figure of 20 per cent, and to attain just as great a rise in the use of renewable energies. And now (2015) the European Commission has proposed an energy union that would pursue even more ambitious goals. The aims are to substantially reduce the dependence of Europe on fossil fuels, to improve supply security, promote "green" economic growth, and protect the climate. For these purposes, the Commission wishes to attain greater energy efficiency, increase the share of renewables, and reduce CO_2 emissions by at least 40 per cent by 2030 (European Commission 2015).

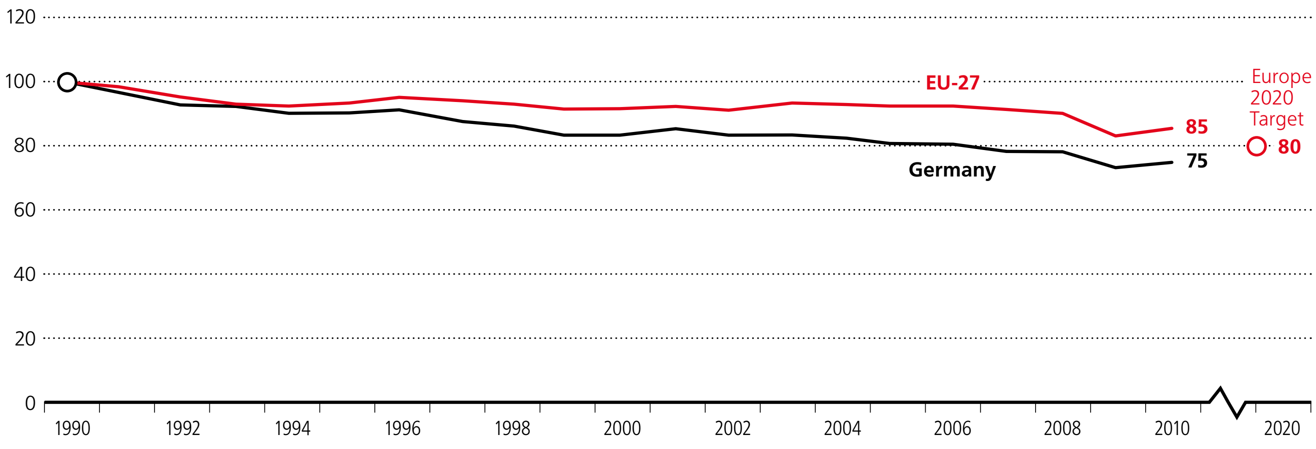
A package of measures is to be taken to reach these goals. They include effective legislation, the modernization of the European energy market, greater transparency in prices and costs, provision of the necessary infrastructure, greater energy efficiency in buildings, and lower use of fossil fuels in transport. Europe is thus to improve the situation not only within its borders but also to assume a leading role worldwide in energy policy and climate protection. This exemplary role was already aspired to in the resolutions of 1997 and the 2008 climate pact, and is fitting, not least because Europe is well advanced in industrialization, consumes large amounts of fossil fuels, and produces more emissions than do poorer countries.

However, there are comparatively poor countries in Europe, too. The climate pact therefore gives Bulgaria, Romania, Slovakia, and other countries that are lagging behind economically the right to increase their emissions in the coming years to attain the absolutely necessary economic growth. For their part, countries like Germany, Denmark and the United Kingdom commit themselves to particularly far-reaching goals in order to secure the developments aspired to for the whole of Europe. Thus joint action in energy and climate policy is already being taken, which the energy union is intended to extend still further. But obstacles are to be expected. For, despite everything the parties have in common, there are considerable differences and conflicts of interest between them (Zachmann 2015).

Probably the biggest conflict is that individual countries insist on pursuing a national energy policy over and beyond the fundamental declarations. This might well seem superfluous egoism, but the real reason is that conditions vary greatly from country to country. For example, Poland generates more than 80 per cent of its electricity from coal, and in so doing protects many jobs in the coal industry. In France, by contrast, the share of nuclear energy is particularly large and is justified on the grounds that this form of power generation produces practically no CO_2 emissions. With the same justification, the UK is planning a new nuclear power station, which the government is subsidizing with the agreement of the EU Commission. According to press reports, this subsidization caused controversy in the Commission, and Austria has announced it will take legal action against it. This could be successful in the specific case, but would do little to change the fact that considerable differences will persist between EU member states in energy policy for the foreseeable future (Kurier 2015).

There are many other examples. The EU Commission, for instance, wants to buy gas jointly, which Poland strongly welcomes in order to gain greater independence from Russian deliveries. By contrast, Germany and most other European countries prefer to deal independently with this important issue, and to use relations that have often been in place for decades. There are also snares in developing renewable

Figure 7
Development of Total Greenhouse Gas Emissions since 1990
Base year 1990=100



Source: Federal Statistical Office 2013, p. 21

energies. If it is only a matter of protecting the climate, these energies should be produced where costs are lowest in order to avoid unnecessary expenditures. Accordingly, the German Renewable Energy Act should also apply for solar energy from Southern Europe and wind power from Northern Europe. But the willingness of German power consumers (and politicians) to accept higher prices is likely to be limited, especially since the promotion of renewable energies has to do not only with climate protection but also with industrial development, structural policy, and jobs in structurally weak regions.

Another example shows how easily national and European aspects can come into conflict. In Germany, energy-intensive industrial plants are largely exempted from the Renewable Energy Act surcharge. The EU Commission regards this as a contravention of competition law, since it amounts to preferential treatment for the exempted plants. There was fierce discussion on the issue, which finally ended with a compromise. It provides for stricter criteria for the plants that continue to enjoy exemption, but basically continues to permit this possibility. From a purely ecological point of view, this compromise could be seen as disappointing. But in this case, too, it would be difficult to explain that in Germany large sums have been spent on the energy transition, while industrial enterprises forfeit their international competitiveness because they obtain no exemption from the higher costs that their foreign competitors do not have to pay, anyway.

The extent to which the ambitious goals of the energy union will be attained and what powers will be vested in it therefore remain to be seen. There is nevertheless much that is still shared. This includes above all the European electricity networks, which have long helped deal with fluctuations and bottlenecks in supply. With the development of renewable energies, this function will become even more important: "A specific minimum interconnection target has been set for electricity at 10% of the installed electricity production capacity of the Member States, which should be achieved by 2020." (European Commission 2015: 9). By 2030, a target of even 15 per cent has been set, which would much facilitate using electricity from hydropower installations in the Alps or Northern Europe as reserve facilities, or to make solar energy from Southern Europe available throughout the continent.

The preconditions for this project are good, for there are already operating networks, the largest of which encompasses the countries of continental Europe from Spain in the West to Hungary in the East, Greece in the South, and Denmark in the North. In addition, the United Kingdom, Ireland, the Baltic countries, and the Scandinavian countries have their own systems. They will integrate more closely in the years to come. The EU Commission puts the sum needed for this and for the general development of European electricity networks at 200 billion euros per year. Private investors are prepared to buy into this, since secure returns are to be expected. In addition, the EU Commission is supporting development through its Structural and Investment Funds, so that the planned Europe-wide network is a realistic objective and facilitates the energy transition.

3.6 COST EFFECTIVENESS

The energy transition started with a promise: "The sun," wrote Franz Alt in 1994, "sends us no bill." Even today, the argument that sun and wind provide free energy is often to be heard. Strictly speaking, it is even true. But if we produce energy with their aid, transport it, use or store it, it costs. In the case of hydropower or the combustion of wood and wastes, the costs involved are relatively low, so that these renewable energy sources are economically competitive, have been used for decades, and receive little or no financial support. With most other renewables, however, the situation is different. From the very outset of the energy transition it was clear that power from renewable sources would be more expensive than "normal" power, at least for a time. The Renewable Energy Act therefore guaranteed them fixed prices, which have always been above the market price, and which will be valid for 20 years. In addition, and also for 20 years, it established a "take or pay" system, so that renewable energies were worth developing and experienced a boom beyond all expectations.

But costs, which when the Renewable Energy Act was adopted in 2000 had required 1 billion euros in subsidies, also skyrocketed. The figure has meanwhile reached 24 billion euros, i.e., some 270 euros per year for a three-person household; this includes not only the renewable energy surcharge but also other levies for renewables (BDEW 2014a: 6). This burden, too, is a consequence of the Renewable Energy Act, which introduced a levy on electricity consumption to finance the additional costs. Some have therefore denied that this is a matter of subsidization, pointing out that the state does not pay a cent. This is a technically correct but a somewhat hair-splitting argument, which becomes absurd when it is claimed that the government is cheating the public. According to Claudia Kemfert, the state is evading its responsibilities, because it is passing on costs already met by the government to power customers (Kemfert 2013: 77). But the public purse is not filled by lottery winnings; the government can only spend what it has collected from the citizens in taxes or in other ways. Whether financed by taxes, by a surcharge on electricity consumption, or by emission certificates makes little difference. Ultimately, the costs have to be met by the taxpayer and/or the consumer.

It should also be remembered that coal and nuclear energy have been heavily subsidized in the past and still are. But coal has always been obtainable for power generation at competitive prices on the world market and subsidies have served (and will do so until 2018) to promote coal and thus protect jobs in Germany. In the case of nuclear power, however, there is another side to subsidization that does not recommend it: public funding has made developments possible that would otherwise not have taken place and whose costly consequences we now have to bear (FÖS 2010b).

But apart from such highly charged political arguments, there is no denying the difficulty of accurately identifying the costs of the energy transition and above all of calculating them. It is too simplistic to count only the price of electricity, heat, and petrol as costs. Just as important are the external costs, i.e., consequences for the environment and climate, which differ considerably for fossil fuels and renewable energies.

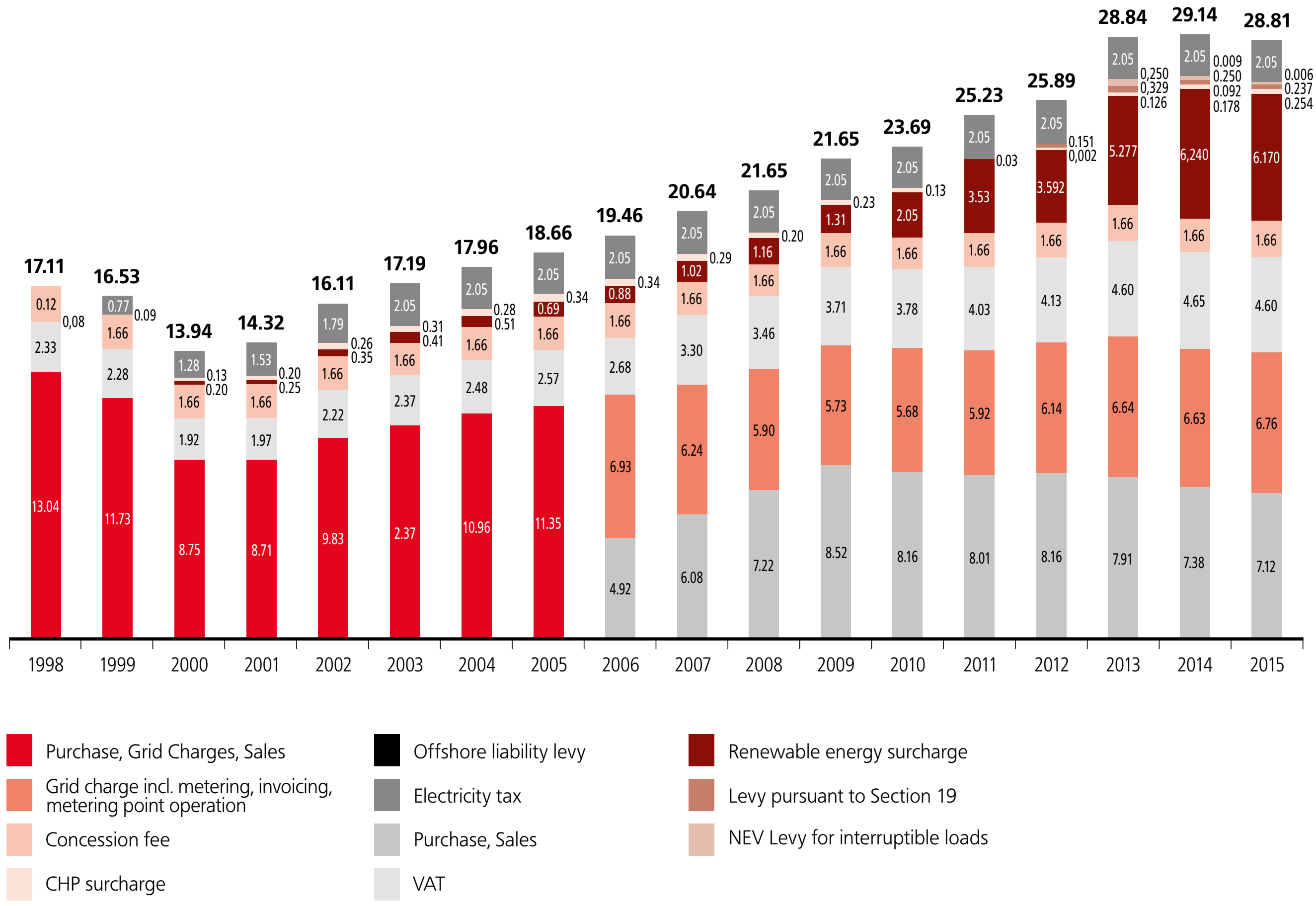
3.6.1 EXTERNAL COSTS

From extraction to consumption, fossil fuels emit not only carbon dioxide but also many other pollutants. These emissions cause a wide range of illnesses, have far-reaching impacts on the environment, and give rise to substantial costs that can be described as "external" because they are not incurred by emitters but are externalized. They accordingly do not appear in petrol, coal, or electricity prices but have to be calculated separately. A study by the Federal Environmental Agency (UBA) puts the external costs of electricity generation from coal and lignite at between 6 and 8 cents per kilowatt-hour. Particularly serious damage is done by lignite and hard coal, for which external costs are estimated to be 8.7 cents and 6.8 cents/kWh, whereas for comparatively clean natural gas the figure is much lower at 3.9 cents (UBA 2007: 76, 82). Even renewables produce external costs, be it in production, transport, installation, or the disposal of old solar systems and insulation material. However, these costs are much lower than for fossil fuels, and, in particular, their contribution to global warming is very low. The UBA study put it at under 1 cent/kWh. In order to calculate the actual costs of electricity generation and consumption, these external impacts on the price of electricity would have to be added, making renewable energies more competitive and requiring lower subsidies. However, nuclear power stations also have a relatively good CO_2 record, and there are environmentalists who are therefore in favour of them. Moreover, they produce particularly cheap electricity. But this is only a commercial calculation. In fact, nuclear power stations produce considerable external costs, as the current debates on expensive permanent repositories, the costly demolition of old plants, and the risk of accidents have shown (FÖS 2010b).

It is important to consider external costs and to take them into account in calculating actual costs. In practice, however, it is a difficult undertaking, despite the studies that have been done on the issue. They have had to rely on estimates, and it is obvious that assessment of the likelihood and extent of damage can vary strongly. There is another, not necessarily smaller problem: international consensus is needed to take these costs into account in setting energy prices. Individual countries could take the lead in this. But then higher energy prices would apply in these countries at the cost of private consumers and industry. What is therefore required is a European arrangement such as already exists in the form of emission certificates. The basic idea is temptingly simple. Whoever emits CO_2 has to buy emission rights. The price is intended to increase gradually, so that "dirty" sources of energy will become more and more expensive and no longer be able to compete on the market.

This had been the plan, but so far it has not come to fruition. Prices have not risen; they have fallen to so low a level that certificates have become practically irrelevant (see figure 9). The main reason is the 2008 global economic crisis, which brought a decline in industrial production. As a result, emissions dropped and hence the price for certificates fell so low that, at the current (2013) level of 5 euros per tonne of carbon dioxide, they no longer offer any incentive. What makes the situation worse is that free certificates had initially been generously distributed to industry to ease the burden on them. If the desired effect is to be achieved, a price of at least 60 euros is needed. But this is easier said than done, because higher prices have to be set by politicians under considerable pressure from industry and from many voters worried about sales and jobs. A gradual rise is therefore more likely, so that external costs and environmental damage will have little impact on electricity prices for the foreseeable future. This puts the energy transition under strain: efforts to protect the environment cause additional expenditure, which – in contrast to external costs – directly affect power prices, driving them up. This consequence had been recognized when the Renewable Energy Act was passed, but it had been assumed that costs would progressively fall and would soon play no role.

Figure 8
Development of Household Power Prices, 1998–2015



Source: BDEW 2015: 48

3.6.2 RENEWABLE ENERGY SURCHARGE AND MARKET PRICE

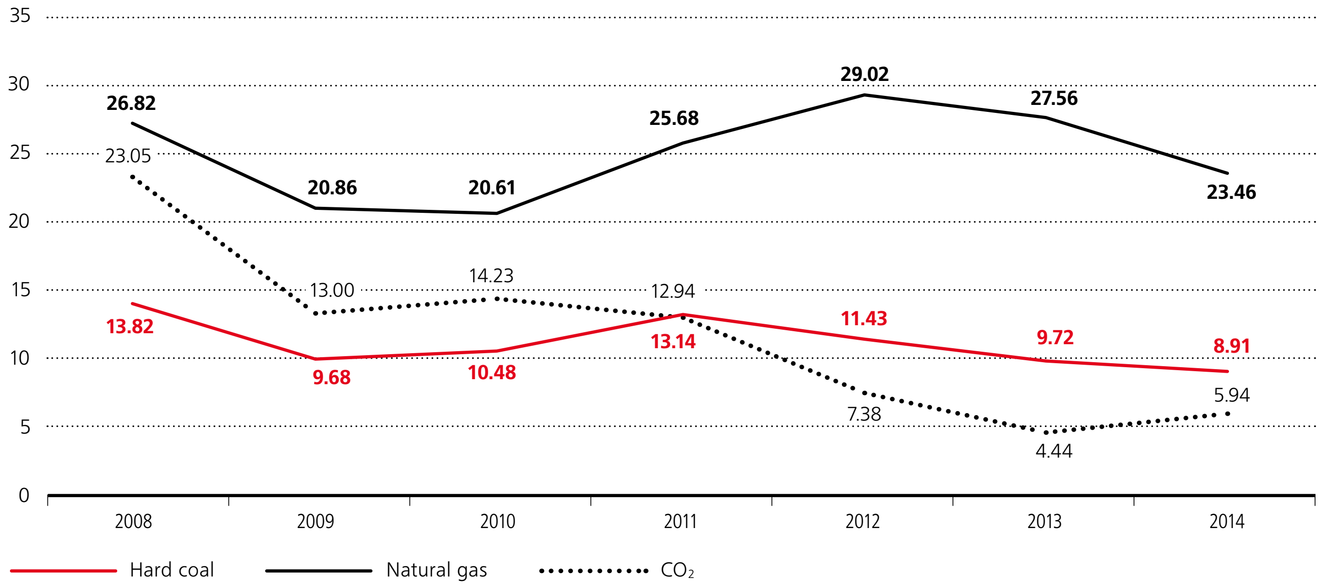
When in 2000 the Renewable Energy Act set guaranteed prices, this was supposed to be a temporary arrangement. It was to provide knock-on financing and encourage demand for renewable energies, research, and lower production costs. Since it was also assumed that prices for oil, coal, and gas would rise worldwide, renewable energies were expected first to become competitive and then even cheaper. These expectations were only partly borne out. Technological progress, greater efficiency, and falling production costs were achieved in wind turbines, biomass plants, and solar panels, and particularly in photovoltaic systems. The electricity they generated was initially so expensive that the guaranteed price rose to 57.4 cents/kWh. Now, by contrast (June 2015), it is only 12.4 cents for small installations and only 8.59 cents for larger ones. At the same time, however, and contrary to all expectations, the price of fossil fuels also fell.

This is a global development; how long it will last is difficult to judge. Sometime or other energy prices will rise again; but at present the low level means that the difference between guaranteed price and market price (differential cost) is unexpectedly high, entailing additional expenditure.

However, in Germany this is also exacerbated by the fact that renewable energies spread so rapidly, putting pressure on the electricity price owing to their sheer growth. Guaranteed prices went with purchase guarantees, and offered such favourable conditions that more and more electricity was produced and put on the market in Leipzig, where all electricity, whether from renewable or fossil sources, is traded. The European Energy Exchange in Leipzig has existed since 2000 when electricity trading in Europe was liberalized to enhance competition. This goal has been attained. Initially, the exchange price rose only to fall again to a mere 4.2 cents (December 2014) because the economic crisis led to lower demand while supply was increasing. For those who generate electricity from renewable energies, this development is not a problem because they are paid at prices guaranteed for 20 years. Since, however, the difference between guaranteed price and the market price on the exchange grew, unexpectedly high subsidies were necessary, which were factored into electricity prices – so that they rose.

Coal and lignite-fired power stations also contributed to the surplus, because they have to operate continuously to produce electricity cheaply. They can react only slowly to fluctuating demand and can reduce output only to a limited extent. Things are much simpler with gas-fired plants, which

Figure 9
Gap between Coal, Gas, and CO_2 Prices, 2008–2014*
Border crossing costs in euros/MWh and certificate prices in euros/t CO_2



Source: AGORA Energiewende 2015

* The gap between coal and gas prices increased strongly from 2010 and closed somewhat only in 2014. CO_2 prices remain low.

also have the advantage of emitting relatively little CO_2. But this is where the merit order effect comes to bear (see figure 10). If prices fall on the energy exchange, power stations whose production costs exceed market prices are shut down one after another. The first to be affected are gas-fired power plants, which operate relatively expensively, so that they became less important. A striking example is the Irsching plant, one of the most modern and efficient in Europe. In the past year, two units produced no electricity at all for the market, but were brought on line only briefly to ease supply bottlenecks. It received compensation, but the relevant contracts are running out, so that the operators have announced they will be shutting down the two units.

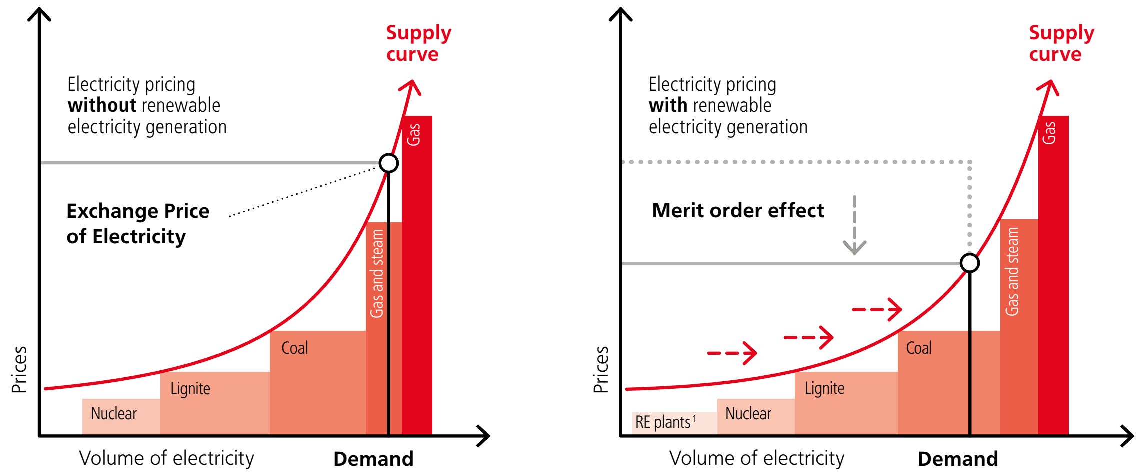
The beneficiaries of this development are power stations that fire hard coal and, in particular, lignite, which have low operating costs and have therefore enjoyed an upswing in recent years. At the same time, lignite combustion produces considerable amounts of greenhouse gases, which jeopardizes a key objective of the energy transition. The Greens leader Simone Peter has even spoken of a grandiose failure, an assessment shared by Greenpeace and other environmental groups "It's a damning indictment that low-carbon technologies come up against economic limits while old coal-fired climate killers remain in use" (Tagesschau 2015).

This statement is not wrong, but is nevertheless somewhat simplistic. After all, the situation is an (unintended) consequence of the Renewable Energy Sources Act, in which the Greens themselves played a decisive role when in government. The act adopted at their urging was designed to improve the prospects for renewable energies. It concentrated on producing renewables, and has proved very successful in achieving its aim. In a certain sense it was too successful, for the volume of electricity generated grew so fast that prices fell, gas-fired power plants became less important, and hard coal and lignite have been increasingly used. This development was not intended, but it is also hard to influence, if only because these fossil power plants have long-term operating licences that cannot simply be revoked. Moreover – it should be recalled – they had been constructed until only a few years ago with general consensus to ensure independence from oil and nuclear power.

Furthermore, the rapid rise in costs came as a surprise and was also difficult to control. Year after year, the competent experts set new guaranteed prices for the various renewable energies without being able to assess with certainty how the costs for wind turbines, solar systems, or biomass power plants would develop in reality. Undesirable developments can occur, such as the boom in PV. When the costs for PV installations fell much more strongly than the guaranteed prices, this opened up unusually good earnings potential. Between 2009 and 2012, an additional 7.5 gigawatts of capacity were consequently installed, so that the share of these plants in the energy mix grew rapidly. However, subsidies grew still faster; in 2014 they accounted for almost 49 per cent of the total, whereas these systems generate only 25.1 per cent of electricity from renewable sources owing to their low utilization rate (BDEW 2014: 69).

Since subsidies also increased for other renewables, the Renewable Energy Act was amended in 2014 to get further developments under control and prevent costs from rising too fast. To this end, the amended act lowered support rates for individual renewable energies, limited volume growth,

Figure 10
Merit Order Effect



Note: owing to renewable energy plants, the supply curve shifts to the right in the right-hand figure.
If demand is constant, this leads to a lower exchange price for electricity. The price difference corresponds to the merit order effect

[1] Energy from fluctuating renewable energy sources (PV, wind): marginal costs = 0

Source: BMWi 2014b: 33

and set development targets for the coming years. The detailed arrangements are extremely complicated and to be understood only by experts, who now have to take almost 4,000 rates into account. There is also some flexibility, for instance where existing wind turbines are replaced by new, more efficient ones (repowering). At any rate, the objective is clear. The new rules are to ensure affordability and the security of supply.

However, they address only some of the costs that will arise in the years to come to create better storage, develop networks, and keep power plants in reserve. Thus the cost of developing power grids is estimated at between 27.5 and 42.5 billion euros (Monopolkommission 2013: 121), and the cost of storage, intelligent electricity metering, etc. is difficult to put a figure too, but will not be inconsiderable. More fundamental changes in support are also being discussed to keep costs down. Since adoption of the Renewable Energy Act, support has been based essentially on price and purchase guarantees that ensure investment security.

Such guarantees apply not only for wind turbines, biomass plants, and solar panels, and therefore for the generation of renewable energies, but also for the overall infrastructure required for transport, use, and storage. Thus firm promises are also made to grid operators, while people living in the vicinity of power pylons are to share in network income. The earnings involved may not be particularly high, but they are a secure income and attractive, since other forms of investment bring hardly any interest. Similar arrangements are meanwhile also demanded by power station operators required to keep plants in reserve, pumped storage plant constructors, and many more expected to contribute to managing fluctuations and enhancing supply security. In this context, the threat to close the Irsching plant can also be seen as a move to obtain support for continued operation.

Guaranteed prices have had the effect mentioned, but have also led to aberrations, unnecessary expenditures, and, not least, expectations that guaranteed revenues will continue to flow. The introduction of market elements and competition in the energy transition is therefore also being considered. One possibility would be to pay a bonus to anyone who reduces CO_2 emissions by a fixed amount or generates a given volume of electricity from renewable energies. Whoever offers the best price are awarded the contract and decide themselves how the target is to be met, by means of solar plants, wind turbines, energy saving, or other means. Like emission certificates, this is a tempting idea. But experience to date has not been conclusive, so that more ventures and discussions are to be expected, especially because any change affects existing structures and interests.

There is also a great deal of discussion about whether industrial enterprises should share the costs of renewable energies. This would not mean the whole of industry, since in 2014 some 96 per cent of establishments also paid the full renewable energy surcharge, including all those in trade, commerce, and services. Controversy focuses on the some 2,000 industrial plants exempted to varying extents from surcharges under the Renewable Energy Act and which therefore contribute little or nothing to the costs of the energy transition. This seems “unjust,” especially because the criteria for their selection are not always convincing. However, the exempted golf course was a fiction. But there are indeed enterprises granted this relief on questionable grounds. Overall, however, the concerns exempted from the surcharge were those that depend on cheap energy to remain competitive. They included aluminium smelters, which consume enormous amounts of electricity, as well as public transport, which needs cheap power for trams and subways, or the weather service, which uses power-intensive computers.

The number of enterprises concerned is small, but they consume some 20 per cent of electricity, so that their preferential treatment costs about 4 billion euros. If this exemption were to be removed, the renewable energy surcharge would fall from 24 to 20 billion euros – which would, however cause new problems. For concerns dependent on cheap power would have to be given relief in some other way. Or they would have to earn more – in the case of public transport, for example, by raising fares. The SPD/Green coalition had already recognized this dilemma and in 2003 therefore introduced the possibility of exemption and thus the redistribution of costs as a "special compensatory arrangement." Corrections were possible, the number of enterprises receiving relief could be reduced. But the potential for savings is likely to be limited if too much strain is not to be put on particularly big power consumers.

However, they benefit from falling electricity prices as do all who buy their electricity on the energy exchange or directly from power companies. Private households can do so too to some extent when they change providers. But they have little scope for savings, whereas concerns with sufficient demand can oblige suppliers to accept the market price, which has been falling for some time. In the industry there are therefore also firms that benefit from falling electricity prices. In principle, this profit could conceivably be siphoned off by introducing appropriate taxes or special levies. But this would require a great deal of effort and expense, would make the energy transition even more complicated than it is anyway, and would have little chance of being realized.

It would be just as difficult to modify redistribution among the states. They benefit to widely differing degrees from the energy transition, since wind turbines, biomass plants, solar systems, and other installations are not evenly distributed throughout the country. Schleswig-Holstein, Mecklenburg-West Pomerania, and Northern Germany as a whole produce a great deal of renewable energy, make a surplus and also create jobs in wind turbine construction. Since these areas are going through difficult times, renewable energies act as an economic development programme, which boosts employment elsewhere, as well. For 2012, the figure given is almost 400,000, but this is to be taken with a pinch of salt. The energy transition also costs jobs, for instance in conventional power stations. Also to be examined is whether the money spent here is not needed elsewhere where jobs could also be created.

In 2013, Bavaria was the state to make the biggest surplus, but had no need for this sort of support, whereas crisis-ridden North Rhine-Westphalia recorded an outflow of 2.9 billion euros and thus the biggest deficit. Ultimately, social redistribution is also involved. This support benefits primarily middle and upper class households that can afford to install solar systems and which receive subsidies for doing so. The poorer sections of the population, by contrast, have no share in this redistribution, while higher power costs claim a larger proportion of their income.

3.6.3 EFFICIENCY AND SAVINGS

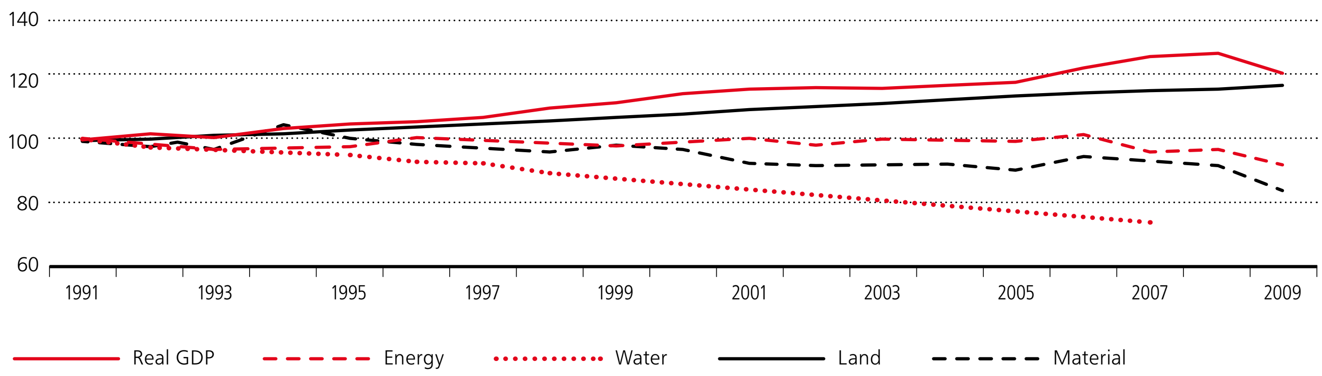
From the very outset, the debate on an energy transition has stressed the need to use energy more effectively and economically. Eppler had pointed this out in 1979; he was joined in this view by Volker Hauff and many experts, taking up an argument already widespread in the nineteenth century, when energy was dear and consequently less used. With the rise of coal and then oil, energy prices fell. The "age of combustion" was heralded in, leading to the "pointless squandering" of fossil energy, as the chemist Clemens Winkler complained in 1900 (Winkler 1900: 4f.).

It was only the oil crisis of 1973/74 that changed the situation. It brought a rise in the prices for oil and other resources, so that it made sense for economic reasons alone to reduce consumption. Since that time, considerable success has been attained in this field (see figure 11). While economic growth had traditionally led to more resources being consumed, these two processes have now to some extent been decoupled from one another. The economy can grow while resource consumption stagnates or even falls. However, this holds primarily for consumption per product produced, whereas overall it is declining only slowly or not at all. Moreover, the so-called rebound effect might develop if greater efficiency leads to lower costs for consumers, inducing them to consume more – we can take the example of cars, where economical engines can lead to more cars being sold and to corresponding increases in resource consumption.

Two challenges are therefore to be faced. First, the consumption of resources in industrial countries is still too high and has to be markedly reduced. On this subject, Ernst Ulrich von Weizsäcker together with other experts published a new Report to the Club of Rome in 1995 (Weizsäcker et al. 1995). They pleaded for a stop to the use of increasing productivity to produce more with less labour input. The aim should rather be the more economical use of nature and natural resources. If natural resources could be used four times more effectively than hitherto, their use could be halved and wealth doubled. The result would be a fourfold growth in resource productivity, "Factor Four," which could be attained by means of an efficiency revolution.

We are still far from this target, even if energy use is declining. By 2050, the federal government wants to decrease the consumption of primary energy by 50 per cent compared to 2008. This is an ambitious goal, and more difficult to attain through political measures than the promotion of renewable energies. So far this endeavour has relied mainly on financial rewards, also to be gained for improving the thermal insulation of buildings, reducing petrol consumption or in the use of technology, where subsidies are paid. However, tax revenues have to be used for this purpose, which are not inexhaustible and whose use is always controversial. Just as important, therefore, are stricter rules that impose more effective thermal insulation, reduce petrol consumption, or require the installation of heat pumps. Together with financial incentives, such rules will lead to greater economies and greater efficiency – albeit only gradually. The efficiency revolution Weizsäcker et al. envisaged is not yet in sight, and is likely to prove difficult as long as energy prices do not rise markedly. The greatest

Figure 11
Economic Growth and Resource Consumption, 1991–2009
Development of gross domestic product and consumption of natural resources, 1991 = 100; land consumption 1992 = 100



Source: IW Köln 2012.

incentive for using energy and other resources more economically is rising costs.

3.7 ENVIRONMENTAL COMPATIBILITY

The question of what brings ecological sustainability in the energy transition is easy to answer: above all reductions in the use of energy (and other resources). The second best possibility is to increase the share of renewable energies. They cause the lowest external costs and, in particular, allow substantial reductions in greenhouse gas emissions. In 2013, 145.8 million tonnes were saved with the help of sun, wind, hydropower, biomass, and other sources. However, biomass poses a problem (BMWi 2014: 7). It can help reduce greenhouse gases, but it can bring considerable ecological disadvantages if monocultures spread, wastewater is polluted, or biodiversity endangered. The further development of biomass has therefore been limited, whereas the ecological record of renewable energies as a whole has been unequivocally positive.

Health aspects must also be considered. Fossil and biogenic fuels emit not only greenhouse gases but other pollutants, as well, such as nitrogen oxide, particulate matter, and mercury. They have a negative impact on both the environment and human health, and emissions have to be reduced as much as possible. Furthermore, climate change – over and above an increase in extreme weather situations – can lead to a loss of species diversity and habitats. However, the further development of renewable energies can affect nature and landscape. More care in selecting suitable sites is necessary to minimize these impacts (BMWi 2014c: 10).

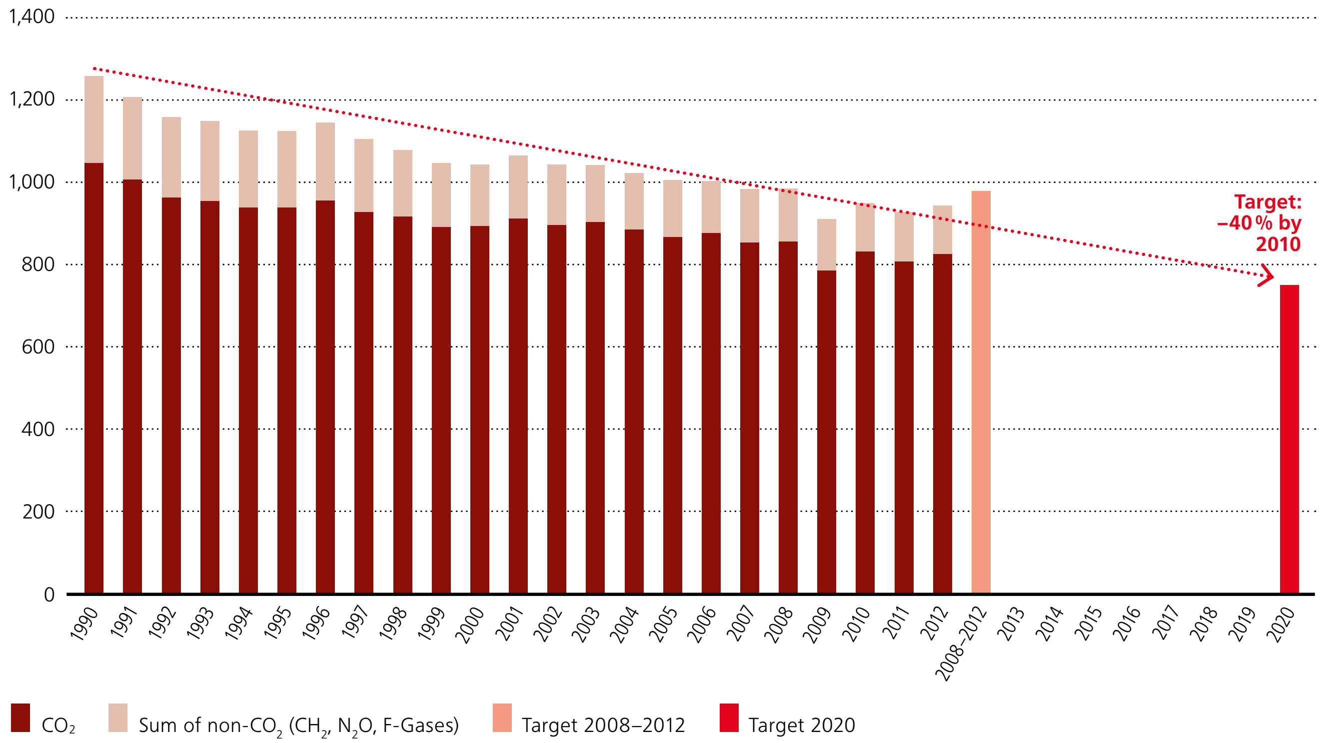
Despite the basically positive record, $C0_2$ emissions in Germany have hardly fallen since the beginning of the energy transition. There was a marked reduction after 1990, but this was due largely to the closure of plants in the former German Democratic Republic, which emitted particularly large amounts of this gas. When official data then takes 1990 as the reference year and claims environmental policy successes, it is against the backdrop of a random, non-recurrent factor. It is also going too far to claim that 145.8 million tonnes of greenhouse gases were saved by the use of renewable energies in 2013. The figure is correct, but only 84.3 million tonnes were saved due to the Renewable Energy Act and its tariffs. The rest of the savings, no less than 42 per cent, were produced by hydroelectric plants, wood combustion, and other traditional sources that would have taken the same share even without the energy transition (BMWi 2014: 7).

Even if data have been somewhat embellished, emissions did fall after 1990, reaching their lowest level in 2009. Thereafter, however, they rose again, and in 2012 the figure for CO_2 had once again nearly reached the level of the year 2000 (see figure 12). Current figures for 2014 are somewhat more encouraging, but are to be attributed largely to the mild winter (AGEB 2014). A key goal of the energy transition had therefore only partially been attained. Furthermore, the situation has worsened, particularly in recent years, despite the rapid rise in the use of renewable energies. There is a simple explanation. The rise led to the above-mentioned electricity glut and to falling prices, a situation in which precisely lignite and coal-fired power stations were able to keep pace. They produce particularly cheap power and have increased their share of the market.

This glut will continue for some years to come. One good thing is that fossil-fuel fired power stations facilitate the security of supply. This is an important objective, but greenhouse gas emissions must also be reduced. For the reasons mentioned, emission certificates are for the moment unlikely to help. As an alternative, the use of coal and lignite could be curbed politically, as is increasingly demanded (Greenpeace 2015). But the problem lies in the small print. As we have seen, these power plants have long-term licences, which cannot be revoked without legal entanglements and additional expense. Moreover, they provide jobs and many are not owned by anonymous "capitalists" but by power utilities or local authorities.

Among the utilities, big groups are still dominant that had long hampered if not prevented the energy transition and

Figure 12
Greenhouse Gas Emissions 1990–2012 and Targets
in mio. t CO_2 equivalents



Source: BDEW 2014: 85

which until a few years ago earned well in the power business. These golden days are over – which does not exactly provoke sympathy. But stockholders include pension funds, insurance companies, and local authorities, which are suffering painful losses as the value of their shares diminishes and dividends are not paid. This is particularly the case for local authorities in the Ruhr District that bought power stations because they offered good returns and helped to finance local budgets. Now they are a heavy burden on authorities that are in dire straits as it is, so that decisions for or against coal and lignite-fired power plants have to take account of many contradictory interests and objectives.

This was brought home to the federal minister of economics Sigmar Gabriel in March 2015, when he suggested reducing the CO_2 emission level of 340 million tonnes in 2014 to 290 million tonnes by 2020. This would mainly affect older hard coal and lignite-fired plants, which emit high levels of carbon dioxide. Gabriel proposed setting ceilings for emissions and imposing a "climate charge" of between 18 and 20 euros per tonne of CO_2. Operators would then have to decide whether to pay this levy, cut back production, or shut down power plants. The environmental organization WWF called this a "start to credible climate protection," since the "oldest and most polluting power plants" would gradually be scrapped (Süddeutsche Zeitung 2015). But this initiative endangers jobs, not only in the power stations affected but also among suppliers and in lignite mining. That 100,000 jobs are at stake, as Frank Bsirske, chairman of the trade union ver.di, feared, seems somewhat exaggerated. But jobs would indeed be affected – in areas that are structurally weak and in financial difficulties. The structural changes taking place here cannot be avoided. But it should not be put under additional pressure.

These decisions are rendered more difficult by the phasing out of nuclear power. When they cease operation, not only will the abundant supply on the electricity market be reduced, which for some time now has brought low power prices; it could also prove more difficult to ensure the security of supply; and, finally, the closure of nuclear power stations will eliminate electricity producers that emit only small amounts of greenhouse gases. They are to be replaced by renewable energies, which, however, require coal and lignite plants to ensure supply security. The development of networks will therefore serve not only to transport from North to South electricity from wind turbines but also from these fossil-fuel plants. The alternative is gas-fired power plants, which emit much lower levels of pollutants and, moreover, could make it feasible to build only two of the three planned power lines. However, once built and in operation, these plants would be in place for many years, making it more difficult to expand the use of renewable energies. And they produce higher costs than the lignite-fired plants, so that their operators, too, would demand financial support. Despite this complex and contradictory situation, gas-fired power plants are likely to become more important in the years to come and displace coal-fired plants – now a worldwide trend. One important reason is hydraulic fracturing or fracking. In Lower Saxony, this technique has been used since the 1960s and has not caused any problems worth mentioning. Now, however, new methods described as unconventional are being used, which involve mixing water with quartz sand and chemicals, pumped at high pressure into shale and other tight-rock formations to extract the gas trapped there. Critics warn against the chemicals use in the process and have doubts about the need to use this technique in Germany (Advisory Council for Environmental Issues – SRU 2013). In late March 2015, the federal government tabled a bill prohibiting fracking at depths of less than 3,000 metres and in sensitive nature conservation and water supply areas but permitting exploratory boreholes for scientific purposes. A commission composed of experts is then to assess the situation, which in concrete cases can result in fracking being allowed (Frankfurter Allgemeine Zeitung 2015).

For some who regard fracking as dangerous and superfluous, these rules are not strict enough because they still allow the technique to be used. Others, who judge the dangers to be less grave and controllable, speak of an obstructive law. These positions are irreconcilable, and once again it is difficult to arrive at an unequivocal appraisal, since widely differing aspects have to be taken into account. Thus in the United States, gas has become so cheap because of fracking that coal-fired power stations can no longer compete and their carbon emissions have fallen. Worldwide, too, fracking gas can displace coal-fired power stations. As far as climate protection is concerned, a direct transition to renewable energies would be preferable. But given the worldwide importance of coal and the plans for improving the corresponding power plants, these consequences have at least to be considered in the global assessment of fracking.

After all, modern coal and lignite-fired power stations, too, could help towards the energy transition in the guise of bridge technologies. This may be a surprising view to take, for basically, their share in power generation needs to be reduced as soon as possible. In Germany, this goal can be reached. But as long as these fossil fuels are available worldwide cheaply and abundantly, they will continue to be very important in China, India, and elsewhere. There are, however, signs that the use of coal will be limited or even reduced in such countries. But there is a long road ahead. It could therefore make sense to use the knowledge we have in this country to refit existing coal-fired power stations or develop new ones in order to attain greater efficiency and reduce carbon emissions. There are considerable differences between old methods and new technologies, so that efficient coal-fired plants in China or India can improve the global climate balance – especially if CO_2 can be successfully captured and stored.

4

CONCLUSIONS

Any representation needs to be recapitulated in concise and unambiguous terms. This is not easy to do for the energy transition. The project is so complex and demanding that we have only been able to consider or rather merely outline certain aspects of the topic. As the saying goes, the devil is in the details. And this is particularly true for the energy transition, where so many issues come together and unexpected consequences occur. So any concise summary of the findings presented is impossible. Nor can they be reduced to unequivocal results.

With some degree of certainty it can be said that the energy transition continues to find broad support and willingness to bear the associated costs. The goals of the federal government can also be clearly enumerated: to increase the share of renewable energies in general energy consumption to 60 per cent and in electricity supply to 80 per cent; to reduce emissions of gases harmful to the climate by the same amount; and to halve primary energy consumption. These targets are ambitious but can in principle be attained even though there is controversy about what methods are advisable, what measures should be taken next, and which are realistic. To take just one example: Will there really be a million electric cars on German roads by 2020 as the federal government plans? If we reach this figure and at the same time reduce the use of fossil energies, including petrol, more electricity will presumably be required to replace them. Is it then realistic to reduce their use by 2050 to the extent officially projected?

There is no clear answer at the present time. The energy transition is in a sort of limbo where, although concrete measures have to be taken, uncertainty prevails about individual steps and about the fundamental direction to be taken. Will there soon be effective storage and ecologically more sustainable methods for producing biomass? Are PV and wind power plants still becoming more efficient and do they offer higher capacity utilization and thus greater supply security? Will the necessary success be attained in thermal insulation and energy conservation? Should price and purchase guarantees continue to predominate or can market elements offer less costly solutions? Will decentralization progress and will we be able to better adapt demand to offer?

Answers to these questions can only be found in the European context. If the German energy transition is to make progress, it is in the fundamental interests of social democracy to give appropriate shape to the nascent European Energy Union. However, even then no clear answers are yet to be found. Uncertainty will persist, various approaches will need to be taken in parallel so that we can learn from experience which are the most appropriate. In other words: the energy transition is a process whose goals have been no more than outlined and which repeatedly changes course.

Given the prospects of global warming, this uncertainty may well give reason to despair. Should drastic and effective emergency measures not be taken? Perhaps in principle, but in fact such measures are not available and there is even a risk that decisions once made will prove mistaken and difficult to correct. We therefore have to live with uncertainty, which does not mean leaning back and doing nothing. On the contrary: We can overcome uncertainty only if we accept the difficulties and contradictions associated with the energy transition. And only if we try over and over again to find ways to attain the goals set.

The SPD will continue to shoulder the important task it has long assumed in the energy transition: to achieve a balance between winners and losers; to take the various interests into account, to find compromises, and above all to secure the consensus that this demanding project calls for. This is no simple task and it is not always a grateful one. But it is indispensable if the goals of the energy transition are to be reached.

Figures

Abbreviations

AGEB	Working Group on Energy Balances
BDEW	German Association of Energy and Water Industries in Berlin
GDP	Gross domestic product
BMWi	Federal Ministry for Economic Affairs and Energy
bpb	Federal Agency for Civic Education
EEG	Renewable Energy Sources Act
EU	European Union, association of states with currently (2015) 28 Member States in Europe, since 1992
EEC	European Economic Community, since 1958 existing association of six European countries, predecessor of the EU
CHP	Cogeneration (CHP)
VAT	Value-added tax Federal
UBA	Environmental Agency

Glossar

Acid rain Acid rain refers to precipitation with a pH-value lower than that of pure water. The main cause of acid rain is air pollution, especially by acidic exhaust gases. Acid rain harms nature and the environment and is considered the main cause of so-called forest dieback or waldsterben.

Biodiversity The term “biodiversity” refers to diversity within species, diversity between species, and the diversity of ecosystems.

Biogenic The term “biogenic” refers to matter of biological/organic origin.

Biomass The term “biomass” covers various substances of organic origin such as excrements. In energy technology it refers to products that can serve in the generation of energy or as fuels.

Bridge technologies Bridge technologies are designed to facilitate a transition. Thus gas-fired power plants can serve in the transition to renewable energies, since they emit less CO_2 than other fossil-fuel fired power stations.

Brundtland Report The Brundtland Report “Our Common Future” was published by a commission headed by Gro Harlem Brundtland (former prime minister of Norway). It addressed the importance of sustainable development.

Club of Rome The Club of Rome was founded in Rome in 1968 and is now a global think tank comprising influential politicians, scientists, and business people. In 1972 the report “The Limits to Growth” was published, which was concerned above all with the finiteness of resources.

Cogeneration plant Cogeneration systems are (mostly smaller) units for generating electricity and/or heat, which are generally located where the heat/electricity generated in used.

Cogeneration/Combined heat and power (CHP) Cogeneration or CHP refers to the simultaneous conversion of fuels into electric power and useful heat in a localized technical installation.

Decentralization of energy supply Decentralized energy supply provides for energy to be produced close to where it is consumed.

Demand Side Load Management The term (also demand load management) refers to the purposive control of demand-side loads.

Desertec Dersertec is the name of a consortium of firms, environmental organizations, and private persons planning to generate green electricity in high-energy locations. There have been plans to generate solar power in the Sahara and transport it to Europe.

Differential cost/renewable energy surcharge Differential cost or the renewable energy surcharge refers to the difference between revenue and expenditure in paying for and selling the electricity from renewable energies.

Efficiency Efficiency (efficiency principle) is a statistical assessment procedure in calculating the energy balance. The energy resources for which there is no uniform conversion factor like the calorific value are assessed on the basis of defined degrees of efficiency. For nuclear energy, an efficiency of 33 per cent is assumed, for power generation from wind, sun, and hydropower an efficiency of 100 per cent.

Emission certificates (emission rights) In order to emit a given amount of carbon dioxide, power stations and certain industrial plants are required to obtain CO_2 certificates. The amount is limited and falls over time.

Energy efficiency Energy efficiency is concerned with the greatest possible effect in converting energy and the smallest possible consumption of energy by buildings, appliances, and machines.

Energy productivity The term energy productivity describes the efficiency of energy use.

Environmental heat. Heat that is contained in the air, the ground, or groundwater and which can be used to provide energy. Heat pumps are used for this purpose.

External costs External costs are costs that arise through economic activities which are not reflected in the market price. Examples are damage to the environment or to health.

Final energy consumption Final energy consumption is the part of primary energy available to consumers after deducting transmission and conversion losses.

Final energy The energy minus all losses that are available to consumers in the form of heat, electricity, or fuels is called final energy. Final energy can take the form of, for example, district heat; electrical power; hydrocarbons such as petrol, kerosene, and fuel oil; wood; and various gases such as natural gas, biogas, and hydrogen.

Fossil fuels Fossil fuels are composed of biomass and have come into being over millions of years under high pressure and at high temperatures. They include oil and natural gas, as well as lignite and coal. Their use leads to the emission of greenhouse gases such as carbon dioxide, which has a harmful impact on the climate.

Fracking Fracking or hydraulic fracturing is a procedure that permits natural gas and oil resources to be extracted in an unconventional manner from caches trapped in deep shale formations. A mixture of water, sand, and chemicals is injected into the rock under high pressure to fracture it.

Geothermal power Geothermal power involves using the energy that is stored in upper strata of the earth or in groundwater. Depending on conditions and needs, the temperature can be used to provide heating and cooling, or to store energy.

Greenhouse gas Greenhouse gases are gaseous substances in the air that contribute to the greenhouse effect. They can be natural in origin but also be produced by human agency. Major greenhouse gases are carbon dioxide, methane, nitrous oxide (laughing gas), chlorofluorocarbons, sulphur hexafluoride, and nitrogen trichloride. Large amounts of carbon dioxide are emitted by the combustion of fossil fuels.

Gross domestic product Gross domestic product is the monetary value of all the finished goods and services produced within a country’s borders in a specific time period minus imports

Gross electricity consumption Gross electricity consumption is the sum of domestic electricity production (wind, water, solar, coal, oil, natural gas, etc.) plus electricity imports minus exports. Net electricity consumption is gross electricity consumption minus grid and transmission losses.

Gross electricity production Gross electricity production is the total amount of electricity generated in a country; subtracting the consumption of power stations’ auxiliary services gives net electricity production.

Gross final energy consumption Gross final energy consumption is the energy used by the final consumer plus energy lost during generation and transport. The gross final energy consumption for renewables is calculated on the basis of final energy consumption by households, transport, industry, and the sectors trade, commerce and services plus own consumption by the transformation sector, flare losses, and power output losses.

Levy pursuant to Section 19 (2) StromNEV This section of the Electricity Grid Charges Ordinance exempts major electric power consumers partly from network charges.

Merit order effect The merit order is the sequence in which power plants contribute power to the market. This is determined by the marginal costs of electricity generation, so that low-cost plants are called upon first. The merit order effect is the consequent fall in prices on the power exchange.

Particulate matter Also known as particle pollution or PM, particulate matter is a complex mixture of extremely small particles and liquid droplets. Particles have a maximum diameter of 10 micrometres (μm) down to no more than 0.1 μm.

Photovoltaic (PV) systems Photovoltaic systems convert solar energy into electrical power.

Power grid The term power grid in energy technology refers to a network of power lines and switching and transformer stations together with the connected power plants and consumers.

Primary energy consumption As defined by the OECD, primary energy consumption refers to the direct use at the source, or supply to users without transformation of crude energy, that is, energy that has not been subjected to any conversion or transformation process.

Primary energy Primary energy includes final energy (see there) but also all deductions such as energy losses in conversion or transmission.

Pumped storage plant When there is a surplus of power and/or if electricity prices are particularly low, these plants pump water into a reservoir (usually a dam) to be used to generate electricity if the need arises. In the energy transition they are to be held in reserve to cope with fluctuations in power supply.

Rebound effect When efficiency in production and consumption increases, fewer resources are needed. Since this also means that consumer prices fall, cheaper products could be bought in greater quantities and/or used more intensively. As a result, individual products will require fewer resources, but overall resource consumption can even increase.

Renewable energies Renewable energies are energies that are obtained from sustainable sources such as water, wind, sun, biomass, and geothermal heat. Unlike fossil fuels such as oil, natural gas, hard coal and lignite, as well as the nuclear fuel uranium, these sources of energy are not depleted over time: they are renewable.

Renewable Energy Sources Act (EEG) The 2000 act stipulates that network operators have to give preference to renewable energies, sets tariff rates (guaranteed prices) for the various types of energy production, and specifies that extra costs are to be divided among all power users.

Repowering Repowering means that old wind power plants can be used more efficiently through innovations but that existing installations can continue to be used.

Smart grids New digital technologies are to link electricity generation, power transmission, and load management efficiently.

Spinning Jenny This was the name given to the first industrial machine for textile production.

Tsunami A tsunami is a tidal wave triggered by earthquakes, which spreads over great distances, reaches enormous dimensions and can cause devastating damage.

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