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Megatrends in the global energy transition

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WIR BESCHLEUNIGEN DIE ENERGIEWENDE

LichtBlick
Generation reine Energie

The leading renewable energy supplier LichtBlick and the conservation organisation WWF Germany are working together to speed up the energy transition in Germany. They pursue a common aim of inspiring people for change and of drawing attention to the enormous opportunities for a renewable energy future.

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Introduction

It was a surprising statement for an important summit: in Schloss Elmau, Bavaria at the beginning of June 2015, the G7 heads of state and government announced the global withdrawal from the carbon economy. As the century progresses, the world must learn to do without lignite, coal, oil and natural gas completely.

In truth this aim is not only urgently needed in order to stem the dangers of climate change, but also achievable. The energy transition has become a massive global force, expansion of renewables is making progress worldwide faster than even the optimists believed a few years ago.

This report provides wide-ranging evidence that the global conversion of the energy system has started and is currently accelerating rapidly. It shows that renewable energies – and solar energy in particular – have undergone an unparalleled development: from a niche technology rejected as being too expensive to a global competitor for fossil and nuclear power plants.

The end of the fossil-nuclear era has in fact already begun. Public investors such as the Norwegian pension fund, insurance companies such as AXA, the Church of England and even the Rockefeller Foundation are withdrawing their money from companies which mine coal, sell oil or transport gas.

And the transformation of the energy sector has long since spread beyond the confines of Germany. Numerous other EU states and countries such as the USA and China have followed the „German energy transition“ example. All over the world a veritable race is now in progress. Germany needs to take care that in future it is not left behind.

The approaches vary from country to country. In Germany as everywhere the details of the energy transition still raise a great many questions, however the major trends are clear. This report follows up these global megatrends. Some findings have been surprising and inspiring. We hope that this report will inspire and motivate you as much as it does us.

Heiko von Tschischwitz

Founder and CEO of LichtBlick

Eberhard Brandes

CEO WWF Germany

Summary

Beginning with the German energy transition, the following report takes a close look at current developments in the energy industry beyond the borders of Germany. The result: Germany has not been alone in pursuing the goals of the energy transition for some time. On the contrary, our country is now part of a global movement which, under pressure from the reality of climate change, the meltdowns at Harrisburg (1978), at Chernobyl (1986) and Fukushima (2011) as well as regional environmental devastation caused by the current prevailing energy system, is trying to get past the fossil-nuclear age and establish a low-risk energy system. The transformation offers enormous opportunities for those who are pioneering the development. For this reason and in view of certain signs of fatigue in pursuing their energy and climate policies, Germany and Europe need to be careful not to fall behind the dynamic of the global energy transition.

Five megatrends can be identified on a global scale:

1. The end of the fossil era has begun

The successful global progress of renewable energies, the signal sent by the G7 states from Schloss Elmau in June 2015, the discussion started after the climate protection pledge in the USA and China on an effective global climate regime plus the decreasing use of coal in China and the USA and a spectacular drop in the price of oil since 2014 all lead to the question of whether the beginning of the end of the fossil age has already begun. Besides the reality of climate change, the drivers of this development are the increasingly volatile energy prices, particularly the above-mentioned drop in the price of oil, and a growing global awareness of the health effects of fossil energy generation, leading to growing regional protests.

2. The energy future has already begun

The energy transition is a global reality. Photovoltaics and wind energy in particular have developed within a few years into new key energies for the 21st century. In 2013 more renewable energy power plants in terms of power generation capacity were set up worldwide than coal, gas and nuclear power plants put together. In terms of investment, the renewables sector is now significantly ahead of traditional energy technologies.

3. The energy future is renewable

The global progress of renewable energies is primarily a result of the almost unbelievable success in reducing the costs. Wind energy plants on land are still the most cost-effective technology for renewable power generation. But in Germany the costs for solar power have dropped by 80 per cent since 2005. Increasing numbers of economy and financial experts are basing their analyses on photovoltaics now becoming the most cost-effective technology for electricity generation in ever more regions of the world. Electricity from the sun and wind will expand its triumphal progress beyond the power sector into the areas of mobility and heating.

4. The energy future is decentralised

Energy generation from wind and sun but also from other renewable energy sources is decentralised. Instead of a few large power plants, in the energy system of the future millions of small plants will generate energy. Many of the stakeholders involved are both producers and consumers of power (prosumers). However, this does not mean that only small power plants will be left. The large systems and plants based on wind and solar power will probably retain their position in the new energy system. But in many poorer regions of the world which have an abundant supply of sun and wind, members of the public as prosumers could benefit long-term from decentralised renewable energy systems.

5. The energy future is digital

energy system of the future characterised by volatile wind and solar renewable energies. The IT and energy sectors are growing together. Only a combination of both will be able to reliably match the energy supply and demand at all times. The rapid cost degression in the storage technology, particularly for small and large battery banks, opens up the possibility of reliable energy supply at any time, finally even with a 100 per cent transfer to renewable energies.

Germany has done the energy transition a great service

- **The energy transition in Germany is a whole-society project whose aims are shared by a vast majority of the population**

- **Germany has helped to mould the global development and now needs to be careful not to change from pioneer to latecomer**

The energy transition in Germany is making progress. Hundreds of thousands of people are committed to its aims.[1] A vast majority of the population supports the transformation of the energy system. However, there is still disagreement as argued in the media i.e. the public opinion that is portrayed there. The argument centres on the How, on the precise form the energy transition will take, but rarely now on the If.

Germany and the Germans can justifiably be proud of having put the energy transition on the agenda not only in their own country. The fact that one of the most successful industrial nations has decided to give up using nuclear power, to get control of the unchecked combustion of coal, oil and natural gas and to usher in the era of energy efficiency and renewable energies arouses great interest all over the world. And that is not all: regulatory instruments and technologies for the energy transition conceived here in Germany are copied, adapted and developed further by other countries.

The aim of the energy transition generation project is a future-proof energy system free of nuclear disasters and the limitation of climate change to a global temperature increase of a maximum average of two degrees Celsius compared to the pre-industrial level.

Undeniably, a relatively small country in terms of area and population like Germany can only make a limited contribution to global hazard control in purely quantitative terms. Only two per cent of the nuclear reactors operating throughout the world are located in Germany (in numbers: 8 of 438)[2]. And Germany's greenhouse gas emissions contribute 2.25 per cent to global climate change.[3] This trend has also been falling for many years. In other words, if it is only Germany which closes its nuclear power plants by the end of 2022 as planned and reduces national greenhouse gas emissions by 80 to 95 per cent by 2050, this alone will not save the planet. From the start, the German energy transition has always been a demonstration of political and economic feasibility. It demonstrates the feasibility of the transition to a sustainable energy system in a highly industrialised country. The message is: this country is getting ready for the future and its society and economy are profiting as a result.

What is more, the "German energy transition" is turning into a successful export in increasing numbers of countries and regions of the world. The days are numbered when opponents of the energy transition could speak of a "German Sonderweg" in relation to the rest of the world. The fourth largest industrial nation has not been alone on this path for quite some time. All over the world influential and less influential nations have set out on their own energy transition. These include what are nowadays seen as the key countries China and the USA, alone currently responsible for half of the greenhouses gases emitted in the world[4].

German energy consumers have done an impressive amount to advance the energy transition first at home and then around the world. In addition, from Sonthofen in the south to Flensburg in the north, hundreds of thousands of members of the public have made the energy transition their own business in a very practical way. They have attached millions of solar modules to their roofs, they have put there savings into tens of thousands of wind turbines, farmers have created a new source of income from bioenergy. As a result, the familiar separation of power producers and consumers which has lasted an entire century is starting to disappear. The Internet is becoming an "Internet for everything", including for a comprehensive intelligent control instrument for the energy system of the future. Now however, when the energy transition is getting underway in ever more and increasingly influential countries of the world, Germany needs to make sure that, in the most crucial years, it stays not just somewhere in the crowd but remains at the forefront.

An optimistic look at the energy transition – Three preliminary remarks

Surprises are unavoidable, renewable energies are disruptive and predictions are frequently just hot air

As far as the surprises go, in the case of renewable energies these have consisted so far in the national, European and global consistent underestimation of their future spread. This is another fundamental distinction between eco-energy and nuclear power whose future importance was overestimated for decades, sometimes vastly so – not only by the International Atomic Energy Agency IAEA[5] and the nuclear industry itself, whose job was and is this kind of propaganda, but also by scientific institutions, international energy agencies and governments. The misleading predictions which underestimated the renewables boom for decades may partly be explained by the close connection of the originators with the existing energy system. For instance, the International Energy Agency (IEA), as one of the institutions of the western industrial nations close to the global energy businesses, only managed to adjust its forecasts on the expansion of renewables in relation to the existing developments after a delay, to then fail once more with the future predictions. The consequences of this repeated IEA forecast exercise in its annual leading publication World Energy Outlook (WEO), despite a certain approximation to reality, has recently been portrayed in detail in a critical report.[6]

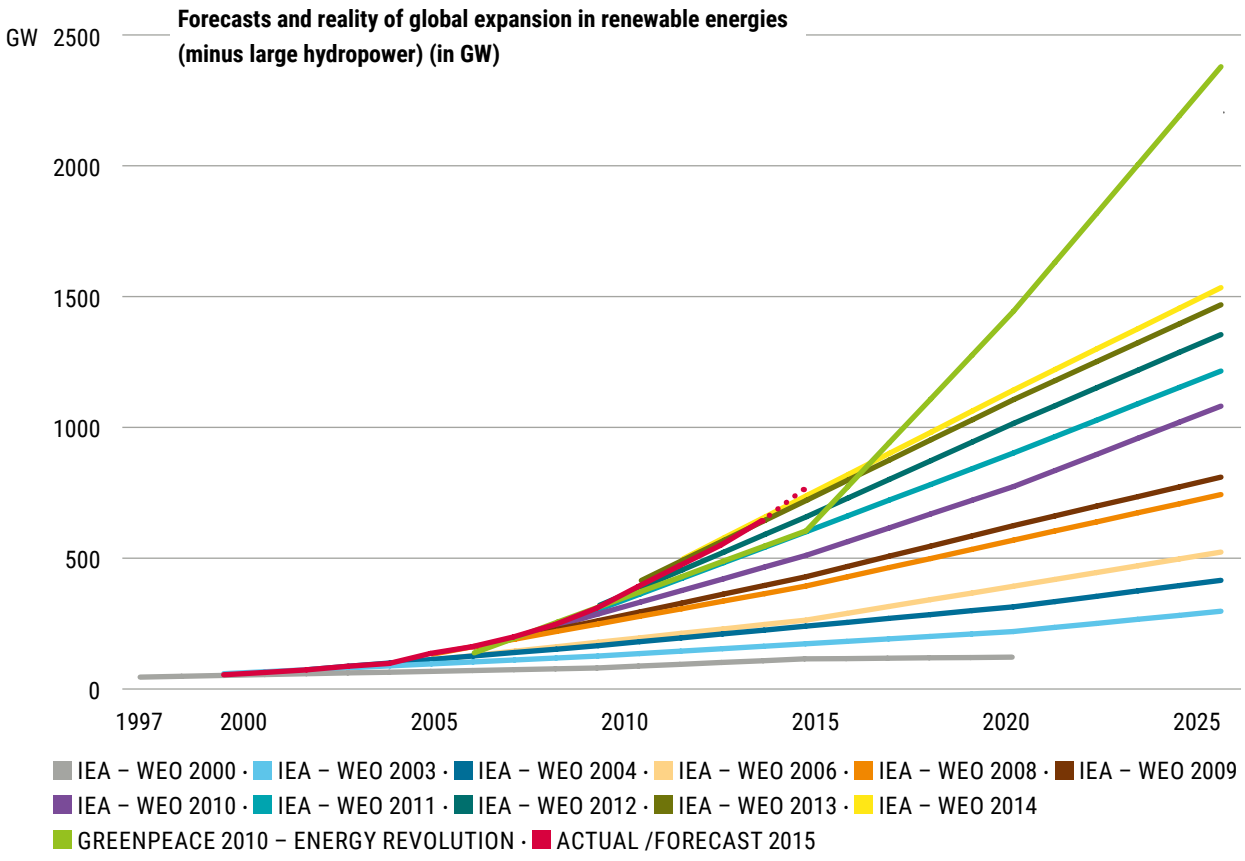

Figure 1: Projections on the expansion of renewable energies globally and their actual development;
Sources: IEA, Greenpeace, IRENA, Projection IHS/WWEA, 2015

Despite a noticeable increase in awareness of the problem, particularly on the issue of global warming, the IEA still finds it difficult to accept the years of above-linear growth of wind and PV capacity, even for the immediate future. In contrast, environmental organisations such as Greenpeace estimate the actual level of global expansion in renewable energies much more realistically overall. Nevertheless, as far as the current explosive expansion in global photovoltaic capacity is concerned, even the environmental activists' forecasts were far below the actual development.

Forecasts and reality of global expansion in solar energy (in GW)

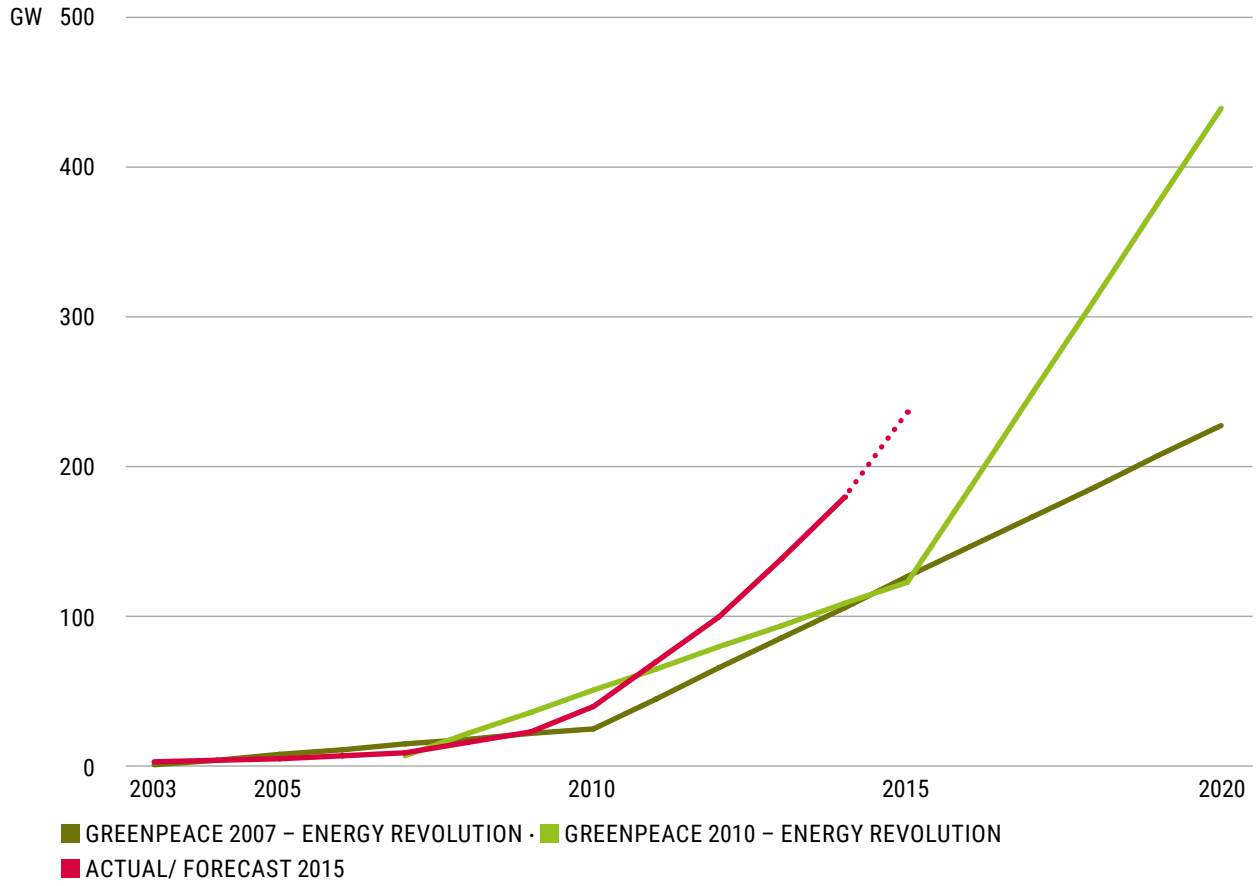

Figure 2: Projections on the expansion of photovoltaics globally and their actual development;
Sources: Greenpeace, IRENA, Projection IHS, 2015

Disruptive is the term applied to technological innovations which have the potential to completely displace established products in existing markets or even whole sectors of industry. Examples from recent times are digital photography, LCD screen technology and LED lighting. However, when renewable energies prove to be disruptive, then the change goes deeper. Just as the Internet changes our communication and consumer habits and not only challenges printed media, television and radio but ultimately also the retail trade as we know it, so renewable energies in conjunction with digitisation have the potential to take away large parts of the commercial basis not only of an inflexible energy industry, but also other key sectors.

So let us risk what at is at first glance a daring prediction: in the energy system of the future, electricity from renewables will develop into a kind of new "primary energy". Power from sun and wind will become competitive and unbeatably cheap by the time the required infrastructure for the new energy system is developed if not before. Charging systems for electricity flat rates will be developed. Cheap electricity combined with an industrial society which takes climate protection seriously and in which energy efficiency is one of the universal operating principles will finally lead to the expansion of the electricity sector far beyond the traditional areas of application. Green electricity will gradually ensure an ever increasing part of our mobility and will also replace fossil heat supply wherever this has not already been saved through intelligent efficiency technologies. At the end it will not only be the railways and local public transport which will be largely electrified but also cars which will probably differ significantly in what they can do from what we are familiar with in present-day vehicles. Lorries and aircraft may well be run on fuels also generated from "green" electricity. Electricity from sun and wind will also heat and cool our living and working spaces, provide our hot water and likewise the process heat for manufacturing.

This might come about, but is not a certainty. Predictions are often, but not always, just hot air. But one thing that is certain is that the future is always open and, with the breakthrough of renewable energies, there will be many more options.

There is no way back to the fossil-nuclear past

The old order is already changing. Even in the upper echelons of the largest and most influential businesses of the fossil-nuclear era the realisation is starting to dawn that there is no guarantee of immortality for their supremacy in the energy world if they do not change direction in time. At the turn of 2014/2015 international oil businesses, the archetypes of global players, were faced for the first time with a drop of over 50 per cent in the price of oil within half a year. A dramatic development of this kind, which has continued into the autumn of 2015 without a detectable reversal of the trend, can no longer be explained by the old models[7], even though some still attempt this undeterred.[8]

There are close parallels to the major telecommunication service providers in the late 1990s whose traditional business model became a victim of the widespread digitisation of global communication[9]. Even the powerful energy providers such as Germany's big four – Eon, RWE, Vattenfall and EnBW – who, like their predecessors, dominated the national energy market for decades as they saw fit, look helplessly at a development which they can perhaps slow down, but can no longer control or halt as in the past. Their power and their influence on the control centres of political administration are eroding. The number of politicians who still actively intercede on behalf of their old business models is shrinking dramatically. Eon and EnBW accept the consequences by attempting to divide up their companies into the competence centres of the future and the past. The aim of this seems to be to get rid of the past as quickly as possible and slim down for the future[10]. The Swedish state-owned business Vattenfall is preparing the escape from German lignite. In the fight for coal generation, RWE is carefully considering how to profitably retire the old dirty assets in order to fill the business coffers for an uncertain future – preferably with state support running into billions.

The coal industry in Germany will still try to wait out the renewable energies for a while. But those who believe that Germany could be the energy transition land but still remain a land of coal are mistaken. Even though climate scientists repeatedly (scientifically correctly) stress that none of the tornadoes and none of the increasingly frequent "100-year floods" can be attributed with absolute certainty to climate change, this does not help. Every extreme weather event somewhere on the globe recalls climate change to the mind of the public and turns attention to its main cause. A recent survey by the German Federal Press Office found that German citizens are now more sceptical about coal power than they are about nuclear power[11]. Whether it will be at the end of a second hurricane Katrina which will strike New Orleans again[12] or whether the 100-year drought in California over recent years will get dramatically worse: when the major industrial nations in the northern hemisphere become increasingly affected by climate change, humanity will conceivably become serious about protecting the world's climate and ending the excessive combustion of coal, oil and gas – particularly if everyone can see that the alternatives are ready to use.

On a global scale, it is not only climate, environment and health protection which count against a further exploitation and combustion of fossil fuels but also the question of war and peace. Many of the known and potential deposits lie in the major crisis regions of the world. Anyone who depends on coal, gas and oil must ultimately also be prepared to secure these resources using military force. Proof that this is not just a theoretical possibility is provided by a glance at the military trouble spots of the recent past. Over the decades, the huge increase in the cost of fossil fuels before the current collapse of the oil price has slowed down development prospects, particularly for countries with few raw materials. Wind and solar energies now provide largely mature and affordable technologies as solutions to both these problems. The word is spreading quickly. Renewable energies have what it takes to make the earth as a whole a more peaceful place with a fairer access to the elixir of prosperity: energy.

However: even megatrends do not catch on by themselves

However much the overall signs point to a change, the energy transition will come, but not by itself. The transformation of the global energy system – and nothing less than this is at stake – remains a race against time if people want to prevent more nuclear disasters such as Chernobyl and Fukushima and an uncontrolled escalation of the consequences of climate change. In former times energy was one of the best-performing and most profitable businesses in the global economy. In the fossil-nuclear era the energy industry created excessive wealth – but so often at the expense of man and the environment. In view of the further growth of the global population, the sector – and above all renewable energies – is and will remain of pre-eminent importance. Because circumstances are as they are and the interests of the old energy industry in many countries around the globe still carry weight, the energy transition will not reach its goals without determined and courageous policies at all levels nor without the dedication of civil society.

On the one hand, according to all surveys in recent years, renewable energies and energy efficiency – not as an enforced regime but as a functional principle of modern societies – have already won: amongst the general public, in a newly-created industry, in government, in the churches, even in some of the unions who, as representatives of the interests of the workers of today, by nature find it difficult to represent those of tomorrow.

On the other hand, the movement which set out in Germany in the mid 1970s on the planned site of the nuclear power plant at Wyhl in Baden-Württemberg, cannot now be stopped by any external force. In the success of the energy transition it must itself remain flexible and adaptable. And it should not fight the obstruction attempts by the losers of the energy transition obstinately head-on, but needs to be a bit cleverer in how it goes about things. It needs to convince the losers (which will inevitably exist) to join in: this is not only a matter of politics, but is a job for everyone who has devoted themselves to the energy transition.

This requires us to retain an awareness of the fact that, despite the speed of the energy transition in Germany and even more in other influential parts of the world, we are only at the beginning of this turning point. The following graphic clearly shows this situation. It was only in 2014 that a slowing down in the expansion of new coal power plants in China, the key country in this context, became apparent.[13] This development, which is still only a glimmer of hope, cannot even be seen in the graph due to the lack of current official data.[14] But in the real world the new trend continues in 2015, despite a further drop in the price of coal. China in particular is cutting back combustion of coal due to the dreadful air pollution in the cities and shrinking growth rates, both in the energy industry and in the industrial sector for the first time since the turn of the millennium.[15]

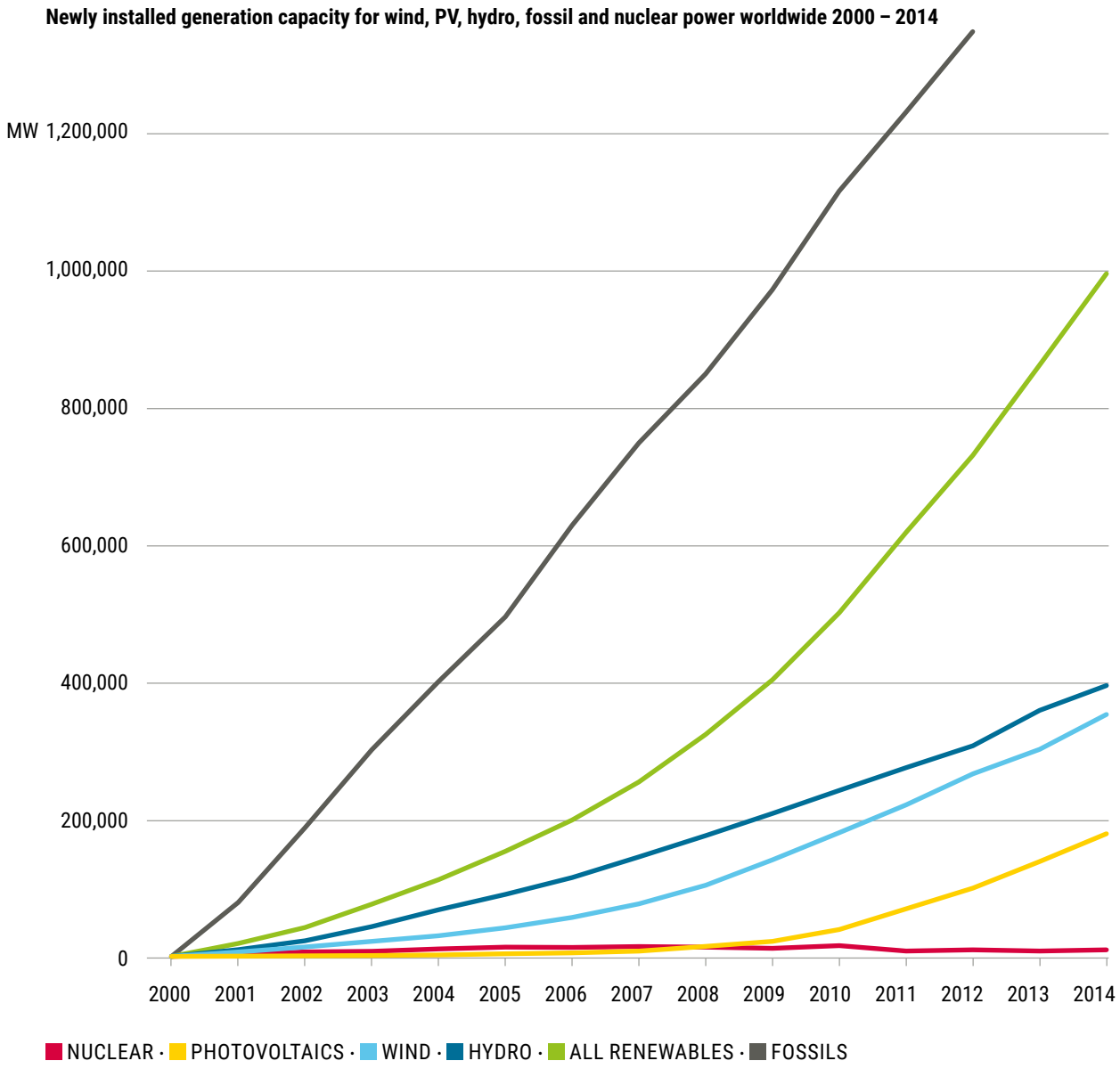

Figure 3: Cumulative global expansion in capacity (in MW); Sources: IRENA, GWEC, eia, 2015

The **megatrends** described below give grounds for optimism for the future. They show that the energy transition is no longer only politically driven but increasingly technologically. Electricity generation from wind and sun is becoming economically competitive. But the actual development over recent years also shows that this is only one condition necessary for success, but is not sufficient on its own. The way into the era of renewable energies and energy efficiency remains hard and a major political project because the underlying conditions all over the world were tailored to the fossil-nuclear power era for almost a hundred years and because these conditions will not vanish into thin air of their own accord. What is certain is that, without the determined redirection of the energy policy framework in all the important countries of the world, the race against climate change cannot be won.

Megatrend 1
The end of the fossil era has begun

- **In order to keep to the internationally agreed two degree limit for global warming, two thirds to four fifths of the known fossil reserves of coal, oil and natural gas have to stay in the ground**

- **The US American Fossil-Free-Movement which campaigns worldwide to remove capital from the big coal, gas and oil companies is extremely popular**

- **There are indications for the first time that the fossil fuel era which has characterised world energy supply since industrialisation is being left behind: coal combustion in China has fallen for the second time in a row and of three coal power plants planned in the world, only one is actually being built**

- **Increasing numbers of analysts from globally operating banks and leading representatives of the global finance industry are interpreting the spectacular fall in the oil price since the second half of 2014 as the beginning of the end of the fossil era**

Global climate change is a reality. Although scientists regularly warn against ascribing individual extreme weather events to human-induced global warming, at the same time it is clear that the increase in these kind of disasters is due to the very real warming of the earth's climate. This manifests as extreme storms, flooding and periods of drought. And with every new "100-year disaster" the willingness of those affected to take action against climate change grows.[16,17]

This was confirmed at the highest level by the G7 heads of state and government in Schloss Elmau in Bavaria with the promise of decarbonising their economies[18]. There is a reasonable chance that the UN world climate conference in Paris (21st session of the Conference of the Parties, COP 21), viewed by many experts as pointing the way ahead, will be more specific and that, by the end of 2015, humanity will indeed be a significant step closer to an effective climate treaty. This would be a blessing for the world. But even the COP 21 in Paris is only one stage in the race against time to stabilise the global climate. Because the states, confederations and global businesses who see themselves as the losers in a comprehensive transformation of the global energy

system, still have enough influence to delay the course of history. The OPEC-countries, Russia and Canada, coal producers like Australia and lastly all the major exporters of fossil fuels will fight as long as they can to extend the basis of their model of prosperity as far into the future as possible.

At the same time, the realisation is dawning in a variety of ways and with increasing clarity that this strategy is reaching its limits – and not only in the countries which import raw materials and are particularly affected by climate change. As long as 15 years ago the legendary former Saudi Arabian oil minister Sheikh Yamani predicted that in 30 years there would be a huge amount of oil reserves but no one who would want to buy or burn them any more. Yamani said at the time: "The oil will stay in the ground for ever. The Stone Age came to an end not for a lack of stones and the oil age will end, but not for a lack of oil.[19]

To reach this point will probably require a bit more than the remaining 15 years which Yamani gave the oil age seen from today's perspective. But aside from the exporters of coal, oil and natural gas, the conviction that only a fraction of the reserves of fossil energy stores we know of to date should be extracted from the earth and burnt is growing at an impressive rate. It is these reserves that determine the value of the global coal, oil and gas companies.

Climate scientists have been pointing out for years that the expanding exploration for fossil fuels is in irresolvable contradiction to the politically agreed target of limiting the worldwide average global warming to two degrees Celsius. In the journal Nature, the most prestigious science magazine in the world, British researchers have recently calculated that a third of the global oil reserves, half the natural gas and over 80 per cent of known coal reserves need to stay in the ground if there is to be a realistic possibility of keeping to the two degree limit.[20] (see Figure 4: CO_2-Emissions from global fossil fuel consumption)

This means that exploration for new fossil fuel reserves is a dangerous economic gamble even now. The extraction of unconventional and mostly very environmentally harmful oil reserves – for example, tar sands in western Canada and deep sea oil – is not compatible with the globally agreed climate targets. From the point of view of global efficiency criteria, only the reserves with the lowest extraction costs should be extracted and burnt. This would mean, for example, that three quarters of the Canadian oil would have to stay in the ground and almost 90 per cent of European coal.

The originally US American fossil fuel divestment network[22] is now making headlines not only in the United States, but is campaigning in many industrial nations for capital to be withdrawn from 200 major coal, gas and oil companies[23] who are continuing to invest in the exploitation of fossil fuels – and is gaining a lot of interest and becoming enormously popular. Hundreds of foundations, universities, churches, pension funds, cities like San Francisco, Seattle and Oxford, the French insurance group Axa and, most strikingly, the heirs of the Rockefeller oil dynasty, are pledging to sell their shares in oil, coal and gas companies and to invest in climate-friendly companies instead[24]. The most recent example of this is the Norwegian government's decision in June 2015 prohibiting state pension funds from investing in companies whose turnover or power generation relies more than 30 per cent on coal[25]. The largest government fund in the world, amounting to almost 800 billion Euros, has up to now had significant investments in coal-related companies. This probably means that shares totalling four to five billion Euros will have to be withdrawn from 50 to 75 companies.[26]

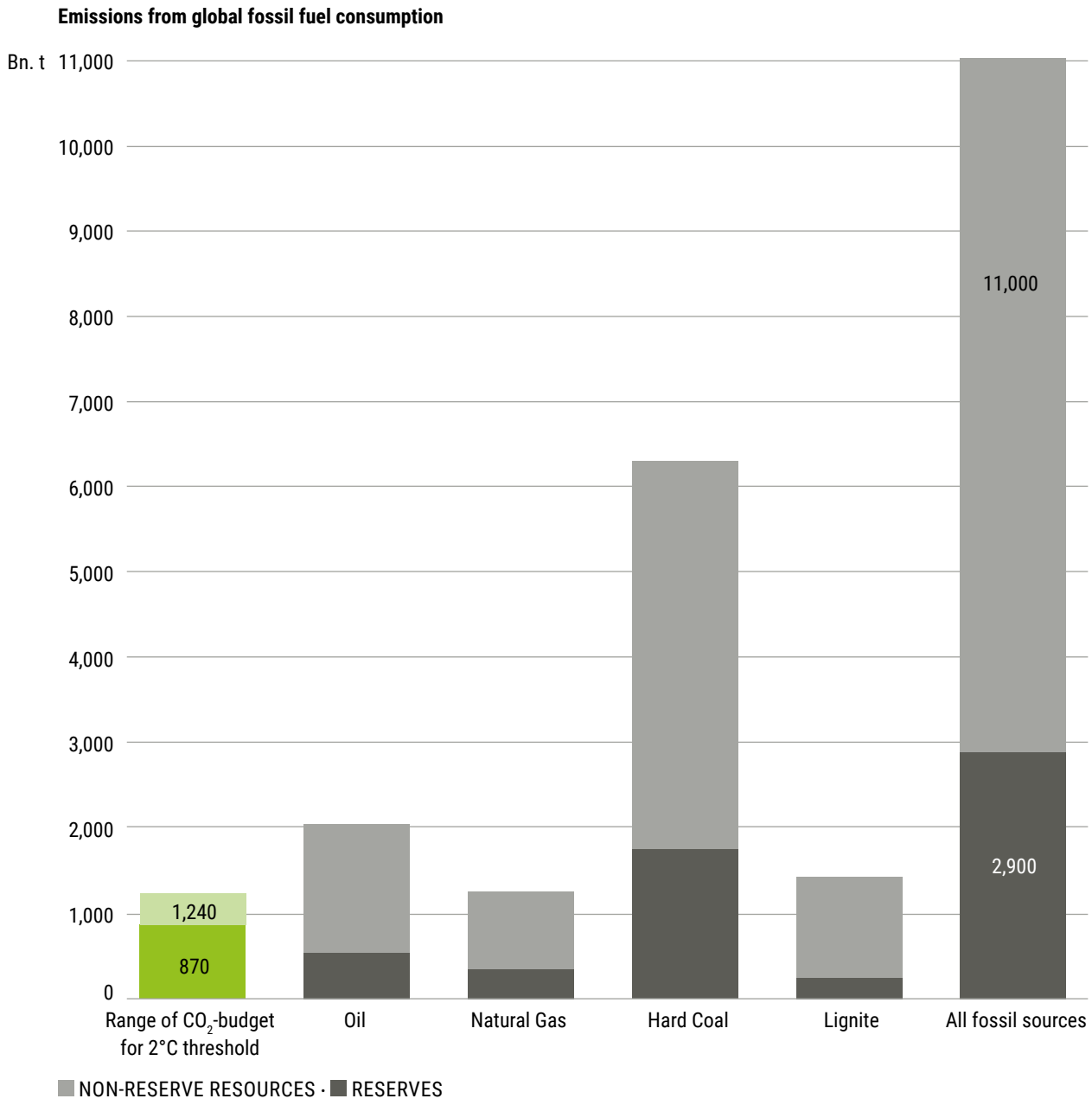

Figure 4: combustion CO_2-Emissions (in bn. t) for reserves and known resources of different fossil fuel sources compared to a 2°C threshold compatible carbon budget; Source: McGlade/Ekins (nature), 2015

But this is not all. There are increasing signs that the unrestricted burning of environmentally damaging fuels is also reaching its limits in the real world. Since 2010, two out of three planned coal power plants have been put on the back burner or completely abandoned and only one finally completed. China's long coal boom is stagnating: in 2014 combustion of coal fell by 1.6 per cent for the first time, utilisation of Chinese coal power plants dropped to the lowest level for over three decades and combustion of coal became increasingly separated from economic growth, even in China.[27,28]

The country which has been responsible for 80 per cent of the increase in coal combustion since the beginning of the new millennium has introduced a policy away from coal, primarily due to the air pollution in its big cities. The change in strategy covers not only power generation but also the limitation of coal-based and energy-intensive industries in favour of service sectors. In the first half of 2015, coal demand in China fell further, which was also evident in the 44 per cent lower coal imports in comparison to the previous year.[29] In India, currently the second main driver of the global combustion of coal, six times more coal power plant projects have been mothballed since 2012 than have been completed, or their construction has been completely cancelled.

Since the beginning of the century, the USA and EU member states (see Figure 15, power plant expansion in Europe) have switched off far more coal-fired power plants than the number of new ones that went on-line. The USA are currently experiencing a change to their power mix unequalled for decades. Almost 200 coal power plants were shut down within three years or their shutdown by 2023 has already been decided upon. At the turn of the millennium over 50 per cent of the power generated in the USA came from mostly poorly filtered coal-fired power plants: now it is just 40 per cent. The rating agency Moody's is predicting that the percentage of coal power will drop further by the end of the decade to only 30 per cent.[30] Just as in Germany, traditional energy suppliers with a high coal percentage in their portfolio are dropping dramatically in value. New expansion is almost exclusively based on natural gas, wind power and photovoltaics.[31,32,33] (see Figure 5: Shutdown and expansion in power plant capacity in the USA from 2015 to 2025)

The development in the USA was initiated and propelled by the shale gas boom, stricter emissions standards for particulates, sodium dioxide, mercury and CO_2 under the Obama administration (Clean Power Plan), the rapid expansion of renewable energies and, last but not least, a powerful national grass-roots effort by the environmental organisation the Sierra Club which campaigns country-wide against old coal power plants with the slogan "beyond coal". Meantime, experts in the USA are warning about investments in new fossil power plants and about the vicious circle in which German coal power plant operators have been caught for years: the rapid expansion in cheap wind and solar power will mean that in future fossil power plants will be idle for longer periods and will therefore produce less power at higher prices, finally making them uneconomical.[34] The other side of the coin is that the phasing out of coal in the USA makes the air there much less harmful in many places. And it enables the USA to move from being an opponent of the movement for better climate protection to a pioneer in global climate politics.[35]

The parallel collapse in the use of coal in China, Europe and the USA in recent years will soon have global effects: in 2014 for the first time in 40 years the global emission of greenhouse gases from the energy sector did not rise, although there was still a growth of three per cent in the global economy that year.[36,37]

Shutdown and expansion in power plant capacity in the USA from 2015 to 2025

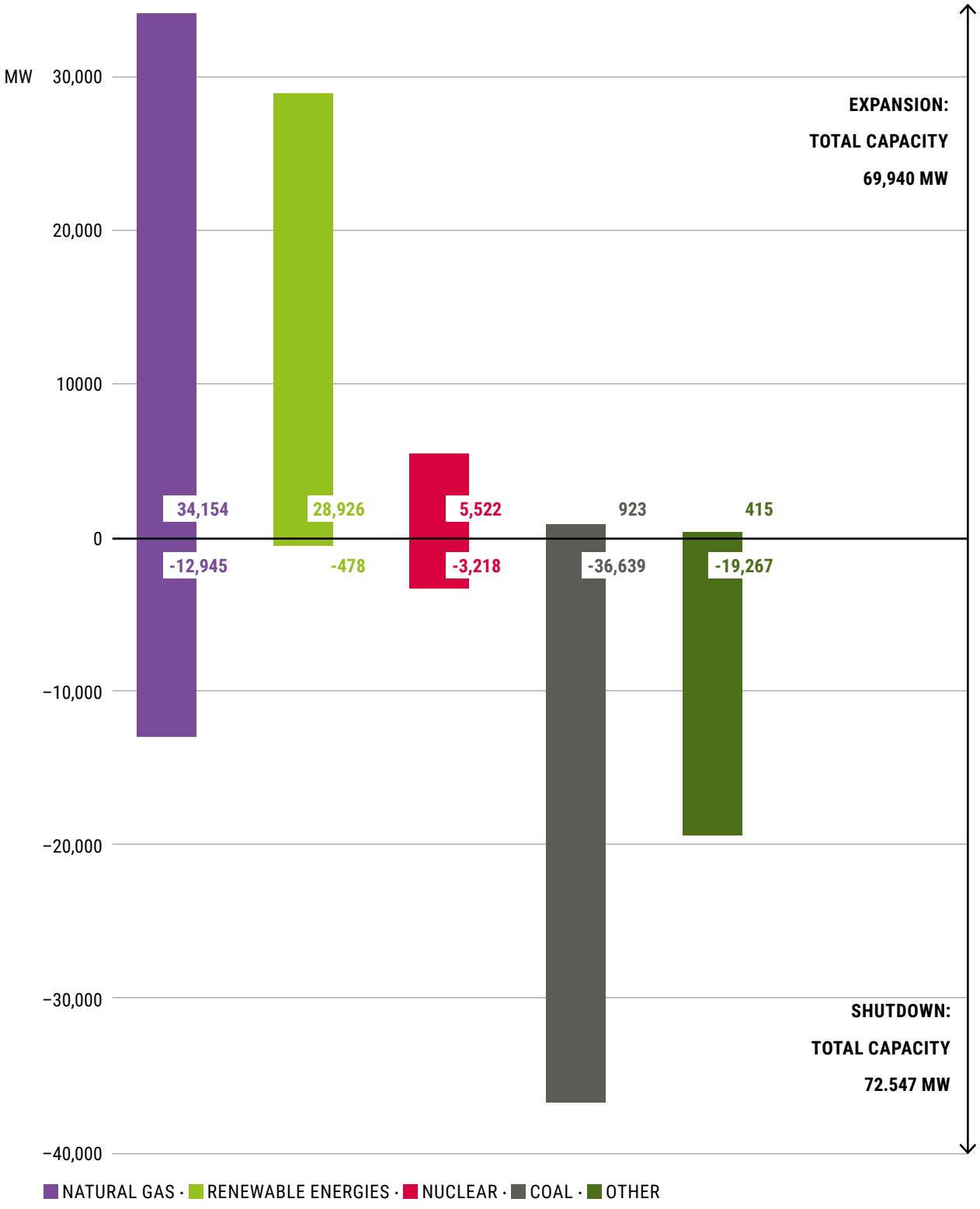

Figure 5: Decarbonising Made in USA: natural gas and renewables replace coal; Source: eia, 2015

So exciting developments can be observed, including the – still ongoing – drop in the oil price by 50 per cent within a few months in the second half of 2014. This collapse has no simple explanation, because a three per cent growth in the economy and major political and military crises in the most important energy regions of the world (a highly explosive and unresolved conflict in Eastern Ukraine, increasing destabilisation in the Middle East caused in part by the terrorist group Islamic State, and lastly the escalation of the Yemen conflict) would lead us to expect the opposite.

Some analysts see the developments on the international fuel markets as a passing phase of uncertainty, but others recognise – above all in the case of coal – the first signs of a final decline.[38] While many market observers see the refusal of the largest oil producer, Saudi Arabia, to restrict its own oil production in the face of falling prices as a strategy to weaken the competition whose production is more expensive, there is a growing number of proven experts with a decidedly different opinion. They interpret the turbulence in the oil market as a kind of advance reaction to the anticipated more stringent approach in international climate policy following the UN conference in Paris – and see a possible outcome as the "end of the oil age" looming on the horizon.[39]

The French broker Kepler Cheuvreux believes that, in view of the climate protection debate and ever cheaper renewable energies, fossil groups are facing losses of possibly 30 trillion US dollars. According to Kepler Cheuvreux, ambitious climate resolutions in international climate negotiations could place the companies tied to coal, oil and natural gas in an insoluble dilemma: if the prices for fossil fuels remain low, the expensive exploration and extraction from difficult oil deposits is unaffordable in the long term. However, if the prices go up again, this could accelerate the substitution of oil by increasingly economical renewable technologies, especially in the mobility sector.[40] The same applies to the heating sector.

Deutsche Bank's research and analysis institute (Deutsche Bank Research) also subscribes to the theory that the current "peak carbon" is driving down the price of oil and not, as was the case a few years ago, the concern about an oil shortage (peak oil) driving it up.[41] If the community of states in Paris at the end of 2015 were really to agree on effective climate resolutions to adhere to the two degree limit or even be seen to be moving towards an irreversible climate protection policy, this would in fact be an "existential threat" to the oil industry, as even the former head of BP, Lord John Browne, recently admitted.[42] For then, according to Deutsche Bank Research, the value of the oil companies would collapse in step with the value of their assets – with unforeseeable consequences for the global financial markets as well.

Word of the fact that these predictions deal with realistic estimates should have got about in the financial sector at least when Mark Carney, head of the Bank of England and former manager of Goldman Sachs, spoke out loud and clear at the end of September 2014. In front of the assembled British insurance sector Carney attested to the "possibly far reaching effects" threatening them with climate change.[43] It was far more than just a matter of the mounting insurance cases from weather disasters, but more of an earthquake which would shake the global financial industry unless a "complete re-evaluation" of these major global enterprises who make their money by extracting or processing fossil raw materials took place. On the basis of a current progress report by the Bank of England[44] Carney, who is also chair of the Financial Stability Board (FSB) of the C20 states, suggested creating a global standard for assessing the damage that companies cause to the environment and which investors could use to assess the risk of their investments.

The warning plea from the head of the Bank of England is only the most recent example of the globally growing awareness that fossil fuels can no longer be burned at will, otherwise the earth will become an increasingly inhospitable place for most of humanity over the medium to long-term. In the meantime the IWF, IEA and the World Bank are warning almost unanimously against the continuance of an energy economy which further expands the use of coal, oil and natural gas and is subsidised globally by governments to the tune of around five billion US dollars every year.[45]

If we do not succeed in starting a systematic withdrawal from the fossil era in time, we will be threatened with a crash in the real economy and financial markets of which the global economic crisis of recent years will only have been a mere foretaste. Presentations like that given by the head of the Bank of England are wake-up calls based on the knowledge that the impacts for a fossil-based economy are coming closer.

This is not changed by the fact that, even after the Fukushima disaster and the exploding costs of a large proportion of the current nuclear power projects, the remaining champions of nuclear energy sense another opportunity to be able to bring their technology into play as a climate friendly alternative to fossil power plants. Fukushima was another horrific reminder of the high-risk nature of nuclear technology. And the exploding costs of the two remaining projects in Western Europe in Olkiluoto in Finland and Flamanville in France, like the planned Hinkely Point nuclear power plant in Great Britain, demonstrate that nuclear power is not only high risk in a technical sense, but also financially. It is difficult to imagine that nuclear technology could compete successfully in future with the new leading technologies of wind and solar power even economically.[46] It is therefore even more of a mystery[47] how the International Energy Authority (IEA) in its World Energy Outlook (WEO) 2014 can predict that the global nuclear power plant capacity is going to increase by half again by 2040, i.e. by around 200 reactor units.[48]

Megatrend 2
The energy future has already begun

- **The Renewable Energy Act devised in Germany is a global success which has enabled wind and solar power to compete with conventional power generation in ever more regions of the earth**

- **Between 2004 and 2014 the global photovoltaic capacity has increased by a factor of fifty and wind energy capacity by a factor of eight**

- **Since 2013 more renewable power capacity is installed annually around the world than fossil and nuclear together**

- **Between 2000 and 2012, 57 per cent of new investment in power generation plants went into the renewable energy sector, 40 per cent into fossil fuels and 3 per cent into nuclear power plants**

The energy transition: a German phenomenon? If this claim was ever true, then it has long since been superceded by actual developments. Nowadays more and more countries all around the world are starting the energy revolution. After decades of crippling indecision in many regions of the world, we are seeing a self-reinforcing process. The crucial question for Germany is no longer whether the age of renewable energies will come, but whether Germany will continue to play a key role in it.

It is true that Germany was an important initiator of this development. For one thing, it was Germany which came up with the Renewable Energy Act (EEG) at the turn of the millennium[49] which, with its guaranteed and reasonable reimbursement for the quantity of power generated over the longer term (usually 20 years) has turned out to be the most successful instrument for introducing what was at the time still expensive power generation from sun, wind and biomass into the largely saturated electricity markets. To date 77 states throughout the world[50] have adopted key elements of the German system. This is Germany's first, conceptual service.

77 countries worldwide guarantee feed-in tariffs

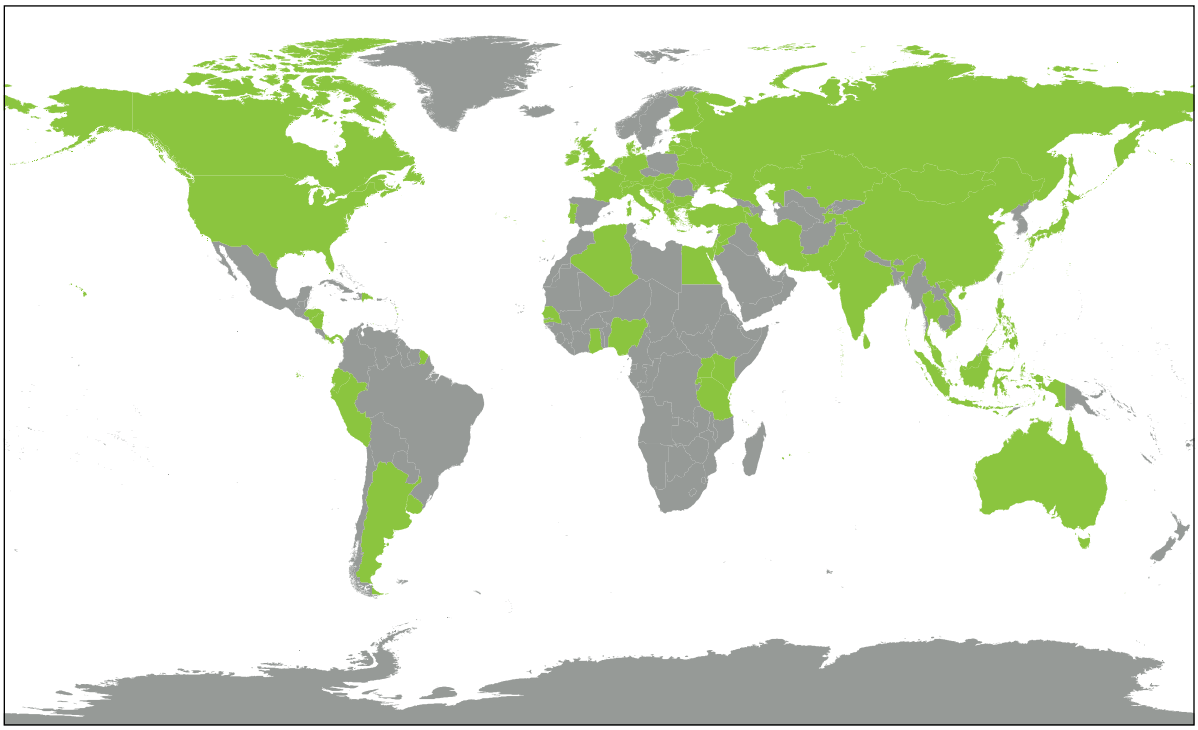

Figure 6: Countries which have introduced a feed-in tariff for power from renewable energies at national or regional level; Source: REN 21, 2015

The second service is of a financial nature: via EEG surcharges and via their electricity bills, German energy consumers have paid a large part of the development and market introduction costs of these key global technologies for the 21st century. The Öko-Institut estimates that, for photovoltaic alone, German energy consumers have taken on "innovation costs" of 107 billion euros up to 2014. Added to this are further billions for other renewable energy technologies.[51] Solar and wind energy in particular thus became affordable for less prosperous countries. The German contribution was and still is considerable, especially for private households which shoulder the EEG surcharge averaging approx. 215 euro/year[52] and likewise for small businesses and those companies which, in contrast to large parts of industry, are not exempt from the surcharges. However, the EEG payments were and still are money well invested. Because the observable global cost reduction in power from renewable energies has turned out – quite unintentionally – to be the most successful development aid programme which Germany has ever launched for the world. On a serious note, these billions help to save the world. But as a driving force for global climate protection and the German export economy, and also for trade in Germany and regional value creation, it also benefits us.

In recent years the cost degression of the leading renewable technologies of photovoltaics and wind energy have lead to a worldwide boom which hardly a single expert predicted at this speed. Between 2004 and 2014 the global installed PV capacity increased almost fiftyfold from 3.7 to 178 gigawatts[53], with over 60 per cent of this growth taking place in 2012 and 2014 alone. In the same period the global installed wind energy capacity increased almost eightfold from 47 to around 370 gigawatts. Wind energy is now the second most important renewable energy source after the traditional hydropower, since electricity was "invented" as a commodity.[54]

In China alone 23 gigawatts of wind energy capacity were added in 2014, roughly equal to the capacity of 20 nuclear reactors. In Germany it was almost 5 gigawatts net[55], this also being an all-time national record, while in the USA it was over 4.8 gigawatts. Wind energy also had a boom in newly industrialised countries such as Brazil (almost 2.5 gigawatts) and India (over 2.3 gigawatts). And South Africa, with just 10 megawatts of installed capacity at the end of 2013, got going properly in 2014 and by the end of the year had over 570 megawatts of wind energy capacity.[56]

In 2014, worldwide expansion in wind energy capacity in a single year exceeded the 50 gigawatt threshold for the first time, something which the Global Wind Energy Council (GWEC) expects to happen again in 2015.[57] Added to this comes a highly symbolic changeover: in the first six months of 2015 the global installed wind energy capacity exceeded that of nuclear power for the first time.[58,59]

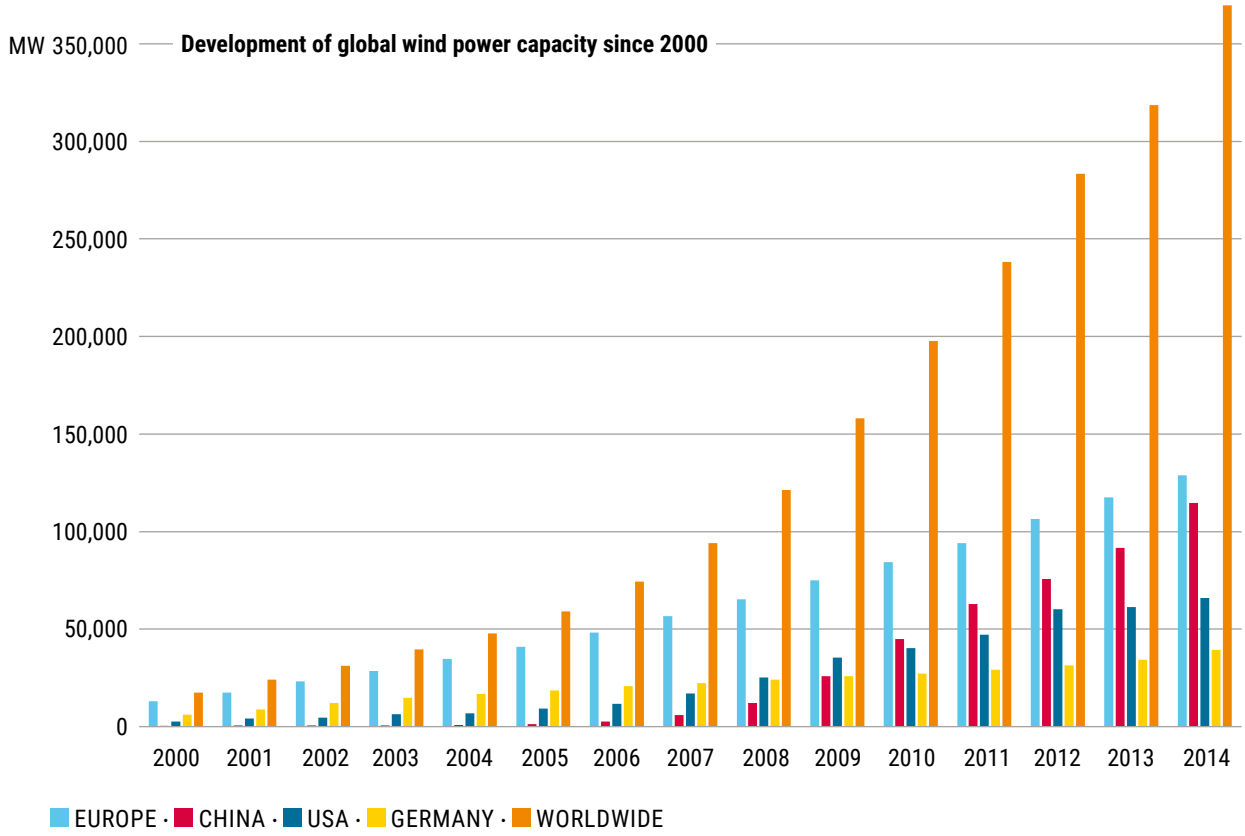

Figure 7: Installed generation capacity from wind power (in MW); Sources: IRENA, GWEC, eia, 2015

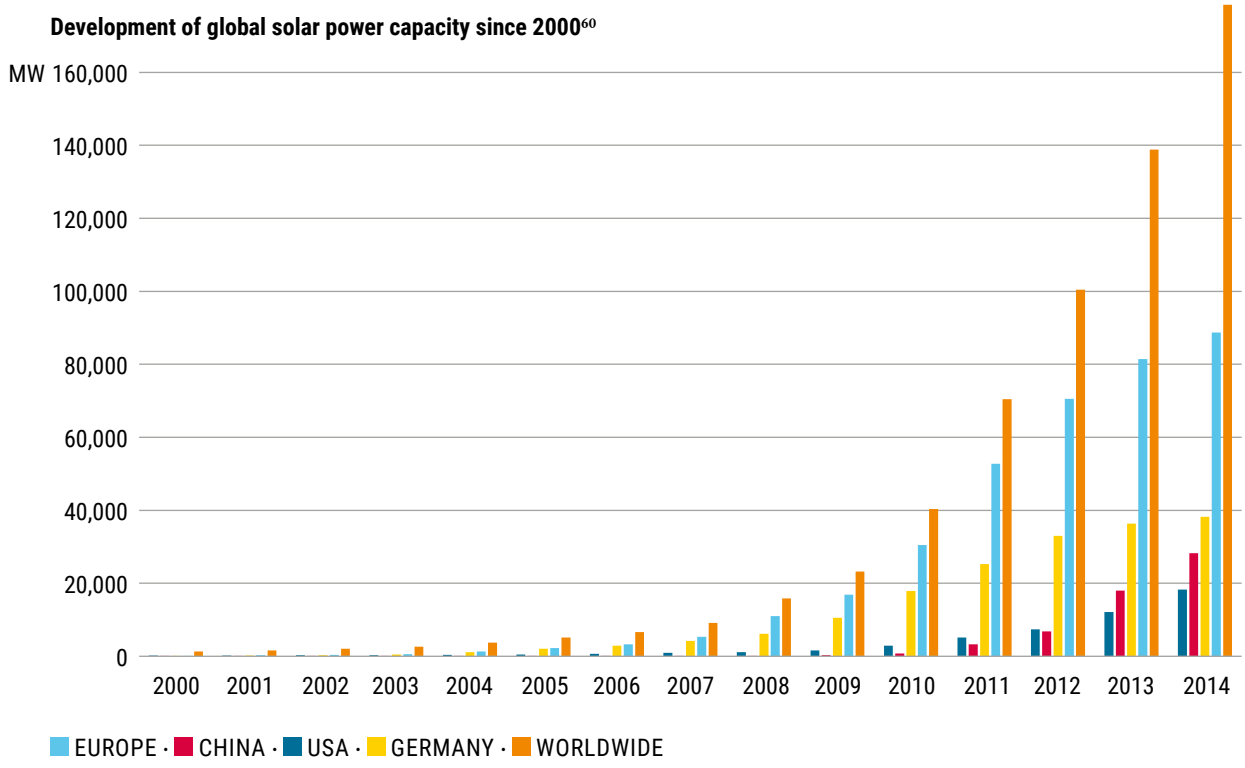

Figure 8: Installed generation capacity from solar power (in MW); Sources: IRENA, EPIA, IEA, BMWi, 2015

The International Energy Agency (IEA) of the OECD states has determined that between 2000 and 2012 57 per cent of all global investment in power generation was made in the renewables sector. Just under 40 per cent of investment went into fossil fuel power plants and only three per cent into nuclear power. .

Annual investment in energy generation

Investment in energy generation	267 billion USD	100.0 %
Fossil energy	106 billion USD	39.7 %
of which coal	55 billion USD	20.6 %
of which natural gas	46 billion USD	17.2 %
Nuclear energy	8 billion USD	3.0 %
Renewable energies	153 billion USD	57.3 %
of which hydropower	52 billion USD	19.5 %
of which wind energy	43 billion USD	16.1 %
of which photovoltaic	37 billion USD	13.9 %
of which bioenergy	17 billion USD	6.4 %

Figure 9: Average annual global investments in the energy generation sector between 2000 and 2012 incl. larger hydropower; Source: IEA, 2014

In addition, in 2013 for the first time more new power generation capacity was installed in the renewables sector – particularly solar and wind – than in the conventional sector.[61]

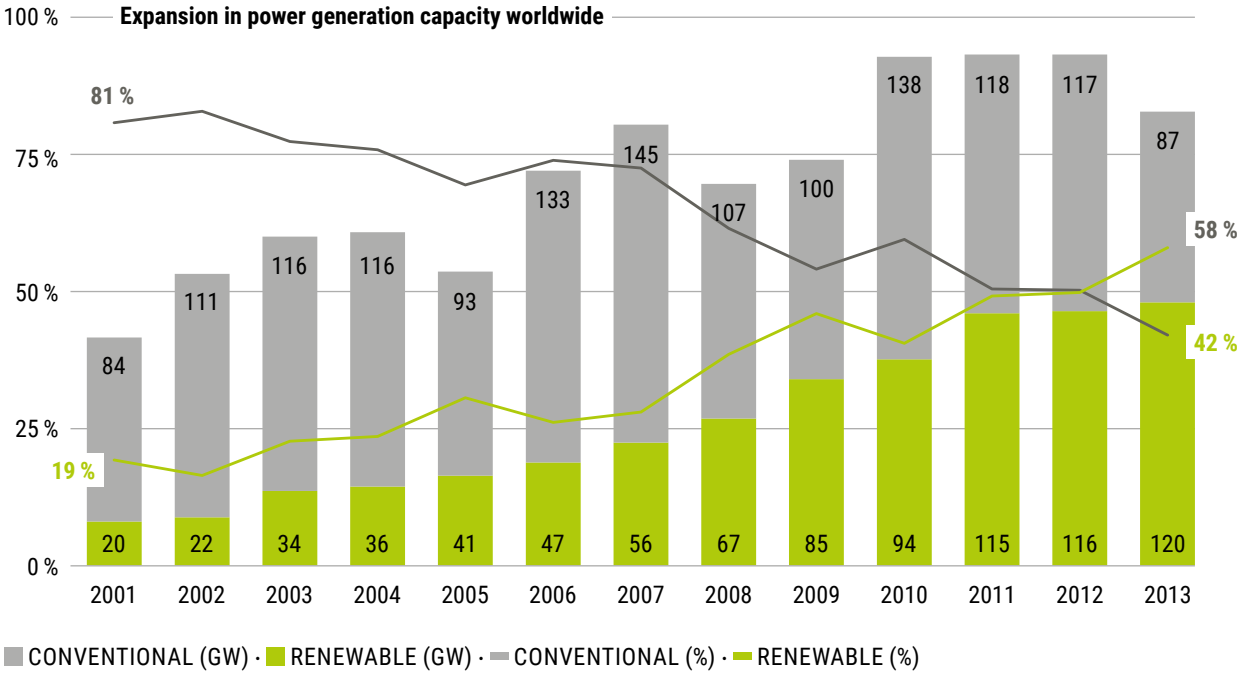

Figure 10: Expansion in power generation capacity worldwide (in GW or %); Source: IRENA, 2015

The development in the global capacity of wind and solar plants in comparison with nuclear power since the turn of the millennium shows in almost unequalled clarity where the future lies... and what is past. However, hydropower – large-scale hydropower in particular – is also undergoing a sustained upturn. Over 390 gigawatts of new hydropower were installed globally between 2001 and 2014, around three quarters (290 GW) in large hydropower plants.[62] Another 180 gigawatts are due to be added to this in the next eight years or so, mainly in China, Brazil, Turkey and India.[63] While these large projects which regularly lead to the most high-performing power plants in the world are, like wind and PV, low emitters of CO_2, there are major problems associated with them such as resettlement of huge numbers of people along the river banks upstream from the planned dam and serious interference with the local and regional ecology. The most famous project of this kind is the Three Gorges Dam on the Yangtze River in the Hubei Province (China), constructed to drive the largest power plant in the world, with a generating capacity of 22.4 gigawatts and annual power generation of 80 to 100 terawatt hours.[64]

Newly installed generation capacity for wind, PV, hydro and nuclear power worldwide 2000 – 2014[65]

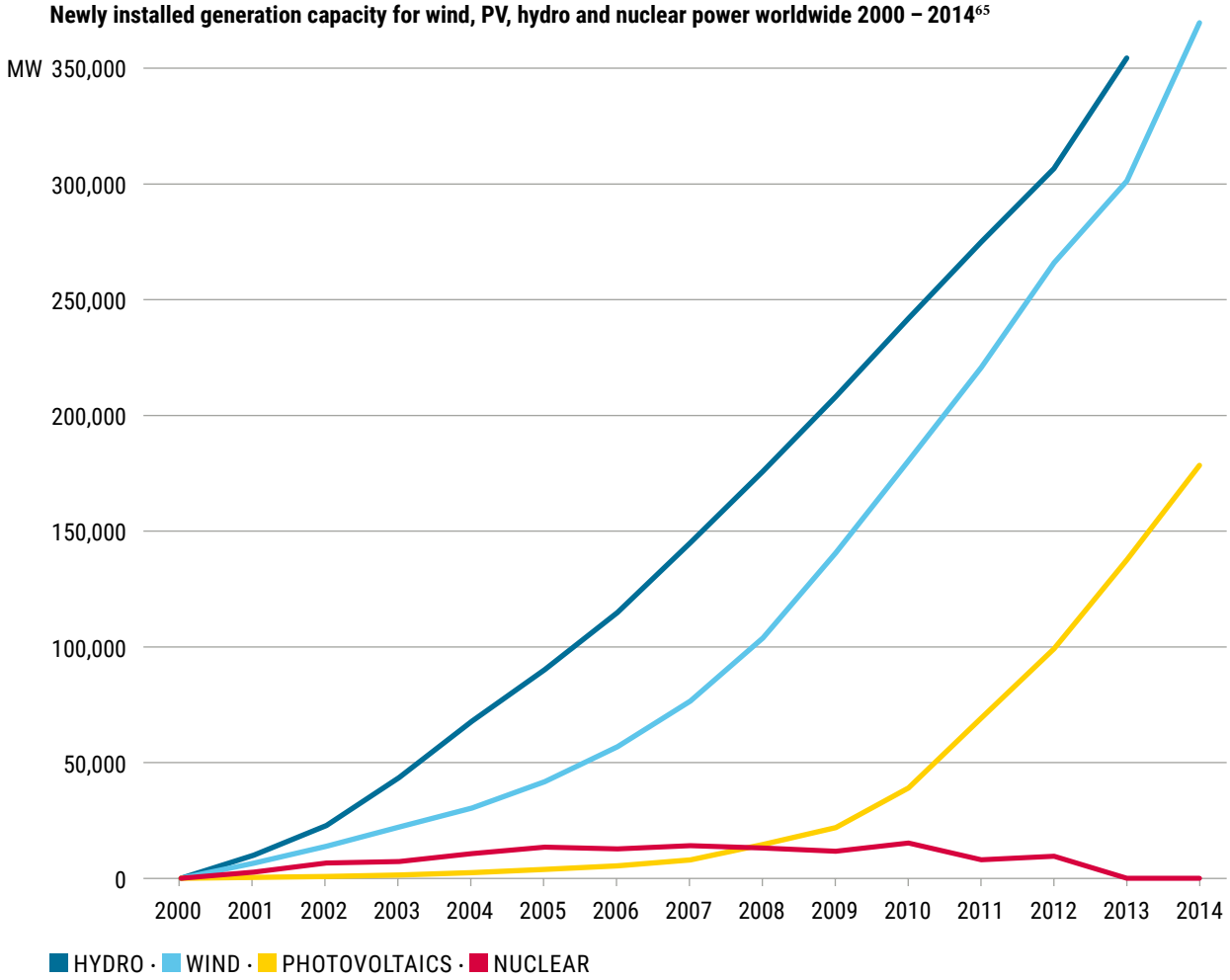

Figure 11: Cumulative growth in capacity worldwide (in MW); Sources: IRENA, GWEC, IAEA, 2015

Investment in renewables has gone through a rapid development in recent years, a megatrend which, while subject to certain fluctuations on the one hand, on the other seems to be totally untouched by the global financial crisis since 2009. What is clearly visible – besides the continuous growth of mainly large hydropower plants – is the enormous increase in importance of photovoltaic and wind power as the principle driving forces of this fledgling process of transformation. This development is new, in practically all countries it is just at the beginning. But it will prove to be robust and long-lasting because its central driving force, the massive drop in the costs of solar and wind power, is having an effect all over the world.

One of the main regional players in this development is without doubt China, the country which for two decades has been pushing all the available technologies for power generation as fast as possible in order to satisfy the energy demands of a rapidly growing population of almost 1.4 billion. After the turn of the millennium, the government in Beijing initially pressed ahead with nuclear power. China is at present the country connecting the most new reactors to the grid by a long way. However, although expansion of wind power only picked up speed from 2009, eco power has now surpassed nuclear, not only in terms of installed generating capacity but, since 2013, also in terms of kilowatt hours generated. Since 2013 it appears that photovoltaic is also set to follow the development of wind power as an important new renewable energy. Although photovoltaics started from a low level, the annual growth has recently been twice as strong. In China electricity generation from wind has been rising annually by around half since 2010, while that from photovoltaic is doubling every year: in 2015 alone it is planned to install a massive PV capacity of 23.1 gigawatts.[66]

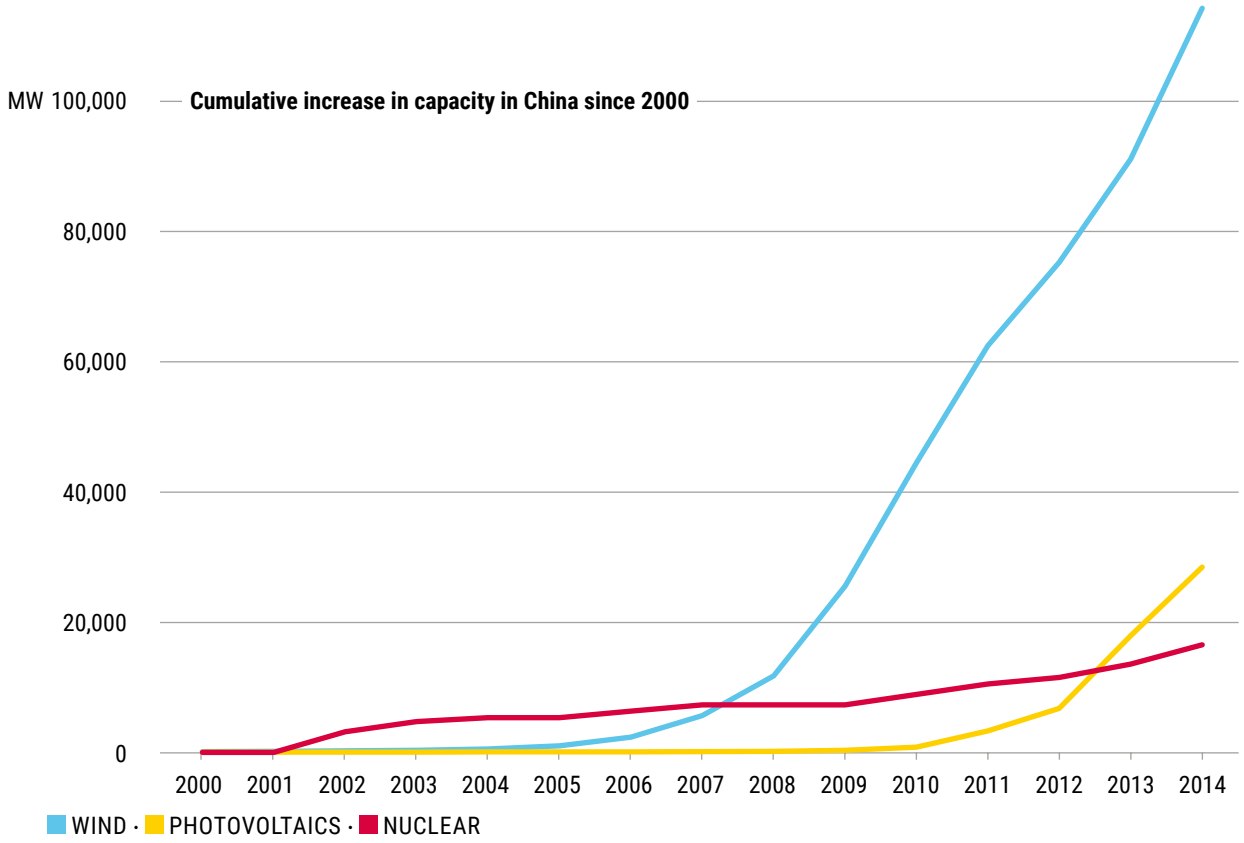

Figure 12: Cumulative increase in capacity in China (in MW) since 2000; Sources: IRENA, IAEA, 2015

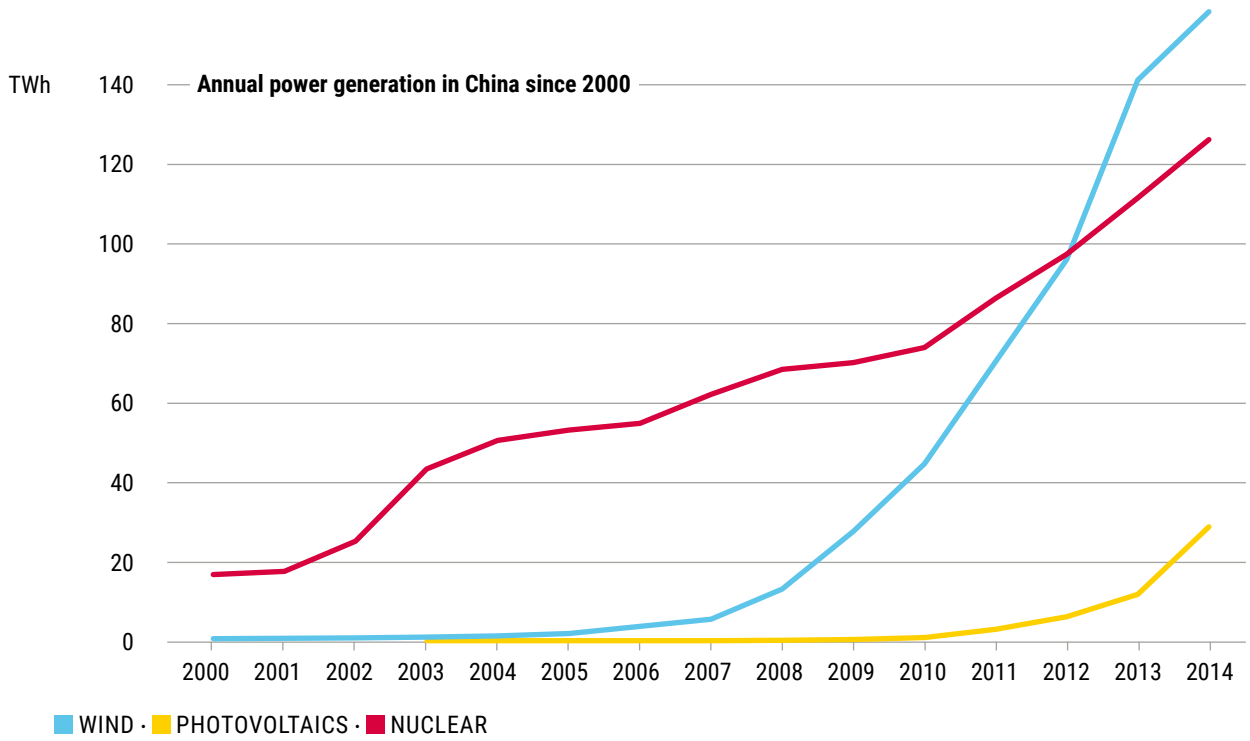

Figure 13: Annual power generation in China (in TWh); Sources: BP, IRENA, 2015

In India, the subcontinent which had previously been completely fixated on the combustion of coal, the prime minister Narendra Modi elected in 2014 has announced a large-scale solar programme. By 2022 at least 100 gigawatts of new solar power capacity is due to be installed, almost three times the total that Germany has achieved since the start of the energy transition. Modi is following a worldwide trend. According to an analysis by the global Renewable Energy Policy Network for the 21st century, REN21, 164 countries are now operating a proactive policy for the market introduction and penetration of renewable energies.[67] The US American consulting firm Frost & Sullivan predicts that the globally installed power generation capacity of renewables will more than double to over 3,200 gigawatts within ten years (to 2025) compared to 2012.[68] For comparison, in 2014 in Germany about 100 gigawatts of conventional and 87 gigawatts of renewable generation capacity were installed.

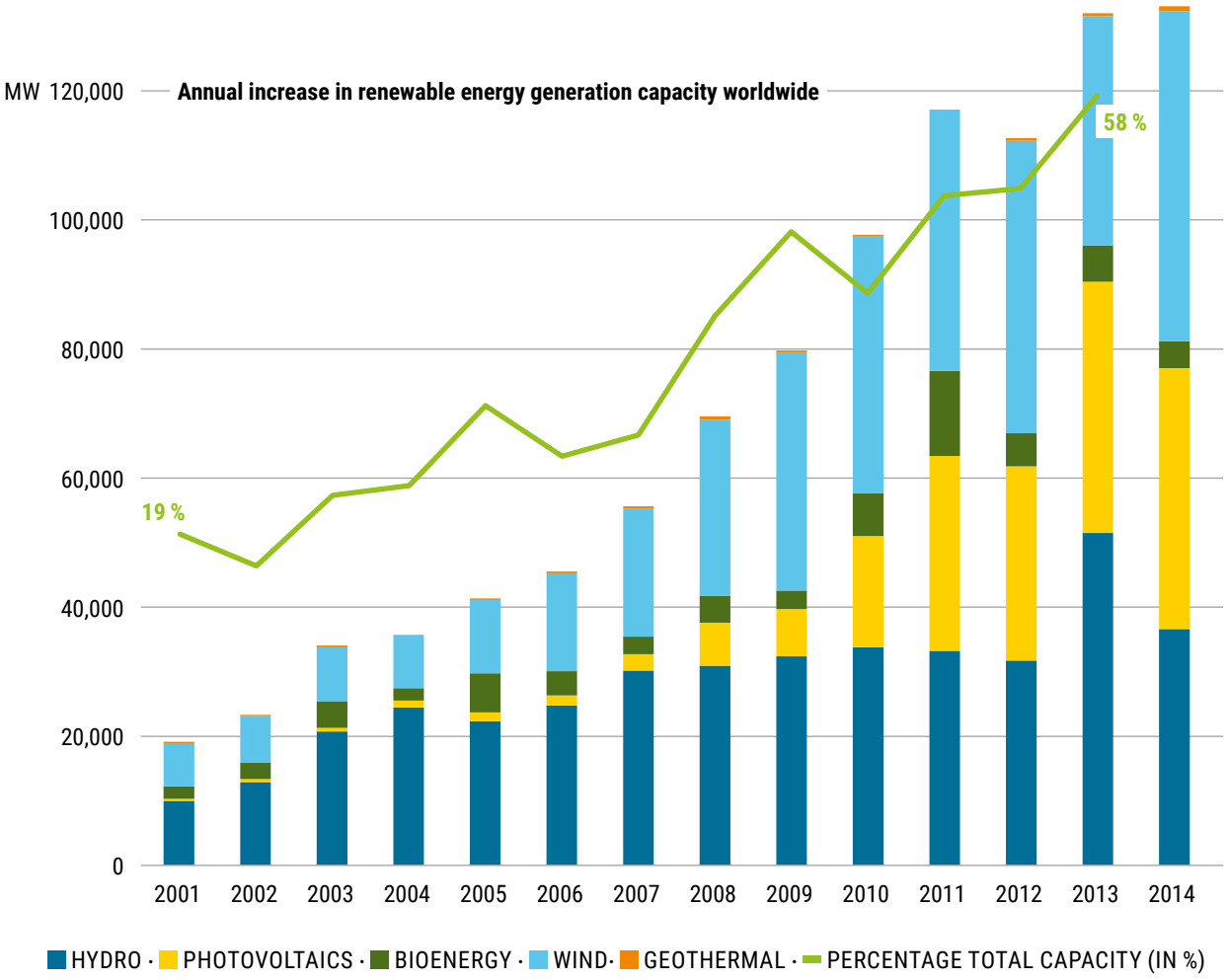

Figure 14: Worldwide newly installed power generation capacity from renewable energies between 2000 and 2013 (in MW); Renewable energies share of total newly installed generation capacity (in %); Sources: IRENA, IEA, 2015

Even in the USA, a country which for many years tended to be seen as obstructionist, the energy transition is getting going, and not just in terms of the shutdown of a three-figure number of coal power plants. After all, with 3.5 gigawatts of installed capacity in geothermal energy, the country is a world leader and generates the most wind power, even ahead of China.[69] Power generation from renewables has doubled under president Obama. And something which not many are aware of is that the USA was the first country to promote renewables via a feed-in tariff – introduced as far back as 1978.[70]

And what about Europe? Despite all the warring energy policies between the member states, the EU as a whole finds itself indisputably on a clear path to the age of renewable energies. Since the turn of the millennium almost 117 gigawatts of new wind power have been installed and almost 88 gigawatts of photovoltaic. On the other hand, considerably more nuclear, coal and oil power plants have been shut down compared to the number of new ones connected to the grid.[71]

Power plant expansion and retirement in Europe 2000 – 2014[72]

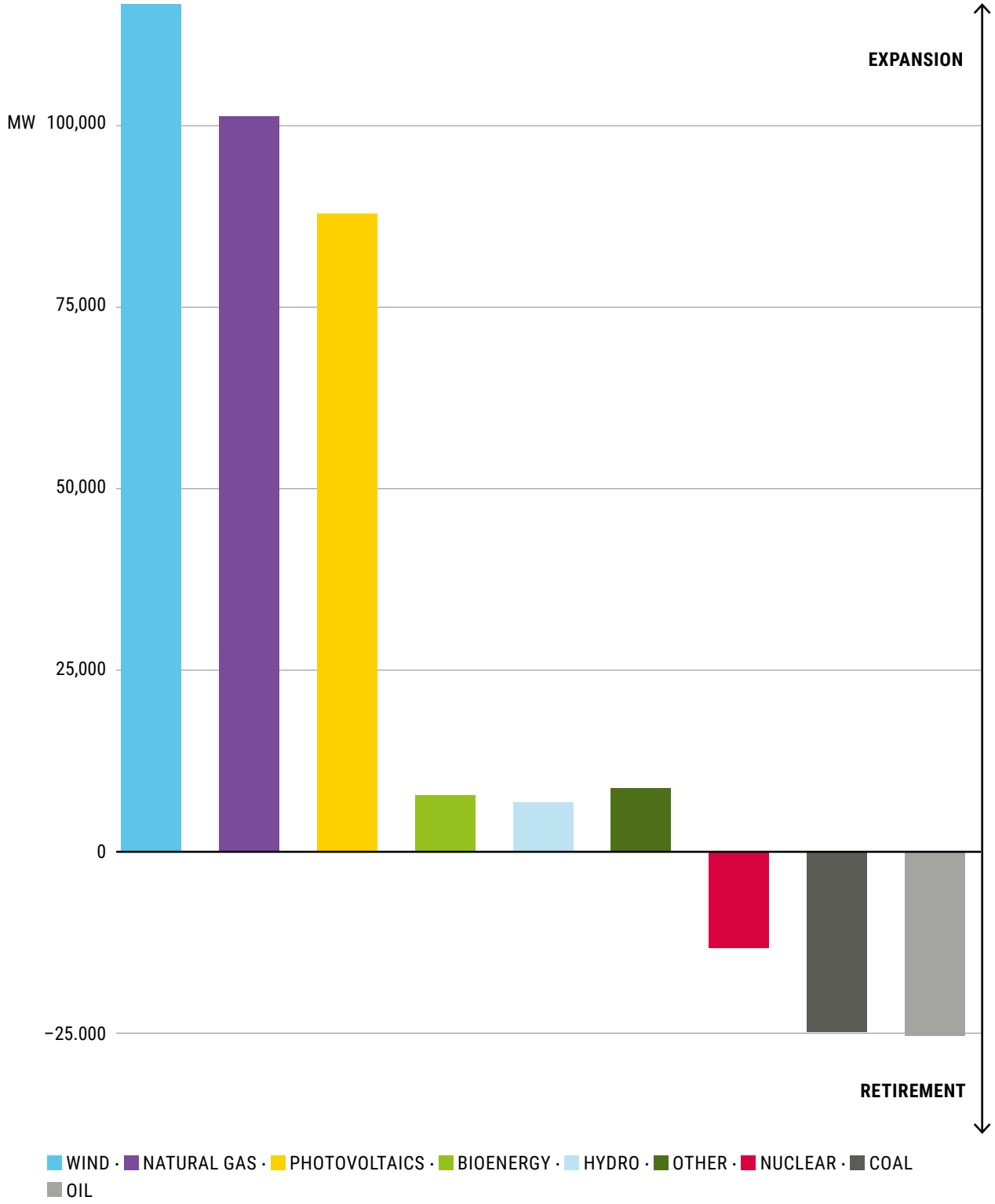

Figure 15: Power plant expansion in Europe 2000 to 2014 (in MW); Source: EWEA, 2014

And one more breathtaking statistic from the European Union: between 2000 and 2013 around 80 percent of investment in power generation went into renewable energy plants, 19 per cent into fossil power stations and one per cent into nuclear power.[73]

In the old world, expansion of new power plants based on renewable energies was therefore as impressive as it was welcome. But this is no longer the exception in the world, but the rule.

There are no grounds for complacency

It is crucially important not to fall behind: for the EU but especially for the long-term world champion exporter Germany as initiator and driver of the global energy transformation. But there are indications that this is happening. The German bioenergy sector was left out in the cold by the EEG amendment, partly because there is no likelihood of cost reductions in the order of magnitude of wind and solar energy. The home market remains frozen at the existing level until the support under the German Renewable Energy Act runs out in 20 years. There is no way of telling what will happen after this date.

In contrast, in 2014 the wind sector, particularly the land-based part, was able to enjoy a new record expansion beyond the corridor fixed via the latest EEG amendment by the Federal Government. 2015 will also likely be a year of expansion for wind power in Germany, even if not quite so far above the average. But the sector is under a cloud of uncertainty due to the planned change in the system from the administration of fixed funding rates to auctions. Expansion of the still comparatively expensive offshore wind power also got going in 2015 after years of delays. However, it does not currently appear to be guaranteed that Germany will remain altogether on course with the expansion of renewable energies and with keeping to its national climate goals.

These uncertainties are particularly evident in the ups and downs of photovoltaics over recent years. The boom years from 2010 to 2012 were followed by a severe depression. Tens of thousands of jobs[74] were lost just as quickly as they had been created. The difficult situation for the German photovoltaic sector also spread out over Europe. In 2009 the countries of the EU still dominated the photovoltaic market with 80 per cent of the global expansion in capacity for solar modules. By 2014 the situation was completely reversed. Europe only accounted for 20 per cent. The message of the most recent development is: the boom continues, if need be without Germany and the EU.

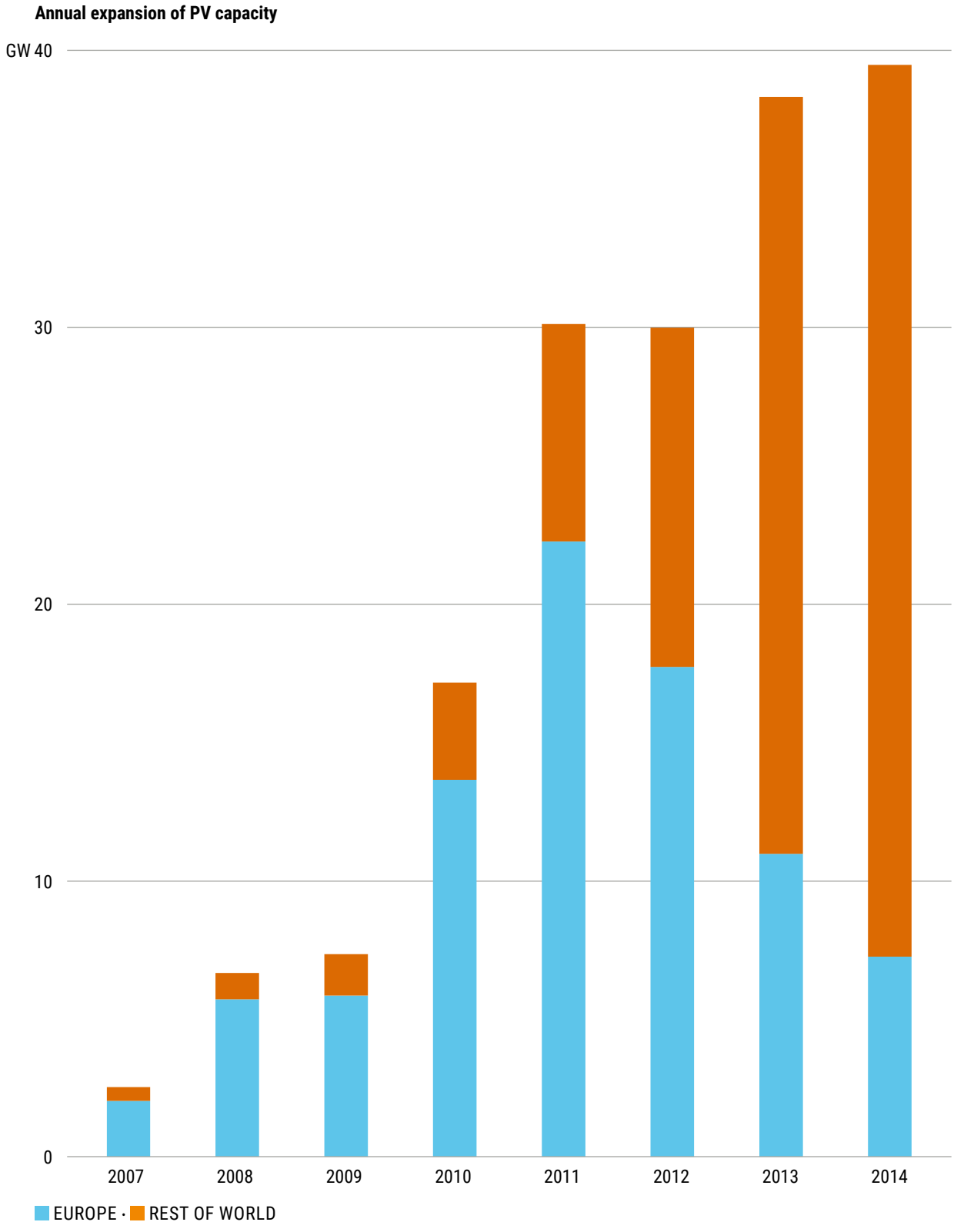

Figure 16: Global expansion of solar power generation capacity (in MW); Sources: IRENA, EPIA, 2015

With hindsight, many experts see the development in photovoltaics as inevitable, because in only a few years solar modules have become a global commodity which can be manufactured just as cheaply or more so in newly industrialised or developing countries than they can in the high-tech location Germany. While there is something in this, stiff competition and the political conditions in the countries concerned will determine the position on the key markets of the future for this and other new energy technologies.

Germany is still in a strong position as exporter of high-quality components in this sector, for instance of production plants, special electronics and software products. The German wind industry's export quota regularly reaches 66 per cent.[75] The export of biogas plants is around the same order of magnitude – trending upwards – because conditions in Germany have deteriorated dramatically due to the EEG amendment of 2014 and only traces of a "home market" are left. So the renewable energy technologies seamlessly continue in a new territory the German economy's traditional guarantor of success: the export of machines, production plants and other high-tech products all over the world.

Meanwhile, there is no time to rest on past success. Quite the opposite: while only a few years ago supporters of wind power were accused of wanting to spoil the whole of Germany with turbines while no one anywhere else in the world was investing in such an expensive and ineffective technology, nowadays Germany only accounts for 10 per cent of the wind turbines installed worldwide. In 2014 the USA generated around 183 terawatt-hours[76] of wind power, China 158 and Germany 57.3. True, compared to Germany the two competing countries have huge areas. But if we take a look at our little neighbour Denmark, in 2014 they generated 39 per cent of the total electricity demand from wind power[77] while in Germany it was just over 10 per cent for the whole country. So Germany is not the wind power world champion it used to be, neither in terms of electricity production nor in terms of the proportion of power generation. However, when expansion in 2014 rather surprisingly reached a historical peak of 5,280 megawatts (gross), in a knee-jerk reaction economic policy-makers in the EU demanded a curb on the speed of the energy transition.[78] As described above, something of this kind has already "succeeded" in the case of photovoltaics. In 2014 the expansion of photovoltaic plants in Germany slipped below the two gigawatt level for the first time since 2008, thus no longer reaching the government's accepted range of 2.4 to 2.6 gigawatts per year[79]. This downward trend continued in 2015.[80] Analysts are anticipating a record global PV growth of 59 gigawatts of solar power capacity in 2015. With a predicted national expansion of around 1.5 gigawatts, the German share of the world market would then amount to only 2.5 per cent.[81,82]

Megatrend 3
The energy future is renewable

- **In Germany the costs of solar energy have dropped by 80 per cent since 2005. Comparable cost developments are happening all over the world and are driving the expansion of renewables**

- **Wind power on land is currently the most cost-effective new renewable energy technology in Germany and the costs are falling further**

- **In sunny regions photovoltaic is already one of the cheapest technologies for power generation and in many regions of the world is well on the way to undercutting all competing technologies**

Amongst the renewables, photovoltaic has become the symbol of an undervalued technology. For a long time it was considered to be unaffordable, unproductive and so small-scale that it would never be able to make a significant contribution to the huge energy demand of a large industrialised area like Germany. Perhaps useful for exotic applications such as the power supply to satellites or space stations or the off-grid stand-alone operation of remote research stations or settlements. This could not have been further from the truth!

Solar power generation is now well on the way to undercutting all traditional forms of electricity production.[83] This has already happened in regions of the world with favourable circumstances, particularly plenty of sunshine and reliable investment opportunities. The new solar era[84] is now beginning. The International Energy Agency (IEA) which for years was the conservative refuge of the OECD states from structural changes to the global fossil-nuclear energy system, now believes that by the middle of the century solar power will supply 27 per cent of the global energy demand, more than every other generation technology.[85]

While the costs of installing new nuclear power plants continue to rise and electricity production from fossil fuels is coming under ever greater pressure due to its effects on the climate and its consequences for health and society, the costs for photovoltaics are in free fall. And the technology is by and large accepted. This is not always the case with wind power because of the visible impact on people's surroundings. But the actual development is no different from that of solar power. The expansion in capacity for wind also regularly exceeds the predictions. Solar, wind and, in some regions, other renewable energy technologies will make up the power generation of the future. Renewable energies are amongst the key technologies of the 21st century.

Renewables will not permanently raise the price of electricity and the energy supply – as is often feared – but in fact actually make it more favourable as soon as the conversion phase is over. Even when you allow for the costs arising from the unavoidable conversion and expansion of our power grid, the necessary back-up

capacity and the need to balance the changeable power sources, the overall system costs will not be higher than for continuing and then carrying out the required staged replacement of the old energy infrastructure.

The savings to be made from the new energy system are all the greater when allowance is made for the resulting damage associated with the combustion of coal, oil and gas and the spread of nuclear technology which global society would have to cope with if things were to carry on as previously. The development towards climate and environmentally friendly renewable energies becomes realistic thanks to scarcely dreamt of technological progress, the start of mass production and favourable financing conditions in many major countries of the world.

The Berlin think tank Agora Energiewende recently put it to the test and analysed the current electricity costs of different generation systems. The result: the onshore wind power parks and ground-mounted photovoltaic parks currently available are fully competitive compared to new conventional power plants. The study compared green power plants with new conventional coal and gas power plants and with new nuclear power plants illustrated by the planned British nuclear power plant at Hinkley Point, and with coal-fired power stations with subsequent carbon capture and storage (CCS)[86].

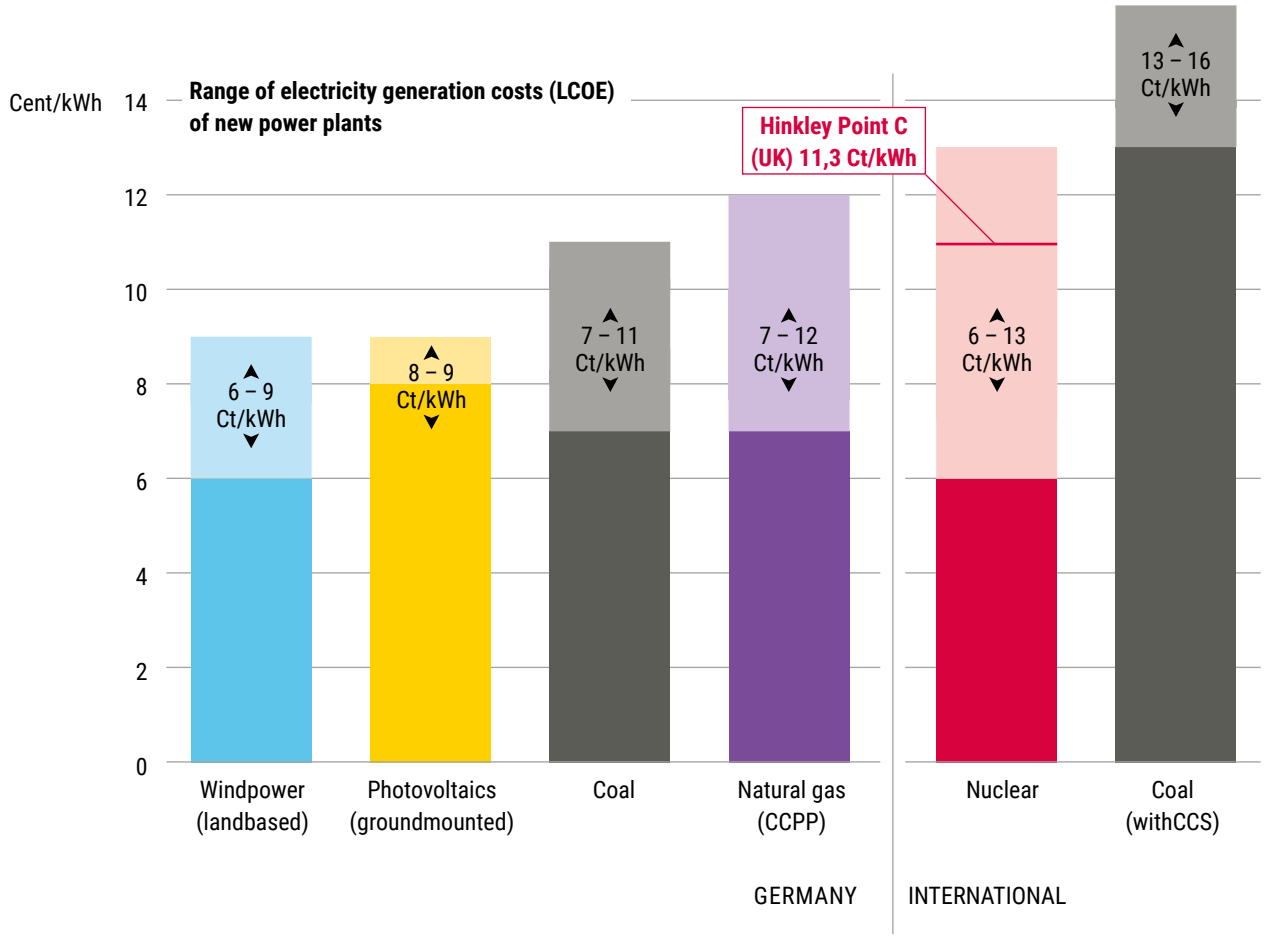

Figure 17: generation costs (Euro Ct/ kWh) of different types of new power plants; Source: Agora Energiewende, 2015

In view of this Germany would be well advised not only to push ahead with its own energy transition but, in order to remain successful as a traditional exporter – of energy technology in particular –, it should also introduce its strengths, products, processes and services into the global development.

Costs in free fall

The most remarkable price development at present is in photovoltaic technology which set out with generation costs of around one euro per kilowatt hour (kWh). In Germany the tariffs for PV electricity from large ground-based parks fell from 43 cent/kWh to 8.7 cent/kWh between 2005 and 2014, in other words by approx. 80 per cent[87]. A similar development took place in the PV systems which German solar enthusiasts had installed on their roofs: the average costs per kilowatt of installed capacity for these kind of small systems declined from 5,100 euro per year in 2006 to 1,602 euro in 2014. And it is quite certain that this development will continue in future. By 2025 a kilowatt hour of solar power from large photovoltaic plants in Europe will only cost something between 4 and 6 cent/kWh, depending on sunshine duration. According to conservative forecasts, this price will be further reduced to 2 to 4 cent/kWh by the middle of the century.[88] Photovoltaic will then be well on the way to being the cheapest global technology for electricity generation.

Evidence that these predictions are more than just crystal ball gazing and are also not restricted to Germany is given by a contract awarded in spring 2015 by Dubai's public energy provider to a Saudi Arabian group of companies for a 200 megawatt solar farm which aims to sell electricity at a feed-in price of 5 euro cents per kilowatt hour (equalling 5.84 $ct/kWh)[89]. This is probably the lowest solar power price achieved in the world to date in a tendering process. The outcome of the global drop in price for photovoltaic is the above mentioned rapid increase in capacity in various regions of the world in recent years.[90]

Tariffs for ground-mounted PV parks in Germany

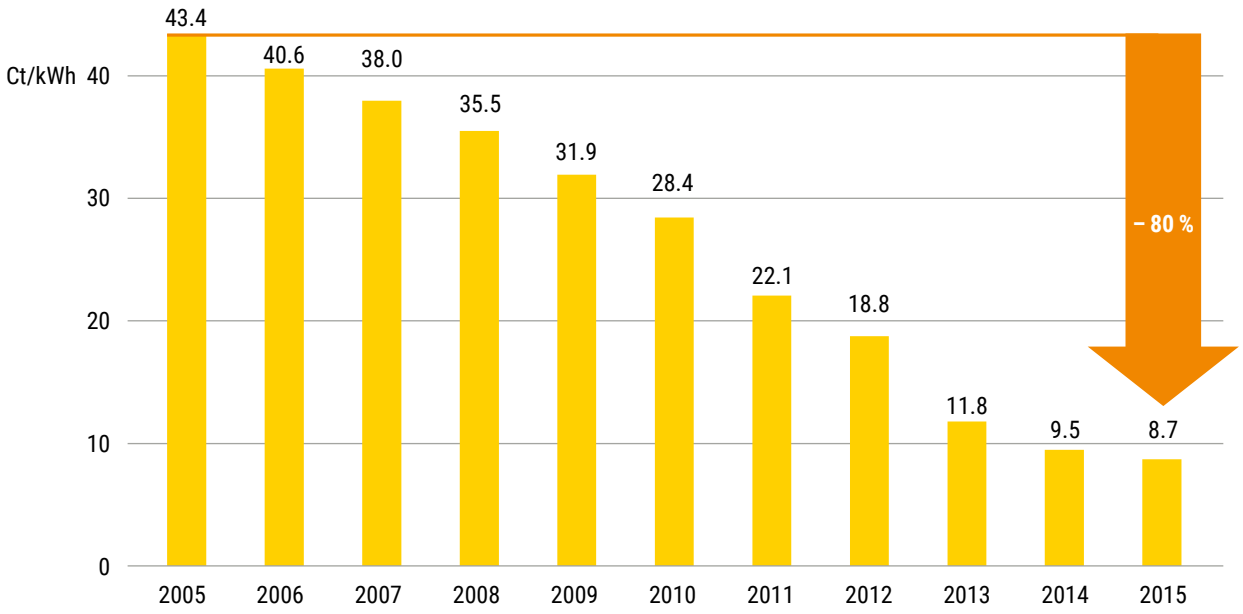

Figure 18: EEG feed-in tariffs for large photovoltaic parks; Sources: Agora Energiewende, Solarförderverein, 2015

Price development of PV roof-mounted systems in Germany

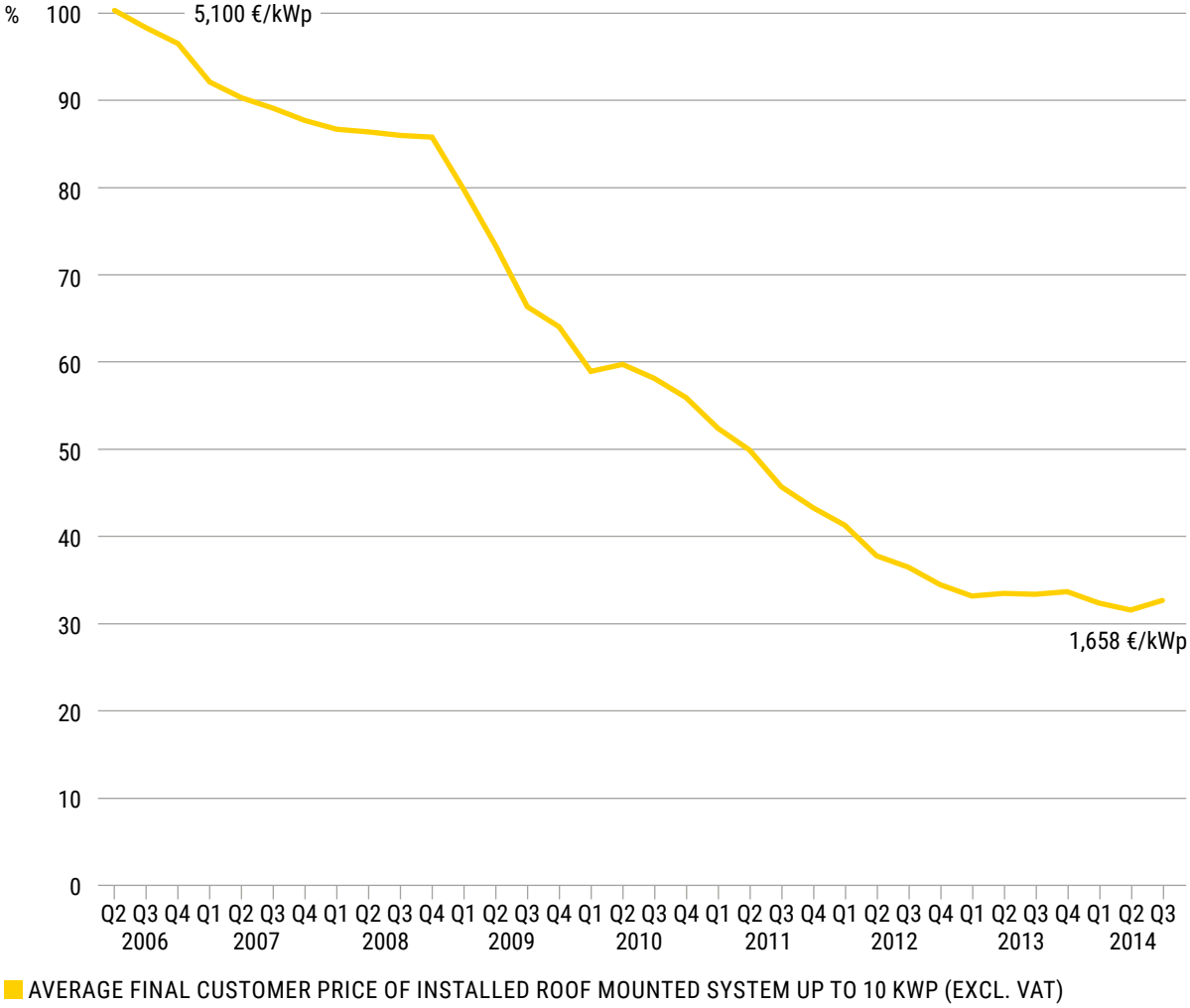

Figure 19: Price development for roof-mounted photovoltaic systems up to 10 kWp in Germany; Source: BSW price index for photovoltaics, 2014

Recently it has not just been those who champion or profit from the energy transition who are predicting a glowing future for solar energy but also numerous global players from the banking and consulting industries. In 2014 one of the largest banks in the world, the New York Citigroup, published a report predicting a break-through for photovoltaics.[91] The bank attributes this rapid development to a further decrease in electricity generation costs, more mature technologies and favourable financial terms. However, there is also a growing need in the electricity industry and from electricity consumers to safeguard themselves against the risks of fluctuating prices or uncertain supplies from traditional power generation from fossil fuels and uranium.

The Citigroup analysts see the most important markets over the next few years in China, Japan, the USA and Great Britain, but these would soon be joined by additional large markets in sunny and highly populated newly industrialised countries such as India and those in South America and the Middle East. An expansion forecast of 662,000 megawatts of installed photovoltaic capacity between 2012 and 2035 published by the International Energy Agency (IEA) in Paris is seen by the Citibank to be too low and described as "highly conservative"[92]. One of the reasons for this judgement is that the banking analysts see the cost development of solar energy and other renewable electricity generation technologies as also providing the key to a much broader energy revolution not just confined to the substitution of power from nuclear energy and fossil fuels, but affecting other energy sectors.

Driven by the fact that, in ever more regions of the world, electricity from the grid is becoming more expensive than that generated on your own roof, Deutsche Bank is expecting further strong growth in the world market for private PV systems, a market which could rely on increasing numbers of large and medium-sized players in all regions of the world.[93] According to the bank's forecasts, the price for roof-mounted solar panels will fall by a further 40 per cent within four to five years.[94]

The French investment bank Kepler Cheuvreux has recently predicted that a 100 billion dollar investment in solar or wind power would be better spent than the same billion dollars in the oil business. The reason is that renewable energies already do much better than the boom energy of the 20th century in terms of the energy output gained per dollar invested. In view of this prognosis, Kepler Cheuvreux expect electric vehicles operated by wind or solar power to be more economical than conventionally fuelled vehicles within two decades.

Even if the forecasts by the large financial institutions – who in the past also predicted a glowing future for nuclear power – are viewed as foolhardy, the fact remains that the forecasts for the development of renewables have to date always been more than confirmed by actual developments.

Developments in wind power are similar to those in photovoltaics. In Germany and other countries of the world which often have a considerably larger wind resource, land-based wind power generation is still the cheapest of all new renewable energy sources. The reason for this is primarily the huge technological progress since the turn of the millennium. The increase in size and effectiveness of the rotors with higher towers have enabled a wind power tariff of as little as 5 to 9 cent/kWh in 2015.[95]

Technological progress initially manifests in the average capacity of the wind power plants added each year. This has increased more than sevenfold within 20 years.

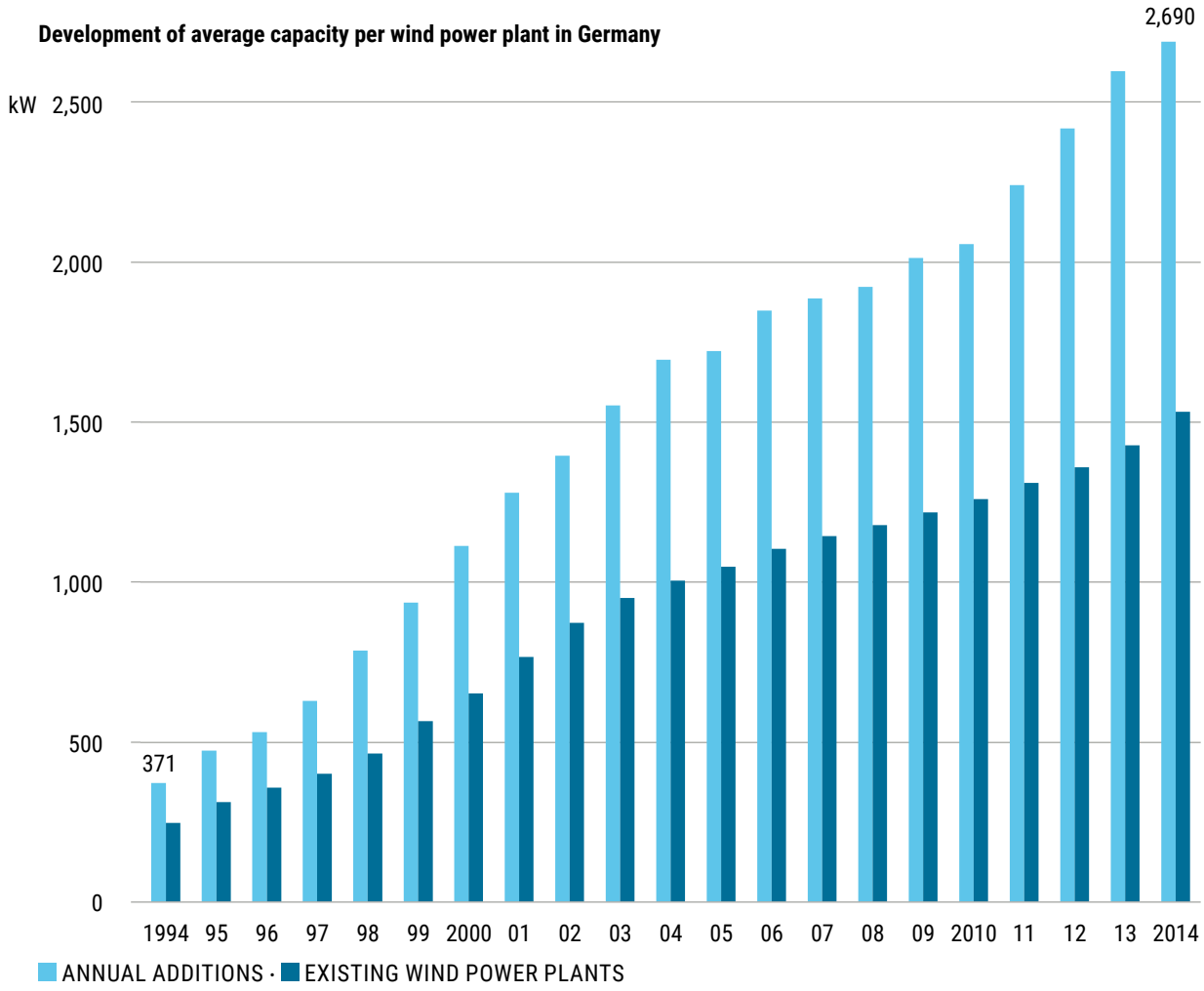

Figure 20: Average capacity of wind power plants according to year of commissioning and existing stock;
Sources: DEWI, Deutsche WindGuard, 2015

The technological maturation is also apparent in the fact that wind turbines can generate ever more kilowatt hours from one unit of installed capacity. This is shown by the trend lines in the following graphic where the curve of power generated climbs more steeply than the cumulative installed capacity of the turbines. In other words: year on year, one megawatt of newly installed wind energy capacity generates ever more megawatt hours of electricity. (see Figure 21: Installed capacity and quantity of electricity generated by wind power in Germany)

Offshore wind power, in other words power generation in large wind parks in the sea, is still significantly more expensive than wind turbines on land, particularly off the German coasts[96]. However, in many regions of the world the higher costs for the more expensive technology for offshore turbines themselves and for the infrastructure (connection to the land, maintenance costs, etc.) are balanced by the larger and more constant wind supply at sea. The rotors turn for nine out of ten hours of the year or more at sea and achieve, compared

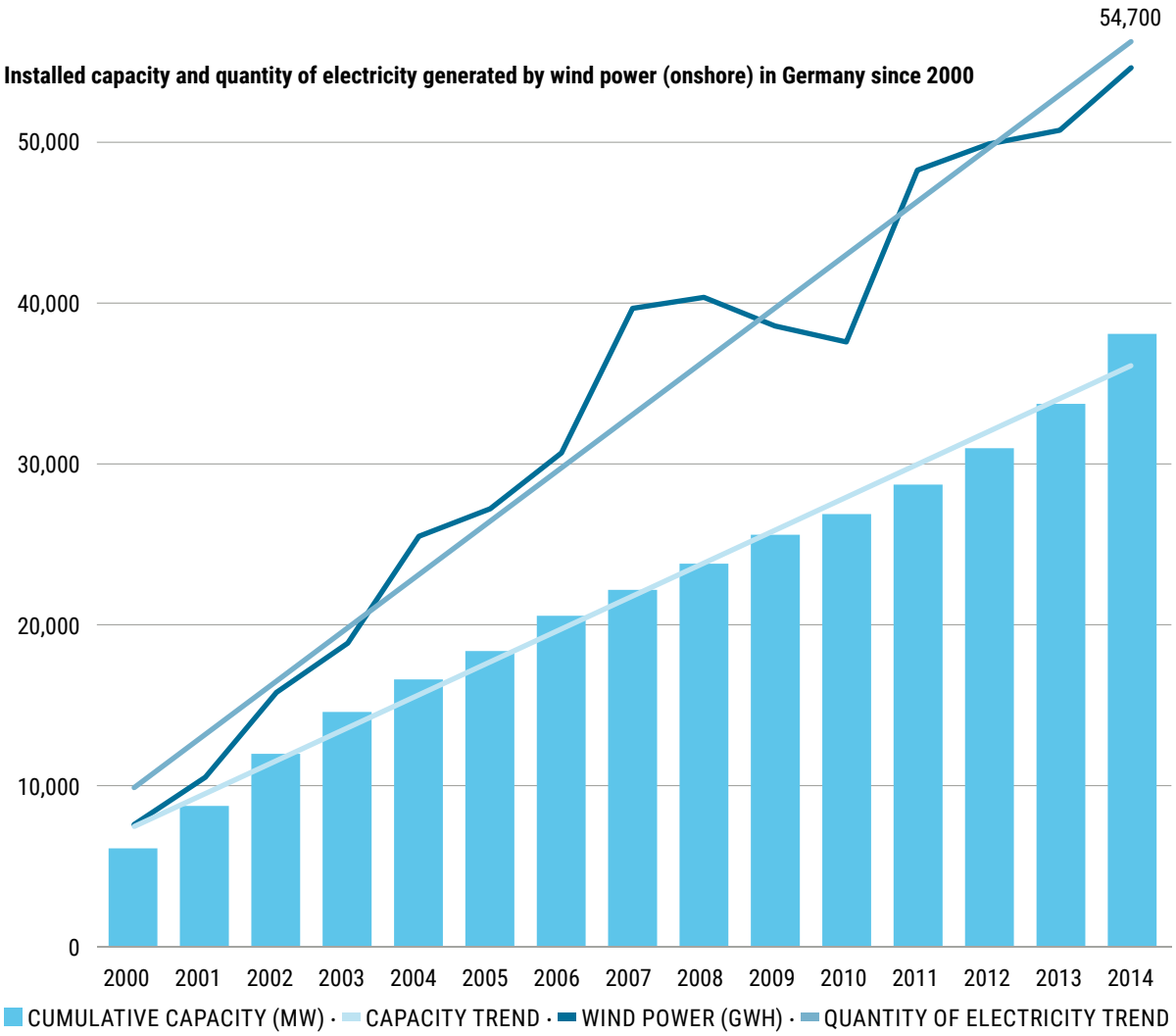

Figure 21: Installed capacity (in MW) and amount of power generated from wind turbines on land (in GWh);
Sources: BMU/BMWi, DEWI, Deutsche WindGuard, 2015

to their maximum power output, 4,000 to 4,500 annual full load hours[97] in contrast to around 2,000 full load hours for good wind conditions in the interior[98]. Offshore turbines are still somewhat in the early stages of their technological learning curve. So considerable cost reductions can be expected in this area too.

The trend towards increasing annual full load hours is important for the economy of the new electricity system, but not just because of the higher energy yield from one energy unit of wind power. The development also reduces the system costs, because a more constant power supply means that a lower proportion of the wind power has to be stored temporarily at high cost and reduces the overheads for balancing the fluctuations in wind power via long transmission lines, storage capacity or a flexible use of the power by the consumer. As part of this, increasing numbers of what are known as "weak-wind" turbines are being installed which begin to turn even at low wind speeds.

Megatrend 4
The energy future is decentralised

- **The central energy supply in fossil or nuclear driven large thermal power plants is coming to an end after over a hundred years because there is now an affordable alternative available**

- **Renewable energies occur in a “diluted” and extensive form. For physical reasons alone electricity generation from renewable energies is therefore decentralised, occurring in millions of plants which, however, do not all necessarily need to be small. Their operation in an industrial nation with developed infrastructure requires central coordination**

- **A decentralised and affordable energy system based on solar and wind energy also promises greater equality of prosperity in the world: the poorer regions have the largest resources**

Up until the turn of the millennium a few hundred large power plants running on coal, natural gas and uranium supplied the whole of Germany with power. The situation was very similar in all comparable industrial nations and even the large newly industrialised countries very resolutely followed this course of development marked out since the beginning of commercial power supply at the end of the 19th century. They also used and still use fossil fuels which have been produced over geological time periods. Now year after year, mankind is burning quantities of coal and natural gas which previously took around a million years to produce. The knowledge that our heritage of coal, oil and natural gas is finite, has changed nothing about this so far[99]. Quite the contrary: combustion of fossil raw materials increased constantly up to the most recent past. It has now become increasingly obvious that it is not the finite nature of fossil resources which will show us the first of nature's limits. It is in fact the atmosphere, which can only cope with the amounts of greenhouse gases produced by human beings at the cost of a global warming unparalleled in the history of mankind.

The primary fuels for generating electricity to date – i.e. the fossil fuels coal, oil and gas – are forms of natural (bio) energy which have formed by concentration through chemical and physical process over millions of years. Solar and wind energy, the main carriers of our energetic future, occur in comparison in an extremely diluted form on the earth. The immediate result of this is that, to enable solar and wind to be used for the rising energy demand of a growing world population, we have to collect this "diluted energy". And because it is physically diluted, it requires large areas and plants.

"Small is beautiful" was and still is an attractive slogan. But nowadays, the systems for producing electricity from renewable energies are often both at once: distributed in a decentralised manner across the country but also unquestionably immensely large. Decentralised power plants will play an important role in satisfying basic energy needs, especially in the regions of the earth which are not yet electrified. It is not by any means certain whether it will even be necessary to create large integrated transport networks here or whether this "development phase" can be skipped in the new solar era. But large wind parks and ground-based solar parks will probably be just as necessary for the desirable industrialisation and the supply of metropolitan regions.

However, the new energy system's key characteristic which makes it obviously different to the traditional single-track energy supply results from its decentralised physics encountering a readiness in society to leave behind the role of purely energy consumers. Domestic housing and small businesses turn into power plants producing power and heat for their own needs and for third parties. The speed with which this fundamental paradigm shift is gaining ground is based on the fact that the technological development for it is available and is affordable for an increasing number of people. This is the situation which, despite all the heated debate of recent years, secures a continuous stable acceptance for the energy transition in Germany.

In the decades ahead we will likely see a mixed structure of millions of small generating units – literally for home consumption – spread across the world. The decentralised basic structure will be closely linked to medium and large power plants, likewise based on renewable energy. The ratio of large to small plants will arise from the natural social and regional conditions and requirements. It is one of the strengths of the new technologies that they can do both of these without forfeiting capacity or becoming uneconomic overall.

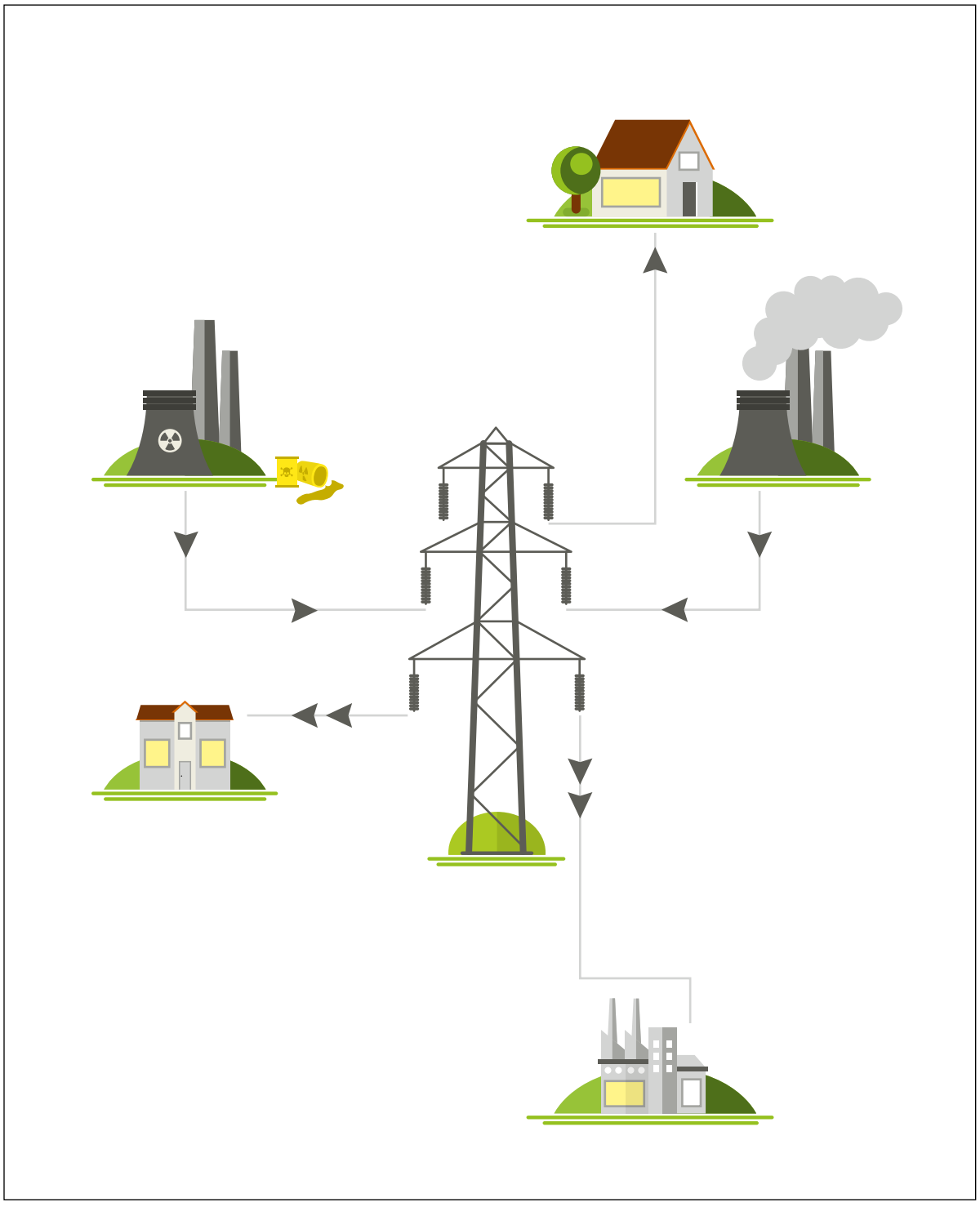

Figure 22: The old energy world: a few hundred coal- and nuclear power plants supply electricity in a one-way-system. The consequences: enormous resource use, climate change, nuclear meltdowns and radioactive waste issues

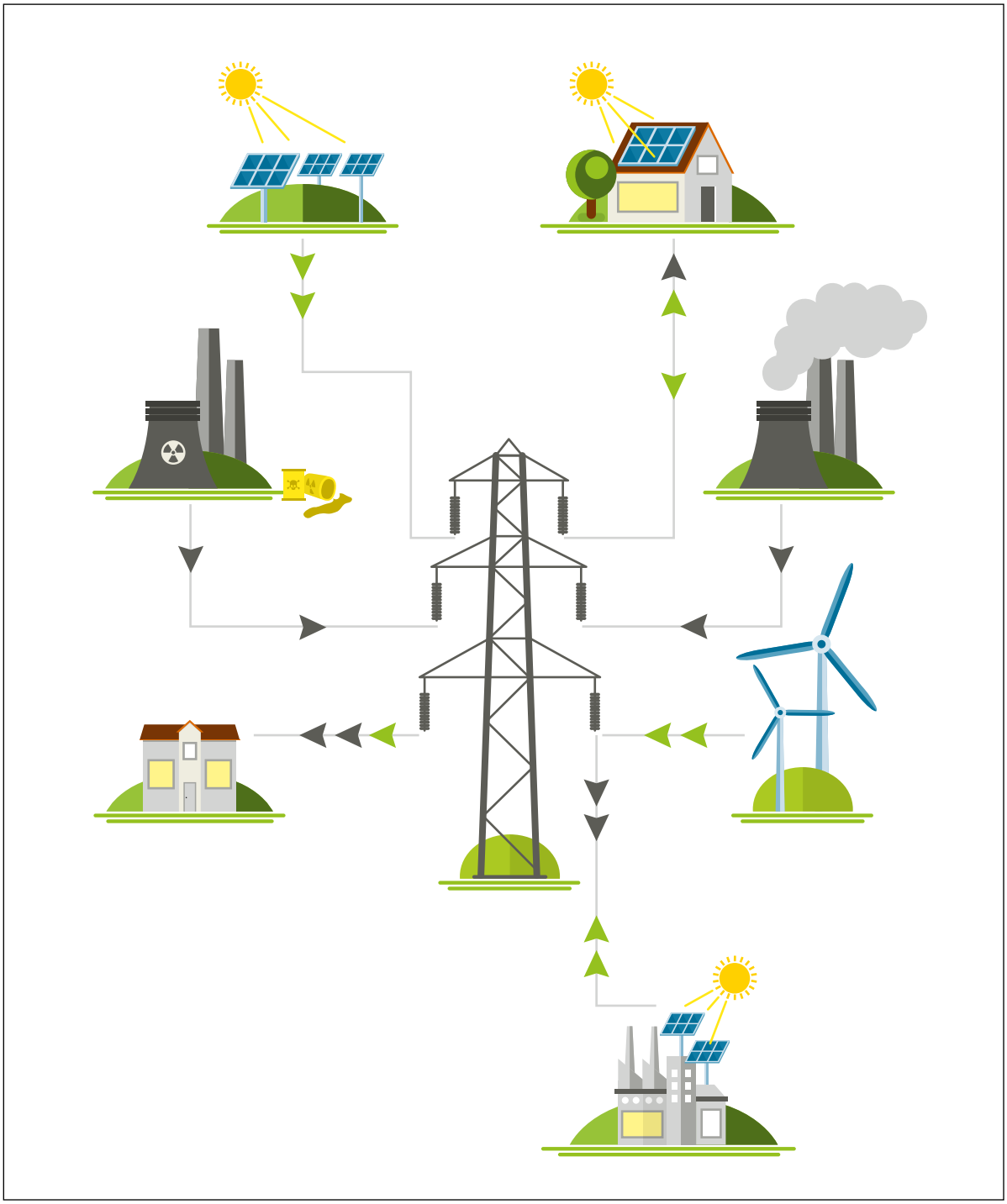

Figure 23: Energy transition: in Germany alone there are now 1,5 Mio. PV-systems and 25.000 Wind power plants installed. These decentralised sources contribute almost 30 % of German electricity production. Buildings become part of the power supply. They use part of the produced electritiy for their own consumption and feed the surplus into the grid. In times of low wind or sunlight, they use energy from the grid.

Large wind parks in windy and mostly uninhabited regions or in the sea can provide wind power for most hours of the year which reduces costs for the (currently) expensive storage of large amounts of electricity. And large photovoltaic ground-based power parks supply kilowatt hours of electricity at a cheaper rate than small roof-mounted PV panels – both in Germany and more so in many sunny and thinly populated regions of the world. There, large solar parks can be set up – beyond what are in any case uncontroversial local island solutions far from the grid – with the aim of developing an industrial infrastructure. Electricity from larger solar power parks like this can also reduce the total costs for a system based largely on wind and sun which needs to be able to reliably ride out not only nights and cloudy spells but also prolonged calm periods without a break to supply. The most important concept for long-term storage of large amounts of electricity beyond large hydropower systems is the use of renewable energy for the electrolytic conversion of water into hydrogen or methane gas which are then used as fuels in conventional gas power plants, ensuring a continuous power supply.[100]

A chance for poorer regions of the world

The new decentralised energy system is developing into an all-embracing promise for the future for the countries of the south which have been amongst the poorer regions of the world up until now. If electricity generation costs fall further, then catch-up development can finally become more than an eternally unfulfilled promise for these countries where 1.5 billion people still live without access to any kind of power supply. According to the World Bank and international energy agencies, over the last 20 years global population growth has almost cancelled out any detectable success in electrifying many countries.[101] Electricity is of course a key commodity for fighting poverty, for access to education, for creating an up-to-date medical system and also for the development of commerce, trade and industry, without which a large proportion of the population have no chance of a life of relative prosperity.

But now all the signs point to a new era: the switch in the energy base suddenly makes the world's solar belt a privileged zone when it comes to producing electricity. The natural resources are available in superabundance in the poor countries and their decentralised ubiquity does not need to wait for an extensive network infrastructure.

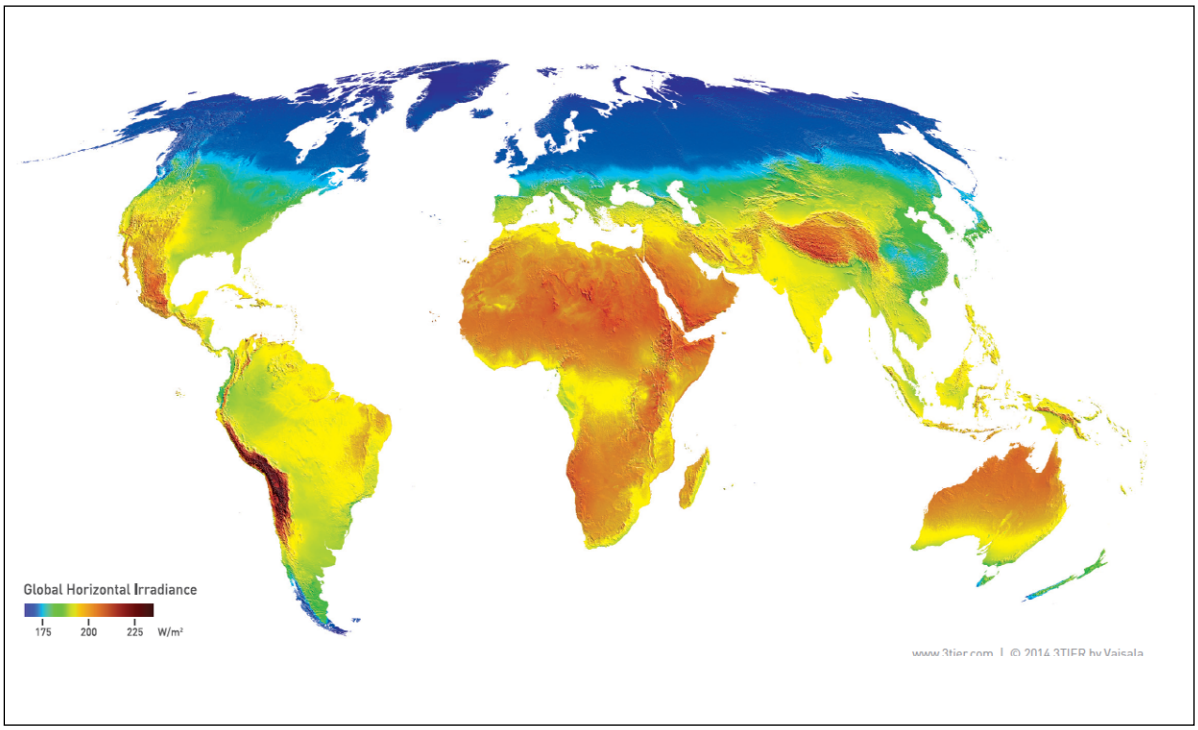

Figure 24: Global solar radiation: An opportunity to redistribute global prosperity?; Source: 3TIER by Vaisala, 2014

The spread of solar systems to satisfy simple basic needs such as light, mobile phones, radio, fridges and machines in businesses and hospitals has already begun.[102,103] But this can only be the – obviously necessary – start. Because lasting prosperity can only arise if the infrastructure developing in the urban centres and metropolises of Africa and Southern Asia have adequate and reliable access to power from renewable energy power plants as an alternative to diesel generators which run on fuel which is generally an expensive import. With the plentiful supply of renewable resources and the constant reduction in investment costs, the opportunities for this are better than ever before.[104] The vision is of a level of prosperity comparable to the industrialised nations but which can manage without the "dirty technologies" on which development in the privileged nations of the north has so far been based. There is a concept for this which is not new: leap frogging. The developing countries leap over the technologies which have proved to be unsustainable elsewhere.

The proportion of countries in the south making new investments in renewable energies is already growing continuously, since PV and wind power have become cheaper year by year. As a result of the economic crisis in large parts of the world, the trend in the industrial countries has not been so clear. Annual investments actually decreased here in 2012 and 2013. The outcome: in 2014 the industrialised countries invested 139 billion dollars in renewable energies, developing and newly industrialised countries 131 billion dollars. The gap is closing. It is a good start.

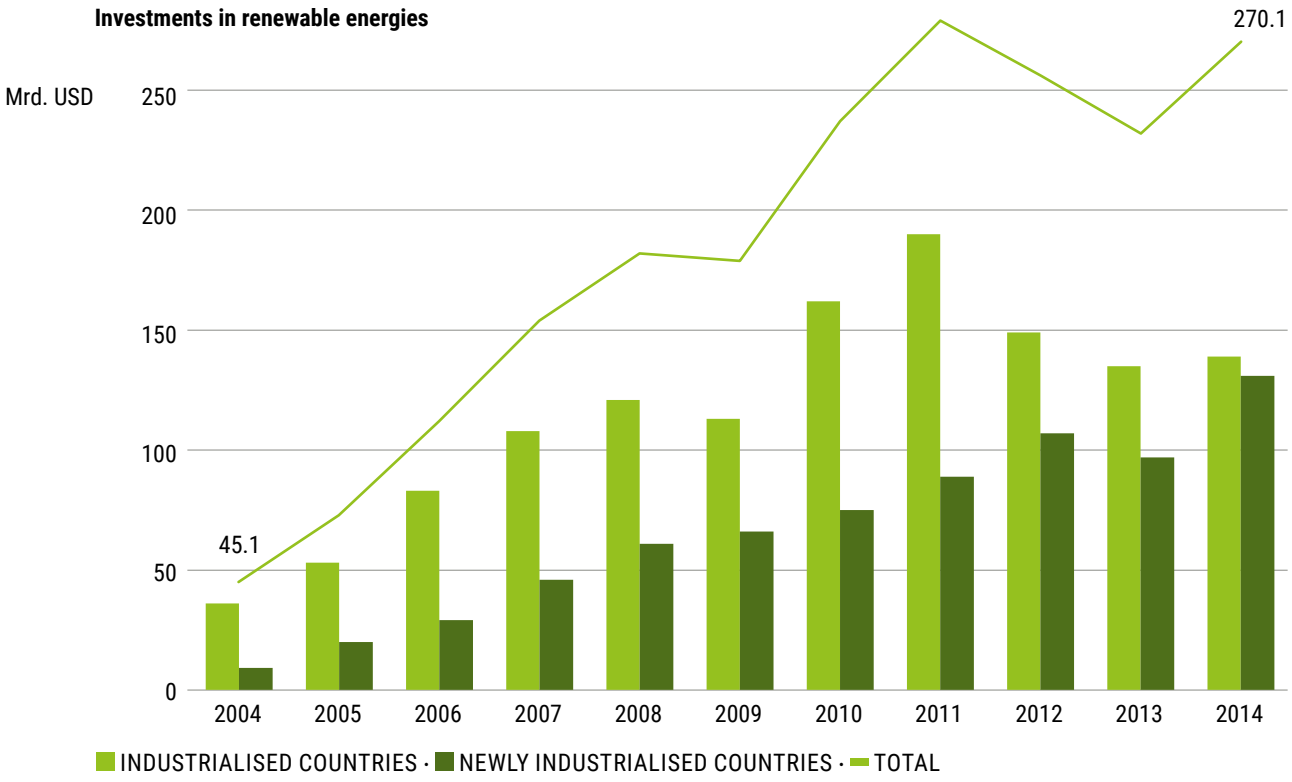

Figure 25: Investments in renewable energies by region (in billions of US dollars); Sources: UNEP, Bloomberg New Energy Finance, 2015

As in future it will no longer be a few hundred large power plants based on the concentrated and easily stored energy raw materials of uranium, coal and natural gas which ensure the supply of power and heat, but millions of small and large power plants which in addition will not all always be available, there will still be a need for central infrastructures such as networks and systems to coordinate the millions of power generating units. By the end of 2014 in Germany more than 1.54 million PV systems and over 25,000 wind turbines were producing power for the gird, giving renewable energy a 30 per cent share in power generation.[105]

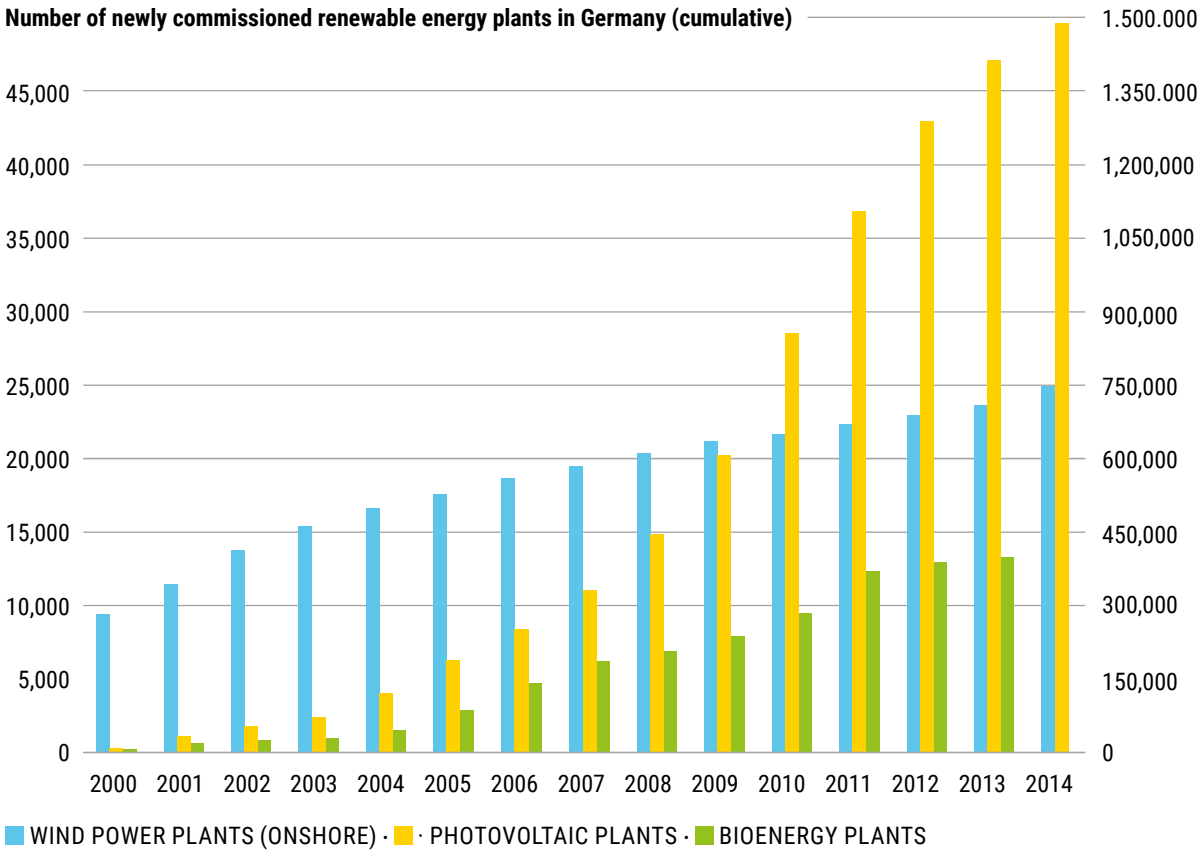

Figure 26: Cumulative net expansion in renewable energy plants in Germany since 2000; Sources: BMWi, ÜNB, DEWI, Deutsche WindGuard, 2015

The fact that in future – with renewable energies providing almost the whole supply at every minute of the year – several million small power plants will need to be coordinated is not the whole story. There is more involved. As mentioned earlier, in the course of this fundamental structural change the clearly defined boundary between energy producers and energy consumers which has been fixed for over a hundred years will become blurred. This ground-breaking change is already in need of new concepts. Time alone will tell whether "prosumers" i.e. people who alternate between their traditional role as energy consumers and a new one as an energy producer, will in future form one of several pillars of the new energy system or even be its main characteristic. But it is already clear that a widely distributed energy system of this kind cannot function without the new information and communication technologies, without an "internet for energy". It is only comprehensive digitisation which can make the start of a second solar age possible.[106]

Megatrend 5
The energy future is digital

- **The area-wide digitisation of the energy sector is both a requirement of and the key to a reliable decentralised energy system characterised by wind and solar energy**

- **In order to implement the energy transition, the IT and energy sectors are growing together with the aim of reliably matching the energy supply and demand at all times**

- **IT platforms linked to the Internet enable automated networking, coordination and intelligent control of thousands of units for energy generation and consumption**

- **Traditional energy suppliers and new companies who view themselves as IT and energy service providers are competing in the quest for new business models in the power house of the energy transition**

- **The anticipated rapid cost degression for battery banks will accelerate the digitisation and decentralisation of the energy transition and its expansion to the mobility and heating sectors**

The greater the success and the higher the proportion of volatile energy from wind and sun in the supply, the more urgent is the question: what happens when the sun is not shining and the wind not blowing? It is an obvious question. The reassuring answer is already there: all the technologies and processes for solving this central system issue are in principle already available, even for a "100 per cent renewable" future.

Perhaps the most exciting news on the way to the new solar era is not the decentralised character of the new energy system after all. This is simply part of the nature of the new key technologies which directly convert what nature supplies in the form of – naturally decentralised – sunshine, wind or other renewable energies into

usable energy sources. Perhaps the greatest attraction is due to the fact that an energy system built on wind and sun can be just as reliable as that based on coal, oil, natural gas and uranium. The claim which every lay person can easily grasp, that a system cannot function if it is developed from energy sources which are not always available, turns out not only to be too simple an idea, but actually wrong. The new system will meet the energy demand just as reliably as the old one.

The property which fundamentally distinguishes the sources of the new energy technologies from the traditional ones is "volatility". The wind blows erratically, the sun only shines through the day and even then not all the time. Power from sun and wind is becoming cheaper and more competitive at an undreamed of rate compared to the traditional power generation in large fossil or nuclear power plants. But an energy system which focuses on these two technologies must cope with the fact than in future there will almost always be too much energy available than is required at any one moment or too little. Perhaps the greatest challenge in setting up the new energy system is therefore to match the energy supply and energy demand every second of every hour, day after day, week after week and year after year.

There is therefore nothing more nor less on the agenda than a complete system change. Because in future the demand will not determine the supply – i.e. the operation of the power plant – but demand will also have to follow the volatile supply, at least in part. The supply which could previously be turned up or down at the press of a button, will in future be volatile, resource-dependent and only able to be influenced by people to a limited extent. So when the sun is shining and the wind blowing there is plenty of power available, and in future an excess of power in fact. Then consumption and demand must be increased and infrastructures created which can store excess power and make it available again at times when the sun has set or the wind has dropped away. This reversed principle requires maximum flexibility, sophisticated predictive ability and high speed, all things which can only be done with intelligence and the new information and communication technologies (IT).

In the past only consumption had to be predicted. This was comparatively easy, particularly as consumer patterns had emerged for weekdays, Saturdays and Sundays and for statistical balancing effects based on the size of the market which enabled the electricity demand to be predicted on every weekday, Saturday and Sunday at every hour of the day. It was comparatively simple to control a manageable number of power plants along these learning curves. This era is coming to an end. In the renewables world based on fluctuating energies it will be replaced by a large number of factors. Complex control mechanisms will become essential, because it will not just be total consumption which needs to be predicted but also the supply. An additional determining factor is the weather which not only varies regionally but also changes very quickly and is hard to forecast. When and where will the sun shine, when and where will the wind blow, when will the solar panels be covered with snow, when will the clinging morning mist lift – if it ever does?

The fluctuations in generation have to be measured and the data recorded and analysed – and all in real-time if possible. But because generation no longer occurs in only 500 large power plants but in millions of de-centralised PV systems and wind turbines, even here there are completely new tasks and challenges. Systems have to be implemented and communicate with each other. Data capture must take place at a high spatial and temporal resolution.

The standard quarter-hourly values used currently represent a comparatively low temporal resolution. It will soon be units of seconds and real-time transmission.

The new situation can best be explained through the example of a household. In the "old market" the electricity meter for domestic customers had only one job, that being to constantly record the customer's consumption which was then usually read once a year. In future if the household has its own generation, its own storage and its own electric vehicle, then power will not just be consumed and taken from the grid but also fed into the grid. The household equipment will also be involved in stabilising and controlling the grid. A number of electricity flows will need to be recorded and calculated and not only once a year but every quarter of an hour. So one value per household per year turns into four per hour, 96 per day, 2,880 per month and 35,040 per year. It goes without saying that this can no longer be taken care of by the customer writing down the meter reading and then sending it on a postcard to their energy provider.

Digitisation enables remote reading of thousands of values per household. If, in addition to consumption values, generation values also have to be recorded for the processes, each household will in future supply over 70,000 measurement values per year. With around 50 million metering points, this is a fundamentally new challenge. Billions of units of data to be accurately processed, correctly assigned, archived and, above all, given a meaning for energy management is the job of a digitised energy industry and the service companies who in future will provide their services in the power house of the energy transition and keep the system operational.

The degree of maturity achieved by the new renewable energy technologies and their rapidly declining costs demonstrate the success of the hardware development of the energy transition. They are the necessary basis for it to succeed. But these alone are not enough. The triumphant progress of renewable energies and the – not to be forgotten – progress in energy efficiency can only become a turning point in the energy industry through the digital revolution, which also calls into question the business models of whole sectors of the economy elsewhere. It is not only the quantum leaps in all possible fields of technological development which is driving the energy transition but also the fascinating opportunities for its networking and control by means of the new information technologies (big data).

In the energy sector we are at the start of a development which will put the transformation in the telecommunication technology – from landline telephone to all-embracing individual networking, everywhere, with everyone and everything – in the shade. We are experiencing the coming together of information technology and the energy sector. New businesses in the energy sector do not define themselves as energy suppliers but in a much more inclusive sense as service providers in the energy field. Their business models are based on a constantly increasing amount of data and the ability to match the decentralised energy production of their customers with their consumption at all times. In fact these companies are developing into IT platforms for coordinating the use of millions of energy generating facilities and in the next step for effectively networking the energy sectors of power, heat and mobility which so far have been largely independent of each other. If we are not mistaken, in the cleaner new energy world, electrical power will also become the key technology for the heating and mobility sectors.

And a German Federal Ministry of Economy White Paper from March 2015 even states, "The electricity market will be the first fully digitised sector of our economy"[107]. More and more experts now doubt whether there will still be a place for traditional energy suppliers in a system of this kind in the long-term. New businesses in the energy industry call themselves IT and energy companies or merge into joint ventures for decentralised energy management. They coordinate photovoltaic modules and wind turbines with heat pumps, thermal storage units and batteries for their private and business clients who, for their part, alternate between their roles as energy consumers and energy suppliers. The virtual power station which was still the codeword for the utmost progress in the energy scene ten years ago will probably disappear in the much more comprehensive IT platforms for coordinating the flow of generation and consumption which are also dedicated to the goal of reliably matching energy supply and demand at all times. (see Figure 27: the new energy world)

So while the start up companies in a digitised energy sector are working out new business models and trying to fit their products to the lifestyle of a completely networked generation culturally habituated to smartphones and then smarthomes, increasing numbers of traditional energy suppliers are trying to get a foothold in the new era. Some of these do not stop at exchanging their generating base – away from coal and nuclear and towards sun and wind – but also work at connecting decentralised prosumers who in future will no longer make do with their role as energy consumers.

The largest German energy supplier Eon caused a sensation when, in autumn 2014, it announced its intention to split the group into a – gradually declining? – company to run the old business (name of the "new company": Uniper)[108] and the new Eon for renewable energies, energy networks and customer solutions[109]. This showed clearly where the former flagship of the Germany energy industry considers the energy future – and the past – to lie. The fact that Eon reconsidered this step in autumn 2015 for obviously tactical reasons changes little[110]. But in this the Germans are no longer alone by a long way. In France, the country of centralism and nuclear energy, amazing things are also happening. In April GDF Suez, the French energy corporation which claims to be the largest independent electricity supplier in the world, renamed itself Engie[111]. The new name is seen as the signal for entry into the new era of "miniaturising the energy industry", said Gérard Mestrallet, the long-standing head of the energy corporation, adding: "The new era is decentralised, carbon-free and digitised".[112]

Which technologies and methods have to be applied and when in order to keep the energy supply from the sun and wind in balance with the energy demand at all times will be decided in the coming years. What seems certain is that it will not be just one method or one technology which supplies the solution for everything. However, the magic words for the new energy world are already decided: they are flexibility and networking, efficiency and diversity – and everything works together because the digital revolution, as the mother of all megatrends, enables their intelligent combination. This will function all the better, the more we succeed in breaking down the former boundaries between the energy sectors of power, heat and mobility and linking these up with each other.

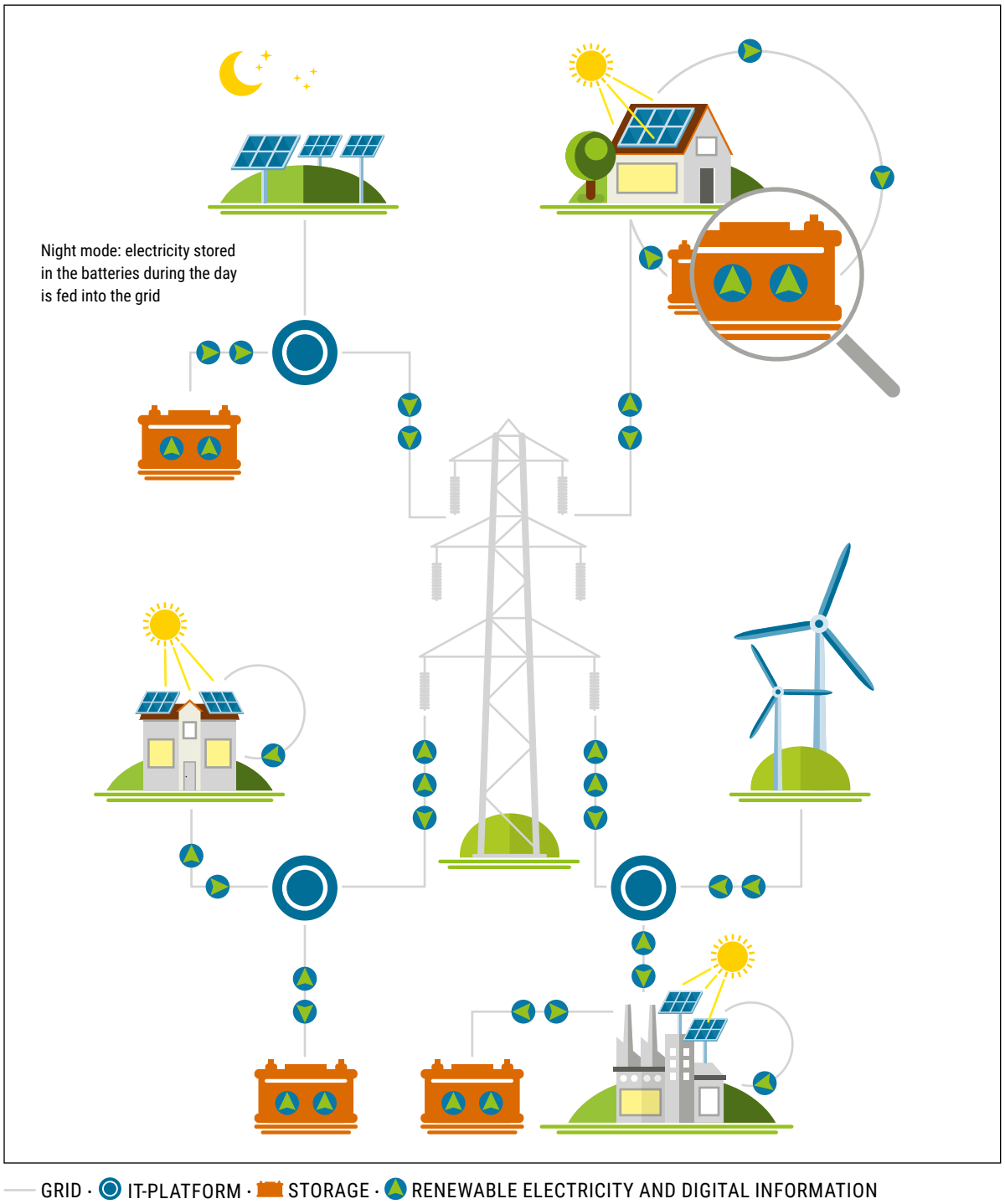

Figure 27: The future energy world: 100 % of the electricity comes from renewable sources. To make up for times with low wind and sun storage is needed. IT-platforms make electricity “intelligent”. They coordinate between fluctuating electricity production, storage and consumption in a digitised electricity market and thus ensure security of supply.

This will be helped by closely interwoven distributor networks but also large transnational transmission lines for the long-distance transport of electricity. The volatile electricity generation from wind power and photovoltaics can be balanced better over larger geographical areas because conventional power plants and, increasingly, energy storage for different purposes can be used jointly and therefore more efficiently in the combined regions and countries.

It is not only the suppliers of energy who are experiencing an upheaval in their technological and logistical base. Energy users are also entering a new world of dealing with the commodity of energy. They will increasingly adapt their consumer behaviour to the supply and preferentially buy electricity when it is available in excess and can therefore be acquired cheaply and not at times of scarcity and high prices. This applies even more to businesses than to private electricity consumers.[113]

The problem of storing electricity was long considered the Achilles heel of the energy transition. Because it is technically complex, because the new system requires different storage technologies for the short, medium and long (seasonal) periods, because they were all considered to be too expensive and, after significant electricity price increases in recent years for private consumers, business operators and some of the industrial users, government shrank back from further potential large price increases. But now relief has come from two directions. First, an improved and newly regulated market control and the alteration and expansion of the power grid have brought relief – the system requires less storage capacity and then only with large market percentages of wind and solar. Second there is a cost development predicted particularly for battery storage which is reminiscent of that which has already arrived for photovoltaic.

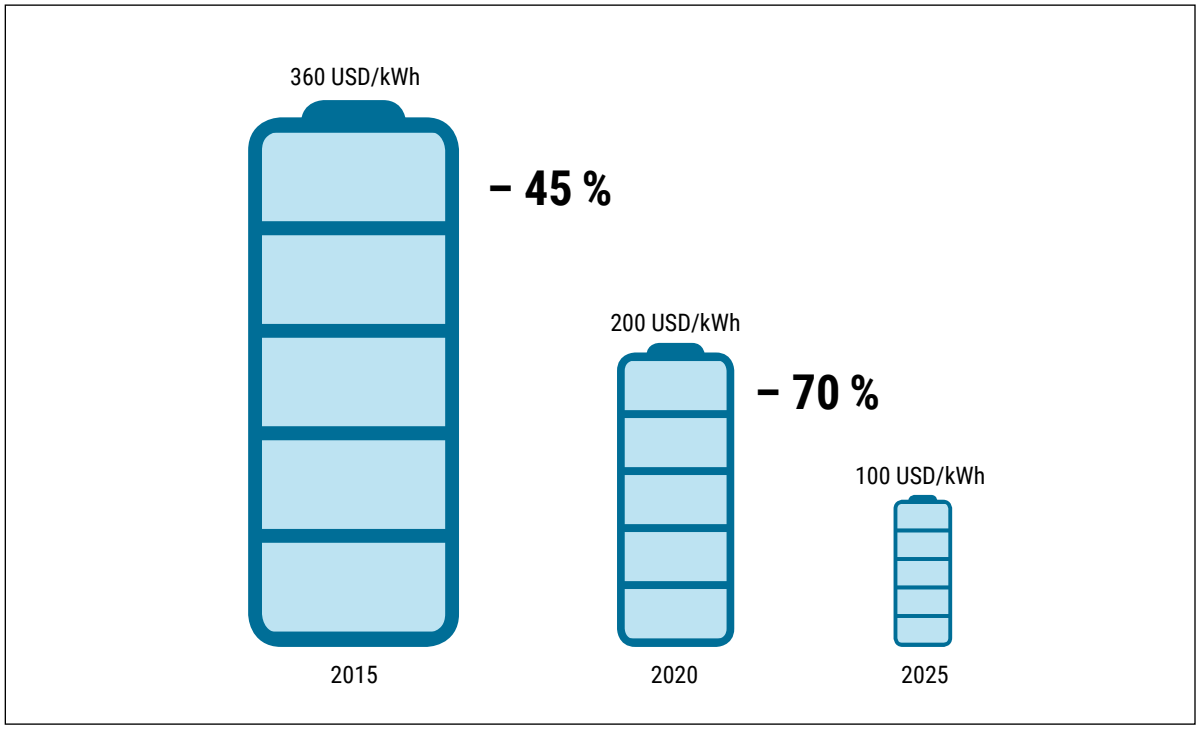

Figure 28: Expected cost degression for lithium batteries; Source: UBS, 2014

The major Swiss bank UBS views photovoltaic in combination with batteries and electric cars as disruptive technologies which will soon seriously shake up both the energy market and the automotive one. UBS researchers are convinced that the mass production of batteries for the fixed and mobility sectors will lead to similar steep reductions in price in battery technology as we have seen for the photovoltaic industry. This will go a long way to solving the problem of volatility in solar power storage, the UBS analysts believe – at least as far as the domestic and commercial sectors are concerned. Private solar energy and mobility systems with the photovoltaic panels on the roof, the lithium battery in the basement and the electric car outside the door would gain acceptance quickly and without subsidies everywhere where electricity and petrol are expensive (for example in Germany) and these kind of systems therefore pay off quickly.

The hope that renewable regeneration combined with batteries could lead more quickly than anticipated to a mass phenomenon was given a new boost at the beginning of May 2015 by an announcement from the Californian electro car and battery manufacturer Tesla. Tesla presented a new battery storage unit for households, trade and middle-sized businesses. The Powerwall Home Battery is designed to assist private and commercial customers to make optimum use of the solar energy they have produced themselves. Like the future batteries for Tesla electric cars, the system will be manufactured in the new "gigafactory" which Tesla is currently constructing with Panasonic in Nevada and will be sold much more cheaply than the domestic batteries based on lithium ions made so far.[114, 115]

In the new energy system excess power during sunny and windy periods will probably not remain excess for long, but quickly find new users and applications. The electricity from the roof can charge the battery bank for the electric cars or house batteries for operating heat pumps or be used for efficient and carbon-neutral domestic heating. Energy efficient combined heat and power plants operated using comparatively environmentally friendly natural gas can be used for domestic heating or to provide industrial process heat and only produce electricity secondarily. These will be fitted with additional heat stores and large-dimensioned "immersion heaters" for using excess power (power-to-heat) in order to be able to supply customised power and heat when it is really needed.

The authors of the UBS study mentioned above do not deny that, according to their analysis, there will be winners and losers amongst the energy suppliers in the transition to the decentralised energy system. According to this the losers will tend to be the large companies with the bulk of their power generation in central and inflexible power plants, the winners will be smaller more flexible energy service providers with many customers and direct access to customers and the opportunity of offering various energy-related services aimed at a range of customer needs.

Outlook

Megatrends by nature do not change suddenly. If this were not so, then they would not be megatrends. The developments on the energy markets identified here and observable all over the world also behave in this manner. The megatrends described point to epochal changes which can no longer be reversed. As in Germany, one of the most important starting points for the global energy transition, on a world scale it is now no longer a matter of whether the energy transition will happen, but only how. And of course when.

This is the crucial point, because the fate of the human race and along with it the natural environment as we know it depends on the question of when and how quickly we can limit climate change to a level which is controllable and bearable for human beings, and avoid further devastating nuclear disasters like those in Chernobyl and Fukushima.

There is no question that renewable energies and their efficient use are the future. They are largely developed and have proved their suitability. What is not decided is whether the new low-risk technologies will take over the global energy supply to a sufficient extent and the sustainable energy supply gain acceptance around the world for a globally sustainable energy system to result. An energy system that has the potential to make the world more peaceful and more just. Everything is in favour of this in principle. But the forces of inertia of the old interests are still powerful and influential. If they do not adapt in time they will have a lot to loose.

But the energy transition now, when it is obviously turning into a global movement, is even less of a foregone conclusion at a global scale. To be successful, the transformation to a sustainable energy system requires a decisive, clever, effective and ultimately vigilant policy everywhere. And a civil society and progressive businesses who pursue the policy with determination. Even if this is successful, the energy transition remains a race against time. Its outcome addresses and answers the big questions: for example whether, despite the multiplicity of conflicting interests, a growing population in a globalised world is in a position to make appropriate strategic decisions on existential questions. It is unquestionably a matter of global historic developments which point far beyond the resolutions of the 21st world climate conference in Paris. But these must form an initial important step. For this generation and all subsequent ones.

1 BDEW: BDEW-Energiemonitor 2015 – Das Meinungsbild der Bevölkerung, https://www.bdew.de/internet.nsf/id/1EE7792DB2C30D45C1257B4A00316189/$file/13%2003%2012%20BDEW-Energiemonitor%202013_kommentierte%20Fassung_final.pdf; http://www.wiwo.de/politik/deutschland/allensbach-umfrage-hohe-zustimmung-fuer-energiewende/10037578.html; http://unendlichviel-energie.de/presse/nachrichtenarchiv/2014/92-prozent-der-deutschen-wollen-den-ausbau-erneuerbarer-energien

2 IAEA, Power Reactor Information System (PRIS), 09.10.2015; http://www.iaea.org/pris/; The International Atomic Energy Authority's (IAEA) statistics are exaggerated inasmuch as the organisation classifies the large majority of Japanese reactor blocks which have been shut down for years due to the Fukushima disaster as "in operation", although no one knows how many of these power plants will ever be started up again.

3 Cf. BP Statistical Review of World Energy, June 2015; http://www.bp.com/en/global/corporate/about-bp/energy-economics/ statistical-review-of-world-energy.html. However, it is also true that only five of the 196 UN states emit more greenhouse gas than Germany: China, the USA, India, Russia and Japan.

4 According to the BP Statistical Review of World Energy, in 2013 the USA produced around 17 per cent and the People's Republic of China 27 per cent – together therefore 44 per cent of global CO_2 emissions.

5 The IAEA was set up in 1957 as a special UN agency for the worldwide promotion of the peaceful use of nuclear power. In 1974 its projection for global electrical nuclear power production in 2000 was 4,450 gigawatts (IAEA annual report, Vienna 1974). In reality it did not even achieve a tenth of this value. In June 2015 the installed capacity of all nuclear power plants was just over 379 gigawatts, according to the IAEA; http://www.iaea.org/pris/

6 Matthieu Metayer, Christian Breyer, Hans-Josef Fell: The projections for the future and quality in the past of the World Energy Outlook for solar PV and other renewable energy technologies, 22.09.2015; http://energywatchgroup.org/wp-content/uploads/2015/09/EWG_WEO-Study_2015.pdf

7 Elias Hinckley: Historic Moment: Saudi Arabia sees End of Oil Age coming and opens valves on the carbon bubble, energypost, 22.01.2015. http://www.energypost.eu/historic-moment-saudi-arabia-sees-end-oil-age-coming-opens-valves-carbon-bubble/

8 Hanns Günther Hilpert, Kirsten Westphal: Ölpreisbaisse – Konsequenzen für Wirtschaft, Geopolitik und Energiewende; SWP-Aktuell 32, Berlin April 2015.

9 Ambrose Evans-Pritchard: Oil industry on borrowed time as switch to gas and solar accelerates, The Telegraph, 20.08.2014. http:// www.telegraph.co.uk/finance/comment/ambroseevans_pritchard/11046842/Oil-industry-on-borrowed-time-as-switch-to-gas-andsolar-accelerates.htm

10 At the moment Eon has got no further than the attempt: dividing up the business into fossil and nuclear energies on the one hand and renewable energies, power trading and networks on the other was dropped again after the German Federal Government had stated its determination – by way of the planned law for extended liability for the dismantling and disposal in the nuclear power industry (Rückbau- und Entsorgungskostennachhaftungsgesetz) – to permanently guarantee the billions in reserves for disposing of the legacies of the nuclear power adventure, even if the business was divided up.

11 Zeit-Online, Kohle unbeliebter als Atomkraft, 16.09.2015; http://www.zeit.de/wirtschaft/2015-09/energie-allensbach-umfrage-kohle-atomkraft; The blog "Phasenprüfer" published a summary of the results of the opinion poll by IfD Allensbach "Einstellungen der Bundesbürger zur Energie- und Klimapolitik" of 11.08.2015 at: http://phasenpruefer.info/wp-content/uploads/2015/09/Umfrage-Bundesregierung-Energiewende-gekuerzt.pdf

12 In 2005 hurricane Katrina devastated New Orleans, killed approximately 1,800 people and caused damage along the Gulf Coast of about 108 billion US dollars.

13 See below under Megatrend 1.

14 The graph for fossil power generation ends in 2012 due to a lack of current data.

15 Joseph Romm: Global coal boom? It ends as China and world wake up to reality of carbon pollution, Energy Post, 26.08.2015; http://www.energypost.eu/global-coal-boom-ends-china-world-wake-reality-carbon-pollution/

16 Ludger Arnoldussen, Peter Höppe: Relevance of changing weather patterns. Munich, 20.10.2014; http://www.munichre.com/site/corporate/get/params_E-1397260355_Dattachment/972311/2014-10-20-Munich-Re-Press-release-Presentation.pdf

17 http://www.preventionweb.net/files/44281_19802014paketweltusdd4zu3.pdf

18 Abschlusserklärung des G7-Gipfels, Juni 2015, p. 17ff; https://www.bundesregierung.de/Content/DE/_Anlagen/G8_G20/2015-06-08-g7-abschluss-deu.pdf?__blob=publicationFile&v=4

19 The Telegraph Interview 25.06.2000: Sheikh Yamani predicts price crash as age of oil ends. http://www.telegraph.co.uk/news/uknews/1344832/Sheikh-Yamani-predicts-price-crash-as-age-of-oil-ends.html

20 Christophe McGlade, Paul Ekins: "The geographical distribution of fossil fuels unused when limiting global warming to 2 oC", Nature, Vol 517, pp. 187-190 (January 2015).

21 Reserves are the raw materials that can be extracted economically using the latest technology; resources are the known deposits without reference to the cost efficiency or technical feasibility of extraction.

22 www.Gofossilfree.org

23 The list of the 200 largest coal, oil and gas companies can be viewed online at: http://gofossilfree.org/top-200/

24 Rockefeller Brothers Trust, press release 22.09.2014: Fund Announces Plans to Divest from Fossil Fuels; http://www.rbf.org/post/fund-announces-plans-divest-fossil-fuels.

25 http://www.theguardian.com/environment/2015/jun/05/norways-pension-fund-to-divest-8bn-from-coal-a-new-analysis-shows

26 Süddeutsche Zeitung 28.5.2015: Vorreiter Oslo; http://www.sueddeutsche.de/wirtschaft/energiepolitik-vorreiter-oslo-1.2497694

27 Christine Shearer, Nicole Ghio, Lauri Myllyvirta, and Ted Nace: "Boom and Bust – Tracking the Global Coal Plant Pipeline", Coalswarm/Sierra Club, March 2015 http://action.sierraclub.org/site/DocServer/Coal_Tracker_report_final_3-9-15.pdf?docID=17381

28 Justin Guay (Sierra Club): "China's Coal Consumption Has Finally Decreased", CleanTechnica, 2014; http://cleantechnica.com/2014/08/26/chinas-coal-consumption-finally-decreased/

29 Joseph Romm: Global coal boom? It ends as China and world wake up to reality of carbon pollution, Energy Post, 26.08.2015;

30 Moody's: US coal industry outlook remains dim on falling consumption and weak met coal prices, Moody's Investors Service 01.10.2015; https://www.moodys.com/research/Moodys-US-coal-industry-outlook-remains-dim-on-falling-consumption--PR_335795

31 Tom Randall: The Latest Sign That Coal Is Getting Killed, BloombergBusiness, 13.07.2015; http://www.bloomberg.com/news/articles/2015-07-13/the-latest-sign-that-coal-is-getting-killed

32 Michael Grunwald: Inside the war on coal, Politico 05/2015; http://www.politico.com/agenda/story/2015/05/inside-war-on-coal-000002

33 After decades of almost total standstill, five nuclear power plant blocks are also under construction in the USA – two each in Georgia (Vogtle 3, 4) and South Carolina (Summer 2, 3), all begun in 2013; and finally the Watts Bar Unit 2 in Tennessee, under construction since 1973 with a twelve year interruption, which is also supposed to produce tritium for atomic weapons. The nuclear power plant projects are a belated outcome of an unparalleled subsidy and support policy of the first Bush administration (2001 – 2009) which Barack Obama continued in part in his first period in office (2009 – 2013). Details available in: Gerd Rosenkranz: Mythen der Atomkraft – Wie uns die Energielobby hinters Licht führt; p. 78 ff; oekom Verlag Munich 2010; https://www.iaea.org/PRIS/CountryStatistics/ReactorDetails.aspx?current=1039; https://de.wikipedia.org/wiki/Kernkraftwerk_Watts_Bar

34 Tom Randall: Solar and Wind Just Passed Another Big Turning Point, Bloomberg Business, 06.10.2015; http://www.bloomberg.com/news/articles/2015-10-06/solar-wind-reach-a-big-renewables-turning-point-bnef

35 Nevertheless, GHG emissions per capita of the population remain at an exorbitantly high level, including in relation to comparable industrial societies in Europe.

36 International Energy Agency (IEA): Global energy-related emissions of carbon dioxide stalled in 2014, Paris, 13.03.2015; http://www.iea.org/newsroomandevents/news/2015/march/global-energy-related-emissions-of-carbon-dioxide-stalled-in-2014.html

37 While there were frequently reductions in emissions, these were always after significant slumps in global economic performance.

38 Mike Corones: Is coal's decline permanent? 06.01.2015; http://blogs.reuters.com/data-dive/2015/01/06/is-coals-decline-permanent/

39 Elias Hinckley: Historic Moment: Saudi Arabia sees End of Oil Age coming and opens valves on the Carbon bubble, 22.01.2015; http://www.energypost.eu/historic-moment-saudi-arabia-sees-end-oil-age-coming-opens-valves-carbon-bubble/

40 Giles Parkinson: Fossil fuels face $30 trillion losses from climate, renewables, 28.04.2015; http://reneweconomy.com.au/2014/fossil-fuels-face-30-trillion-losses-from-climate-renewables-11465

41 Rineesh Bansal, Stuart Kirk: Peak carbon before peak oil, DB Research Konzept, Januar 2015, p. 19; https://www.dbresearch.com/PROD/DBR_INTERNET_EN-PROD/PROD0000000000349119/Konzept+Issue+02.pdf

42 Critical Resource: Lord Browne calls for stronger industry action on climate. London, November 2014; http://www.c-resource.com/lord-browne-calls-for-stronger-industry-action-on-climate-change/

43 Mark Carney: Breaking the Tragedy of the Horizon – climate change and financial stability (London 29.09.2015); http://www.bankofengland.co.uk/publications/Documents/speeches/2015/speech844.pdf

44 Bank of England: The impact of climate change on the UK insurance sector (September 2015); http://www.bankofengland.co.uk/pra/Documents/supervision/activities/pradefra0915.pdf

45 IWF Working Paper: How Large Are Global Energy Subsidies? May 2015, p. 18; https://www.imf.org/external/pubs/ft/wp/2015/wp15105.pdf

46 Cf. EN 43

47 Cf. EN 6

48 IEA: World Energy Outlook 2014.

49 By the Red-Green German Federal Government but, even back then, with the support of all parliamentarians of all parties represented in the Bundestag.

50 Cf. Renewable Energy Policy Networks (REN 21): Renewables 2015 – Global Status Report, p. 153, although this – in contrast to the REN 21 report – only lists countries but not states or provinces; http://www.ren21.net/status-of-renewables/global-status-report/

51 Felix C. Matthes, Markus Haller, Hauke Hermann, Charlotte Loreck, Vanessa Cook (Übersetzung): Konzept, Gestaltungselemente und Implikationen eines EEG-Vorleistungsfonds. Gutachten für den Rat für Nachhaltige Entwicklung, p. 4., Berlin 2014; http://www.oeko.de/oekodoc/2013/2014-599-de.pdf

52 Calculated for an average household with annual consumption of 3,500 kWh at 6.17 cent/kWh EEG surcharge in 2015.

53 European Photovoltaic Industry Association, Global Market Outlook 2014 – 2018; http://www.epia.org/fileadmin/user_upload/ Publications/44_epia_gmo_report_ver_17_mr.pdf; Projections for 2014 by ZSW et. al, Vorbereitung und Begleitung der Erstellung des Erfahrungsberichts 2014 - Vorhaben IIc Solare Strahlungsenergie (as of 04/2014); https://www.bmwi.de/BMWi/Redaktion/PDF/XYZ/zwischenbericht-vorhaben-2c,property=pdf,bereich=bmwi2012,sprache=de,rwb=true.pdf

54 Global Wind Energy Council (GWEC), Global Wind Report 2014, Brussels, 04/2015; http://www.gwec.net/wp-content/uploads/2015/03/GWEC_Global_Wind_2014_Report_LR.pdf

55 The net expansion of onshore wind power in Germany was 4.385 GW. In addition, in 2014 offshore wind turbines with a total capacity of 0.529 GW were connected to the grid; Deutsche Windguard, Wind Statistics 2014; http://www.windguard.de/service/knowledge-center/windstatistik/jahr-2014.html

56 Cf. GWEC (EN 54)

57 GWEC (EN 54)

58 GWEC: Global Wind Energy Statistics 2014, Brussels, 10.02.2015; http://www.gwec.net/wp-content/uploads/2015/02/GWEC_GlobalWindStats2014_FINAL_10.2.2015.pdf

59 This change of position is primarily symbolic. It indicates where the future lies and what belongs to the past. However, nuclear power will continue to produce significantly more electricity than wind power for some years to come, because the rotors of wind turbines only turn when the wind blows whereas nuclear power plants produce electricity round-the-clock for most of the year.

60 International Renewable Energies Agency (IRENA): Data and Statistics, Renewable Energy Capacity; http://resourceirena.irena.org/gateway/dashboard/

61 Cf. IRENA: Rethinking Energy 2014 – Towards a new Power System. Abu Dhabi 2014; http://www.irena.org/rethinking/Rethinking_FullReport_web_view.pdf

62 IRENA (EN 60)

63 Omar Ellabban, Haitham Abu-Rub, Frede Blaabjerg: Renewable energy resources: Current status, future prospects and their enabling technology, Renewable and Sustainable Energy Reviews, 2014, p. 748 (751); http://www.researchgate.net/profile/F_Blaabjerg/publication/265166458_Renewable_energy_resources_Current_status_future_prospects_and_their_enabling_technology/links/5408147c0cf2bba34c248e10.pdf

64 https://en.wikipedia.org/wiki/Three_Gorges_Dam

65 The World Nuclear Industry Status Report 2014; Paris, London, Washington 07/2014; http://www.worldnuclearreport.org/IMG/pdf/201408msc-worldnuclearreport2014-hr-v4.pdf

66 http://www.pv-magazine.de/nachrichten/details/beitrag/china-hebt-photovoltaik-zubauziel-2015-auf-23-1-gigawatt-an_100020759/

67 REN 21 (EN 50)

68 Frost & Sullivan, “Photovoltaic, Wind and Hydro Star as Top Renewables”, London, 26.01.2015; http://ww2.frost.com/news/press-releases/photovoltaic-wind-and-hydro-star-top-renewables-finds-frost-sullivan/

69 REN 21, pp. 48/72

70 The national feed-in tariffs were introduced in 1978, but only implemented by a few federal states. A feed-in tariff has now been introduced into five federal states for their respective territories and is offered by energy utility companies in some other federal states. www.eia.gov/todayinenergy/detail.cfm?id=11471

71 Nuclear power: since 1997 no new reactor units have been connected to the grid in Western Europe. In Eastern Europe there have been five since 2000: two each in the Czech Republic and the Ukraine and one in Romania.

72 European Wind Energy Association (EWEA): Wind in Power – 2014 European Statistics; http://www.ewea.org/fileadmin/files/library/publications/statistics/EWEA-Annual-Statistics-2014.pdf

73 Cf. IEA: Special Report, World Energy Investment Outlook, 2014, p. 162; http://www.iea.org/publications/freepublications/publication/WEIO2014.pdf

74 In 2013 alone almost 50,000 jobs were lost in the solar sector. Cf. the studies by the BMWi on the employment effects in the energy sector at: http://www.bmwi.de/DE/Themen/Energie/Energiedaten-und-analysen/arbeitsplaetze-und-beschaeftigung.html

75 According to the German Wind Energy Association (BWE) the export ratio of the German wind power producers was between 66 and 67 per cent in the years 2010 – 2012.

76 BP Statistical Review of World Energy – June 2015, Data Workbook; http://www.bp.com/statisticalreview

77 In absolute figures this means that in 2014 Denmark generated 13.08 TWh of power from 4.855 MW installed wind capacity.

78 Michael Fuchs, Joachim Pfeiffer: Förderung von Windkraft an Land läuft aus dem Ruder – Zubau der Erneuerbaren wirksam steuern; Press release by the CDU party, 29.01.2015. http://www.cdu-lg-bw.de/pressemitteilungen/944-dr-joachim-pfeiffer-foerderung-von-windkraft-an-land-laeuft-aus-dem-ruder

79 Bundesnetzagentur: Einspeisevergütung für Photovoltaik-Anlagen sinkt nur um 0,25 Prozent; press release 30.12.2014; http://www.bundesnetzagentur.de/cln_1421/SharedDocs/Pressemitteilungen/DE/2014/141230_PVZubau.html?nn=524852

80 Bundesnetzagentur: Die Fördersätze für Photovoltaik-Anlagen werden nicht abgesenkt; press release 30.09.2015; http://www.bundesnetzagentur.de/cln_1431/SharedDocs/Pressemitteilungen/DE/2015/150930_PV-Anlage.html?nn=265794

81 http://www.pv-magazine.de/nachrichten/details/beitrag/ihs-hebt-weltweite-photovoltaik-zubauprognose-fr-2015-auf-59-gigawatt-an_100020782/

82 http://www.pv-magazine.de/nachrichten/details/beitrag/trendwende-auf-dem-deutschen-photovoltaik-markt-nicht-in-sicht_100020763/

83 Agora Energiewende, Current and Future Cost of Solar Photovoltaics, Berlin 25.2.2015; http://www.agora-energiewende.de/fileadmin/downloads/publikationen/Studien/PV_Cost_2050/AgoraEnergiewende_Current_and_Future_Cost_of_PV_Feb2015_web.pdf

84 The first solar era lasted as long as people on the earth lived without making any appreciable use of the geological fossil legacy of coal, oil and natural gas. Essentially they lived for millennia from what the sun provided in terms of energy in the form of heat, wind and hydropower and what it allowed to grow as nourishment in the soil. After the short intermezzo of the fossil-nuclear era, a growing population in the 21st century again thought about the sun. Energetically we will again live like our great grandfathers and grandmothers, “from hand to mouth”.

85 IEA, Technology Roadmap – Solar Photovoltaic Energy, Paris 29.9.2014; http://www.iea.org/publications/freepublications/publication/technology-roadmap-solar-photovoltaic-energy-2014-edition.html

86 Agora Energiewende: Understanding the Energiewende, 2015; http://www.agora-energiewende.de/fileadmin/Projekte/2015/Understanding_the_EW/Agora_Understanding_the_Energiewende.pdf

87 Feed-in tariffs for large PV systems (as of 01.01.2015).

88 Cf. EN 83

89 http://www.utilities-me.com/article-3451-dewa-and-acwa-power-consortium-sign-solar-park-ppa/

90 See Figures 8, 11,12,17; estimates on the future PV electricity generation costs for a range of countries are given in an Agora presentation at: http://www.agora-energiewende.de/fileadmin/downloads/publikationen/Studien/PV_Cost_2050/Agora_Future_Cost_of_PV_Key_Insights_Presentation_web.pdf

91 Citi Commodities Research, Energy 2020: The Revolution Will Not Be Televised As Disruptors Multiply, New York 2014; https://ir.citi.com/ceUKTj9wAJSPHBmpGoRGfQYz1rZm8CKVCFO7wPNIGAzn7%2feoGJhCRKXBw2LnpF%2bmPt5wCNmiHIw%3d

92 Citi, Cf. EN 91

93 Deutsche Bank's 2015 solar outlook: accelerating investment and cost competitiveness; https://www.db.com/cr/en/concrete-deutsche-banks-2015-solar-outlook.htm

94 Deutsche Bank report: Solar grid parity in a low oil price era; https://www.db.com/cr/en/concrete-deutsche-bank-report-solar-gridparity-in-a-low-oil-price-era.htm?kid=responsibility.inter-ghpen.headline

95 See para. 49 EEG 2014; according to this, the basic tariff for wind turbines on land is 4.95 cent/kWh, the initial tariff is 8.90 cent/kWh for continuing degression, where the digression gradient depends on whether the expansion corridor is maintained or whether it is exceeded or not reached.

96 In the North Sea in particular, wind parks cannot be established near the coast but only far outside the nature conservation zones of the Wadden Sea and at a considerable distance from tourist centres.

97 A comparison of the performance of different wind energy systems (offshore and onshore) at different sites can be found on the Fraunhofer IWES Internet portal "Windmonitor"; Offshore wind turbines: http://windmonitor.iwes.fraunhofer.de/windmonitor_de/4_Offshore/5_betriebsergebnisse/1_Volllaststunden/; Onshore wind turbines: http://windmonitor.iwes.fraunhofer.de/windmonitor_de/3_Onshore/5_betriebsergebnisse/1_volllaststunden/

98 Annual full load hours is a measure of the capacity factor of a wind power plant calculated from the quotient of the annual electricity output and the rated capacity of the plant. This must not be confused with the number of operating hours per year of a wind power plant. At very good sites, modern turbines reach around 7,500 operating hours in an average wind year, even on land.

99 This idea has been commonplace in the environmental debate at least since 1972 with the publication of the study on the future of the global economy entitled "The Limits to Growth" commissioned by the Club of Rome and written by David Meadows et al.

100 To what degree a total supply can be organised on the basis of small systems alone will be decided primarily on technological and economic grounds. Predictions are difficult to make in this realm but disruptive developments are quite possible.

101 The World Bank, Global tracking framework – Executive Summary, 05/2013; http://documents.worldbank.org/curated/en/2013/01/17747254/global-tracking-framework-vol-1-3-exekutive-zusammenfassung

102 Solarserver: Solarstrom für den Rest der Welt: Netzunabhängige Photovoltaik für Millionen Menschen, 08.11.2013. http://www.solarserver.de/solar-magazin/solar-report/solarstrom-fuer-den-rest-der-welt-netzunabhaengige-photovoltaik-fuermillionen-menschen.html

103 http://www.plugintheworld.com/mobisol/

104 World Bank and UN activities: http://www.nachhaltigkeitsrat.de/news-nachhaltigkeit/2013/2013-12-19/ein-weltweiter-katalysatorfuer-erneuerbare-energien/?blstr=0Weltbank

105 Figure 26 is not actually complete because – due to gaps in the available data, particularly from the early days of solar power – only PV systems and wind turbines which were connected to the grid after the turn of the millennium are shown. (At the end of June 2015 a total of 25,152 land-based wind turbines were in operation in Germany with an installed capacity of 39,209 megawatts. Source: Deutsche Windguard: Status des Windenergieausbaus an Land in Deutschland – 1. Halbjahr 2015).

106 Cf. EN 84

107 Bundesministerium für Wirtschaft und Energie (BMWi): White Paper "Strommarkt", March 2015. http://bmwi.de/BMWi/Redaktion/PDF/E/eckpunkte-papier-strommarkt,property=pdf,bereich=bmwi2012,sprache=de,rwb=true.pdf

108 Eon press release; Eon treibt Konzernumbau voran; Essen 27.04.2015. http://www.Eon.com/de/presse/pressemitteilungen/pressemitteilungen/2015/4/27/Eon-moves-forward-with-transformation-key-organizational-and-personnel-decisions-made.html

109 Eon press release: Neue Konzernstrategie: Eon konzentriert sich auf Erneuerbare Energien, Energienetze und Kundenlösungen und spaltet die Mehrheit an einer neuen, börsennotierten Gesellschaft für konventionelle Erzeugung, globalen Energiehandel und Exploration & Produktion ab; Essen, 30.11.2014. http://www.Eon.com/de/presse/pressemitteilungen/pressemitteilungen/2014/11/30/new-corporate-strategy-Eon-to-focus-on-renewables-distribution-networks-and-customer-solutionsand-to-spin-off-the-majority-of-a-new-publicly-listed-company-specializing-in-power-generation-global-energy-trading-and-explorationand-production.html

110 Cf. EN 10

111 GDF Suez press release: GDF-Suez becomes ENGIE; Paris 24.04.2015. http://www.gdfsuez.com/en/journalists/press-releases/gdf-suez-becomes-engie/

112 Frankfurter Allgemeine Zeitung 19.05.2015: "Ein Scheitern der Klimakonferenz brächte Chaos".

113 To create an energy system with clear pricing signals which induces energy producers and consumers to adopt a "behaviour beneficial to the system" is amongst the great challenges faced by government in the regulatory support for the new system.

114 http://www.teslamotors.com/powerwall. In cooperation with LichtBlick, it is planned to integrate power storage units into the energy markets, at first in Germany and then in other countries.

115 Lichtblick media announcement: Kooperation für die globale Energiewende: LichtBlick bindet Tesla-Batterien in die Energiemärkte ein. Hamburg, 01.05.2015; http://www.lichtblick.de/medien/news/?detail=329&type=press

www.energiewendebeschleunigen.de