HEINRICH BÖLL STIFTUNG

Energy Transition
The German Energiewende

By Craig Morris, Martin Pehnt

An initiative of the Heinrich Böll Foundation
Released on 28 November 2012
Revised January 2014

www.energytransition.de

Imprint

Authors:
Craig Morris
Martin Pehnt

Editors:
Dorothee Landgrebe
Arne Jungjohann
Rebecca Bertram

Design:
Lucid. Berlin

Released on 28 November 2012
Revised January 2014

Heinrich Böll Stiftung
Schumannstr. 8
10117 Berlin
Germany

Phone: +49 – (0)30 – 285 34 – 0
Fax: +49 – (0)30 – 285 34 – 109

Email: energiewende@us.boell.org

You can also contact one of our 29 offices worldwide
working all on energy and climate issues

About us

The Heinrich Böll Foundation is a catalyst for green visions and projects, a think tank for policy reform, and an international network. The primary objectives guiding our work are establishing democracy and human rights, fighting against environmental degradation, safeguarding everyone's rights of social participation, supporting non-violent conflict resolution and defending the rights of individuals. We work with 160 project partners in over 60 countries and currently maintain offices in 29 countries.

Authors

Craig Morris – Born in the United States, Morris has been living in Germany since 1992 and working in the renewables sector since 2001. In 2002, he founded Petite Planète, a translation and documentation agency focusing on renewables. He is the author of two books in German and English, has served as editor of several energy magazines, and currently writes daily at Renewables International.

Martin Pehnt – A trained physicist, Pehnt is scientific director of the Institute for Energy and Environmental Research (ifeu), where he heads the Energy Department. He previously worked at the National Renewable Energy Laboratory (USA) and the German Aerospace Center (DLR). He now serves as an advisor many national and international organisations, including German federal ministries, the Environmental Protection Agency, environmental NGOs, utilities, the World Bank, IRENA and the GIZ. Pehnt teaches at various universities, including the University of Kassel and the University of Freiburg.

Editors

Arne Jungjohann – is the Director of the Environment Program at the Heinrich Böll Foundation's Washington office. He previously served as a senior advisor for the German Green Party in the German Parliament on energy and climate legislation. He holds a master in political science from the Free University in Berlin.

Dorothee Landgrebe – is the Head of Department for Environmental Policy and Sustainability at the headquarters of the Heinrich Böll Foundation. Her main focus is domestic and European energy, nuclear and climate protection policies along with the ecological conversion of the economy ("Greening the Economy"). She is a lawyer by training.

Rebecca Bertram – is the Director of the Environment and Global Dialogue Program at the Heinrich Böll Foundation's Washington office. Her work focusses on building a global dialogue on German and European energy and climate policy. Rebecca holds a Masters degree in International Affairs and Economics from the Johns Hopkins University's School of Advanced International Studies (SAIS).

About the project

Germany has drawn a lot of international attention for its aim to switch to a renewable energy economy and leave nuclear and fossil energy behind. A lot of the international reporting about the German Energy Transition, or Energiewende, has, however, been misleading – for instance, when it comes to the role of coal power, energy price trends, and carbon emissions.

This website aims to explain what the German Energy Transition is, how it works, and what challenges lay ahead. It is intended to provide facts and explain the politics and policies to an international audience. The website highlights the effects of the Energiewende on the German economy, environment and society and addresses the most important questions.

All the texts and graphs are under Creative Commons License (CC BY SA) with the aim to make this information available to the public. We encourage you to use the materials in your work. In return, we would appreciate it if you would tell us what you have used.

We welcome your feedback and encourage you to comment and discuss the German Energiewende with us.

This project is accompanied by a blog. A team of international energy experts will write on how the German energy transition develops and how it relates to other countries.

Content

1 Why the Energiewende **1**
A – Fighting climate change 2
B – Reducing energy imports 4
C – Stimulating technology innovation and the green economy 4
D – Reducing and eliminating the risks of nuclear power 6
E – Energy security 7
F – Strengthening local economies and providing social justice 8

2 Technology as a key issue **10**
A – Efficiency 11
B – Less electricity from coal 14
C – Wind power 16
D – Biomass 18
E – Photovoltaics 19
F – Other renewables 21
G – Grid and power storage 23
H – Flexible power production (no more baseload) .. 26
I – Energy by the people 28

3 Policies for clean energy **32**
A – Nuclear phaseout 33
B – Renewable Energy Act with feed-in tariffs 34
C – Emissions trading 38
D – Environmental taxation 39
E – Cogeneration Act 40
F – Renewable Energy Heating Act and Market Incentive Program (MAP) 42
G – Act on Accelerating Grid Expansion 43
H – Energy-Conservation Ordinance (EnEV) and financial support schemes 44
I – Ecodesign/ErP Directive 46
J – Efficiency Fund and Climate Initiative 47
K – Discussion about energy market reform in 2014 .. 48

4 History of the Energiewende **49**
A – Origin of the term “Energiewende” 52
B – Wyhl – the nuclear plant that never was 52
C – The oil crisis 53
D – Chernobyl – change comes slowly 54
E – Full-cost compensation for photovoltaics 55
F – EU court says feed-in tariffs are “not state aid” .. 56
G – Renewable Energy Act (EEG) 56

5 International perspectives **57**
A – Renewables in South Africa: The need for a developmental case 58
B – There’s more renewables in the Philippines 59
C – Germany supports regional renewables – Will the Czech Republic get onboard? 60
D – Jordan seeks a “solar-torch” from Germany 61
E – Transatlantic Take-Away: Political Will is more important than Pure Resources 63
F – The Energiewende – blueprint for the energy transition in Japan? 65
G – India’s Opportunity to Leapfrog into the Renewable Age 66
H – China’s Sustainable Energy Development 69

Content

6 Questions & Answers 71

A – Is the energy transition affordable? 72

B – How will Germany ensure that the poor can still afford energy? 74

C – When will renewables pay for themselves? 74

D – Is the energy payback from wind and solar ever positive? 75

E – Why aren't low-carbon goals enough in themselves? 75

F – Will Germany import more power from abroad after the nuclear phaseout? 76

G – Didn't Germany overreact to Fukushima? 77

H – Aren't renewables a relatively expensive way to lower carbon emissions? 78

I – Won't the nuclear phaseout increase Germany's carbon emissions? 79

J – Wouldn't nuclear power be an inexpensive way to reduce carbon emissions? 79

K – Will the lights go out? 80

L – Will the energy transition kill jobs? 81

M – Do Germans support the energy transition? 82

N – How can Germany be both a green leader and remain an industrial powerhouse? 83

O – How are energy-intensive companies exempted from the surcharge for renewable power? 83

P – What role will shale gas play in the German energy transition? 84

Q – Why did carbon emissions increase in 2013? 85

R – Is Germany undergoing a coal renaissance? 85

S – How much electricity storage will Germany need? 86

T – How could the cost of Germany's energy transition be decreased? 86

7 Key findings 87

8 Glossary 91

1 Why the Energiewende

There are reasons to switch to renewable energy and to increase energy conservation, and there are reasons to do so now.

A – Fighting climate change	2
B – Reducing energy imports	4
C – Stimulating technology innovation and the green economy	4
D – Reducing and eliminating the risks of nuclear power	6
E – Energy security	7
F – Strengthening local economies and providing social justice	8

A – Fighting climate change

The burning of coal, oil, and gas is causing our climate to overheat. Our current energy supply is not sustainable. One major aim of the German Energiewende it is to decarbonize energy supplied by switching to renewable sources and reducing demand by means of greater efficiency.

Based on a large body of research conducted by scientists from around the world, the International Panel on Climate Change (IPCC), which does not conduct its own research but rather reports on the general international scientific consensus, has repeatedly warned that the effects of rampant climate change could be disastrous.

In 2011, a survey found that 66 percent of Germans believe that climate change is a "very serious" problem, far more than the mere 27 percent who felt that the economic crisis was the biggest problem – perhaps because Germany's economy has proved so resilient over the past few years partly thanks to green technology. Not surprisingly, the survey found that 79 percent of Germans believe that energy efficiency and combating climate change are good for economic growth and can create jobs.

The German business world agrees. In 2009, another survey taken among 378 leading businesspeople, researchers, and politicians in Germany just before the Climate Summit in Copenhagen, Denmark, found that more than four fifths believed that the pioneering role that Germany has played in reducing greenhouse gas emissions would lead to technological leadership.

What's more, Germans feel a responsibility to act. They understand that they are one of the countries that has contributed the most to carbon emissions over the past 150 years, and their current position as a leading industrialized nation brings with it a responsibility towards countries that not only still have a lot of development ahead of them, but will also be more severely impacted by climate change. Germans assume this responsibility mainly in two ways:

1. a commitment to international climate funding; and
2. the energy transition.

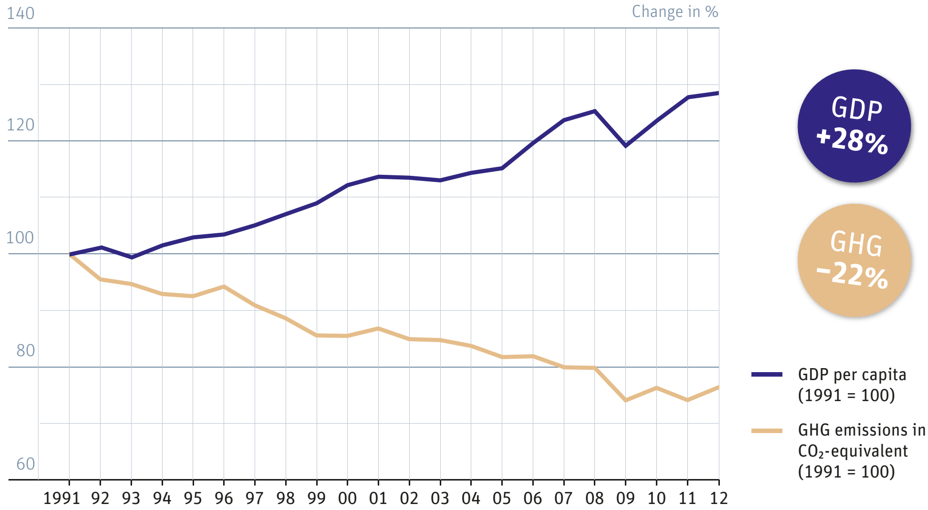
The carbon budget

Climate experts say that a certain amount of global warming is unavoidable at this point because the climate reacts with such inertia, and the warming would continue for a few decades even if carbon dioxide concentrations in the atmosphere were to stabilize at the current levels – which are drastically higher than anything in recent history. Around the beginning of the Industrial Revolution in the 19th century, the atmosphere had 280 parts per million (ppm) of carbon dioxide, but we are now approaching 400 ppm.

Germany: growing economy, declining emissions

Change of Gross Domestic Product (GDP) and Greenhouse Gas (GHG) emissions in Germany, 1991–2012

Source: BMU, BMWi, Destatis



In order to keep the planet from heating up more than two degrees Celsius, which would prevent the most disastrous changes, we need to keep that figure from rising above 450 ppm. Many scientists believe that returning to 350 ppm is a good long-term goal, but that would require a net subtraction of carbon dioxide (CO2) from the atmosphere – at present, we continue to add CO2 to it.

Relative to 1990, Germany reduced its carbon emissions by 25.5 percent at the end of 2012, thereby overshooting its target for the Kyoto Protocol of 21 percent for the end of 2012. But Germany aims to go further, with targets of a 40 percent reduction by 2020 and an 80 to 95 percent reduction by 2050.

While these targets may seem ambitious, the industrialized world needs to move faster in light of the consequences we face. If we are to stay within the "carbon budget" of 450 parts per million, then no more than 1,230 billion tons of greenhouse gases can be added to the atmosphere. In 2004, around 50 billion tons of such heat-trapping gases were emitted; at that rate, we would use up this budget in only 25 years, meaning we would need zero emissions globally starting in 2030.

Furthermore, if we admit that developing countries have a right to increase their emissions slightly as they develop, then the burden of lowering emissions falls even more upon already industrialized countries. In other words, Germany needs to reduce its emissions by 95 percent, not 80 percent.

Renewables and efficiency are the solution

In 2010, the WWF asked Germany's Institute of Applied Ecology and corporate consulting firm Prognos to study what would need to be done to reach that 95 percent reduction without reducing our standard of living. The short answer is that we can first become considerably more efficient in order to reduce energy demand, including for heat; then, we switch our power supply over to renewables. The only major problem that remains is the transportation sector, where a wide range of solutions will be needed. Nonetheless, the study found that emissions from transport can be reduced by 83 percent below the current level by 2050.

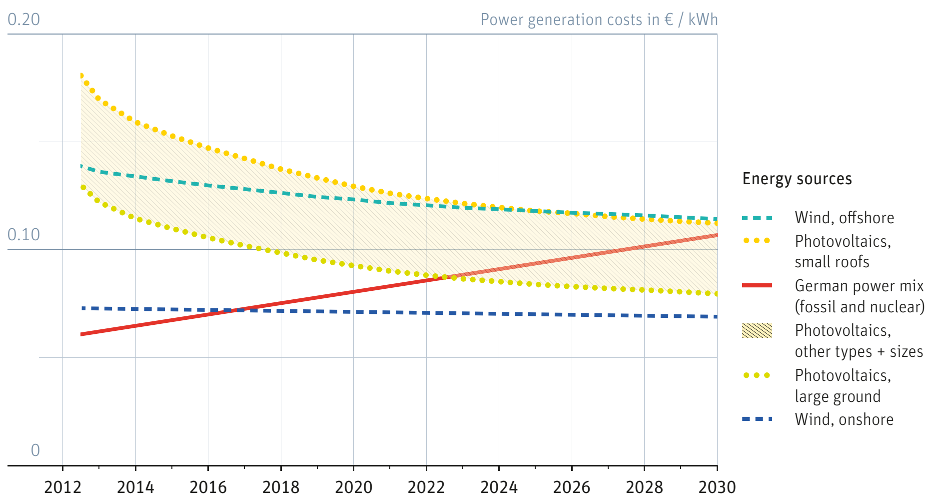
Many efficient technologies are already available, such as LED lights instead of conventional light bulbs. When it comes to air conditioning and heating, passive houses can provide pleasant levels of comfort at very low levels of energy consumption.

Renewables can increasingly cover a larger share of the energy we still have to consume. In Germany, renewables offset an estimated 146 million tons of CO2-equivalent emissions in 2012, 101 million tons of which was in the power sector alone. Biomass is also generally carbon-neutral, meaning that the amount of carbon emitted is roughly equal to the amount that the plants bound during growth. Biomass in the German electricity, heat, and transport sectors reduced CO2 emissions by roughly 66 million tons in 2011.

Renewables are becoming competitive

Forecast of power generation cost in Germany up to 2030

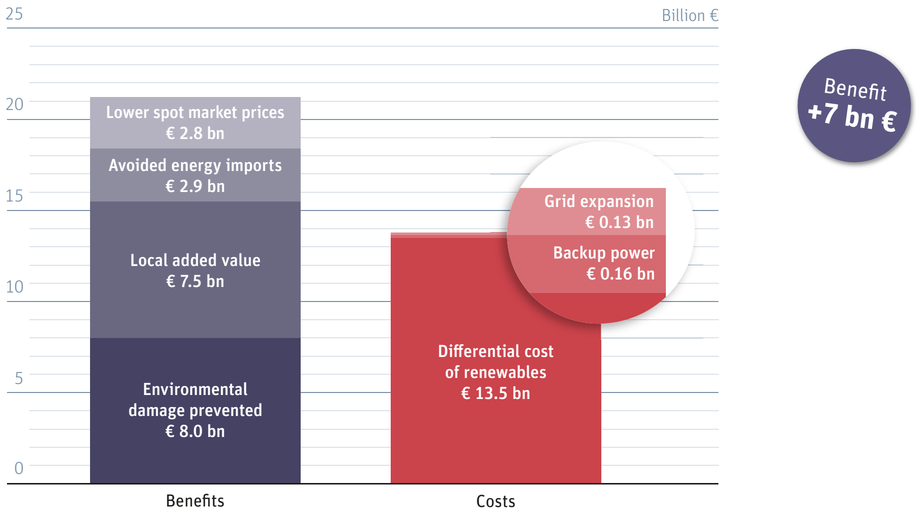
Source: Fraunhofer ISE



Renewables save Germany more than 7 billion euros per year

Costs and benefits of renewables in energy use, Germany, 2011

Source: www.unendlich-viel-energie.de



B – Reducing energy imports

Germany imports 70 percent of its energy. Renewables and energy efficiency help reduce imports significantly, thereby increasing Germany's energy security.

In 2012, Germany spent 87 billion euros on energy imports, equivalent to eleven percent of its expenses for imports. Germany imports more than 70 percent of its energy, including uranium. The German Environmental Ministry estimates that renewable energy offset 6.7 billion euros in energy imports in 2010 alone. Most of that renewable energy was electricity and heat, however, with domestic renewable motor fuel production making up only around five percent of the pie.

Energy efficiency can also significantly help reduce energy imports. A study conducted by the IFEU Institute of Heidelberg in cooperation with the Institute of Economic Structures Research found that a scenario with more efficient energy consumption would reduce energy imports by four billion euros in 2030 compared to a scenario without these efficiency gains – and that figure would continue to rise. In this respect, the energy transition also increases energy security.

C – Stimulating technology innovation and the green economy

The energy transition boosts green innovations, creates jobs, and helps Germany position itself as exporter of green technologies.

Germany is an export-based economy and is positioning itself as an innovator in green technologies. The German Solar Energy Association (BSW) estimates that exports made up 60 percent of German PV production in 2012, up from 55 percent in 2011 and 14 percent in 2004 – and the target is 80 percent for 2020. The German Wind Energy Association (BWE) puts the wind industry's current export ratio at 65 to 70 percent.

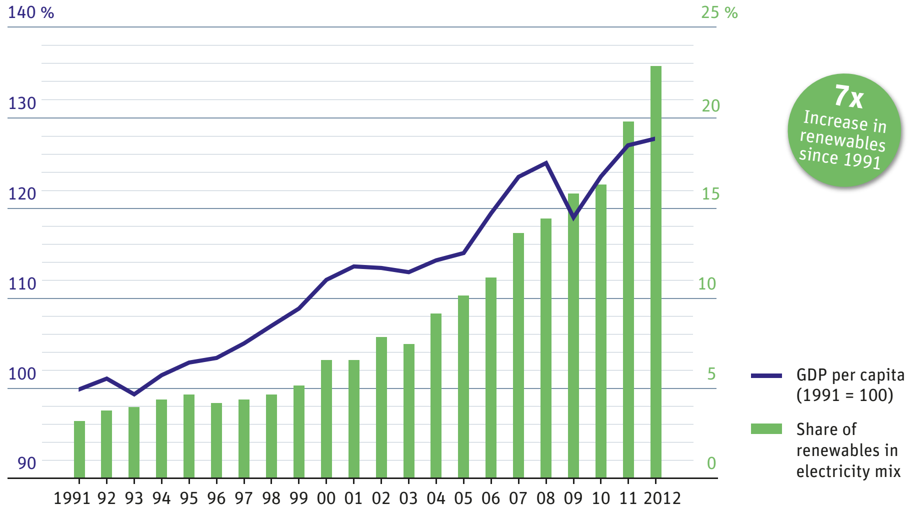
The market for products that increase energy efficiency is already significant, which is especially important, because this market will only continue to grow, like the market for renewables. Germany is a major player on both of these markets. In 2004, Germany made up 17 percent of the global efficiency market – an even larger share than the US, Japan and Italy had.

A study conducted by corporate consulting firm Roland Berger found that the market for energy efficiency products will continue to grow rapidly, doubling in volume from 2005 (450 billion euros) to 2020. Not surprisingly, a lot is being invested in development in this sector, where Germany makes up the second largest share of the pie at 20 percent, behind the US at 24 percent.

Renewables help make economy healthy

Gross Domestic Product and share of renewables in power generation from 1991–2012, Germany

Source: BMWI, AG Energiebilanzen, Destatis



In particular, midsize firms are benefiting from the growing demand for energy efficiency products and applications, with more than half of the sales revenue from environmental protection goods (of which energy efficiency is a subcategory) being posted by firms with fewer than 250 employees.

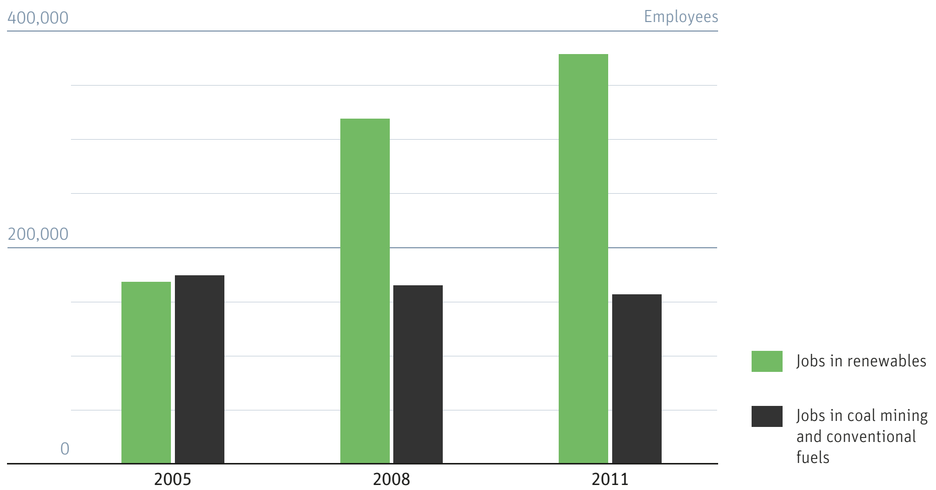
The strong position in local and global green technology markets creates jobs. In Germany, some 380,000 people already work in the renewables sector, and the German Renewable Energy Federation (BEE) estimates that the figure could rise to 500,000 by 2020.

Nonetheless, the number of "green jobs" in Germany fell slightly in 2012 by around one percent due mainly to layoffs in the solar sector.

Renewables create more jobs than conventional energy does

Employment in Germany in renewable and conventional energy sectors, 2005–2011

Source: BMU, BMWI

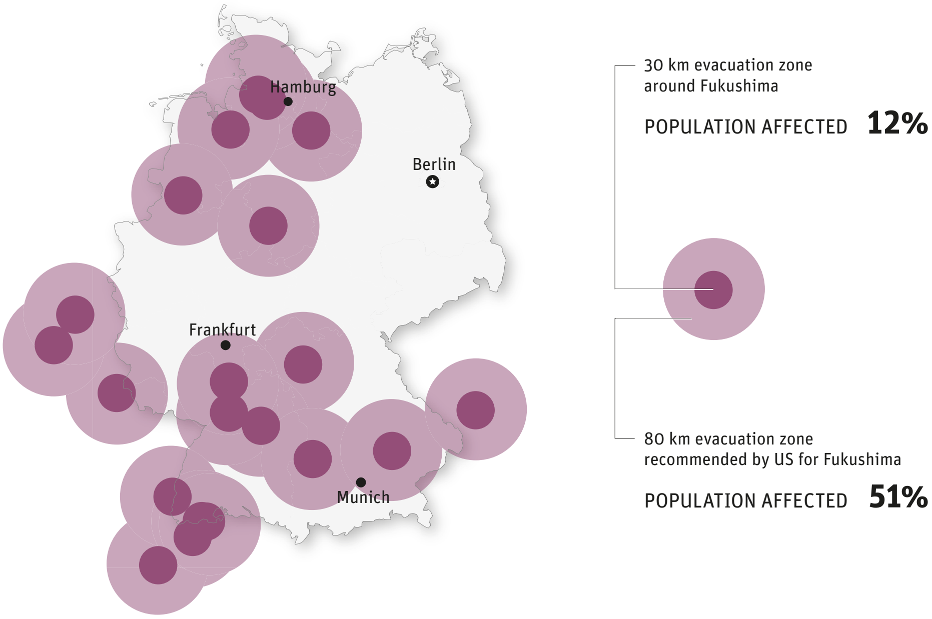


These figures represent "gross job creation," meaning the absolute number of jobs that have been added. A thorough study of the German market estimates a net job creation of around 80,000, rising to 100,000 – 150,000 in the period from 2020 to 2030. One reason why renewables have such a tremendous positive impact on net job creation is that renewable power directly offsets power from nuclear plants, and very few people work in the sector.

Recognizing the danger of nuclear power

30/80 km zones around nuclear reactors in Germany and nearby reactors of neighbouring countries

Source: http://opendata.zeit.de/atomreaktoren



D – Reducing and eliminating the risks of nuclear power

Germany rejects nuclear power because of the risks, the costs and the unsolved waste issue. In addition, nuclear power does not have the potential to play a major role in the world's energy supply.

In the debate about Germany's energy transition, the environmental community often focuses on carbon emissions. Supporters of nuclear power no longer speak only of "power too cheap to meter" but now also call for "low-carbon technologies" (though some carbon is emitted during plant construction and uranium mining), a term that encompasses not only renewables, but also nuclear power.

The German public sees a significant difference between nuclear and renewables, however. Indeed, as we discuss in the History section, the energy transition movement started in Germany in the 1970s as a popular protest against nuclear power.

There are five main problems with nuclear power:

1. the risk of a nuclear disaster at a plant (such as the rather well-known ones at Fukushima, Chernobyl, and Three Mile Island, but also lesser-known ones, such as the Kyshtym accident);
2. the risks of proliferation (plutonium from nuclear plants for military purposes)
3. the risk of radiation from the storage of nuclear waste;
4. cost, with nuclear being unbankable at the moment – banks will not finance the construction of new nuclear plants because the cost is too high in comparison to renewables, so all plants currently on the drawing board in Western countries have massive state support – the new Hinkley Point nuclear plant proposed in the UK is to have feed-in tariffs higher than what Germany pays for solar in addition to state guarantees for bank loans; and
5. the limited availability of uranium resources.

The third risk is even greater because we will pass it on to future generations, who will not even be able to consume the nuclear power we produce today but will be forced to deal with our waste. Even when all of our nuclear fission plants have been shut down, mankind will have to protect its repositories of spent nuclear fuel rods for up to 100,000 years.

Those who nonetheless support nuclear power and deem these risks manageable also believe that we will not be able to make do with a 100 percent renewable energy supply. In fact, nuclear power is far more limited than renewables. Nuclear plants produce electricity but not useful heat or motor fuel. Indeed, as with current coal plants, the use of waste heat from nuclear plants is a technical challenge, and nuclear security trumps waste heat recovery. Finally, nuclear plants will not directly be able to produce any kind of liquid fuel, aside from hydrogen, though the process is inefficient – roughly half of the energy is lost in the process.

In contrast, solar heat is quite efficient, and systems can be installed directly where heat is consumed (such as on your house). Waste heat from biomass units is also easily recovered, and such cogeneration units can have high total efficiencies well above 80 percent.

The true future of nuclear

In the end, however, it does not matter whether you believe 100 percent renewables is possible or not. Nuclear is simply too small a player on global markets; it does not even account for six percent of global energy supply right now, and more plants are scheduled to be taken off-line over the next decade than are expected to go online. The International Energy Agency, which has supported nuclear power since its founding in 1973, believes that the world can roughly triple the number of nuclear plants from the current level (approximately 440) to around 1,400 by 2050 – equivalent to 35 new nuclear plants per year – but the WWF has estimated that this highly unlikely scenario would only lower global carbon emissions by ten percent. That outcome is too little, too slow, and too expensive to contribute meaningfully to tackling climate change. In addition, severe resource issues would arise in the process. At current rates of consumption, uranium for light-water reactors will only be available at affordable prices for roughly the next 30 years. Nuclear is therefore not a solution, even if you believe the risks are manageable and your main goal is to reduce carbon emissions.

If we can gradually transition to a renewable energy supply, then it seems irresponsible to have nuclear plants today – and unethical to pass on these risks to future generations.

E – Energy security

Renewables reduce Germany's dependency on energy imports, making Germany less vulnerable to rising prices for fossil fuels and to political influence from abroad.

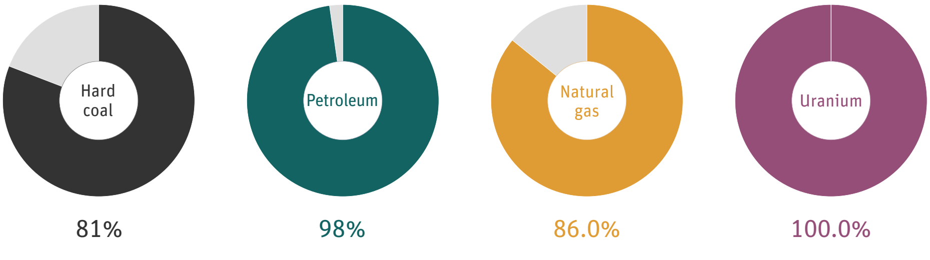
Energy security reflects the availability of affordable energy. Demand for energy is increasing in a growing number of emerging countries – especially those with large populations, such as China and India – and may outstrip supply, which will lead to considerable price hikes. Germany is especially vulnerable here because it imports so much of its energy.

In addition, as the world saw in the 1970s when OPEC restricted its oil supply to certain countries, energy imports can dry up for political reasons overnight. A few years ago, Russia discontinued its natural gas supply to Ukraine, which also affected downstream western European countries. The more energy a country gets from within its own borders, the less vulnerable it is to such political disruptions, for which it may not even be responsible. A diversification of energy carriers also means a diversification of producing countries.

More renewables strengthen Germany's energy security

Share of imports of conventional energy sources in Germany 2012

Source: BMWi



In western Europe, Germany is by far the largest importer of gas from Russia. What's more, Germany only produces around 15 percent of its own natural gas, importing roughly 40 percent from Russia.

In the winter of 2011-2012, Russia even reduced imports to Germany by as much as 30 percent because Russians were consuming so much gas themselves during a long cold spell. While Germany does have sufficient storage reserves to cover such gaps, domestic production of renewable gas will make supply more consistent.

Renewables and energy conservation can reduce the dependence of countries that consume energy on countries that provide energy resources. Over the past few decades, this dependency has constantly increased. Reducing this dependency would also promote global peace; after all, wars over resources and the "oil curse" are directly related to the problems that many politically fragile regions face.

Renewable energy can consist of numerous small, distributed units, but it can also consist of a small number of large, central plants. In the latter case, the power stations can be gigantic solar arrays in deserts or large wind farms on coastlines. The Desertec project, which aims to set up large solar power plants and wind farms in Mediterranean countries (including northern Africa) to generate electricity for Europe, is one example showing that renewables need not be distributed. Proponents of Desertec say the cost of such electricity will be lower, economic development will be stepped up in relatively poor countries, and power generation will be more reliable because the best sites will be chosen. Nonetheless, it remains to be seen whether renewable power would continue to be exported from northern Africa to Europe if there were political turmoil.

F – Strengthening local economies and providing social justice

Local ownership of renewables provides great economic payback to investing communities. Energy efficiency and renewables together give the poor a way around higher prices for fossil fuels.

When communities invest in projects themselves, the economic payback is much greater than when large, out-of-town firms invest. According to a study produced by the US National Renewable Energy Laboratory in 2009, the "operations-period impact is on the order of 1.5 to 3.4 times" greater than in absentee-owned projects.

But while community ownership is widespread in Germany, it faces tremendous obstacles in other countries. At the World Wind Energy Council's 2012 conference, the session on community ownership found that community power was considered a "seemingly politically contentious form of activism" in Canada, Australia, and the US in particular. Yet, macroeconomically, it also makes a great deal of difference whether we purchase energy from domestic sources or import it from abroad.

For instance, you can import heating oil to heat your home, and that money leaves the country, but if you install solar hot water collectors to cover part of your demand for heat, you get the energy for free and a much greater share of your energy expenses will stay within your country – and possibly even within your community. Some of your investment will come back to benefit you indirectly as tax investments in infrastructure (schools, roads, research, etc.). There have been a number of estimates for specific programs in Germany. For instance, a lot of government funding for renewables is funneled through Germany's KfW Bank. Its building renovation program has been estimated to produce three to five euros in tax revenue for each euro of tax money invested. And these building renovations not only help decrease imports of heating oil and natural gas, but also protect and create a lot of jobs in the construction sector.

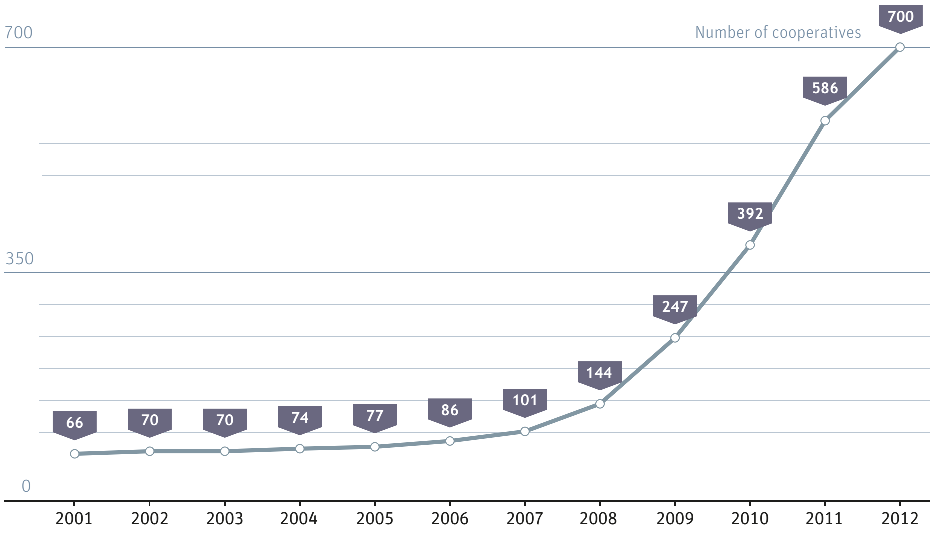
Local added value also has a welcome side effect – it increases acceptance of change. When the wind farm is funded partly by the community, there is far less NIMBY-ism than when an anonymous out-of-town investor is behind the project. In Germany, hundreds of energy cooperatives have come about; here, citizens come together to invest in renewables – and, increasingly, in energy efficiency. In addition to numerous power plant projects, local power grids are also being purchased from large grid operators so that communities can have more control of their own grids.

Increasingly, German regions and municipalities are discovering the economic opportunities in renewables and energy efficiency, especially for communities that produce more energy than they consume over the year. For more on how investments in renewables can stimulate the local economy, see the section 2 – I – Energy by the people.

Citizens form cooperatives to drive the energy transition

Number of energy cooperatives in Germany, 2001–2012

Source: www.unendlich-viel-energie.de



Protecting the poor

Another important aspect of the energy transition is social justice. Energy efficiency in particular not only helps promote domestic added value, but also reduces energy poverty. As energy prices continue to rise in Germany, energy poverty is moving into the foreground as an issue. Over the long run, the price of renewable energy will remain stable (there are no fuel costs for wind or solar, and equipment costs continue to drop), whereas the cost of fossil fuel and nuclear will only continue to rise, so the energy transition itself is a way of keeping energy poverty in check.

Rising energy prices impact low-income households the most; after all, on average they spend a higher portion of their income on energy needs and are the least likely to be able to afford investments in energy efficiency such as energy renovations, efficient appliances, and fuel-efficient vehicles. The most efficient way to combat energy poverty is to implement energy efficiency measures on a large scale – including renovating low-income households to reduce energy demand.

The German government is currently sponsoring "energy audits" in a nationwide project as part of the energy transition. The goal is to help people who have been unemployed for a long time and receive welfare to conserve power, heating energy, and water. In addition, fixtures that reduce power and water consumption (such as compact fluorescent light bulbs, power strips with on-off switches, and water-saving showerheads) are provided. These energy audits are one example of how the energy transition can produce innovative cooperation concepts.

2 Technology as a key issue

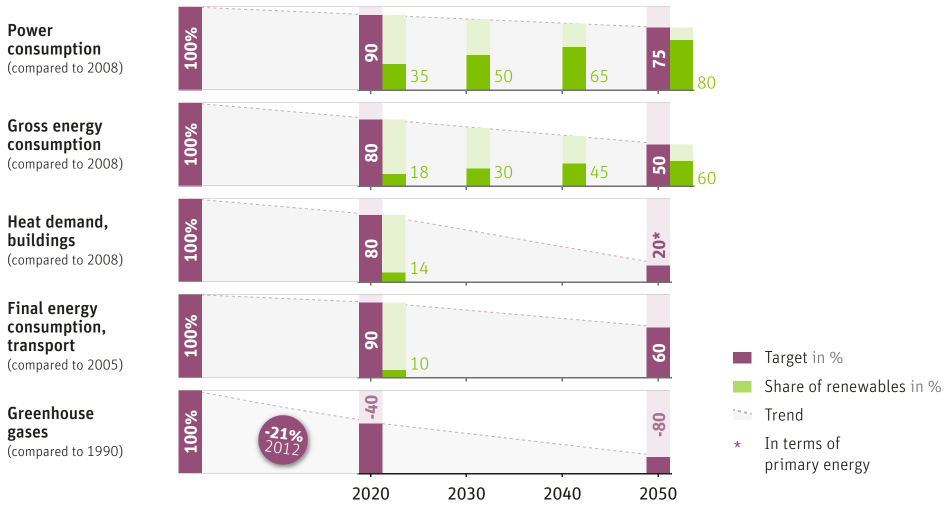
Germany has resolved to replace fossil and nuclear energy with renewables – but the process is more complicated than that. Most of all, it involves lower energy consumption through efficiency and conservation and requires that energy consumption be tailored to availability. And in addition to all of this, people who used to be mere consumers will increasingly also become energy producers.

A – Efficiency	11
B – Less electricity from coal	14
C – Wind power	16
D – Biomass	18
E – Photovoltaics	19
F – Other renewables	21
G – Grid and power storage	23
H – Flexible power production (no more baseload)	26
I – Energy by the people	28

German energy transition: high certainty with long-term targets

Long-term, comprehensive energy and climate targets set by the German government in 2010

Source: BMU



A – Efficiency

A renewable energy economy will only be possible if we lower energy consumption considerably. Policies to improve efficiency are in place, but they consistently fall short of what is not only theoretically possible, but also what is reasonable.

When people talk about Germany's energy transition, they often think mostly of the switch from nuclear and coal power to renewables – but in fact, a renewable future will only be possible with significantly lower energy consumption.

As the authors of Factor Four showed 15 years ago, lower consumption does not entail a lower standard of living – on the contrary, our consumption of fossil energy detrimentally affects our health and is contributing to climate change, which is a threat to civilization. Furthermore, by consuming nuclear power, we create "mines" of nuclear waste that will threaten future generations for millennia.

Over the past two decades, economic growth has generally outstripped the growth in energy consumption in most industrialized nations. It has been estimated that energy productivity – economic output per energy consumed – increased by around 50 percent from 1990 to 2012.

Perceptions of energy use

What people want is not energy, but energy services – the things we do with energy. In other words, we do not want gallons of gas, but mobility; not electricity and fuel oil, but cold food storage and well lit, comfortable homes. Over the past decade, our computers and handheld devices have become far more high-performance even as they increasingly make do with less power. Such advances are possible in a wide range of fields. In our buildings, for instance, we can provide a comfortable indoor climate with not only energy-intensive air conditioning and heating systems, but also properly filtered air and low concentrations of carbon dioxide. In other words, buildings of the future will be even better than the ones today even though they consume less energy.

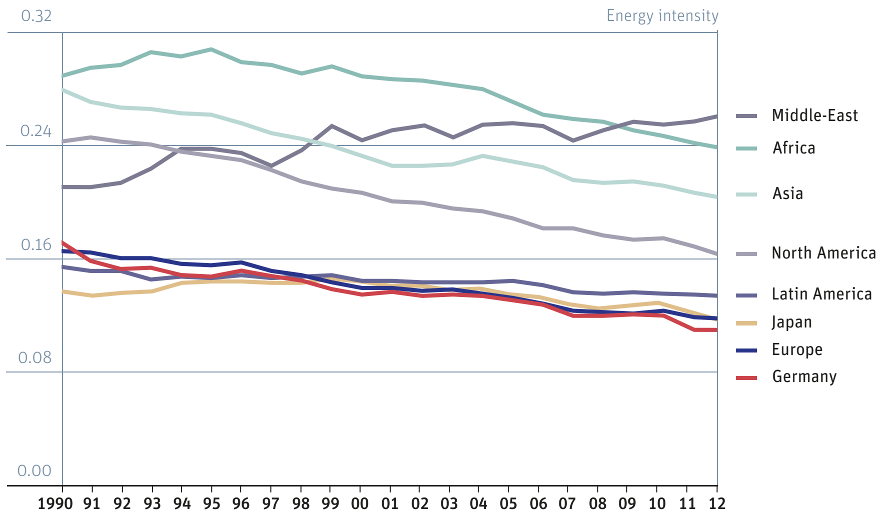
When it comes to efficiency, however, we face a special obstacle: information. Economists who believe that the market takes care of everything most efficiently assume that all market participants are equally and sufficiently informed – and therefore that all efficiency measures that pay for themselves have already been utilized.

In fact, while most consumers may know what their monthly power bill is, they may not know how many kilowatt-hours they consume, nor are they used to assessing how much a particular appliance will cost them per year in terms of power consumption. Yet, without such information, it is impossible to assess the payback on investments in energy efficiency. So even if we believe that the market comes up with the best solutions, the government still needs to ensure that everyone is properly informed.

Germany continues to produce more GDP with less energy

Energy intensity (=energy use per unit of GDP) of different world regions, 1990–2012

Source: Enerdata Yearbook



Raising awareness

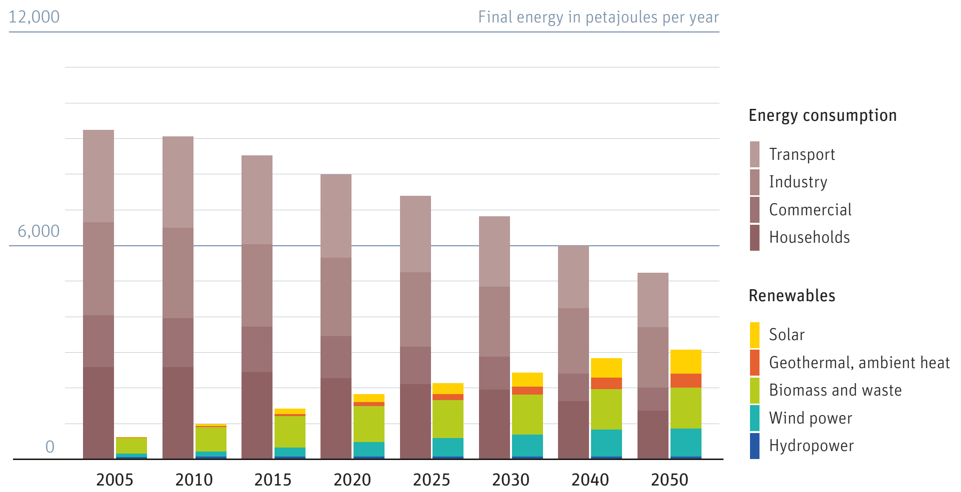
The example of standby power consumption is especially illustrative. Unbeknownst to most consumers, household appliances – from coffee machines to toasters, televisions, game consoles, and computers – consume power even when they are "off." It has been estimated that such "standby consumption" amounted to four percent of gross power demand in Germany from 2004 to 2006, more than the three percent of German power supply consumed by all electric trains and trams in the country! Consumers are not always aware that the annual power costs for an inexpensive appliance might even exceed its purchase price.

One example of the government providing market participants with information is the European Union's Ecodesign directive, also known as the ErP (Energy-related Products) directive. It aims to make products more sustainable over their entire lifecycle (not just in terms of energy) partly by providing labels as guides for consumer purchases and by imposing stricter energy efficiency standards for designs. This law is dealt with in detail in its own section; see Ecodesign/ErP Directive.

Germany's plan: ramp up renewables, drive down energy consumption

Final energy supply and demand in Germany 2005–2050, scenario

Source: DLR Lead Study, scenario A



The European Union (EU) is also working to reduce energy consumption in buildings, and Germany is at the forefront of that movement as well. In 2002, it adopted the Energy-Conservation Ordinance, which was made stricter in 2009. Some homes built as early as the 1990s demonstrate what the standard of the future will be: passive houses, which become plus-energy homes when solar roofs are added to them. The EU will require that all houses constructed starting in 2020 be "nearly zero-energy homes," essentially making German passive houses the standard within Europe.

While these new laws will help when it comes to new buildings, Germany needs to address the situation with existing buildings. The country's renovation rate, the number of buildings renovated per year, is too low in Germany at around one percent; the figure needs to be increased to three percent. In addition, renovations often do not go far enough. Frequently, not enough insulation is added, and the building service technologies used do not fulfill the requirements that buildings will have to meet in 40 years. These matters are also dealt with in their own section; see Energy-Conservation Ordinance (EnEV).

Improving efficiency

Another area where there is a lot of room for improvement is power efficiency. Studies have shown that the yearly power consumed by electric motors used in industry could be reduced by around 30 TWh up to 2020 – enough to make several central station power plants redundant. Similar conservation potential can come from the use of efficient lighting systems and a switch from inefficient electric heaters to more efficient systems.

Germany has set an ambitious goal for itself of a ten percent reduction in power consumption by 2020 and a 25 percent reduction by 2050.

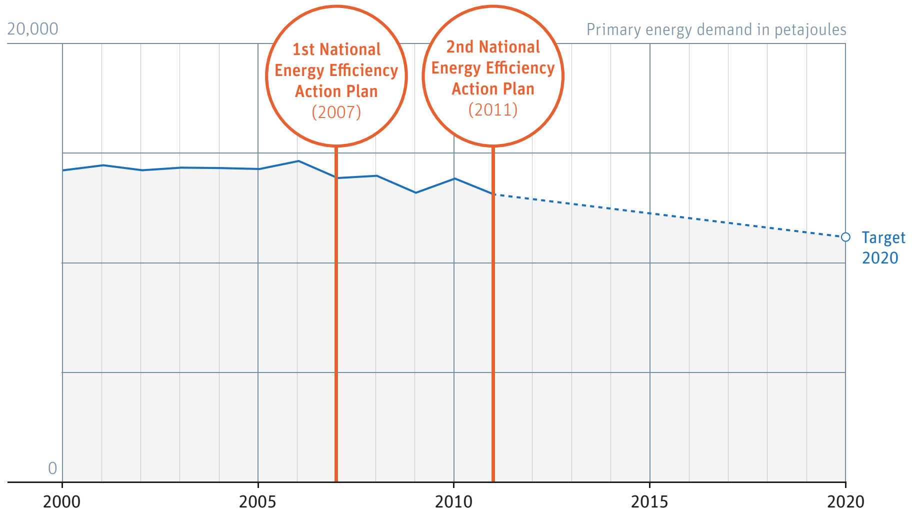
Unfortunately, not enough is being done to promote energy efficiency. While the EU has binding targets for carbon emissions (a 20 percent reduction below the level of 1990 by 2020) and renewables (20 percent by 2020), the target for energy efficiency (a 20 percent reduction in primary energy consumption by 2020) is not binding.

Energy efficiency is probably the field where the energy transition has been least successful so far. On paper, Chancellor Merkel's coalition considers energy efficiency and conservation to be important; yet, the governing coalition has repeatedly blocked the implementation of an ambitious European efficiency directive. At the beginning of 2012, some 40 energy experts signed a memorandum that stated that "the gap between ambitious energy conservation targets and political reality has to be closed." Crucial instruments such as tax incentives for building renovations and stricter energy conservation ordinances were blocked. At the same time, environmentally damaging taxes and subsidies

Germany's plan: drive down energy demand

Primary energy demand in Germany, 2000-2020

Source: AGEB, BMWi



were not done away with, such as tax exemptions for kerosene for airlines and tax write-offs for gas-guzzling sedans for company employees. In other words, Chancellor Merkel's coalition is accused of pursuing a double standard in its energy policy.

We will not be able to get 100 percent of our energy from renewables if we continue to consume at the current rate. Energy efficiency is not a nicety – it is indispensable for the energy transition.

B – Less electricity from coal

To meet the climate targets, Germany must reduce electricity from coal. In the interim, coal consumption might increase slightly, as it did in 2011 and 2012, but the rising price of carbon and the increasing competitiveness of renewable power will make this trend short-lived – and Germany will stay within its carbon emission limits during the process. Furthermore, carbon capture and storage is expensive and unsafe, and the German government has already stated that it will not promote the technology against popular will.

When Germany resolved to shut down eight of its seventeen nuclear plants in 2011 and phase out the rest of them by 2022, there was concern that coal power would be ramped up to fill the gap left behind by nuclear – but that is not the plan, because the country cannot meet its climate targets with coal power. After all, roughly half as much carbon is emitted when natural gas is burned instead of hard coal. Lignite, which is domestically available in Germany in large quantities, is three times more carbon intensive than natural gas. Furthermore, coal plants do not ramp up and down as fast as flexible turbines fired with natural gas do, making the latter a better way of filling in hourly gaps in renewable power production. For more information on natural gas as a bridge to a future with renewable gas supplies, see 2 – H Flexible power production (no more baseload).

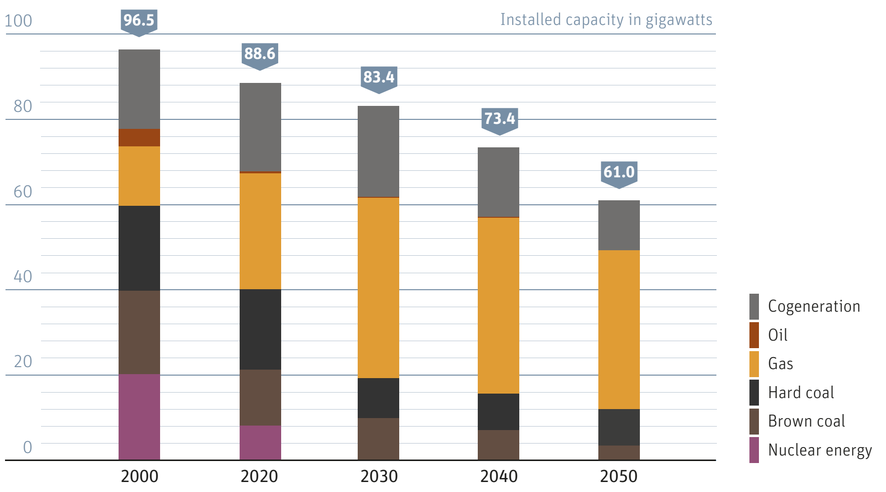
For a number of reasons, however, coal power consumption has temporarily increased:

1. The decision to shut down eight nuclear power plants came suddenly, and industry has not yet had time to replace the missing capacity, so power providers have no choice but to fall back on existing power plants.
2. The economic downturn within the EU has reduced energy consumption, thereby indirectly reducing carbon emissions and making the price of carbon – and hence, the price of coal power – lower (see Emissions trading).
3. At present, a few new coal plants are going online that had been planned and constructed several years before the decision to phase out nuclear energy.

Germany's plan: declining role for coal power

Overall installed conventional electricity generation capacity, in Germany, 2000–2050

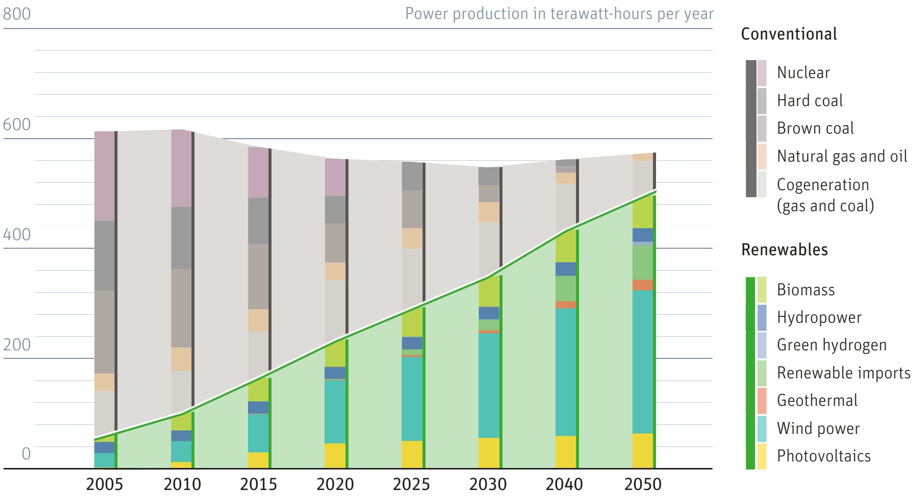
Source: Fraunhofer IWES



Germany's plan: switch from coal and nuclear to renewables

Electricity generation in Germany 2005–2050, scenario

Source: DLR and Fraunhofer IWES



In this chart based on Lead Scenario 2012, a scenario study commissioned by the Federal Ministry of the Environment, renewables would make up 85 percent of Germany's power supply by 2050. New electricity consumers (electromobility, heat pumps and, starting in 2030, hydrogen for transportation), however, slow down the reduction in consumption.

Plans for new coal plants

Just a few years ago, Germany's biggest four energy firms planned to build more than 30 new coal plants, but their current plans are much more modest. A number of projects have been abandoned for various reasons ranging from tremendous local protests to difficulties in procuring water rights and – most of all – a reassessment of profitability in light of the boom in renewables. By 2015, coal power capacity (both hard coal and brown coal) is expected to increase in Germany by nearly 9 gigawatts, but these plants will increasingly face a lower capacity factor as renewables offset more and more medium load and baseload power supply. Furthermore, no coal plants have been planned since the nuclear phaseout of 2011, while several on the drawing board at the time have since been abandoned.

CCS not an option for coal power

Over the past decade, there has been a lot of talk worldwide about carbon capture and storage (CCS), which the technology's proponents misleadingly call "clean coal." Essentially, this technology captures pollutants and carbon dioxide for separate storage. For industrial processes such as cement production, in which it is extremely difficult to reduce emissions further, CCS could be an option to reduce greenhouse gas emissions. In power plants, however, CCS is viewed by most energy experts as unattractive because it drastically reduces the efficiency of the power plants, thus severely increasing fuel costs.

Furthermore, CCS investments turn out to be prohibitively expensive. Germany set up the first such test facility designed by Siemens in 2006 at Schwarze Pumpe, a coal plant run by Swedish utility Vattenfall. The results were apparently not encouraging, since Vattenfall announced at the end of 2011 that it had abandoned plans for a second demonstration project of 300 megawatts, which would have been ten times the size of the pilot facility at Schwarze Pumpe, thereby even foregoing funding from the EU for the first full-size CCS plant. Vattenfall said it was unable to go ahead with its plans because the German states with suitable storage potential refused to accept the risk.

In addition, environmentalists are generally not excited about the technology, as stored pollutants and CO2 will only create further problems for future generations, who will have to make sure that the storage facilities do not leak. Local communities do not wish to have repositories for carbon dioxide near them, so Merkel's coalition – which supports CCS – reached a compromise with the German states in 2012. Now, the states will be able to veto plans to construct carbon dioxide repositories, making it highly unlikely that any such repository will ever be built. The agreement also specifies that the states – and hence taxpayers – will be liable after the first 40 years of operation, with the company liable for the first 40.

Furthermore, the target for storage has been reduced from eight million tons per year to four million. To put this into perspective, it has been estimated that 3.5 billion tons of carbon dioxide would need to be stored away each year worldwide if we are to stay within our emissions targets. In other words, Germany now plans to contribute roughly 0.1 percent of carbon storage towards that goal.

In July 2012, Germany's Energy Minister Peter Altmaier himself gave up on the idea of CCS within Germany: "We have to be realistic. We cannot store carbon dioxide underground against the will of the population. And I do not see any political acceptance in a single German state for CCS technology with hard coal and brown coal power plants."

C – Wind power

Germany began switching to renewables primarily with wind power in the early 1990s. Nowadays, onshore wind power is the cheapest source of new renewable power and makes up roughly 8 percent of the country's power supply. What's more, the onshore sector is largely driven by midsize firms – and small investors. Both of those aspects will, however, be different in the fledgling offshore wind sector.

In 2012, Germany got roughly 7.3 percent of its electricity from wind turbines, almost all of which were onshore. By 2020, Germany plans to roughly triple the share of wind power (both onshore and offshore). But the fledgling offshore sector differs greatly from traditional onshore wind; while the latter mostly consists of midsize firms and distributed wind projects owned largely by communities and small investors, the former is almost entirely in the hands of large corporations, many of which have opposed the switch to renewables up to now. The traditional onshore sector therefore argues that older onshore wind farms should be repowered; turbine technology has made great advances since the 1990s, so far fewer turbines can now produce much more power. Onshore wind power is also considerably less expensive than offshore wind power.

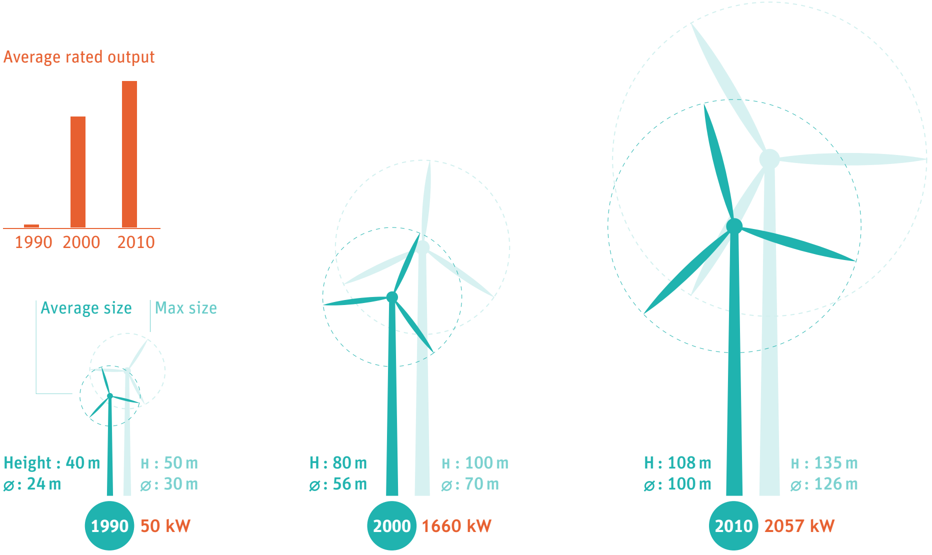
Repowering is an important issue in Germany. Because the wind sector has been at work here for two decades, the first wind farms that received feed-in tariffs have reached the end of their service lives, and even the ones that still have a few years left do not use the available space as efficiently as the latest turbines can. After all, the output of an average turbine installed today is about ten times greater than that of the average turbine made in the mid-1990s. In other words, by replacing old turbines with new ones – by repowering – we can produce ever greater amounts of wind power even as we reduce the visual impact of wind farms.

Germany also has plans for offshore wind power: the government aims to have ten gigawatts installed in German waters by 2020 and 25 gigawatts by 2030.

Wind turbines 40 times more powerful today than 20 years ago

Development in size and power of wind turbines, 1990–2010

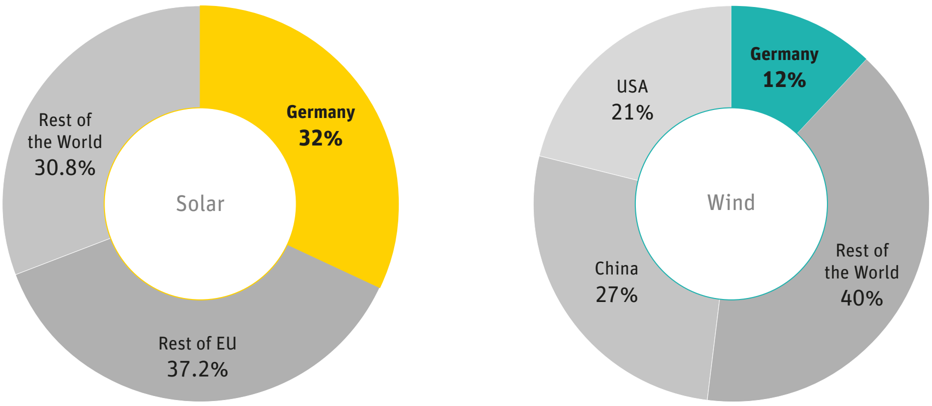
Source: DEWI



Germany is a global leader in wind and solar

Solar and wind operating capacity, Germany and rest of world, 2012

Source: REN21



In 2010, Germany's first offshore wind farm – the Alpha Ventus test field – was connected to the grid, followed by Bard 1 and Baltic 1, the first commercial wind farms, in 2011. Permits have already been granted for an additional 20 offshore wind farms within Germany's Exclusive Economic Zone in the North Sea along with three in the Baltic.

Offshore wind farms are expected to provide power more reliably, as the wind on the open sea is more constant. On the other hand, offshore wind power currently costs two to three times more than onshore wind power. Furthermore, the German wind sector is somewhat lukewarm about offshore wind power because these projects are firmly in the hands of large corporations, whereas onshore wind in Germany is largely owned by citizens; indeed, the Merkel government's support for offshore wind is sometimes interpreted as a special incentive for Germany's largest power companies, whose nuclear plants the government is shutting down.

Increasing acceptance of onshore wind

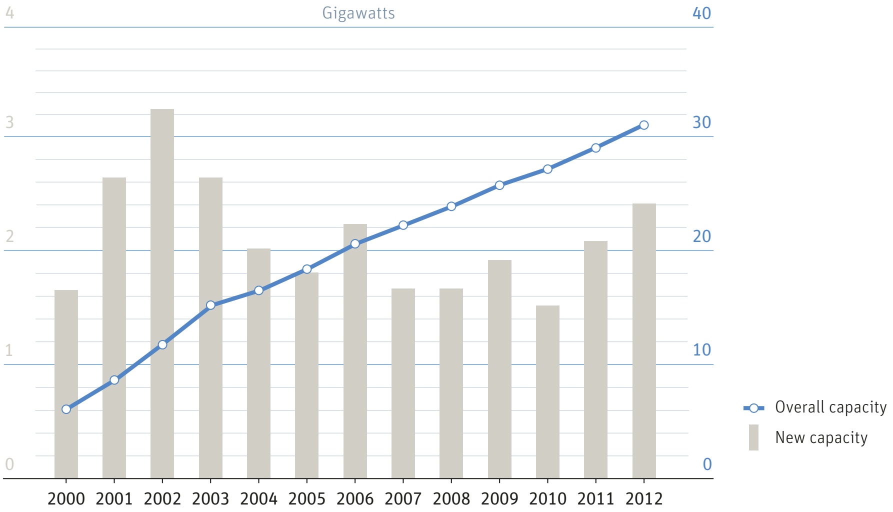
In contrast, the German wind sector has traditionally consisted of community-owned projects that grow "organically": a few turbines are put up, and when the community realizes what good returns the wind farm provides its investors, more people want to get involved and install new turbines. As the turbines go up, people also realize that concerns about noise are grossly exaggerated. Internationally, concern about the health impact of wind turbines is restricted to places with very few of them. Health effects are not an issue in the debates in Germany and Denmark, the two countries with the greatest density of wind turbines. On the contrary, people realize that the health effects are positive when clean wind power replaces dirty coal power and potentially dangerous nuclear power. Finally, as the wind farms grow, people get used to the "visual impact" and start to see the turbines as no more intrusive than power pylons, buildings, and roads – and less noisy than cars. For more information on community ownership of renewables in Germany, read 2 – I "Energy by the people".

Thanks to the technical developments seen in recent years, the use of wind power has also become more attractive in inland regions. In southern Germany – especially in the southwestern state of Baden-Württemberg, which still has very little wind power – planning barriers were recently removed to facilitate the installation of wind turbines on hillsides and in forests. At the same time, new turbines must fulfill strict ecological criteria. The state of Baden-Württemberg – which for the first time ever has a government led by the Green Party – plans to increase its annual newly installed capacity more than tenfold.

Germany has steady wind power growth

Cumulative and newly installed wind power capacity in Germany, 2000–2012

Source: DEWI



Germany's wind sector peaked in 2002, when roughly 3.2 gigawatts was newly installed, but the market has since stabilized at nearly 2 gigawatts of new capacity per year, equivalent to 2.5 percent of peak demand (around 80 gigawatts). In contrast, the US is the second-largest wind power market in the world behind China in terms of absolute capacity, but US peak power demand was around 770 gigawatts in 2010, so Americans would have to install nearly 20 gigawatts of wind turbines each year to keep up with Germany's performance in terms of power demand. Unfortunately, the US has never come close to reaching that level, having peaked at just over 10 gigawatts in 2009. In 2012, the US market is likely to come in far below that level.

D – Biomass

Biomass is the most versatile of all types of renewable energy as it can provide heat, electricity, and motor fuel. Not surprisingly, biomass is expected to make up nearly 2/3 of Germany's renewable energy consumption by 2020. But serving as a source of energy is only one thing biomass does well – it also provides food and materials for production (such as timber and oils). As a result, demand for biomass is great from a number of competing sectors. Unfortunately, the potential for sustainable biomass is limited, and the focus in German policy is on promoting the use of residue and waste.

Biomass is a special source of renewable energy in a number of ways. First, it can directly provide all three types of energy carriers: electricity, heat, and fuel (liquids, solids, and gas). Second, it is easily storable and dispatchable; when there is not enough sun or wind, biomass-fired generators can be ramped up as need be. Third, the major drawback: biomass requires strict management to be sustainable. No matter how many solar panels we install, we will not use up the sun any faster, nor will we measurably reduce the amount of wind on Earth if we keep installing wind turbines. But with biomass, we have to avoid resource depletion, prevent monocultures from reducing biodiversity, and ensure that the energy needs of rich countries are not met at the expense of food needs in poor countries.

Because it can cover such a wide range of energy services, biomass makes up a far greater share of the world's energy supply than hydropower or nuclear (which only provide electricity) – indeed, more than all other renewables combined. According to the International Energy Association's (IEA) World Energy Outlook 2011, "biomass and waste" covered roughly ten percent of global energy demand over the past decade, whereas the share of nuclear power has fallen to below six percent.

Biomass in Germany

Nowadays, when we talk about biomass, we increasingly mean ethanol from corn, biodiesel from rapeseed, biogas from organic waste and corn, wood pellets made from sawdust, etc. – as opposed to firewood, dung, etc.

Bioenergy generally comes from two sources: forestry and agriculture. Within the EU, Germany is the greatest producer of wood, and wood is by far the greatest source of bioenergy in the country. Roughly 40 percent of German timber production is used as a source of energy, with the rest used as material. Germany is also the leading biogas market – in 2010, more than 60 percent of Europe's electricity from biogas was produced there, with further dynamic growth to come.

In 2011, Germany was already using nearly 17 percent of its arable land for energy crops. Studies show that this share can be increased as a result of the decrease in population in the next few decades and increasing hectare yields in the agricultural sector. Environmental organizations, however, point out the environmental impacts of energy crops; for instance, the large increase in the cultivation of corn for use in energy production (and the problems associated with corn monocultures) is frequently associated with the plowing of valuable grassland. Energy crops can also have adverse effects on the quality of groundwater and cause soil erosion. To prevent these effects, Germany's revised Renewable Energy Act (EEG) limits the amount of corn and grain eligible for special compensation. In addition, a set of incentives seeks to encourage increased use of less environmentally polluting substrates, such as material from landscape management activities and residues.

The German Environmental Ministry estimates that in 2012, bioenergy made up 5.7 percent of power consumption, 9.2 percent of heat demand, and 5.5 percent of fuel consumption. The potential of sustainable domestic bioenergy in Germany would therefore seem to be limited to around ten percent of overall energy supply – at least at current levels of consumption – but Germany could increase those shares by reducing consumption (see 2 – A – Efficiency).

Today, Germany uses more than 600 PJ of biomass, mainly of domestic origin. The domestic supply could be roughly doubled, assuming an entirely sustainable production chain, to cover around one tenth of the current primary energy demand.

The challenge will be to double biomass usage for energy without drastically increasing imports. Germans are already concerned about the clearing of rainforest for palm oil plantations and about conflicts with food production in developing countries. As the German Environmental Ministry has stated, "the expansion of biomass production for energy use [must not conflict] with food security, the right to food, and the protection of the environment and nature." Therefore, along with the European Renewable Energy Directive, biofuels and other liquid bioenergy carriers must satisfy strong sustainability criteria to count towards the targets for quotas and be eligible for the bonuses set forth in the Biomass Sustainability Ordinance. It remains unclear, however, whether strict criteria are sufficient to prevent the use of biomass for energy from increasing food prices around the world.

For the future, the use of biomass seems particularly important in two areas: as fuel for air transportation and heavy-duty vehicles (where electromobility or other technical alternatives are not readily available) and for cogeneration, because cogeneration plants convert biomass to electricity and heat with the highest efficiency and greenhouse gas benefits.

In addition, biogas and hydrogen in particular are seen in Germany as a crucial way of storing energy seasonally to provide sufficient electricity on the dark evenings of winter, when power consumption is the highest in Germany and no solar power is available (see 2 – H – Flexible power production (no more baseload)).

E – Photovoltaics

Over the past decade, Germany has been criticized for its commitment of photovoltaics, which was once an expensive technology. But PV is now cheaper than offshore wind, competitive with biomass, and scheduled to become competitive with wind power in the foreseeable future. Germany has helped make solar inexpensive for the world. The challenge now is to integrate large amounts of solar power in the country's power supply.

Photovoltaics is the term for solar panels that generate electricity. Solar thermal produces heat, such as for hot water supply or space heating. Solar heat can also be used to generate electricity in a technology called concentrated solar power (CSP), though the technology is mainly useful in deserts, not in Germany.

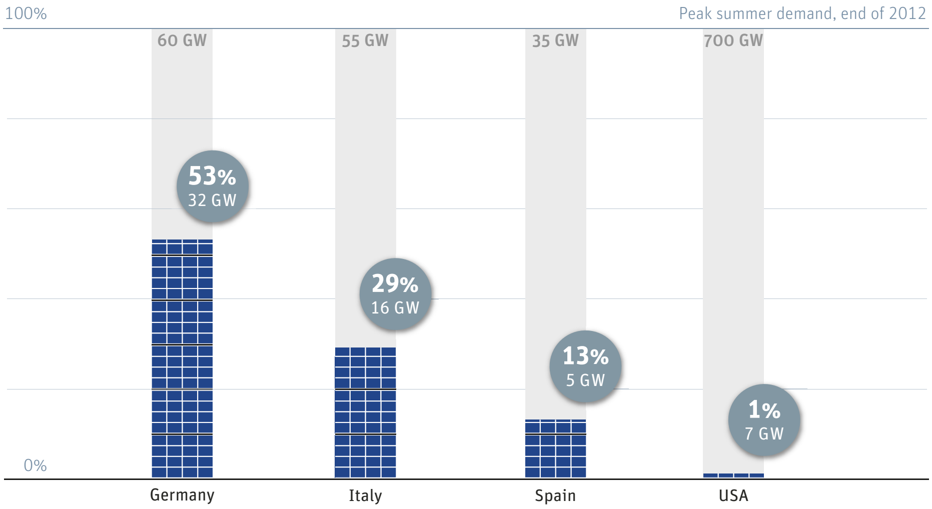
Though not known to be particularly sunny, Germany has developed the largest solar photovoltaics market in the world. The price of photovoltaics has plummeted over the past two decades, more than for any other type of renewable energy, and experts believe that it will be competitive with coal power sometime in the next decade. Already, solar power can provide up to 50 percent of German power demand for a few hours on sunny days of low power consumption. But the German example shows that power markets will need to be redesigned for solar to go further because solar drives down wholesale power rates, making backup powerplants increasingly unprofitable.

Photovoltaics (PV) is what most people think of when they hear the word "solar." While PV has long been considered the most expensive type of renewable power widely used commercially, prices have plummeted in the past few years (by roughly 50 percent from 2008 to 2012), and PV is now cheaper than concentrated solar power and offshore wind power.

Germany's installed solar PV capacity is already half of power demand

Germany has most solar PV installed in absolute (32GW) and relative terms (53% of peak demand)

Source: REN 21, own calculations



IIn absolute terms, Germany has more PV installed than any other country (roughly 35 gigawatts in the fall of 2013), but perhaps the most important comparison is installed PV in relation to peak summer demand. After all, the most solar power is generated on summer afternoons.

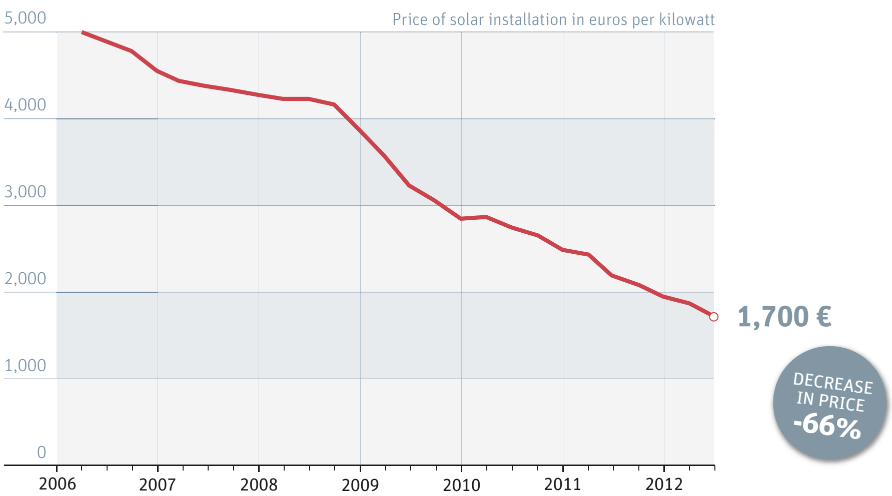
In Germany, power demand is lower in the summer than in the winter because Germans can largely do without air conditioning in the summer, whereas a lot of electricity is needed in the winter for heat, lighting, etc. As a result, photovoltaics alone was able to meet around half of the country's power demand on a few days in 2012.

For years, proponents of photovoltaics have pointed out how production of solar power coincides with peak power demand around lunchtime, so that relatively expensive photovoltaics turns out to be a good way of offsetting even more expensive power generators to meet that peak demand. Almost everywhere, PV is still an excellent way to meet peak demand – everywhere except Germany, that is, for the country now has so much PV installed that peak demand is no longer an issue. Photovoltaics now offsets a large chunk of the medium load during the summer in Germany and can even offset a bit of baseload production.

Price of solar down in Germany by 66% since 2006

Average system price for installed rooftop solar of up to 100 kilowatts

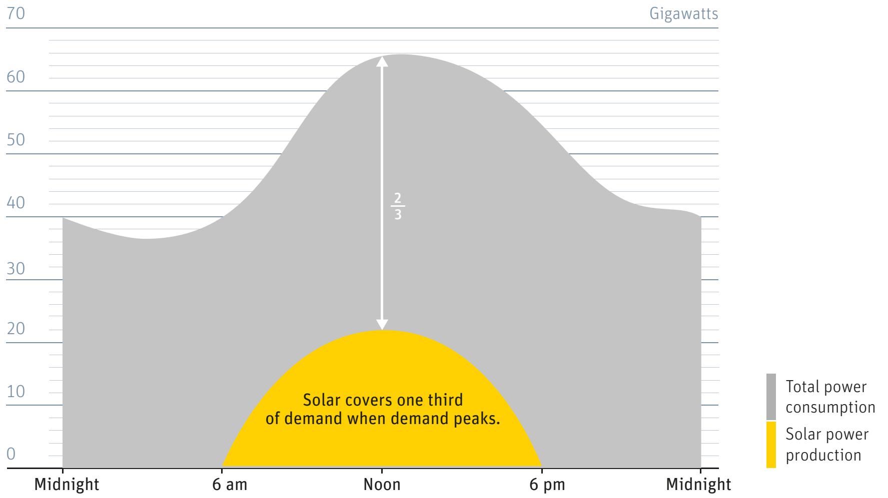
Source: EUPD Research and BSW-Solar



Solar PV can already cover a third of peak power demand

Power demand and solar power production in Germany. Estimate based on actual data from May 2012

Source: Frauenhofer ISE, EEX



On a normal business day in Germany, solar power (yellow) is produced exactly when power demand picks up. In the example above, conventional power (gray) only has to increase from around 33 gigawatts at three in the morning to around 42 gigawatts at 8 AM and again in the evening. In the middle of the day, wind power (not shown here) and solar power keep conventional plants from having to ramp up to more than 60 gigawatts, as they would have had to do 20 years ago. With additional wind electricity, even less conventional power will be needed.

One result of all of this solar power is drastically lower profits for the country's conventional power plant owners, whose plants are now simply no longer able to run at full capacity; in addition, they cannot sell at such high prices because PV obliterates the need for peak power at noontime. All of this has come about so quickly that politicians are now looking for ways to redesign the German power market to ensure that enough generating capacity remains online and dispatchable for those hours in the winter when Germany reaches its absolute peak power demand for the year (around 80 gigawatts), which also happens to be a time when no solar power at all is available. In this respect, Germany offers a unique glimpse into the future for other countries.

On the shortest day of 2011, Germany's installed PV capacity still managed to produce as much power as a large nuclear reactor for three hours, thereby helping to offset peak demand for power.

F – Other renewables

Other types of renewable energy include solar heat and geothermal energy (which can be used to generate electricity or provide heat). While Germany does not have great geothermal potential like Iceland and the United States, for instance, certain applications are nonetheless worthwhile. Solar heat has mainly not been as successful as solar electricity because Germany has not paid enough attention to solar heat in its energy policies.

Germany also has geothermal resources – heat from below ground. The first geothermal power plant in Germany went into operation in 2003, though it has not yet led to many subsequent projects. The financial crisis has not helped over the past few years because geothermal projects in particular have high upfront costs, high operating costs and, a bit like oil wells, may prove to be unprofitable if the site chosen turns out to be unsuitable.

The general public remains concerned about microseismic activity, noise, and impacts on groundwater. Early community involvement, careful siting of the power plants, and the best available exploration and operation technology are therefore crucial to minimize risks and increase acceptance. Nonetheless, compared to North America and developing Asia, the geothermal potential in OECD Europe (including Germany) is markedly smaller and restricted to certain attractive regions, where good energy yields with high temperatures can be achieved. Growth of geothermal electricity generation is therefore expected to be significantly slower than for wind and solar.

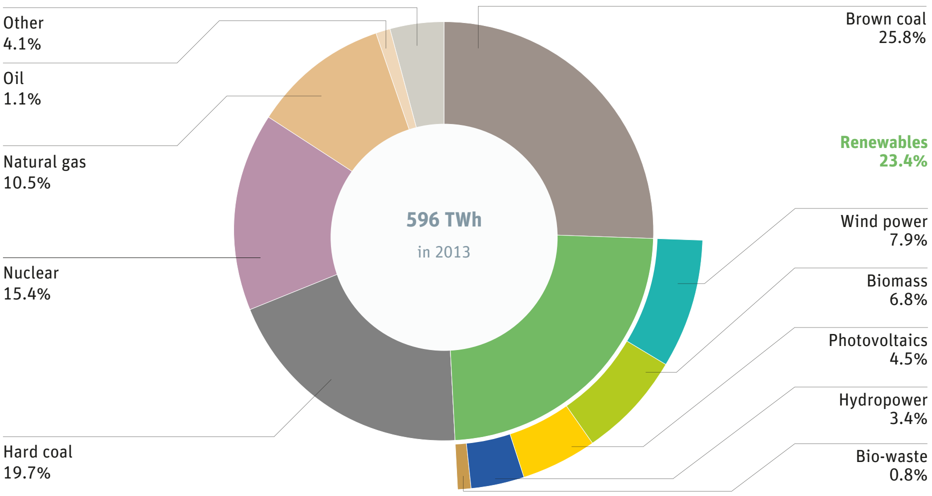
Renewable heat

When heat is generated from renewable energy – such as biomass and solar thermal – one speaks of "renewable heat," but the term can also encompass the recovery of waste heat for heating

Renewables are a strong and growing pillar in power supply

Share of renewables in Germany's gross electricity generation including exports, 2013

Source: AGEB



applications. Because heat makes up roughly 40 percent of German energy consumption, the potential for renewable heat is greater than for renewable electricity, since overall electricity only makes up 20 percent of the country's energy consumption. Nonetheless, Germany has not had much success in promoting renewable heat, partly because it has never offered feed-in tariffs for it. The German government has a goal of getting 14 percent of the country's heat from renewable sources by 2020. Under the Renewable Heating Act, all new buildings are required to have a heating system with a minimum share of renewable energy.

The potential for renewables to cover heat demand is very great, partly because efficiency can reduce demand considerably. Nonetheless, renewable heat has not grown as fast as renewable power, mainly because Germany has better legislation for the latter (feed-in tariffs).

Renewable heat from biomass

Up to now, most renewable heat has come from biomass, with the most common feedstock being woodchips, firewood, and, increasingly, wood pellets. Germany's Market Incentive Program also supports the generation of renewable heat from biomass, with strict requirements for efficiency and emissions. In addition, waste heat from biomass units is used in district heat networks. Indeed, Germany's Renewable Energy Act requires that most biomass units recover part of the waste heat produced in the process of generating electricity ("cogeneration of heat and power").

Renewable heat from solar thermal

Increasingly, new technologies using renewable energy sources are appearing on the market. In addition to biomass, for instance, there is "shallow" geothermal, in which heat is taken from just below ground or from groundwater. This heat can then be used in combination with heat pumps, as can heat from ambient air. In 2011, nine percent of the heating systems sold in Germany were based on a heat pump.

Solar thermal panels can be also installed on homes and businesses to cover demand for heat. In 2011, Germany was the third largest market for solar thermal in the world behind China and Turkey. At the end of that year, Germany had an estimated 1.66 million solar thermal systems installed with a collective heat output of around 10.7 gigawatts spread across approximately 15.3 million square meters of surface.

In the case of buildings, in particular, the investments in efficiency may offset consumption over decades, but the upfront costs may still be prohibitive. To overcome such obstacles, Germany has implemented a Market

Incentive Program, which provides funding for renewable heat systems (solar thermal collectors, modern biomass heaters, and efficient heat pumps). For more information, see Market Incentive Program (MAP).

Nonetheless, this market has not grown nearly as quickly as the PV sector. Growth rates of around ten percent per year are common in the solar thermal sector, whereas PV installations grew by around 60 percent annually from 2009 to 2011. One reason for solar thermal's sluggishness is that Germany does not have special feed-in tariffs for solar heat, only for solar power. Solar heat has therefore depended partly on government rebates funded by an eco-tax and emissions trading.

At present, solar heat only covers around one percent of Germany heat demand, which is especially unfortunate since heat makes up around 40 percent of German energy consumption, whereas electricity only makes up 20 percent (the other 40 percent is motor fuels).

In other words, the potential for renewable heat is much greater than the potential for all sources of electricity in Germany's transition to renewables.

G – Grid and power storage

While everyone agrees that the German grid will need to be expanded for renewables to make up a greater part of power supply, there is no consensus on what exactly needs to be done. Some estimates put the amount of new lines that need to be built at 4,500 kilometers, whereas the renewables sector believes half of that would suffice. Today, the German grid consists of 35,000 kilometers of transmission lines plus 80,000 kilometers of high-voltage lines – all of which was built for the conventional power sector, so the new lines required for renewables are minor in comparison.

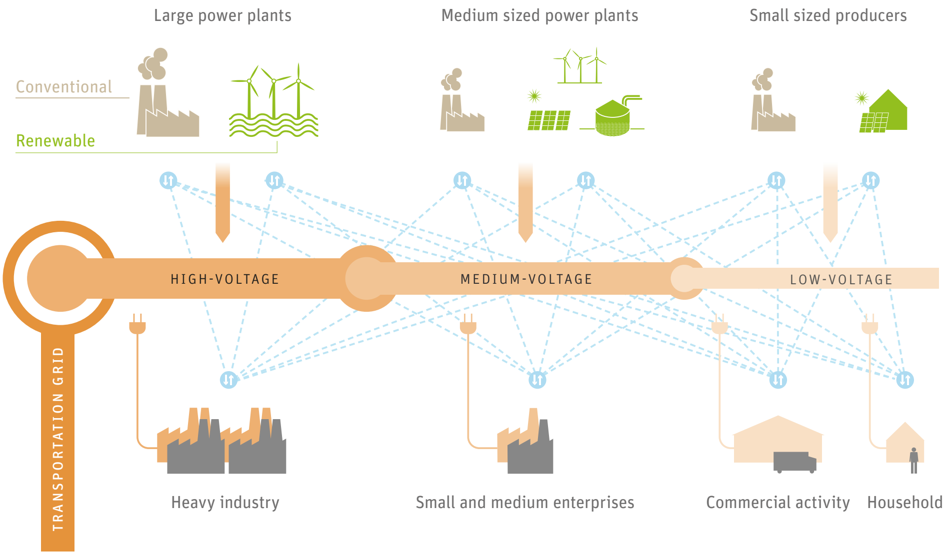
The switch to renewable electricity will be technically challenging because solar and wind power are not dispatchable, meaning that you cannot turn wind turbines and solar panels on the way that you can ramp up central coal and nuclear plants to match power demand. A number of solutions are possible.

The general problem is that the exact amount of electricity that is needed at a given moment has to be available at that moment, lest the grid collapse. We have therefore traditionally tailored power production to demand. A number of storage options are currently being discussed, from underground compressed air in natural caverns to pumped storage (hydropower), flywheels, and batteries. Most importantly, Germany plans to use natural gas in the interim as a bridge fuel to be eventually replaced by sustainable biogas and hydrogen made from excess wind power and solar power; here, solar and wind power could be stored as a gas (called "power to gas" or P2G), allowing it to be used as a motor fuel, for heat applications, or to produce dispatchable power. Finally, "smart grids" will help tailor power demand to the available renewable power supply – the opposite of what we do now.

The future power grid will be bidirectional and intelligent

Electricity and information flow in power grid

Source: IFEU



The need for power storage

European integration could be a solution, especially in light of Germany's limited pumped-storage capacity (hydropower). It has been proposed that Germany could export large amounts of power to Norway and Switzerland, for instance, which have tremendous hydro-storage potential, but at the moment connections are insufficient. It also remains to be seen whether the two countries (neither of which is even a member of the EU) would be willing to flood more of their pristine valleys so that Germans can have a stable supply of renewable electricity.

But over the midterm, most organizations believe that the need for power storage will be minimal in Germany. A study produced in October 2012 for the WWF found that there would not be a major market for storage technologies until 2030, and the German engineering organization VDE does not expect much demand for storage until Germany has 40 percent renewable power, a target that is admittedly likely to happen closer to 2020.

Putting renewable grid expansion into perspective

But before we discuss these options, let's put all of this in perspective. First, Germany has gone from 3% renewable power at the beginning of the 1990s to more than 23 percent in 2013 without any major changes to its grid. After all, wind power, biomass, and solar power are largely distributed sources of energy – at least the way Germany is doing it (see 2 – I "Energy by the people").

Critics of renewables sometimes complain when the grid has to be expanded for renewables. As one critic put it, "The problem with wind farms is that you have to build them in places where you don't need electricity. The electricity then has to be moved somewhere else."

In fact, this statement describes coal power better than wind power. You can spread solar, wind power, and biomass fairly evenly across the landscape in a way that you cannot do with conventional power. In contrast, brown coal plants are never built where power is needed, but rather where the brown coal is dug out of the ground. Even power plants fired with hard coal (anthracite), which is traded globally, were traditionally built close to the source of the coal, such as in Germany's Ruhr Area. Clearly, however, it is much easier and less expensive to transport large amounts of power across power lines than it is to haul loads of coal. And while one could argue that coal plants are often located close to industry (as is the case in the Ruhr Area), this description puts the cart in front of the horse. Go back some 200 years to the beginning of industrialization – most of the towns in the Ruhr Area were small villages. Coal plants did not go up in the Ruhr because industry was there; rather, industry developed there partly because the area was littered with coal reserves.

Furthermore, while nuclear plants are built more or less where power is needed, not where uranium is mined, all central plants are so huge that the grid is always expanded for them. In the 1960s and '70s, new nuclear power plants in Germany not only required the grid to be expanded, but also led to the installation of a large number of electric home heating systems that generated heat from power overnight so that the nuclear plants would not have to be ramped down each day. A distributed supply of renewable power is a much softer approach with a much smaller impact on the environment. Hermann Scheer, the late German expert on renewables, once compared distributed power supply to our conventional centralized power supply by saying that the latter is like "cutting butter with a chainsaw."

Grid expansion

There is a consensus that the grid needs to be expanded for more renewables to be integrated, but there is less agreement about a number of details, such as how many lines need to be added, where they need to go up, and what kind of lines should be used. Furthermore, the renewables sector itself has an interest in making the energy transition affordable and has therefore come up with a number of inexpensive alternatives to extensive grid expansion. In addition, people do not want to live near power lines, so public input is needed for planning – and that requires greater transparency.

The current German grid is divided up as follows:

The transit grid consisting of some 35,000 kilometers of 220 and 380 kV lines. This is the ultra high-voltage level at which Germany is connected to its neighbors and power is transported across long distances.

The distribution grid consisting of the following:

- Some 80,000 kilometers of high-voltage lines (60 to 110 kV) for conglomerations and large-scale industry.
- Some 500,000 kilometers of medium-voltage lines (6 to 30 kV) for many large facilities such as hospitals.
- Some 1,100,000 kilometers of low-voltage lines (230 and 400 V) for households and small businesses.
- Germany has four investor-owned utilities operating the four sections of its transit grid, but there are more than 800 distribution grid operators.

How many kilometers?

So what needs to be done for the country's energy transition? At the moment, a lot of wind power is in the north and a lot of solar is in the south. The German Energy Agency (dena) has published two studies (Grid Study I and II) estimating that some 4,500 kilometers of ultra high-voltage lines would need to be added if Germany is to increase its wind power capacity from 27 gigawatts to 51 gigawatts by 2020 – ten gigawatts of which would be offshore in the North Sea and Baltic Sea. But some in the renewables sector believe that this length could be cut by more than half.

Indeed, both of these studies met with great criticism among proponents of renewables in Germany, mainly because the underlying data were not published, so the findings could not be further scrutinized. But even at the proposed level, a near doubling of wind power capacity would still apparently only require the transit grid to be expanded by less than 13 percent. Furthermore, a lot of these lines would not be needed if the government promoted more onshore wind in the south rather than additional offshore wind in the north. In the past few years, the wind industry has come up with special wind turbines with taller towers and longer blades designed especially for use in weak-wind locations, such as southern Germany. Such onshore turbines in the south would not require as many power lines, thereby reducing the overall cost of Germany's energy transition, and onshore wind is also much less expensive than offshore wind to boot.

Likewise, some proponents of solar would also like to see feed-in tariffs for photovoltaics adjusted by region (as is done in France) so that more PV is installed in the north, thereby facilitating grid integration.

Below the transit grid level, the German government has produced a list of "urgently needed lines" totaling around 1,900 kilometers, only 200 kilometers of which has been built. Part of the problem is local opposition (people do not wish to live next to overhead power lines), but complicated red tape and financing also slow things down. Underground cables are an option, but they are more expensive.

But again, keep in mind that we are talking about adding 1,900 kilometers to a grid consisting of hundreds of thousands of kilometers set up exclusively for the country's nuclear and fossil energy supply.

Alternatives to grid expansion

Germany's renewables sector is not, however, just sitting back and waiting for the government to provide a future-proof grid. The solar sector has come up with a way of making the use of ultra high-voltage lines more efficient: solar power plants can act as "phase-shift oscillators" to stabilize the grid's frequency. The solar sector hopes that this approach will reduce the number of lines that need to be built.

The wind sector is also full of ideas. Under German law, there is a regulation called "n+1"; it means that whenever a line is set up, there has to be a reserve line that can take up its capacity in case it fails. The wind sector has come up with a solution that could mean that this requirement is no longer necessary: dedicated power lines to connect renewables.

Furthermore, the European Union plans to step up interconnections between countries, which could help reduce the length of new power lines required in Germany. At the same time, however, surges in wind and solar power production in Germany are already pushing power into Poland and the Czech Republic, in particular, so further integration would be a challenge for those countries. Some Polish officials have already stated that they might need to reduce rather than enlarge their power connections with Germany so they can have better control of their own grid.

H – Flexible power production (no more baseload)

Already, it is clear that intermittent solar and wind power will eventually cut deeply into baseload power. Germans have been aware that baseload power is incompatible with intermittent renewables for years. To complement renewables, we will need dispatchable power plants that can ramp up and down relatively quickly. Such plants more closely resemble today's medium and peak load (such as gas turbines) than the baseload (such as nuclear plants, which do not ramp easily). To pay for such reserve generating capacity, the power market will need to be redesigned, however, which is why Germany is now increasingly talking about a capacity market and a strategic power reserve.

What do you do when the sun isn't shining and no wind is blowing? Outside Germany, it is often said that conventional power plants will be needed as bridge technologies as we switch to renewables this century. In particular, there is talk about the need for baseload power, which fluctuating wind turbines and solar panels cannot provide. Germany already gets so much of its power from wind and solar that it has a different viewpoint. To the surprise of many foreign onlookers, Germans realize that baseload power demand will soon be a thing of the past. What is needed is flexibly, quickly dispatchable power generation, not baseload.The difference is easy to understand if we consider central power stations, such as coal and nuclear plants. Ideally, these plants are switched on and run near full capacity until they need servicing. Nuclear plants in particular do not easily ramp up and down within a matter of hours, and attempts to do so are bad for the bottom line in two ways: first, fixed costs remain the same, with only fuel costs being slightly reduced, so the cost of power from the plant increases; and second, the plants themselves undergo thermal fatigue, which can shorten their overall service lives.

For Germany's four biggest power companies, this new situation represents quite a dilemma. They set up their generating capacity based on the assumption that they would be able to sell power at a great markup during times of peak consumption. Now, power consumption remains unchanged and still peaks at above 70 megawatts on certain days, but solar and wind push back conventional power production into the lower 40s – roughly the level of baseload power that big power corporations are set up to cover. Just a decade ago, these power companies still belittled wind and solar power as niche technologies that would never be able to make up a big chunk of power supply; now, solar and wind power are increasingly making these firms unprofitable.

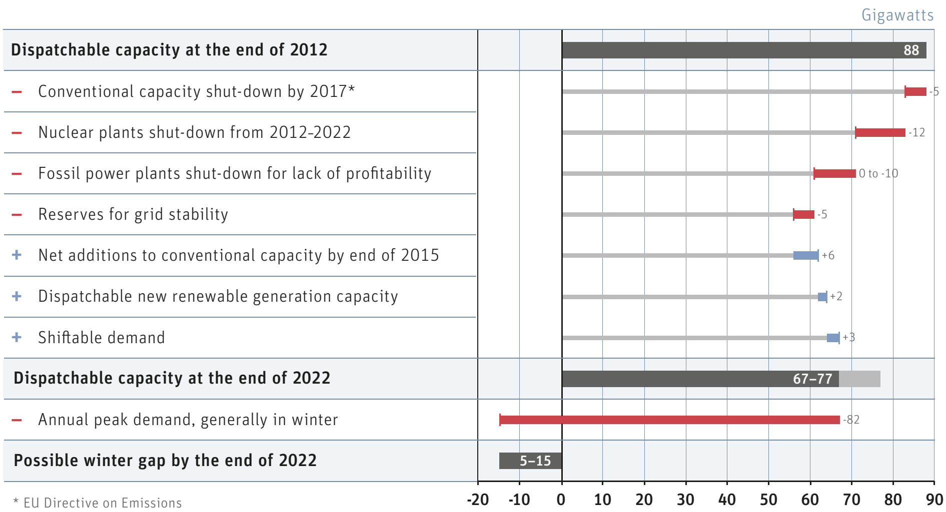
Unintended outcome: renewables push back natural gas

This outcome is partly intended (see the next section, "Energy by the people") and partly unintended. The unintended part is that renewables are making investments in natural gas turbines unattractive by replacing the medium load, meaning that natural gas turbines do not run for as many hours a year.

Does Germany need a capacity market to close the "winter gap"?

Trends in dispatchable capacity 2012–2022

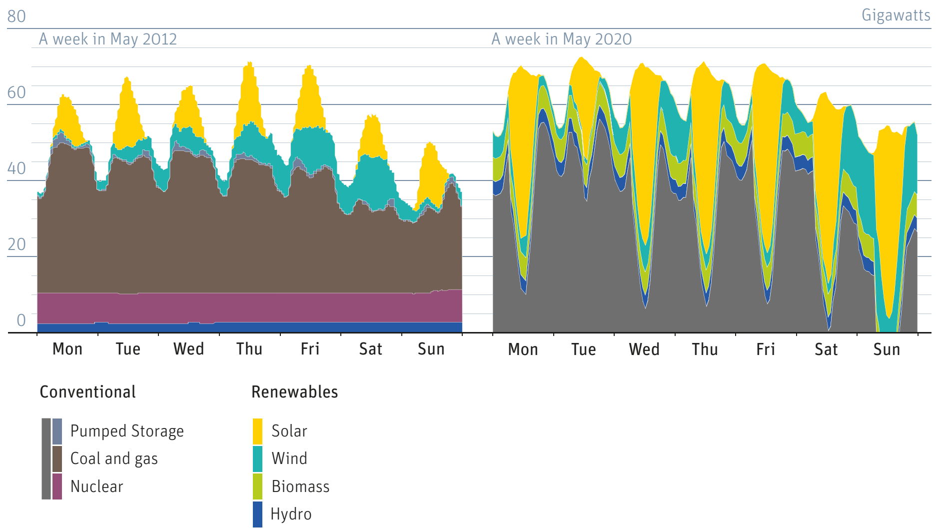
Source: Agora Energiewende



Renewables need flexible backup, not baseload

Estimated power demand over a week in 2012 and 2020, Germany

Source: Volker Quaschning, HTW Berlin



Essentially, Germany needs to have a dispatchable installed capacity at the level of its peak demand for the year, which is currently around 80 gigawatts and occurs on winter evenings – when the sun is not shining. A large part of that 80 gigawatts therefore needs to be built as dispatchable gas turbines. This option is generally considered the best technically as it requires no additional infrastructure and would allow electricity to be stored seasonally. German researchers have estimated that the storage capacity in the country's current natural gas lines can contain enough gas to meet the country's power demands for four months.

Though this option seems the best in terms of technology, it faces a financial challenge: power prices are now so low on the exchange that investments in additional generating capacity would not be profitable. Not only are Germany's four biggest power firms abandoning plans to set up new gas turbines; there have also been rumors that some of the existing turbines might be taken off-line because they are no longer running for enough hours per year.

While this outcome was predictable, the situation has come about faster than most proponents of renewables expected, especially in light of the extremely fast growth of photovoltaics from 2010 to 2013. If the German PV market continued to grow at the level of those two years, the country could have more than 150 percent of peak demand in the summer, when demand peaks at between 60 and 70 gigawatts during the week and as little as 50 gigawatts of the weekend. One German researcher's "dental chart" shows what the effect would be if "only" 70 gigawatts of PV is installed by 2020 (keep in mind that the government's official target is 52 gigawatts by 2020).

Here, the chart has no baseload power at all; the gray area now represents medium and peak load. Clearly, Germany will need a fleet of very flexible, dispatchable power generators that can ramp up every day from around ten gigawatts to 50 gigawatts or more within just a few hours. The country does not have this much flexible generating capacity at present, and all current plans for new power plants are now in question given the new market conditions of lower wholesale prices.

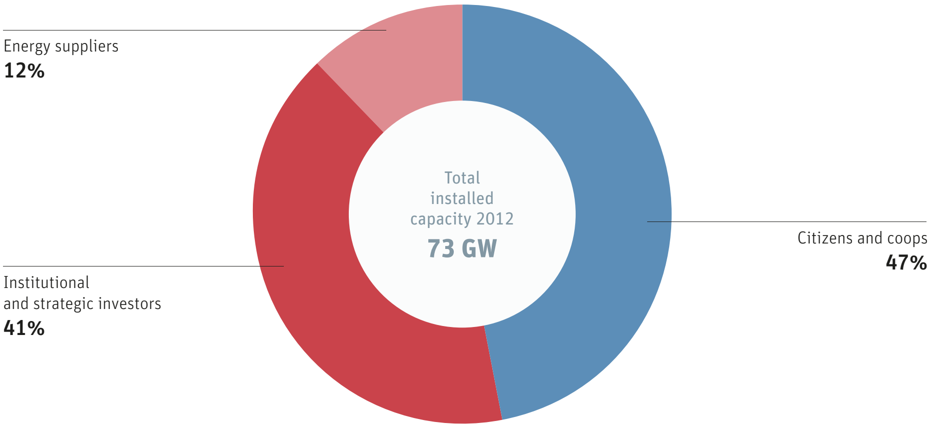
One possible remedy currently being discussed is capacity payments. Here, owners of quickly dispatchable generators would be paid not only by the kilowatt-hour generated, but also by the kilowatt kept on standby. Similar programs exist in other countries, such as Ireland.

In July 2012, the German Environmental Agency (UBA) spoke out against capacity markets, which it fears will be too expensive. Alternatively, the UBA proposes a "strategic reserve." Here, power companies would be paid for a certain amount of generating capacity maintained in service, not for the power generated from these plants; the rest of the power market would therefore remain undisturbed. The authors of the study estimated that a strategic reserve equivalent to five percent of peak demand would only add 0.1 cents to the price of the kilowatt-hour.

German energy transition is a democratic movement

Ownership of renewables in 2012

Source: AEE, www.unendlich-viel-energie.de



I – Energy by the people

Germans can switch power providers. In fact, they are not only free as power consumers, but also free to become "prosumers" – simultaneously producers and consumers. They can even sell the power they make at a profit. Germany's Renewable Energy Act stipulates that the little guy's power has priority over corporations. German feed-in tariffs have helped produce all of this community ownership, thereby simultaneously reducing NIMBYism (not in my backyard).

In most countries, the energy sector has long been in the hands of large corporations because electricity came from large central stations. Renewables offer an opportunity, however, to switch to a large number of smaller generators, and this distributed approach offers an opportunity for citizens and communities to get involved – an opportunity that is not being taken advantage of everywhere in the switch to renewables.

Some countries are switching to renewables by requiring utilities to produce more green power with policies called "quota systems." These policies set targets for utilities to reach, and penalties can be imposed if the targets are not met. The focus here is generally on cost, with the assumption being that utilities will choose the least expensive source of renewable power. For instance, the British Wind Energy Association lists wind projects as submitted, approved, refused, and built, categories that do not exist in countries with German feed-in tariffs. Rejections are thus a natural part of requests for proposals, which are also common in the US.

In contrast, no single organization in Germany has the task of reviewing wind farm proposals for approval or rejection; instead, local governments decide where wind farms can be built and how they will be designed (space, number of turbines, etc.). Utilities face no penalties because, in fact, it is not their responsibility to ramp up renewables. Utilities are also eligible for feed-in tariffs, but these firms nonetheless rarely make such investments. Overall, the difference between the two approaches – feed-in tariffs versus quotas – is striking. Under quotas, only the least expensive systems go up after time-consuming reviews, and they remain in the hands of corporations; under feed-in tariffs, everything worthwhile goes up quickly, and ownership of power supply rapidly transfers to citizenry. In other words, Germany is democratizing its energy sector.

This focus on cost is justified in quota systems (like Renewable Energy Standards in the US) because excess profits would go into the hands of a small group of corporations. Proponents of such quota systems correctly charge that the cost impact of feed-in tariffs is generally greater than the cost of quota systems, but they overlook two aspects: first, countries with feed-in tariffs generally install a lot more renewable generating capacity; and second, if properly designed, profits from feed-in tariffs go back to small investors, not multinational players, thereby breaking the stranglehold that large corporations have on the energy sector. In other words, many of the people who face slightly higher retail rates also receive revenue from those increases.

The Dardesheim wind farm has grown organically over the past two decades, and turbines continue to be gradually added. Visiting the wind farm is like going to a wind turbine museum. At the bottom of the tower on the right, local children were allowed to paint life-size figures. Photo: Craig Morris

Until recently, the American Wind Energy Association (AWEA) had a section on its website called Projects, which listed wind farms by location, size, and owner. At the time, Germany had the most wind power capacity of any country in the world. Nonetheless, DEWI, the organization that collates statistics on German wind power, said they never produced such a table: "We cannot say who owns a particular wind farm in Germany because ownership is splintered across scores, and sometimes hundreds, of local citizens and businesses."

In Germany, if you think your money would be wisely invested, you can generally go ahead with your project without concern that the government or your utility might reject your idea. Of course, there can still be resistance to projects from your local community. For instance, when the Druiberg Energy Park in Dardesheim got started, there was concern among locals about the potential impact, but the turbines did not bother anyone once they were up and running, so people began to focus on the wind farm as a safe investment. Those who had not yet invested were jealous of those who had. It was hard to get going, but easy to keep growing.

In the beginning, town hall meetings were held – for years. To ensure local acceptance, leases were signed not only with landowners on whose property turbines were built, but also with owners of adjacent properties. Whenever new turbines are built, people from the village (population: 976) are allowed to purchase shares in the wind farm, as are inhabitants of neighboring villages. In addition to the participation of the local community, thorough planning and careful impact assessments ensure that only the best sites for wind projects are developed.

These examples from Germany are common, not exceptional. Dardesheim was not even the first in 1994. That honor may go to the small town of Friedrich-Wilhelm-Lübke-Koog near the Danish border. Meanwhile, in Freiburg, Germany, a town of some 220,000 people in the southwestern corner of the country, citizens funded roughly a third of the investment costs for four turbines put up on a nearby hill, with the other two thirds coming from bank loans. The project manager says he could have gotten more of the money from the bank, and it would have been better financially; after all, interest rates from the bank are around 4.5 percent, whereas the project pays a dividend of up to six percent to citizen investors. Furthermore, a lot more paperwork is involved when you have hundreds of small investors instead of a few big loans from banks. But the Freiburg project, like so many others in Germany, was willing to forgo some profit in return for greater community acceptance – so that locals can negotiate with locals, not with an out-of-town corporation that makes everyone feel like it could get its way anyway.

The latest projects attempt to make communities not just net exporters – selling excess power to the grid and only purchasing power from it when not enough renewable energy is available – but entirely self-sufficient. For instance, the Island of Pellworm has combined solar, wind, biomass, and geothermal in a hybrid power plant connected to a smart grid with energy storage to reduce the dependency of its 1,200 inhabitants on energy imports by 90 percent.

There are also community-owned biomass projects. In 2004, a local farmer in the village of Jühnde formed a cooperative with nine other farmers who wanted to grow energy crops. More than 70 percent of village residents agreed to switch their heating systems over to a district heating network connected to a new village biogas unit. The biomass unit runs largely on local corn crops. For several years now, the villagers have been paying local farmers and businesses for their heat instead of paying for foreign oil and natural gas.

A community-owned PV array on a noise barrier in Freiburg, Germany. Source: fesa GmbH 2006

When Jühnde switched over to its renewable heat supply, it drew a lot of attention across the country and served as an example for scores of other communities – and continues to do so. Indeed, there was a bit of a boom in corn as an energy crop, which drew some criticism. People feared monocultures and were concerned about the impact on biodiversity and landscapes, but anyone who has seen the Corn Belt in the United States, soy plantations in Brazil, or palm oil plantations in Malaysia would find Germany's largest cornfields quite small in comparison.

New projects will continue to depend on local support. If the citizens affected don't want to be surrounded by even more cornfields, the project will not go forward.

Overall, it is estimated that "energy cooperatives" – community-owned renewables projects – have leveraged 800 million euros in investments from more than 80,000 private citizens. It is often said that only the wealthy can make such investments; for instance, critics charge that you need to own your own home to have a solar roof. But more than 90 percent of Germany's energy cooperatives have already set up solar arrays, and a single share in such cooperatives costs less than 500 euros in two thirds of the cooperatives – with the minimum amount less than 100 euros in some cases. As the head of Germany's Solar Industry Association (BSW-Solar) puts it, "Energy cooperatives democratize energy supply in Germany and allow everyone to benefit from the energy transition even if they do not own their own home."

Furthermore, energy cooperatives are moving beyond power production to include grid ownership. In the 1990s, the movement began with the Schönau Power Rebels, residents of a village in the Black Forest that forced their local utility to let them purchase the local grid. Now, the movement continues to spread across the country, including to Hamburg and the capital city of Berlin, where residents campaigned to have the utility and over control of the grid to a group of citizen investors. In Hamburg, the citizen grid takeover succeeded; in Berlin, it did not.

Social transition

The energy transition is not just a technical challenge; it will also challenge us to change our behavior. If the goals of Germany's energy transition are to be met, Germans will have to pursue "sufficiency strategies" focusing on a cultural transformation – a process that cannot be completed overnight, but will take time and require a lot of awareness-raising. Germany is a society in which people love their creature comforts, so as all of these devices become more efficient, we must ensure that people do not simply decide, say, that a car with twice as good gas mileage means they can drive twice as much for the same price. Aside from the increase in energy prices already taking place, this discussion about policies to change behavior is just getting started in Germany. Already, it is clear that new ownership and financing models (such as energy cooperatives) will not only allow people to get involved in new ways, but also increase acceptance of local change and awareness of energy consumption.

Increasingly, new modes of flexibility will need to be tried out. For instance, the first German cities now have apartment swapping platforms so that parents whose children have left home can move into accessible apartments of the right size. Housing associations are working on flexible housing concepts to allow rooms to be easily separated in order to put an end to the unbroken growth in per capita living area over the past few decades. Elsewhere, residential complexes now have ultra-efficient washing machines for common use in the basement, and car sharing provides people with efficient mobility to suit their needs. But people should not be forced to adopt such ideas. Rather, they will come up with such solutions themselves as they become more aware of the problems posed by rising energy prices and the impact of carbon emissions.

3 Policies for clean energy

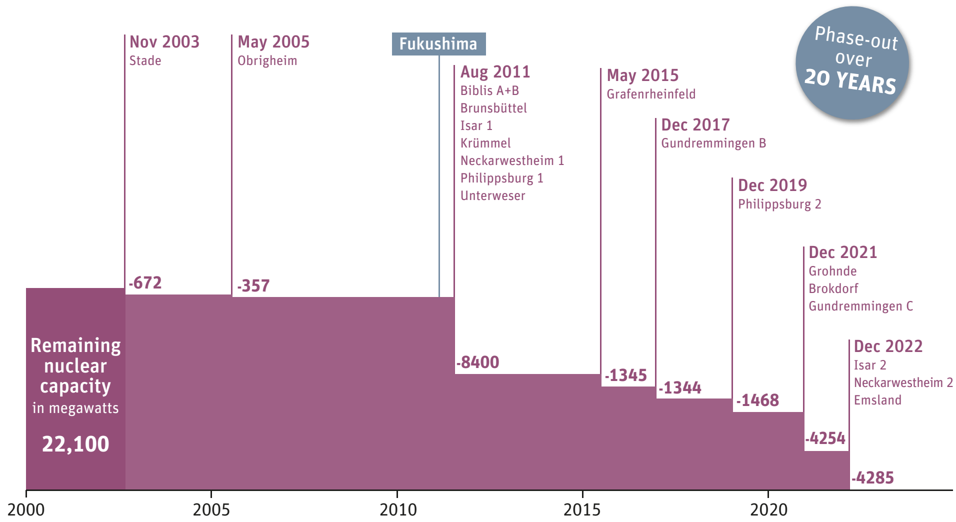
Germany has implemented a number of laws and programs for its energy transition, and there are also some at the level of the EU. The most important ones are listed below.

A – Nuclear phaseout	33
B – Renewable Energy Act with feed-in tariffs	34
C – Emissions trading	38
D – Environmental taxation	39
E – Cogeneration Act	40
F – Renewable Energy Heating Act and Market Incentive Program (MAP)	42
G – Act on Accelerating Grid Expansion	43
H – Energy-Conservation Ordinance (EnEV) and financial support schemes	44
I – Ecodesign/ErP Directive	46
J – Efficiency Fund and Climate Initiative	47
K – Discussion about energy market reform in 2014	48

Germany is gradually shutting down all nuclear power plants

Declining nuclear energy installed capacity in Germany, 2000–2022

Source: Institute of Applied Ecology, BMJ, own calculations



A – Nuclear phaseout

The nuclear phaseout is a central part of Germany's energy transition. Germans view nuclear as unnecessarily risky, too expensive, and incompatible with renewables (see 2 – C). By around 2022, the last nuclear plant in Germany is to be shut down; at the beginning of 2011, 17 were still in operation. The country plans to fill the gap left behind by nuclear power with electricity from renewables, power from natural gas turbines, lower power consumption (efficiency and conservation), demand management, and – in the interim – the rest of its existing fleet of conventional power plants.

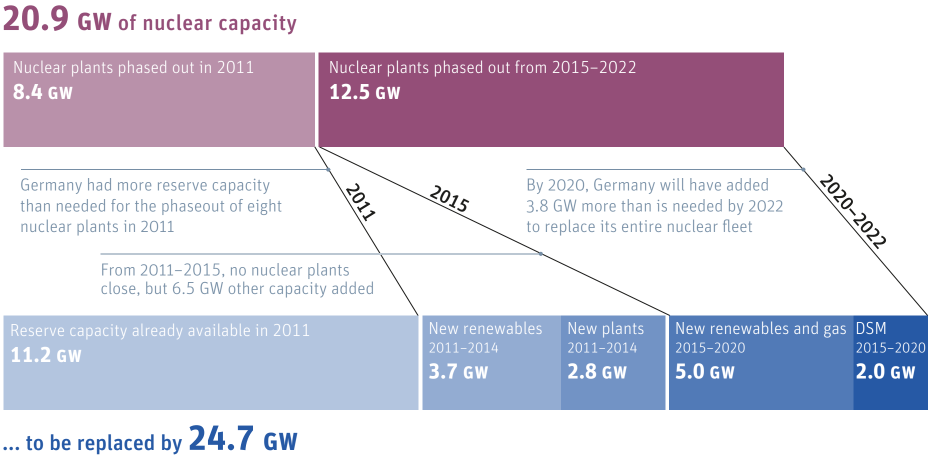
In 2000, the governing coalition of the Social Democrats and the Greens under Chancellor Gerhard Schroeder reached an agreement with Germany's nuclear sector to shut down the country's nuclear plants after an average service life of 32 years. At the time, the country had 19 nuclear plants with commissions that had not expired.

The firms were allowed, however, to allocate kilowatt-hours from one plant to another. In this way, the firms themselves could decide to shut down one plant ahead of schedule but transfer that plant's remaining kilowatt-hours to another plant that, say, was located in a more critical area on the grid. Depending on how much nuclear power had been produced by then, Germany would have switched off its last nuclear plant around 2023.

Germany can easily replace its nuclear capacity on the phaseout schedule

Replacing nuclear plants with reserves, new renewables, gas, and demand-side management (DSM)

Source: Institute of Applied Ecology, own calculations



Germany's Big Four power companies (EnBW, RWE, Eon, and Vattenfall of Sweden) had no choice but to accept this compromise they had reached with Schroeder's government, but they seem to have pursued a strategy of waiting it out – and of switching from nuclear to coal and natural gas rather than to renewables. By the end of 2011, these firms collectively only made up seven percent of Germany's new investments in renewables (to learn more about citizen investments in renewables, read 2 – I "Energy by the people"). During that same timeframe, the share of nuclear in German power supply fell from 30 percent in 1999 to 23 percent in 2010 – a clear sign that the phaseout was already underway, with two of the country's 19 nuclear plants having been phased out already.

Policy reversals

Then came the nuclear meltdown in Fukushima, Japan, on March 11, 2011. In Berlin alone, an estimated 90,000 people took to the streets to protest nuclear power. The German government resolved to shut down eight of the country's 17 reactors, with a ninth, which was already out of service after a few incidents, being prevented from going back online. The decision became final two months later, essentially meaning that Chancellor Merkel's coalition suspended the previous nuclear phase-out by only a few months before doing an about-face. Now, Germany is back on course to be nuclear-free by 2022. For each of the remaining nine nuclear plants, a concrete date has been set for decommissioning.

Despite the Merkel coalition's complete reversal of its nuclear policy, the public did not seem to believe the change of heart. State elections held in the wake of Fukushima often seemed like a referendum on nuclear power, with a large block of votes shifting to the Green Party, most notably in the southwestern state of Baden-Württemberg, where the Greens won the governorship for the first time ever.

B – Renewable Energy Act with feed-in tariffs

Perhaps no other legislation has been copied worldwide as much as Germany's Renewable Energy Act (EEG), making it a tremendous success story. The law specifies that renewables have priority on the grid and that investors in renewables must receive sufficient compensation to provide a return on their investment irrespective of electricity prices on the power exchange. The resulting high level of investment security and the lack of red tape are often cited as the main reasons why the EEG has brought down the cost of renewables so much. In contrast, quota systems do not provide investors with security or incentives to ensure that a wide range of renewables technologies are deployed so they can become less expensive.

In the early 1990s, Germany came up with a very simple policy to promote electricity from renewable energy sources, including wind power, solar energy, and small hydropower generators. In 2000, these feed-in tariffs were revised, expanded, and increased; every three to four years, they are reviewed and the law is amended. See the section on History for more information.

Owners of solar arrays and wind farms have guaranteed access to the grid. Grid operators are required by law to purchase renewable power, with the (intended) result being that conventional power plants have to be ramped down – in the process, renewable power directly offsets conventional power production.

While feed-in tariffs themselves have been widely copied outside of Germany in more than 50 countries, the central aspect of grid access is occasionally overlooked. Projects that would be profitable thanks to feed-in tariffs may then remain stuck in limbo for lack of a grid connection.

The situation is by no means perfect in Germany, either; any German project developer can probably complain about delays in the grid connections. But overall, most grid connections are fairly easy to get in a timely fashion, and project planners in other countries would probably love to have the grid access terms stipulated in Germany's EEG.

The standard contract for feed-in tariffs that you sign with your utility is two pages long in Germany. In contrast, the United States has Power Purchase Agreements (PPAs), which can easily be 70 pages long and are individually negotiated between the seller and the buyer (say, a utility company). In Germany, feed-in tariffs are guaranteed for 20 years, which would be quite long for PPAs. And let's not forget one important aspect – you will need a lawyer, if not a team of lawyers, to formulate a PPA, whereas the average German has no problem understanding the two-page contract for feed-in tariffs.

Flexible tariffs

The feed-in tariffs themselves are quite simple to explain. Basically, you take the cost of a particular system, divide that figure by the number of kilowatt-hours the system can reasonably be expected to generate over its service life (generally 20 years), and you get the cost of that system per kilowatt-hour. Now, tack on whatever return on investment (ROI) you want to provide, and you have your feed-in tariff. In Germany, the target ROI is generally reported at around five to seven percent.

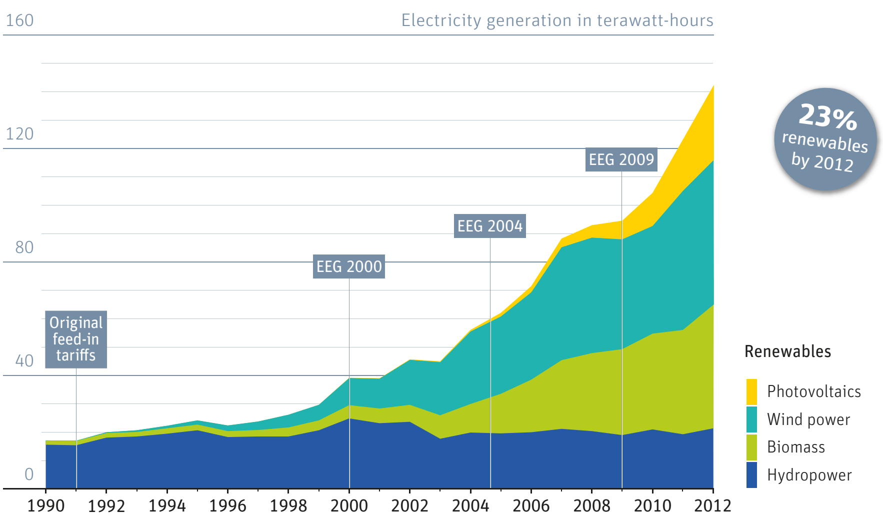
This approach allows distinctions to be made not only between technologies (such as solar, wind, and biomass), but also between system sizes. After all, a giant ground-mounted photovoltaic array on a brownfield will produce electricity that is cheaper than power from a large number of distributed solar rooftops on homes. By offering different feed-in tariffs for different system sizes, you ensure the economic viability of the various applications, thereby preventing windfall profits for large projects.

The EEG sets very ambitious targets. For instance, Germany plans to get at least 35 percent of its power from renewables by 2020, at least 50 percent by 2030, and at least 80 percent by 2050. This legal requirement to switch power generation almost entirely to renewable sources is one of the main pillars of Germany's energy transition.

Feed-in tariffs grow renewables

Renewable electricity generation in Germany, 1990-2012

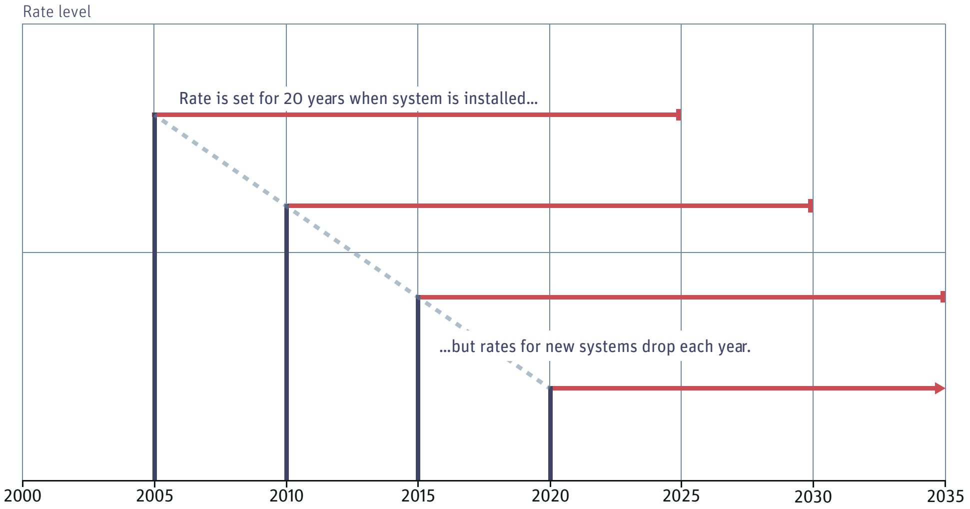
Source: BMU



Feed-in tariffs provide investment certainty and drive costs down

Simplified generalization of feed-in tariff with 20 year duration

Source: Own estimates based on WFC



Criticism of feed-in tariffs

Critics of feed-in tariffs charge that the policy does not promote the least expensive type of renewable energy.

This outcome is not, however, unintended; it is what makes feed-in tariffs successful to begin with. Think about it – quota systems (such as Renewables Obligations in the UK and Renewable Energy Credits in the US) generally require utilities to generate or purchase a certain amount of their electricity from renewables (say, ten percent by 2020). The utility then looks for the cheapest source of renewable power, which is almost always wind power – and it is almost always large wind farms, not community projects with just a few turbines. But we will never bring down the price of photovoltaics by focusing on wind turbines.

Repeatedly, critics of feed-in tariffs have charged that the policy "picks winners," but in fact quota systems always pick wind, whereas feed-in tariffs support all of the specified types of energy equally. The confusion is based on a misunderstanding. Up to now, conventional power sources have generally competed with each other. For instance, power companies leave their least expensive power plants online as much as possible and only switch to more expensive generators as demand increases. But if renewable power always has priority, then it does not compete with conventional power on price anyway. In addition, in quota systems, financing institutions add risk surcharges. Thus, financing costs are higher than in a feed-in tariff scheme, which provides long-term reliability for investors.

It would not be correct, however, to conclude that there is no competition with feed-in tariffs. For a given feed-in tariff, companies – from panel manufacturers to local installers – compete for customers. For instance, let's say you want to put a solar array on your house. In Germany, you will get a couple of estimates from local installers, who will probably also give you a couple of options (such as monocrystalline or polycrystalline panels, or panels made in Germany or abroad). All of the companies you could buy from compete with each other.

Feed-in tariffs unleash the market

Not surprisingly, feed-in tariffs do not lead to unnecessarily high prices. In fact, Germany has the cheapest solar power in the world not because it has so much sunlight, but because of investment certainty and market maturity due to its feed-in tariff policy. Solar is so much cheaper in Germany than it is in sunny parts of the US, for instance, that the largest, most cost-efficient utility-scale solar power plants there still produce considerably more expensive power than small to midsize arrays in Germany.

Up until 2008, when the bottleneck in the supply of solar silicon finally worked itself out, critics of feed-in tariffs charged that Germany had been paying too much for photovoltaics with its feed-in tariffs, thereby keeping the cost up for the rest of the world, including developing countries in particular. But since prices began to plummet in 2008, we don't hear that criticism anymore – because it wasn't true in the first place.

Changes in German feed-in tariffs for PV did not bring about these lower prices; on the contrary, German politicians have been rushing to reduce solar feed-in tariffs to keep up with falling prices. Those who once claimed that German feed-in tariffs kept the price of solar up for the rest of the world should now explain why prices are down so much without being driven by cuts in German feed-in tariffs for PV.

The truth is that solar can get cheaper even if feed-in tariffs remain unchanged because there is still a competitive market. If you want to install a solar roof, you will pick one of the least expensive offers on the market.

Cost of the EEG

The EEG's feed-in tariffs have scheduled reductions, usually annually, to ensure that the price for renewable power continues to drop. Unfortunately, the current market design has a flaw that actually makes the retail rate increase for consumers when renewables lower the wholesale rate for industry.

To maintain dynamic development for renewables on the market, the feed-in tariffs for newly installed systems decrease from year to year. The "degression rate" – stepped, scheduled tariff reductions – depends on the maturity of the different technologies. Hydropower tariffs go down one percent per year, wind 1.5 percent, and biomass two percent. For photovoltaics, the degression rate depends on the market volume in the preceding year.

The cost of these feed-in tariffs is passed on to power consumers. By 2012, this surcharge had raised the retail price by around 3.6 cents per kilowatt-hour – equivalent to roughly ten euros per month for the average German household; for 2013, the surcharge increased by 47% to 5.3 cents. These investments not only reduce energy imports, but also lower greenhouse gas emissions and the cost of resulting climate change.

But while renewable power has raised the retail rate in Germany, it has lowered wholesale prices. Solar power in particular is generated in the early afternoon at a time of peak consumption. Normally, even the most expensive generators are switched on during such hours (the technical term is "merit-order effect"), but less expensive solar power largely offsets this costly peak demand power in Germany now.

Some changes are needed

Ironically, lower wholesale rates have increased the EEG surcharge because of the way that surcharge is calculated – the price of wholesale power is reduced from the cost of renewable power, and the difference is passed on as the surcharge. Hence, as renewables make wholesale power cheaper, they also seem to make up an ever larger share of the power price, so consumers perceive renewable power as a cost driver – simply because of the calculation's design.

In contrast, industry is benefiting tremendously from the current market design. Not only do they generally pay wholesale rates, not retail rates, but energy-intensive industry and the railway sector in particular are largely exempt from the EEG surcharge. In other words, German consumers and small businesses currently cover an inordinate share of the cost of green power.

Increasingly, the EEG surcharge is becoming an issue for social policy – how will the poor continue to pay their power bills? Proponents of renewables are increasingly calling for the exemption for energy-intensive industry to be done away with, as the sector already benefits from lower wholesale prices thanks to renewables and should gradually have to share a greater chunk of the burden. It has been estimated that the EEG surcharge would have come in at less than 2.5 cents per kilowatt-hour in 2012 (rather than nearly 3.6 cents) had energy-intensive industry been required to pay the full surcharge.

C – Emissions trading

An emissions trading system (ETS) puts a limit on emissions for the long term. The policy is the main instrument in the EU to lower greenhouse gas emissions in industry, the power sector, and most recently the aviation sector. The EU-ETS has been criticized, however, for a lack of ambition and too many loopholes – an outcome that comes as no surprise, given that policy makers had to make concessions to strong electricity and industry lobbies to get the system launched at all. These concessions include offsets, unambitious targets, and a lack of adjustments to economic downturns.

The EU-ETS

The EU's main climate policy instrument for the industrial and power sector is its Emissions Trading Scheme (EU-ETS), which covers roughly half of the greenhouse gas emissions within the European Union. Overall, the goal is to cap the emissions for different sectors. Each year, the amount of carbon that can be emitted is reduced, putting pressure on firms to lower their emissions by investing in efficiency measures or buying allowances from other emitters.

This system thus produces a price for carbon. Proponents of emissions trading point out that the least expensive solution will always be chosen. For example, it might be cheap for utility firm ABC to shut down a very old coal plant and switch to natural gas or renewables to replace that capacity. As a result, ABC might not emit as much carbon as it holds in carbon certificates, so it could sell the unused certificates to utility firm XYZ, which has a relatively new coal plant in operation but needs to purchase a few allowances nonetheless.

Absolute cap, but bumpy start and design flaws

The EU-ETS has, however, gotten off to a bumpy start. Launched in 2005 in a pilot phase, it was comprehensively revised in 2009/2010. The price of carbon remained low, thus giving little financial incentive to switch from coal to low carbon fuels. Nonetheless, the platform does put a ceiling on emissions, which is why Germany's nuclear phaseout will not lead to more emissions. The ETS caps the power sector, so Germany's carbon emissions cannot rise above that level with or without nuclear power. (Read the Q&A section concerning the question of rising emissions)

A number of design flaws have kept the system from being more successful. To begin with, when the pilot phase began in 2005, a generous volume of certificates was handed out for free to major emitters. The result was nonetheless higher power prices because the firms charged consumers for the value of the certificates they had received for free. In 2013, certificates will no longer be allotted for free but will instead all be auctioned off for the power sector; major carbon emitters will finally have to pay for all of their carbon allowances.

The rise of renewable electricity and the economic downturn since 2008 mean that too many allowances are still in circulation. In November 2013, the EU finally managed to improve the situation slightly – and only temporarily – in a process called "backloading" – essentially, postponing the issue of new carbon emission allowances to create a short-term production in supply. Nonetheless, carbon prices are not expected to rise from the current level of around five euros per ton to the 30-50 euros originally envisioned in 2005. The German government has not been supportive of stricter emissions trading rules, and the new coalition agreement from 2013 indicates that the new government will not call for a higher carbon price either.

A major problem continues to be the role of offsets, which will be expanded starting in 2013. They basically allow European companies to reduce their emissions not at home but in developing countries, with the Clean Development Mechanism (CDM). Unfortunately, the requirement that offsets be "additional" (meaning that the project would not have taken place anyway to fulfill existing environmental laws) may be preventing environmental regulations from being made stricter; after all, stricter rules would require more action, and the CDM then has to go even further. In other words, the stipulation that a project be additional may provide an unintended incentive to keep other regulations lax. Steps must therefore be taken to ensure that offsets are not barriers to stricter environmental regulations.

Overall, criticism of offsets centers on the question of whether developed countries "outsource" too much of their emission reduction responsibilities to the developing world, thus avoiding structural changes in their own economy. In the next phase of the EU-ETS, for example, Germany firms may achieve up to 50% of their mandatory emission reduction with offsets – a level that many believe is too high.

Emissions trading and feed-in tariffs

Emissions trading has sometimes been viewed as in conflict with feed-in tariffs (see "Renewable Energy Act with feed-in tariffs"). While the ETS aims to reduce emissions in the traditional power sector, feed-in tariffs promote investments in renewables. Some analysts argue that if the only goal is lowering greenhouse gas emissions, the ETS would deliver this goal most efficiently because market members would choose the cheapest way to reduce emissions; they charge that many types of renewable energy are only economically viable because of feed-in tariffs.

In fact, renewable power primarily offsets gas turbines and electricity from hard coal plants in Germany, thereby reducing carbon emissions dramatically. Rather than viewing feed-in tariffs and emissions trading as competitors, most Germans understand that feed-in tariffs allow us to reduce the ceiling on carbon emissions for emissions trading faster than we would otherwise be able to do.

During the discussions in 2009, Germany's premier economics research institute, DIW, came out strongly in favor of both instruments in a paper entitled "We need both," arguing essentially that if renewable energy has the potential to reduce carbon emissions faster than the emissions trading platform can, then the obvious thing to do would be to lower targets for emissions trading – not to get rid of feed-in tariffs.

Emissions trading internationally

Outside of Europe, emissions trading has been struggling even more up to now. Nonetheless, the policy will likely pick up not only in the EU, but also worldwide. California is starting its own cap and trade program in 2013, and its carbon price is higher than the EU's; it is complemented by the voluntary emissions trading platform along the East Coast of the US (RGGI). China recently implemented a pilot platform in seven provinces. Finally, Australia plans to link to the EU emissions trading system by 2015.

Finally, it is worth mentioning that Germany is one of the few countries that not only met its Kyoto targets, but surpassed them with flying colors. The Germans had what sounds like a relatively ambitious target of a 21 percent reduction below the level of 1990 by the end of 2012 (the UK's target was a 12.5 percent reduction; France's, zero percent), but much of that was related to the special situation of the former East Germany, whose decrepit industrial sector was shut down or revamped in the 1990s. Nonetheless, Germany overshot the target by a wide margin, reducing its emissions by 25.5 percent by the end of 2012.

D – Environmental taxation

Tax the bads, not the goods – as the slogan puts it, environmental taxation increases taxes on environmentally unfriendly activities (such as fossil fuel consumption). But it is also revenue-neutral, for the tax revenue can be used to lower the costs of something society considers good (such as, in the case of Germany, labor, when the revenue is used to offset payroll taxes). The policy was very successfully implemented in Germany and has created some 250,000 jobs even as it reduced fuel consumption and made German workers more competitive internationally.

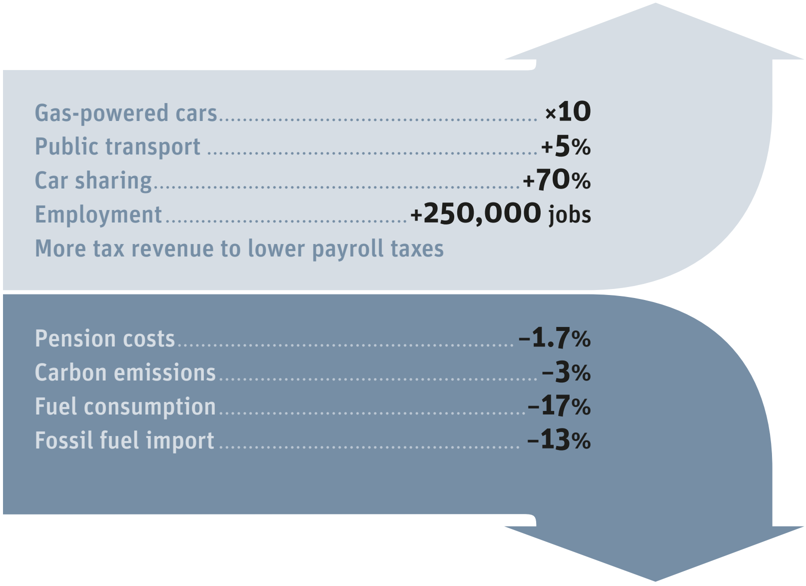
Since 1951, Germany has had a petroleum tax, which has been called the energy tax since 2006. As of 2007 (the last time it was changed), 65.45 cents was charged per liter of gasoline, for instance, roughly equivalent to around 2.50 euros (more than three dollars) per US gallon. In other words, Germany's petroleum tax alone costs roughly the same as gasoline itself does in the United States, for instance, and we still need to add on sales tax!

Unlike the previous petroleum tax, environmental taxation is revenue-neutral, meaning that it offsets a revenue stream somewhere else. In the case of Germany's "eco-tax," some of the revenue went to a budget that funded renewables, but most of it was used to lower payroll taxes because the government felt that the main thing hurting the German businesses was the high cost of German workers. From 1999-2003, an eco-tax was implemented for the first time in annual increments

Eco tax reform: taxing energy instead of jobs

Benefits of Germany's ecological tax reform which raised taxes on energy and cut payroll taxes

Source: Green Budget Germany



under the governing coalition of the Social Democrats and the Greens. It applied not only to gasoline and diesel for vehicles, but also to heating oil and fossil fuel (natural gas, coal, oil, and LPG) used to generate electricity.

Tax the bads, not the goods

The idea that a tax paid at a filling station should help offset employee pensions struck Germans as a bit odd at the time, but it is in fact what makes revenue-neutral environmental taxation special. The idea is that you tax "bad" things so that people will consume less of them (such as finite fossil fuel), not "good" things that you want more of (such as jobs). And because the tax is revenue-neutral, political opponents cannot claim that taxes are being raised – because another revenue stream already being paid is lowered in the same amount of the new levy.

Each year from 1999-2003, the tax on a liter of gasoline/diesel was increased by 3.07 cents, which is not much, but it sent a signal to consumers to get ready for a 15.35 cent increase over that five-year period. The public was able to react to these higher prices in a number of ways, all of which were desirable: driving less, driving in a way that reduced fuel consumption, buying more efficient cars, carpooling, taking public transport, cycling or walking, or moving from the countryside into the city, where they could more easily do without a car.

According to Green Budget Germany, which lobbied for the eco-tax, fuel consumption dropped each year during the implementation of the eco-tax, and the number of people using public transportation increased every year. Likewise, sales of efficient cars also increased each year. In addition, payroll taxes dropped by 1.7 percent, and less expensive labor is estimated to have led to the creation of 250,000 new jobs. See Green Budget Germany's Memorandum on the eco-tax from 2004 for more information.

E – Cogeneration Act

Germany wants to get 25 percent of its power supply from cogeneration units because cogeneration is much more efficient than separate power and heat generation. The Cogeneration Act therefore pays bonuses for cogeneration relative to system size irrespective of the feedstock.

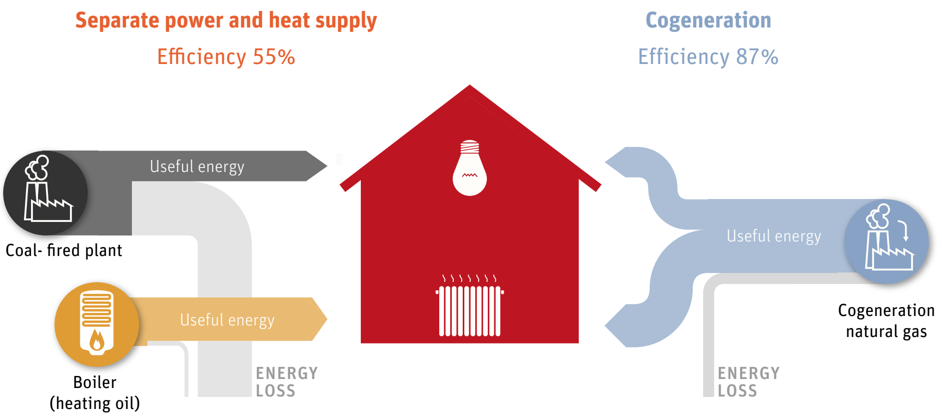
Although it is possible to count kilowatt-hours of heat just as we count kilowatt-hours of electricity, Germany has never offered feed-in tariffs for renewable heat.

Instead, in 2002 the country adopted the Cogeneration Act.

Why cogeneration is more efficient than conventional coal power plants

Comparing the energy efficiency of cogeneration with conventional coal power plant and heating system

Source: ASUE



With a coal fired power plant, more than half the energy input is wasted.
Cogeneration reduces the primary energy demand by 36%.

Cogeneration is when part of the waste heat from a power generator is recovered, thereby increasing the overall efficiency of fuel consumption. The goal defined in 2009, when the first amendments went into effect, was for Germany to get 25 percent of its power supply from cogeneration units by 2020 (compared to 14.5 percent in 2010). Because heat can be much more easily and efficiently stored than electricity, such units could generally be ramped up when power is needed, and heat would be stored for later.

There is a debate in Germany about whether cogeneration units should be run based on power demand as opposed to heat demand, however. Critics of the current policy argue that shortfalls in heat production may require the use of inefficient backup heating systems to cover peak demand, which can worsen overall efficiency. Nonetheless, it is clear that cogeneration is far more efficient than the separate generation of power and heat. German energy conservation organization ASUE puts the potential total efficiency of cogeneration at 87 percent, compared to only 55 percent for separate power and heat generation.

The law sets a bonus for each kilowatt-hour of power produced by the cogeneration unit, and that power has priority on the grid. Interestingly, there is no special payment for the heat generated; the incentive comes in the form of a bonus for the power produced. Furthermore, the only requirement for efficiency is that the cogeneration unit must reduce primary energy consumption by ten percent compared to the provision of the same amount of heat and power from separate generators.

The latest amendment

The law was amended in 2012. Now, the bonuses are as follows:

1. less than 50 kW of electric output: 5.41 cents per kilowatt-hour
2. 50 to 250 kW (a new size category): 4 cents per kilowatt-hour
3. up to two MW: 2.4 cents per kilowatt-hour
4. above two MW: 1.8 cents per kilowatt hour-hour

Upfront bonuses are also paid for revamped systems already in use, heat storage facilities, and district heating networks. In addition, the law now also covers systems whose waste heat is recovered for cooling applications (tri-generation = power, heating, and cooling).

Power-generating heating systems for individual households – called nano-cogen or micro-cogen – are also eligible for a flat-rate bonus for 30,000 full-load hours of operation. These household cogeneration units can theoretically be collectively managed as a "swarm" to perform the same function as a central power station. One German green power provider believes that a swarm of residential cogeneration units could cover up to ten percent of peak demand, but the approach has yet to take off.

Many of the cogeneration units operate with conventional natural gas or even coal, which are not a renewable resource. Many environmental activists argued against promoting coal cogeneration. The government, however, decided to grant the bonus regardless of the feedstock used.

F – Renewable Energy Heating Act and Market Incentive Program (MAP)

Germany's Renewable Heat Act aims to increase the share of renewable heat to 14 percent by 2020. New building owners are obligated to get a certain share of their heat from renewable energy, and owners of old building get financial support for renovations. This funding was temporarily cut during the last economic crisis although every euro spent here generates more than 7 euros in private investments. Now, the programme is back in place.

In 2009 – long before the disaster in Fukushima – Germany's Renewable Energy Heating Act was passed. It aims to increase the share of renewable heat to 14 percent by 2020. New building owners – private persons, firms, and the public sector, even if the building is to be rented – are required to get a certain share of their heat from renewable energy systems (such as solar collectors, a heat pump, or a wood-fired boiler). The owners can choose how to meet these obligations at their discretion. Those who do not wish to use renewables can use more insulation or get heat from district heating networks or cogeneration units.

Because renewable heating systems can be planned from the outset when new buildings are constructed, the Renewable Energy Heating Act only applies to this sector. In existing buildings, the German government supports renovations of heating systems with its Market Incentive Program (MAP), which was originally instituted in 2000. This program now supports only existing buildings; new buildings are no longer eligible.

Homeowners, small and midsize businesses, freelancers, and municipalities can apply for special funding for the following types of systems:

- small and large solar heat collectors
- biomass-fired furnaces with automatic feed systems (such as wood pellets)
- highly efficient firewood gasifiers
- efficient heat pumps
- visualization of such systems

The MAP offers upfront bonuses to reduce the purchase price. For instance, 90 euros is granted per square meter of solar collector, 2,400 euros for small water/water heat pumps, and 2,000 euros for small wood boilers (which have very low particle emissions).

The purpose is to ensure that sensible ways of using renewable energy are promoted when the current building standard does not go far enough. For 2012, the MAP has a budget of 366 million euros.

Budget reliability

As the backlog of available funding shows, the program has not lived up to its potential. Because it is a budget, the MAP is vulnerable to the whims of politicians, who may want to discontinue it if they suddenly need to cut spending. The last time this happened was during the recent economic crisis, when industrial output – and hence, carbon emissions – temporarily dropped. As a result, firms had no need for additional carbon certificates, so the price of carbon plummeted.

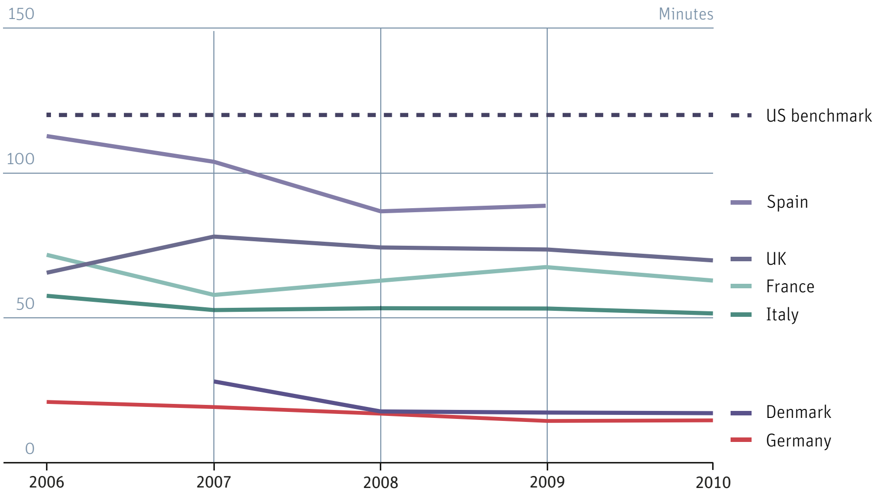
The MAP got some of its funding from emissions trading, so the economic downturn ironically also meant there was suddenly less money for energy-efficient heating systems in old buildings. This outcome was especially unfortunate because, as one study conducted in 2010 found, every euro in MAP funding generated more than seven euros in private investments, making the MAP an especially effective type of subsidy.

It should also be pointed out that there are similar MAPs offering upfront bonuses for other technologies, such as geothermal and district heating, and there is also talk of having an MAP to fund batteries that store solar power.

Grid reliability and renewable growth seem to go hand in hand

Minutes of power outages per year (excl. exceptional events), based on Saidi

Source: CEER and own calculations



G – Act on Accelerating Grid Expansion

The energy transition will need an expanded, adapted grid to cope with more renewable power. Neither has been progressing fast enough, so the German Parliament has passed the Act on Accelerating Grid Expansion. But there is no agreement on how much needs to be done where.

The energy transition will require properly functioning infrastructure; in particular, the grid will have to be adapted. The current grid is designed to take power from central power stations to consumers, but the future will be more complex.

Large power plants will continue to export power to the transit grid, but it will need to be changed so that power from wind turbines (both onshore and offshore) in the north can reach consumer centers in the west and the south. These lines will also be used for power trading. At the low-voltage and medium-voltage levels of the grid, a growing number of small, distributed generators – solar arrays, cogeneration units, individual wind turbines, and small wind farms – will be connected, and special controls will ensure that everything runs smoothly. The grid will become more intelligent.

Up to now, grid expansion has not been progressing fast enough. Only a ninth of the 1,800 kilometers of new lines that need to be finished by 2015 had been completed in late 2012. Lines to connect offshore wind turbines are especially crucial. For some time, it was unclear who was financially liable if wind turbines had been installed offshore, but the grid connection was not ready. In the summer of 2012, the German government brokered a compromise between wind farm investors and grid operators by resolving that the former would be compensated by the latter – but the costs could be passed on to consumers. This compromise sets a double standard for wind power. Small onshore wind farms have to pay for their own connections up to the nearest transformer station, and they receive no compensation from grid operators if the capacity behind the transformer station needs to be upgraded and is not done in timely fashion. The onshore wind sector, which has traditionally been driven by community projects and small to midsize businesses, is therefore frustrated because grid operators – former subsidiaries of Germany's Big Four utilities, which have not always helped small onshore wind farms – are getting special treatment for their grid connections.

In 2011, the German Parliament passed the Act on Accelerating Grid Expansion (NABEG). It calls for a review of ultra-high voltage lines by Germany's Network Agency and for high-voltage (110-kilovolt) lines to be installed as underground cables as a rule. In addition, there is to be great public input and transparency at an early stage of planning to increase public acceptance. A Grid Development Plan will analyze for the necessity of creating a "Federal Need Plan", which would become law. The goal is not just grid expansion; existing grids will also be upgraded and optimized. For instance, special temperature-resistant power lines could be used to transport greater amounts of electricity without requiring further lines to be installed. Temperature monitoring would also allow power lines to be used closer to full capacity when the wind cools them off – which generally happens when there is also a lot of wind power.

H – Energy-Conservation Ordinance (EnEV) and financial support schemes

When it comes to the construction of new buildings, the German energy transition began in 1990 with the development of highly efficient passive houses. Unfortunately, although many buildings can now be renovated to fulfill the Passive House Standard, a lot of progress still needs to be made towards increasing the energy efficiency of renovated buildings. Germany could improve things by making its Energy Conservation Ordinance stricter, especially in light of rising energy prices, and by considerably increasing the renovation rate.

In Germany, roughly 40 percent of all energy is consumed in buildings, most of it for heating. This area is crucial in Germany's energy transition because most renewables produce electricity, which makes up the smallest part of German energy consumption at 20 percent. In contrast, oil and gas continue to dominate the heating sector with a combined share of more than three fourths of the heat market.

Building retrofits – the area that requires the most attention

In Germany, most of the energy used for heating, cooling, and hot water is consumed in buildings, most of which were built before 1978, when Germany implemented its first requirements for insulation. The energy transition has yet to take proper account of the potential from renovations. Instead of ensuring that renovations are as comprehensive as possible, German law encourages building owners merely to make the most urgent minor repairs. For instance, Germany still has more than three million boilers older than a quarter of a century.

In other words, the low renovation rate is not the only problem; not enough is done during renovations. Buildings are not properly insulated during renovation, and the technologies that would pay for themselves the most are not used often enough. As a result, buildings renovated today will soon need to be renovated again.

The reasons for these shortcomings include a lack of awareness, a lack of motivation, financing problems, low returns on investment, and insufficient skills among firms, planners, and tradespeople who perform renovations.

The dilemma of tenants and landlords is another major issue. Building owners do not have proper incentives to invest in renovations that merely lower the utility costs for their tenants. The situation is especially serious in Germany, where 22 million of the country's 39 million families do not own their own homes.

Trying to improve the situation

At present, Germany is focusing on increasing its renovation rate from one percent per year (meaning that all buildings would be renewed within 100 years) to three percent (so that all buildings would be renewed within 33 years).

The energy transition has made great progress when it comes to electricity, for which a number of policy tools have been implemented, but progress in building renovations has been slower. If things are to speed up here, policies will have to be changed. The Energy Conservation Ordinance (EnEV) includes requirements for energy audits, replacements for old heating systems, and the quality of renovation steps. However, that last point is only effective if renovations are actually carried out. In Germany, there is no legal tool for speeding up retrofits. The EnEV is being revised in 2012, but the changes will not keep pace with the technical requirements for keeping up with rising energy prices.

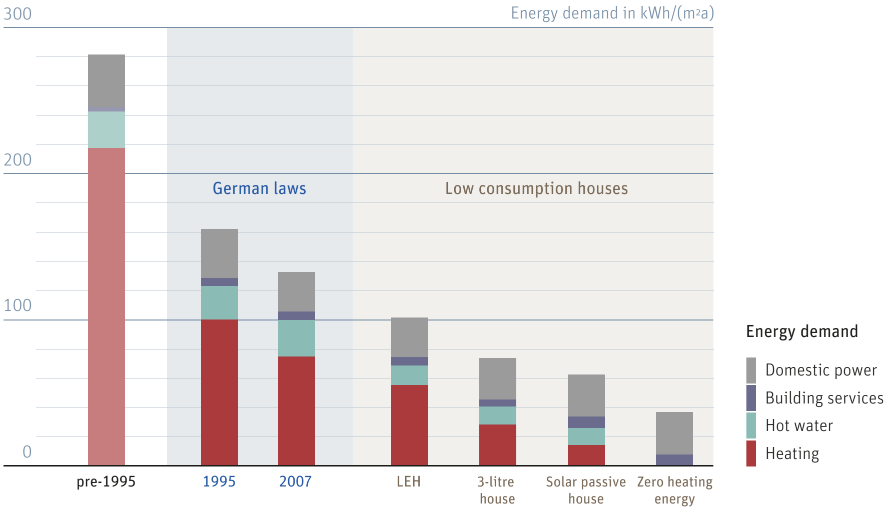
Instead, Germany is focusing on information and financial support. Germany's KfW Bank provides special low-interest loans for energy-efficient renovations, although more than 50 percent of this funding is still devoted to new buildings. Furthermore, laws protecting the rights of tenants were revised in 2012 to help encourage building owners who rent their properties to invest in renovations.

What is needed is a substantial increase in funding for retrofits. Low-income families often live in poorly insulated buildings and therefore face high energy costs. Yet, building owners are not willing to invest in renovations because they will not be the ones who benefit from lower utility bills. The only way around this dilemma is providing funding for renovations in such situations, but the energy transition has yet to address this problem sufficiently.

The housing sector offers large potential for energy savings

Characteristic energy demand of buildings

Source: IFEU 2011



One option currently being discussed is to make funding for renovations available from sources that are not governmental budget items – such as an efficiency surcharge added to the price of gas and oil or by making renovation work more tax-deductible. The proposal is a reaction to sudden budget cuts in 2010 that drastically reduced the funding available; as a result, people have become wary of making future investments, lest the amount of available funding change once again. Up to now, political bickering and arguments over mandates have unfortunately made agreements unreachable. It would also help to move beyond building renovations and look at how entire neighborhoods and city districts can be made more energy-efficient. In 2012, the KfW Bank started a special support scheme entitled "Energetische Stadtquartiere" that provides financial incentives to municipalities to plan, organize, and implement district-wide retrofit schemes and to implement district heating networks.

The Energy Conservation Ordinance (EnEV)

In 2002, Germany adopted its Energy Conservation Ordinance (EnEV). For the first time, this legislation provided a way of creating an eco-balance for a building by counting not only the useful energy provided to the building, but also the primary energy needed in the process, which includes losses in generation, distribution, storage, etc. In addition, EnEV includes requirements for the quality of renovation steps, energy audits, and replacements for old heating systems. The current EnEV specifies that new homes must not consume more than 60 to 70 kilowatt-hours of energy per square meter of heated indoor area per year for heating and hot water.

Passive houses

The current EnEV figure seems like a lot when you consider that way back in 1990, a number of German architects built houses that make do with only 15 kilowatt-hours of heating energy per square meter – the first passive houses. So little energy is needed for heating that some residents of passive houses simply invite friends over for dinner when the apartment starts to get cold. Heat from the kitchen and from human bodies suffices to warm the house.

Passive houses basically allow you to completely do away with heating systems even in a cold climate like Germany's. Heating expenses are cut by an estimated 90 percent compared to a conventional new building, partly because backup heating systems can be so much smaller.

Passive houses are a combination of high-tech and low-tech. The low-tech aspect is relatively straightforward: homes are built facing the south in Germany. The southern façades have large glazed surfaces to allow a lot of sunlight and solar heat in during the cold season; in the summer, overhanging balconies on the south side provide shading, thereby preventing overheating, as do deciduous trees planted on the southern side of the building, which provide additional shade in the summer but lose their leaves in the winter to let the sunlight pass through.

The high-tech aspects mainly concern the triple-glazed windows, which allow light and heat to enter but largely prevent heat from exiting the building. Most importantly, passive houses have ventilation systems with heat recovery, which also help prevent mold.

In short, passive houses are an excellent example of how Germany's energy transition will produce much higher standards of living even as energy consumption is reduced and made more sustainable.

Plus-energy homes

Some cities in Germany (such as Frankfurt) already require the Passive House Standard for all new buildings constructed on property purchased from the city. The EU has also stipulated that all new buildings will have to be "nearly zero energy" homes starting in 2020.

And when solar roofs are added to passive houses, you end up with homes that essentially produce more energy than they consume – at least in theory. Called plus-energy homes, such buildings are not, however, off the grid; rather, they export solar energy to the power grid at times of excess production and consume power from the grid at other times. And of course, any gas needed for cooking purposes, etc. also has to be purchased as usual.

I – Ecodesign/ErP Directive

The Ecodesign Directive, another important energy transition tool, is the main regulatory instrument for cutting off the products with the worst environmental performance. This essential regulation was initiated throughout Europe; it remains one of the most important tools for reducing demand for new grids and power plants in Germany, thus making it a crucial part of the energy transition.

The 2005 Ecodesign Directive (called the Energy-related Products Directive (ErP) since 2009) has its roots in Brussels. It regulates the efficiency of energy-consuming products, with the exception of buildings and cars. The ErP Directive sets minimum standards for many different product categories. It also considers lifecycle assessments for certain products to determine their environmental impact and detect ways to make improvements.

As of 2012, 31 products fell under the directive, including consumer electronics, refrigerators, freezers, and electric motors. The directive applies not only to products that use energy themselves (such as computers and boilers), but also to products that affect energy consumption (such as windows and showerheads). Additional directives for individual products are produced and revised in a continuous process. By 2020, the directive is expected to reduce power consumption within the EU by twelve percent compared to the business-as-usual scenario.

There are also European standards for energy labeling. This "efficiency tag" addresses the important market failure based on a lack of information; customers do not readily have the information they need about what energy consumption will cost them if they buy a particular device. The ErP Directive works to remedy that situation.

In this way, the ErP Directive cuts off the products with the lowest performance, whereas the labeling scheme tries to guide demand towards the highest efficiency level by convincing customers to buy the best products.

Specific regulations

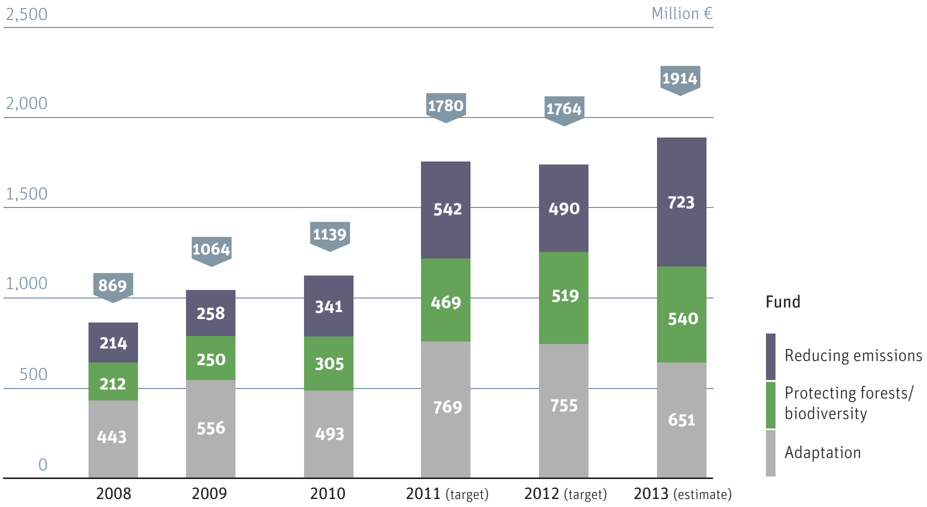
Probably the most effective measure was the regulation of standby and off-mode power losses. Appliances on standby used to consume dozens of watts even though they were essentially off from the consumer's point of view; one example is a television that remains reachable for the remote control. Today, the ErP Directive requires that such devices must not consume more than one watt when on standby, and that amount is to be reduced to 0.5 watts. For consumers, there are no drawbacks. The most well-known directive is the one on domestic lighting, which bans the use of most incandescent bulbs. The lighting product portfolio has changed from incandescent bulbs to compact florescent bulbs and LED lighting.

By 2020, phasing out incandescent light bulbs will result in energy savings across Europe of 39 terawatt-hours, equivalent to the power generation of six old coal power plants. The eco-design regulation for electric motors will even lead to a reduction of 135 terawatt-hours by 2020 – equivalent to 20 coal power plants.

Germany is the second biggest funder of international climate finance

Bilateral and multilateral cooperation assistance in million Euros, Germany 2008–2013

Source: Oxfam



Such efficiency rules are defined throughout Europe because the EU places great store on the free trade of goods within the common market. The ErP Directive therefore directly applies to Germany and all other EU member states.

Although the ErP Directive was handed down by Brussels, it is a crucial part of Germany's energy transition because it reduces the need for great expansion and new plant construction by reducing energy consumption.

J– Efficiency Fund and Climate Initiative

Germany is the second largest donor of financing for climate protection worldwide. German climate funds promote action to mitigate climate change by enabling efficiency measurements, funding renewables, electric mobility, etc. Nevertheless, Germany is far behind the internationally agreed target of 0.7 percent of gross national income for Official Development Assistance.

According to the OECD, Germany is the second-largest donor of financing for climate protection (behind Japan). Nonetheless, like almost all other OECD countries, Germany is far behind the multinational commitment made at the beginning of the 1970s to provide 0.7 percent of its gross national income for official development assistance. An estimated 1.27 billion euros of Germany's budget from 2010 was set aside for climate protection and adaptation in developing countries.

In 2010, the Special Energy and Climate Fund was created along with the National and International Climate Protection Initiatives (now known as Climate Initiatives). They mainly get funding from the trading of emissions certificates to promote actions that mitigate climate change, such as efficient cooling systems, small cogeneration units, energy audits for low-income households, consultation networks for small businesses, and, in the future, highly efficient industrial technologies and production processes – to name just a few examples.

The International Climate Initiative (ICI) finances pioneering projects and advisory services outside Germany. Since its beginning, some 277 projects have been funded, totaling some 634 million euros, plus another 1.6 billion euros from implementing agencies and other public and private-sector sources. The ICI focuses on climate policy, energy efficiency, renewables, adaptation to climate change, and reducing deforestation and loss of biodiversity. According to the official website, priority is given to "activities that support creating an international climate protection architecture, to transparency, and to innovative and transferable solutions that have an impact beyond the individual project."

Each year, multipliable projects in developing, newly industrializing, and transition countries are selected to receive support. To give a few examples, the ICI strengthens the capacity of South Africa's Department of Environmental Affairs to develop a progressive national climate policy; it also supports a loan program in Mexico for solar thermal collectors and training salesmen and property developers. Another ICI project is developing new insurance products to protect Ghanaian farmers against financial risks resulting from extreme weather events. Funding also goes to a biodiversity monitoring and incentive system for the conservation and restoration of high biodiversity forests in Vietnam as well as measures for protecting the Brazilian coastal forests.

A large part of the money is devoted to electric mobility, more efficient new power plants, and (starting in 2014) compensation for energy-intensive firms to keep power prices down for them. Environmental protectionists say that the funding is skewed in favor of utilities and automobile manufacturers, with too little left over for energy conservation and greenhouse gas reductions. The low price of carbon certificates is another problem. Revenue from emissions trading was only half as great as expected in 2012 at around 350 million euros. In 2013, the fund's budget is to grow to a full two billion euros.

The campaign is going in the right direction, and it seems clear that more funding will come from the trading of emissions certificates over the next few years. An Efficiency Fund – a reliable source of sufficient funding for such energy efficiency measures as renovations, new pumps, highly efficient lighting, energy-efficient production processes, etc. – has been on the agenda for some time now.

K – Discussion about energy market reform in 2014

In 2014, the new German government aims to change energy policy primarily in order to keep the cost of electricity from rising further. The focus is not on the rising cost of heat and motor fuels, both of which have risen faster than the cost of electricity over the past decade.

There is reason to believe, however, that the price impact from new wind and photovoltaics will be minimal. The main cost increase has been from the latter, which was roughly 4 times more expensive only six years ago. But feed-in tariffs for PV have fallen from around 50 cents to less than 10 cents for systems from 1-10 MW and less than 14 cents per kilowatt-hour from the smallest rooftop arrays. Going forward, the main cost increases will be system costs – lower capacity factors from conventional plants, grid upgrades, and eventually power storage.

No changes are expected in 2014 to feed-in tariffs for photovoltaics, which are scheduled to expire once 52 gigawatts has been installed. At the current growth rate of around four GW and just over 35 GW installed, feed in tariffs for photovoltaics would be phased out around the end of 2017.

Changes are expected for wind power, however, with the focus being shifted towards wind farms in sites with the best wind resources. The goal overall, according to German Energy Minister Gabriel, is to keep costs from rising further. But while the cost of a kilowatt-hour of wind in the windiest areas is low, a concentration of wind farms in just a few areas will only raise the cost of grid upgrades and backup power. Furthermore, citizen involvement in the energy transition will be reduced if communities are told that there local sites simply are not windy enough.

In addition, the European Commission in Brussels is currently investigating industry exceptions to the renewables surcharge and to grid fees, with the latter being an outright industry subsidy unrelated to the energy transition. Here, the German government may be forced to react and will probably work with Brussels to reach a compromise.

The question of capacity markets might not be decided in 2014 as it is considered a midterm project. At present, Germany has an "energy-only" market on which payments are based on the amount of energy sold. Specifically, no payment is provided for the provision of idling backup capacity. As variable renewables continue to make up a larger share of power, and conventional plants will increasingly run at lower capacity – and the less power they generate, the less profitable they are. To prevent too many of them from shutting down, special capacity payments may be made, and such a market is expected to be announced or rolled out in 2015.

Opinions differ as to whether capacity markets are needed. The Berlin-based think tank Agora Energiewende is concerned about a shortfall of generation capacity by the end of the nuclear phaseout in 2022. Likewise, the BDEW, a lobby group that represents utilities, says a capacity market is needed. In contrast, grid operator Tennet believes the energy-only market will continue to ensure energy security without a capacity market.

4 History of the Energiewende

The German Energiewende did not just come about in 2011. It is rooted in the anti-nuclear movement of the 70s and brings together both conservatives and conservationists – from environmentalists to the church. The shock of the oil crisis and the meltdown in Chernobyl lead to the search for alternatives – and the invention of feed-in tariffs.

Timeline Energiewende 50
A – Origin of the term "Energiewende" 52
B – Wyhl – the nuclear plant that never was 52
C – The oil crisis 53
D – Chernobyl – change comes slowly 54
E – Full-cost compensation for photovoltaics 55
F – EU court says feed-in tariffs are "not state aid" 56
G – Renewable Energy Act (EEG) 56

Timeline Energiewende

1974
The Federal Environment Agency is founded.

1977
As a reaction to the oil crisis, the first "Thermal Insulation" and "Heat Operation" Ordinances are approved, regulating the maximum energy demand for buildings and efficiency requirements for heating systems.

1978
Germany creates the Blauer Engel (Blue Angel) label that certifies the environmental friendliness of products – 14 years before the Energy Star was created in the US. Whereas the Blue Angel was brought about by a coalition ranging from environmentalists to unions and church groups, the Energy Star was a product of the US Environmental Protection Agency.

1980
Publication of the study entitled Energiewende (Energy Transition), showing that economic growth can continue even as we consume less energy.

1983
For the first time in history, the Green Party enters the German national parliament and gives environmental concern a voice.

1986
In Chernobyl (Ukraine), a nuclear power plant melts down. Five weeks later, the Federal Ministry of the Environment, Nature Conservation, and Nuclear Safety is founded.

1987
German Chancellor Helmut Kohl (CDU) speaks of the "threat of grave climate change from the greenhouse effect" in the German Parliament.

1987
The Fraunhofer Institute for Solar Energy Systems makes the Rappenecker Cottage the first solar-powered, off-grid mountain cottage for hikers in Europe.

1991
The Feed-in Act is adopted under Chancellor Helmut Kohl's coalition of the conservative Christian Democrats and the Libertarian FDP provides the first feed-in tariffs and stipulates that green power has a priority over conventional power.

1991
The "Schönauer Stromrebellen" (the Power Rebels of Schönau, a small town in the Black Forest) form a ground-roots movement to buy back their local grid.

1992
The Fraunhofer Institute for Solar Energy Systems builds an off-grid solar home in Freiburg, Germany to demonstrate that a normal family could meet all of their energy needs at home from renewables.

1996
KfW, a state-owned development bank, launches its Carbon Reduction Program to support refurbishment of housing stock, particularly in the former German Democratic Republic.

1997
The Power Rebels of Schönau finally get control of their local grid and begin ramping up renewables.

1998
The German power market is "liberalized," meaning, for instance, that power firms and grid operators have to be legally separate entities; for renewables, the change meant that new power providers could go into business selling only green electricity; despite liberalization, the country does without a regulatory body for seven years.

1999
The 100,000 Solar Roofs Program gets the solar market going in Germany. In addition, the Market Incentive Program is launched, a multimillion financial support scheme for renewable heating systems.

1999–2003
Germany implements an "eco-tax"; each year, a few cents are added to the price of a liter of gasoline and to a kilowatt-hour of fossil–based electricity; the result is greater sales of fuel-efficient cars and slightly lower overall consumption.

2000
Drawn up by the Social Democrats and the Greens under Chancellor Schroeder, the Renewable Energy Act (EEG) replaces the Feed-in Act and specifies that the rates paid will be linked to the cost of the investment, not to the retail rate.

2000
Chancellor Schroeder's coalition reaches an agreement with nuclear plant owners to phase out Germany's nuclear plants by roughly 2022.

2001
The European Court of Justice confirms that feed-in tariffs do not constitute "state aid" and are therefore legal.

2002
The Initiative Energieeffizienz is established, focusing on the promotion of end use efficiency in households and commerce.

2002
Adoption of the Heat-Power Cogeneration Act. With two subsequent amendments, it is the most important instrument to support combined heat and power.

2004
Photovoltaics is taken up without restriction in the EEG.

2005
Germany's Network Agency, which previously monitored telecommunications and postal services, starts overseeing the power grid and gas market, partly to settle a dispute about grid fees related to renewable power.

2005
The EU launches its emissions trading system.

2007
Germany's Integrated Energy and Climate Program defines new targets, policies and support schemes for efficiency and renewables.

2009
The EEG is amended for the first time without input from the Social Democrats or the Greens; the new law increasingly focuses on what Chancellor Merkel's coalition understands as "market instruments".

2009
The Renewable Energy Sources Act for Heat is the first law explicitly addressing Renewable Heating, requiring builders to implement renewable heating systems.

2009
Adoption of the Eco-design of Energy-using Products Act, which implements the European ecodesign directive in German law.

2010
Chancellor Merkel's coalition resolves to extend the commissions of Germany's remaining 17 nuclear plants by 8 to 14 years.

2010
The Sustainability Ordinance for biomass addresses the issue of sustainable biomass production.

2010
The Special Energy and Climate Fund, the first German efficiency fund, is created and funded by revenue from carbon emission certificates. Due to the low price level of these certificates, the fund's volume is cut in half.

2011
The nuclear accident in Fukushima causes Chancellor Merkel to reverse her position on nuclear and adopt a somewhat more rushed phaseout of nuclear power than under Chancellor Schroeder's scheme; 40 percent of nuclear generating capacity is switched off for good within a week, with the last plant to be shut down roughly in 2022.

2012
May
50%: Germany sets new world record for solar power generation.

November
German power exports reach record level.

2013
January
Surcharge for renewables increases to 5.3 Cents per kWh. German power exports also increased by nearly 50 percent.

2014
Surcharge for renewables increases to 6.3 Cents per kWh.

A – Origin of the term "Energiewende"

In the 1970s, the term "Energiewende" was born in an attempt by opponents of nuclear power to show that an alternative energy supply was possible.

The term "*Energiewende*" (which we translate here as "energy transition") did not just come about in the past few years. In fact, it was coined in a 1980 study by Germany's Institute for Applied Ecology.

That groundbreaking publication was perhaps the first to argue that economic growth is possible with lower energy consumption – a theme later taken up in many books, such as Factor 4 from 1998. Previous publications, such as *Limits to Growth* (1972), mainly consisted of warnings without proposing specific solutions. *Energiewende* was one of the first attempts to propose a holistic solution, and it consisted of renewable energy and energy efficiency. Published as a book in 1982, *Energiewende*'s subtitle is "Growth and Prosperity Without Oil and Uranium."

The Institute of Applied Ecology had itself only just been founded with funding not only from environmental organizations (such as Friends of the Earth), but also from a Protestant organization that funded research. To this day, conservation and conservatism remain closely related in Germany, and this connection means that conservative politicians in Germany cannot be assumed to oppose renewables, as is the case elsewhere. On the contrary, a number of prominent proponents of renewables are members of the Christian Democrats (CDU), such as Peter Ahmels, who headed the German Wind Energy Association (BWE) for eleven years.

Another good example is German solar activist Wolf von Fabeck, who helped institute the first feed-in tariffs in Germany in his town of Aachen in the late 1980s. A former military officer, von Fabeck became an environmentalist when he saw the effects of acid rain brought about by coal plant emissions, and he became a proponent of solar when he realized the impossibility of protecting nuclear power plants from military attack. The first meetings he held about solar power took place at his local church, and his pastor was his main associate in the beginning. Other examples include Franz Alt, author of *Der ökologische Jesus (The Ecological Jesus)*. A number of modern churches in Germany have solar roofs.

B – Wyhl – the nuclear plant that never was

The Energiewende movement came out of the movement against nuclear power in the 1970s. One reason for the sustained success of the movement over the past few decades is its inclusiveness; from the outset, conservatives and conservationists worked together.

The *Energiewende* movement came out of the movement against nuclear power in the 1970s. In 1973, plans were announced to build a nuclear plant in the village of Wyhl in the Kaiserstuhl winegrowing area on the border to France. The decision turned out to be fateful, for it created a strong, sustained resistance movement across large parts of society. Students from nearby Freiburg joined forces with Kaiserstuhl winegrowers and scientists like Florentin Krause, author of *Energiewende*.

Club of Rome gets the Peace Prize of the German Book Trade Club, 1973

Source: Bundesarchiv, B 145 Bild F-F041173-0013

Photo: Reineke, Engelbert October 14, 1973

Sticker against the planned nuclear plant at Wyhl, 1975

Photo: AlMare

In 1983, the governor of the state of Baden-Württemberg reacted to the incessant protests by declaring the Wyhl project "not urgent," essentially abandoning plans for the plant indefinitely. The success of the movement encouraged people across Germany and Europe to believe that they could stop nuclear plants from being built. Throughout the 1980s, a number of local *Energiewende* groups were formed throughout Germany as people looked for ways to act locally.

This anti-nuclear movement was one reason why the Greens were founded as a political party. Around 1980, the Greens began consistently getting more than five percent of the vote – the limit required to enter Parliament.

C – The oil crisis

The oil crises lead to the first energy efficiency policies.

The oil crises of 1973 and 1979 also got people thinking about how energy supply could be changed. For the first time, Germany realized the economic risk of rising energy prices and that, as US President Jimmy Carter told Americans in 1977, "Conservation is the quickest, cheapest, most practical source of energy. Conservation is the only way we can buy a barrel of oil for a few dollars."

In Germany, conserving energy was also found to be a way of reducing dependency on imports of raw materials. Some of the steps taken in Germany were short-lived (such as the ban on Sunday driving) or had limited effects (such as the implementation of daylight saving time). Nonetheless, the foundations were laid for a new policy of efficiency. Germany's Economics Ministry launched the first campaign, which was entitled "Conservation – our best source of energy." An important step came in 1976, when Germany passed the Energy Conservation Act, which set forth the first requirements for building insulation: "Those who construct buildings must design and install insulation so that preventable energy losses for heating and cooling are avoided in order to conserve energy." Even today, the current Conservation Act still begins with this first sentence of the original law.

On June 27, 1980, the Bundestag's Inquiry Commission on Future Nuclear Energy Policy made most of its energy policy recommendations under the heading of "promoting energy conservation and renewable energy." Suggestions for the transport sector included "adopting rules for limits on specific fuel consumption in vehicles" and "speed limits on the autobahn."

These proposals led to a lively, controversial discussion among the general public starting in 1982. In the end, the German government was only able to put a stop to the strong public demand for further changes by forcing the automotive industry to install catalytic converters, which can only run on unleaded fuel, thereby forcing oil firms to sell unleaded gas. In 2000, the European Union banned the sale of leaded gasoline altogether. These steps may have helped reduce pollution, but they did not improve energy conservation.

"NO GAS"
1973

License: public domain

Since 1982, there have been repeated attempts to water down conservation policy. For instance, in the 1990s the tile industry opposed the use of thermal transmittance coefficients to determine the need for additional insulation. Another controversy concerned the obligation of owners of existing buildings to replace old boilers and insulate heating lines even when no other renovation was planned. Nonetheless, the basic idea of conserving energy resources has remained a part of German policy and become even more widespread since the 1970s.

D – Chernobyl – change comes slowly

In 1986, the reactor in Chernobyl exploded, and radioactive rain fell on Germany. The Germans lost their faith in the safety of nuclear power, but did not know yet how to replace it.

In 1986, the reactor in Chernobyl (Ukraine) exploded, and radioactivity detectors across Europe began registering spikes in ambient radiation levels; the Soviet Union initially did not announce the accident. Germans heard on the radio that it was not safe for children to play outside. Public trust in the safety of nuclear reactors reached all-time lows, though German engineers and politicians continued to assure everyone that Chernobyl was a fluke – the result of obviously inferior Soviet technology. Over the years, German engineers and politicians repeatedly claimed that German nuclear plants are safe and that no such accident as in Chernobyl is even possible in Germany – a claim made by Chancellor Merkel's coalition as recently as August 2010, less than a year before Fukushima changed her mind.

Still, the question in 1986 was how to replace nuclear power. Since the publication of *Energiewende* in 1980, nothing had really changed in Germany. Solar power was still so expensive that it was

Chernobyl Nuclear Power Plant
2007

Photo: Mond
License: CC-BY-SA 3.0

Source: EnergieAgentur.NRW
License: CC-BY-2.0

mainly only used by NASA in outer space and to provide small amounts of power in areas with no grid connections. And while wind power did get off to a big start in the early 1980s, when California already got one percent of its electricity from wind turbines, policy changes during the Reagan administration led the market to collapse. In the late 1980s, only Denmark was still expanding wind power at a considerable extent; Danish turbine manufacturers had been among the main suppliers to those first California projects.

E – Full-cost compensation for photovoltaics

At the end of the 80s, local utilities in three German towns introduced "full-cost compensation" — proto feed-in tariffs — for photovoltaics, which led to the implementation of Germany's first national feed-in tariffs.

In addition to Wolf von Fabeck (mentioned above), others were interested in finding ways to replace nuclear power and, increasingly, coal power; after all, acid rain had become a concern, as had man-made climate change from carbon emissions – with German Chancellor Helmut Kohl of the Christian Democrats even speaking in the Bundestag of the "threat of grave climate change from the greenhouse effect" in 1987.

At the end of the 1980s, von Fabeck's newly founded Solar Energy Association (SFV) managed to get the local utility in his hometown of Aachen to pay two deutsche marks for a kilowatt-hour of power from photovoltaics after it was demonstrated that the utility already paid that much or more to cover peak power demand, which photovoltaics would offset. The idea – compensation for power generated is sufficient to cover the cost of the investment – has become known as the Aachen Model. Yet, the idea did not even come from Germany. Aachen was specifically copying a similar policy in two Swiss towns, and California had adopted a similar policy at the beginning of the 1980s with its Standard Offer Contracts.

Indeed, two other German towns – Freising and Hammelburg – had even implemented a full-cost compensation policy slightly before Aachen, but Aachen drew the most attention. One person behind the success story in Hammelburg was Hans-Josef Fell (Greens), who later was one of the chief architects of the Renewable Energy Act (EEG) from 2000 along with Social Democrat Hermann Scheer.

But first, these small, disparate success stories led to the implementation of Germany's first national feed-in tariffs in 1991 in an unusual coalition between the Greens and the Christian Democrats. At the time, the two parties were hardly on speaking terms with each other (that has since changed). But the CDU had one condition – the proposed law would not be submitted as a joint effort between the Christian Democrats and the Greens, but merely as a Christian Democratic proposal.

Legend has it that the law, which was only two pages long, almost did not come about. It was the last thing voted on in the parliamentary session in 1990, and it passed mainly because the CDU did not think that a couple of windmills would do much harm anyway.

F – EU court says feed-in tariffs are "not state aid"

In 2001, the European Court of Justice ruled that feed-in tariffs do not constitute "state aid" and are therefore not illegal subsidies, thereby paying the way for the boom of renewables.

The law quickly led to a boom in in wind power in particular, so the conventional power sector decided to challenge the policy's legality. EU Competition Commissioner Karel van Miert openly stated that he considered feed-in tariffs to be illegal subsidies, and around that time German power provider Preussenelektra (which merged with Bayernwerk in 2000 to create E.on Energie) decided to challenge feed-in tariffs in court. The matter went all the way to the European Court of Justice, which ruled in 2001 that feed-in tariffs did not constitute "state aid" and were therefore not illegal.

As the Court explained, EU member states can require private power firms to purchase renewable power "at minimum prices higher than the real economic value of that type of electricity, and, second, distribute the financial burden resulting from that obligation" to consumers because renewable energy is "useful for protecting the environment" and for reducing "emissions of greenhouse gases which are amongst the main causes of climate change which the European Community and its Member States have pledged to combat."

In layman's terms, the Court basically ruled that feed-in tariffs are in fact open to everyone, including large power corporations, so they do not discriminate against any market players and therefore do not distort competition. Rather, they promote a particular type of energy to the disadvantage of other types in order to reach goals for the common good supported throughout Europe. Specifically, they are not subsidies because no particular firm receives payment from the government, and the cost of feed-in tariffs is passed on to ratepayers, not taxpayers; it is not an item in the government's budget.

G – Renewable Energy Act (EEG)

Germany's Renewable Energy Act guaranties full-cost compensation to cover the actual cost of a specific investment in terms of size and technology. The rates offered are guaranteed for 20 years starting in the year of installation to protect investments, but the rates drop for newly installed systems each year to put price pressure on manufacturers.

The ruling (see previous section 4.f.) came just in time to confirm the legality of the Renewable Energy Act in 2000. The main difference between this Act and the Feed-in Act of 1991 was that feed-in tariffs were no longer linked to a percentage of the retail rate, but were instead differentiated by the actual cost of the specific investment in terms of system size and technology type (also look at Policies for clean energy: Renewable Energy Act with feed-in tariffs).

In 2004, the law was adjusted to do away with the 100,000 Roofs Program for photovoltaics, which provided an upfront bonus for the purchase price; instead, solar arrays were now eligible for feed-in tariffs in full. In 2009, the law was once again amended, making it three times larger than in 2004; what had begun as two pages nearly two decades before now had 51 pages.

"EEG closer to the market"

The EEG of 2009 was the first to be amended by the grand coalition of Social Democrats and Christian Democrats, with the Greens no longer in power. While the basic tenants of the EEG were retained – feed-in tariffs and the priority of green power – a number of SPD and CDU politicians felt that the policy should somehow be changed to bring renewables "closer to the market."

The main changes in the 2009 EEG therefore reflect what these politicians think constitutes a market. For instance, producers of wind power are increasingly encouraged to sell directly on the power exchange instead of receiving feed-in tariffs, and a "marketing bonus" is also offered because of the extra work involved. Yet, this option only needs to be exercised if it proves more profitable than feed-in tariffs, so it essentially constitutes a risk-free bonus – not exactly what you would expect from a policy that promises "more market." Germany's traditional onshore wind sector overwhelmingly opposes this option because it provides windfall profits and unnecessarily raises the cost of the energy transition for consumers.

Which brings us to where we are today.

5 International perspectives

With its Energiewende, Germany has raised the bar in terms of setting the pace for renewable energy policies. By going renewable, Germany has created more than 380,000 new jobs, built up the world's leading green technology sector, and has reduced its dependency on fossil fuel imports. But how is the German energy transition perceived internationally? What do other countries make of the Energiewende? Are there other best practices for an energy transition?

A – Renewables in South Africa: The need for a developmental case 58
Emily Tyler

B – There's more renewables in the Philippines 59
Pedro H. Maniego

C – Germany supports regional renewables – Will the Czech Republic get onboard? 60
Martin Sedlák

D – Jordan seeks a "solar-torch" from Germany 61
Batir Wardam

E – Transatlantic Take-Away: Political Will is more important than Pure Resources 63
Christopher Flavin

F – The Energiewende – blueprint for the energy transition in Japan? 65
Kimiko Hirata

G – India's Opportunity to Leapfrog into the Renewable Age 66
Srinivas Krishnaswamy

H – China's Sustainable Energy Development 69
Fuqiang Yang

A – Renewables in South Africa: The need for a developmental case

By Emily Tyler, Independent climate mitigation economist, October 2012

In contrast to Germany, environmental questions are not yet a voting issue in South Africa. However, providing greater access to energy is a high priority. What can a developing country take away from Germany's experiences? What are the chances of South Africa taking a leading role in Africa's Energiewende?

The German *Energiewende* or 'Energy Transition' sets the country on a path to transform the way it generates and uses energy. Whereas in 2011 Germany generated electricity in relatively equal measure from lignite ("brown") coal (25%), renewables (20%), hard coal (19%), and nuclear (18%), the remainder coming from natural gas, the goal of the *Energiewende* is to generate 80% of electricity from renewable sources by 2050. Nuclear is to be entirely phased out by 2022. The country has travelled a long road to arrive at the point where a commitment to the *Energiewende* is possible. It is an ambitious statement of political will, accompanied by a technological gamble: "Where we want to be is in black and white. The problem is how to get there", says Paul Hockenos, a US-American energy expert living in Germany.

What is the possibility of a similar 'Energy Transition' occurring in South Africa? In contrast to the developed and highly industrialised Germany, South Africa is a developing country, struggling with high levels of poverty and inequality. Its energy landscape is dominated by coal, and it needs to meet an anticipated fourfold increase in electricity demand within two decades. Renewables currently contribute less than 1% to total electricity production, and are targeted to rise to only 9% by 2030. Perhaps most significantly, there are no clear signs of the government moving beyond a rhetorical support for substantial renewable energy in its energy and economic policies. Conversely, plans for a new fleet of nuclear power stations to meet the rising electricity demand are due for sign off by the end of this year.

There are a number of ingredients, which, from a South African perspective appear key to having enabled the writing of the *Energiewende* into policy in Germany. First, environmental issues are voting issues in the country; its citizens are engaged in the issue of how their energy is provided. Further, many Germans are willing and able to pay the current premium tariff to support renewables. Subsequently, the *Energiewende* enjoys support across the political spectrum, thereby ensuring its survival through election cycles. Second, there is a plausible economic case for the *Energiewende*'s implementation. The country has an advanced manufacturing base, capable of responding to a major stimulus for rapid renewable energy technology innovation and diffusion, thereby creating jobs and dominating this growing sector internationally. Thirdly, aside from lignite coal, Germany imports most of its fossil fuels which strengthens the economic case for domestic renewables.

At face value, South Africa does not yet enjoy any of these key ingredients, and therefore is unlikely to commit to an Energy Transition in the near future. However, considering them does provide insights as to what might bring such a commitment forward. Because development trumps environment as a policy and political priority in South Africa, the requisite political and citizen support for an Energy Transition would need to be achieved by framing it primarily as a developmental one. The combination of electricity tariffs rising in the baseline, opportunities for rural areas through energy decentralisation and the cost and corruption risks of nuclear could form the basis of a compelling developmental case. A plausible economic case for the country is also necessary. This is likely to be renewable technology specific, potentially involving leveraging the country's dominant industrial position in Southern Africa to specialise in the adaptation and installation of low-tech, energy poverty alleviating renewable technologies en mass in the continent. South Africa also has an abundant solar regime, a resource which Germany succeeded without, which enhances the case for solar energy generation. Put together, these factors may contribute sufficiently to competitive advantage for the country to occupy a leadership space in this niche.

Until the development and economic cases are convincingly made, it appears unlikely that South African political leaders will entertain, let alone promote, such an ambitious plan as that of the German *Energiewende*. Right now, a transition to renewables departs substantially from the existing institutional, policy and regulatory reality of the South African energy sector. However, the German experience tells us that if political leadership can be achieved, and citizens engaged, the possibility of a similar Energy Transition happening in South Africa may not seem as remote.

B – There's more renewables in the Philippines

By Pedro H. Maniego, Jr., Chairman, National Renewable Energy Board, Philippines October 2012

The Philippines was one of the first nations to commit to renewable energy and it has long since abandoned the idea of nuclear power. As demand for power steadily increases, the Philippines is in a position to fill this need with renewables. How can Germany's successes inform the Philippines' continued progress?

The successful transition of a world economic leader like Germany to renewable energy confirmed that a pro-renewable agenda is not only possible, but practical. Being a country that is blessed with abundant solar, wind, hydro, tidal, geothermal and biomass resources, the transition is even more practical for us. Considering the world-wide imperative to mitigate climate change by reducing greenhouse gas (GHG) emissions, the Philippines really has no choice but to adopt a pro-renewables agenda.

In the aftermath of the peaceful EDSA revolution in 1986, the Philippines decided not to operate the then newly-built nuclear power plant in Bataan. Despite the massive brown-outs experienced by the country from the late 1980s to the early 1990s, the nuclear plant was never tapped for power production. To resolve the crisis, the government instead granted licenses with take-or-pay provisions – requiring utilities to pay even for unused renewable electricity – to independent power producers. Since the approved rates were much higher than the generation charges of the government owned National Power Corporation, the electricity rates in the Philippines was often cited as the highest in Southeast Asia.

A similar power crisis is imminent within the next few years. The buffer between peak electricity demand and dependable power capacity remains thin. This year, Mindanao has already experienced almost daily brown-outs, while Luzon and Visayas are suffering from them intermittently. To increase the base-load capacity, the Department of Energy approved the construction and/or expansion of 11 coal plants. Some sectors also proposed the revival of the Bataan nuclear plant as a solution to problem. The current administration maintained that long and comprehensive studies are required, and the decision should be left to the next administration.

Unfortunately, the passage of the Renewable Energy Act of 2008 has not encouraged the development of the renewables sector yet. The Act was not able to arrest the dramatic decline in the share of renewable energy in the power generation mix from 32.6% in 2009 to 26.3% in 2010. In contrast, the share of power generation from fossil fuel sources increased from 67.4% to 73.7% in the same period. Unless more renewable energy resources are deployed in the next few years, their share in the power mix will continue to decrease. Nevertheless, the Philippines is still way ahead in renewable energy utilization compared to its Asian neighbours and most countries (*i.e. 38.9% of the primary energy consumption in 2010*). But the Philippines must not waver in its determination to leave coal power behind and move on to a renewable energy dominant future. If given a choice, power companies would rather build large coal plants than an equivalent number of small renewable energy plants. They contend that the time and effort required to develop a 300 MW coal plant and a 1 MW renewable energy plant are almost the same. However, the policies and objectives in the Renewable Energy Act are very clear: energy self-reliance, sustainable energy development, reduced dependence on fossil fuels, and reduction in harmful emissions. The National Renewable Energy Program set a target of tripling the installed generating capacity of renewables from 5,438 MW as of 2010 to 15,304 MW by 2030, while the Power Development Plan aimed at doubling the total installed generating capacity from 16,359 MW as of 2010 to 32,909 MW by 2030. Based on these goals, the share of renewables in the power mix will increase to 46.5% in 2030. If the responsible government agencies will just firmly implement the relevant energy and environmental laws, the move to 80% renewables by mid-century is likely attainable.

The German *Energiewende* has shown that effective implementation of the law could reap huge dividends. Germany was able to more than triple the renewable energy share in its power generation mix from 6.3% in 2000 to over 20% in 2011. The successful transition yielded many benefits for Germany: reduced dependence on nuclear and fossil fuels, lower GHG emissions, leadership in solar and wind power technologies, and huge increases in levels of investment and employment.

The transition to renewable energy is not only for wealthy countries. In the 1970s, the Philippines decided to develop its geothermal resources. At that time, power generation from fossil fuels like coal and oil was much cheaper. However, the Philippines wanted to minimize its exposure to fuel price fluctuations in the world market. The commitment to geothermal power has produced tremendous benefits to the country. The cost per kWh of geothermal power is not only stable, but is now much lower than coal and oil. The Philippines is recognized as a world leader in geothermal energy technology and production, being second only to the United States.

In the long term, solar power could wean the Philippines away from imported fuels and sustain real energy independence. The prospects for solar energy in the country are literally bright and sunny. If a country like Germany, with its much lower solar irradiation, can harness the sun, why can't the Philippines do likewise? With one of the highest electricity rates in the world, grid parity may be reached in two to three years. Moreover, the FIT, net metering and open grid access mechanisms are expected to be finally approved by Energy Regulatory Commission and implemented within the year. The potential for solar power development in the Philippines is limited only by its affordability and cost per kWh compared to other technologies.

C – Germany supports regional renewables – Will the Czech Republic get onboard?

By Martin Sedlák,
Executive Director, Alliance for Energy Independence
October 2012

Czech energy policy is still very focused on coal and nuclear sources, though there is a clear public desire for renewables. Germany's nuclear phase-out and increase in renewables can serve as an inspiration for the future of the Czech energy sector. How can Germany's Energiewende provide inspiration for its Czech neighbors?

Clean energy sources are reducing Germany's dependence on fossil fuels and nuclear power, and are creating new jobs. Renewables play an important role in supporting employment during an economic recession, and in building energy independence in Europe. It is precisely for this reason that the Czech Republic should take note of the rising trajectory of clean energy in Germany.

A rational way forward

Support for renewables in Germany has been stable since the early 1990s. German politicians are not contemplating merely an increase in installed wind, solar and biomass energy capacity, but also a transformation of the power transmission system to make green energy easily available to consumers. Changes in purchase prices are debated at a roundtable, where clean power producers, politicians, regional representatives and consumers are represented. While this is perhaps common practice in Germany, the Czech Republic still needs to develop to such a state of affairs.

One of the main advantages of the German system for supporting renewables is that as investment costs decline, fixed rates fall slowly along with them, and offer various pricing classes that motivate even small energy users to get involved in transforming the energy industry.

Another important element in the German "Energiewende" is a shift towards local ownership. The dynamic growth in green energy sources is shifting electricity production closer to consumers; to a large extent these renewable power plants are owned by families, farmers and small entrepreneurs, rather than by multinational companies.

By strengthening the role of renewables the state can free itself from nuclear and coal dependence throughout the entire economy.

Alongside green energy sources, Germany is also emphasizing increased energy efficiency. The Czech Republic is one of many countries which can find inspiration in the German plan – using revenues from the sale of emissions allowances after 2013 to modernize buildings. Germany is gradually renovating and weatherizing the homes of millions of families who pay high sums for heating and electricity.

The Czech way backward

The Czech energy sector is influenced mainly by the energy company ČEZ. Through the active support of previous governments, the state-controlled company has achieved a dominant position in the market. This is reflected today in EZ's influence on the formulation of national energy policy, which continues to support nuclear and coal, restrict renewables and gives inconsistent support for energy conservation.

Clean energy experienced a bright moment in the Czech Republic in 2005, when Parliament approved a law supporting for renewable energies inspired by the German system. The introduction of support launched the growth of wind, biomass and gradually also solar energy sources, which today cover ten percent of domestic energy consumption.

There was a snag in solar energy, however. In 2010, when there was a sharp decline in the price of photovoltaic technology, legislators did not manage to amend the law to reduce the level of support. This was followed by a strong negative campaign by EZ against renewables, which the power company alleged were increasing the price of electricity. In fact, however, green energy accounts for only about 10 per cent of the final electricity price, while other regulated components (such as the fee for distribution) amount to as much as 35 per cent. Nevertheless, this experience is also reflected in a mistrustful posture toward the German decision to eliminate nuclear energy.

Today's right-wing government headed by Petr Neas is preparing an energy plan which calls for an increase in the nuclear component from 35 percent to 50 percent, while allowing renewables to grow to a mere 15 to 20 percent. The Czech Republic is in danger of becoming technologically isolated. If EZ builds new reactors at Temelín, they will come online around 2025, but by then wind and solar power will be economically more attractive than electricity from new nuclear plants. Long-term, clean energy sources could cover up to two-thirds of today's demand for electricity, according even to conservative estimates. And there are also great opportunities to lower energy demands by modernizing buildings using thermal insulation and more efficient heating systems.

The absence of a vision in the Czech Republic?

The Czech Republic can also find inspiration in a well-considered strategy of long-term goals. The German government bases its vision on a range of studies and calculations. In the Czech Republic, however, sustainable long-term economic policies have thus far been elaborated on only by non-governmental think tanks. The official energy policy only contemplates developing large-scale, conventional resources. But exploiting renewables or increasing energy efficiency can provide a needed impulse for domestic industry (which consumes much more energy than in the countries of the original EU-15), reduce consumption of fossil fuels, and reduce the negative impacts on human health and the environment. The Czech Republic does not need more nuclear energy anyway; at present, we export up to 17 TWh of electricity, which is more than Temelín produces in a year.

Better times may be on the horizon, however. With the help of market research agency SC&C, the Alliance for Energy Independence asked people what kind of energy they want. An overwhelming majority would welcome more solar panels on the roofs of buildings, small hydroelectric plants and thermal biomass conversion plants supplemented by wind or biofuel stations. The public supports the gradual phasing-out of coal energy and restrictions to mining of coal and uranium. What will happen depends in particular on the willingness of Czech politicians to free the country from its dependence on EZ, and on their ability to learn and draw inspiration from the German experience. A new (clean) industrial revolution has begun with the leadership of Germany.

D – Jordan seeks a “solar-torch” from Germany

By Batir Wardam, coordinator for Jordan's 3rd United Nations national communication for climate change and an environmental writer.

Jordan's climate makes it an ideal candidate for the use of renewable energy technologies. Ample sun and a reasonable potential for wind should lead this country towards a green energy future. But there is talk about building new nuclear power. Germany's Energiewende reminds Jordan about its own conflict of renewables vs. nuclear when moving to a low-carbon future.

The global energy crises that erupted in 2007 due to the increase of the oil price had a grave impact on those countries that depend on imported oil for their own energy supply. Jordan was, and still is, among those countries most affected by the oil shock.

Clear Vulnerabilities

Jordan imports 96% of its national energy mix from outside sources. This translates to around 20% of GDP and puts a heavy burden on the public budget, which is already constrained by operating costs and subsidies. Moreover, Jordan is vulnerable to any unforeseen surprises in the energy supply chain. When the people of Jordan wake up in the morning and switch on the light, they used to receive a staggering 80% of their electricity from imported Egyptian natural gas with all the associated security risks.

On February 4th, 2011, in the midst of the Egyptian revolution, an explosion hit the natural gas pipeline in the Sinai which delivers natural gas to both Jordan and Israel. Since that day, natural gas supplies have stopped and Jordan had to turn to using fuel oil for its energy supply at an additional cost of $2.2 million US per day. There have been 15 such explosions since and Jordan has never managed to receive a sustainable supply of natural gas. In this period, Jordan switched to the use of its reserves of diesel and heavy oil to compensate the loss of natural gas. In November 2012 the government of Jordan raised the price of fuel and propane for household uses, causing a widespread wave of political protests all over the country. With a newly signed agreement with the IMF, Jordan is expected to raise electricity prices later in 2013.

Therefore, the equation is very clear for any political decision maker. Jordan is in dire need of a domestic supply of energy. The obvious choice should be renewable energy, especially solar. Jordan is currently looking to have 10% of its energy mix generated from renewable sources by the year 2020. Thus, the country is implementing a plan to generate 600MW of wind energy, and 600MW of solar energy to reach this target. This will require an investment of $1.4-2.1 billion US based on figures from 2007. However, research has proven that Jordan's potential is certainly much greater than this target and Jordan could even aim to become a net exporter of renewable energy within the region.

The Looming Nuclear Lobby

Unfortunately, this environmental and economic potential is in danger of being wasted due to the strong influence of the nuclear energy lobby in Jordan, which has managed to position their project as a top priority and marginalized the renewable energy sector. Jordan is now seeking a nuclear energy program that could generate 1 GW at a cost of more than $7 billion US with high environmental and health risks.

In the last couple of years Jordanian society has been engaged in a wide and heated debate on the feasibility of nuclear energy as a "secure" source of energy in relation to renewables. The question was "should we go nuclear or solar?" The impact of the "Arab Spring" with more political openness and social mobilization was a major impetus for raising the bar of the debate and questioning the justification, feasibility and even the integrity of the nuclear program compared to renewable energy alternatives.

Taking Germany's Lead

The German case of a gradual phase-out of the nuclear energy and strategic shifting into sustainable alternative was widely cited by legislators, politicians, activists, journalists, and researchers who oppose the Jordanian nuclear program. It has been mentioned, discussed and hailed in a number of advocacy and public awareness activities.

In an internal memo submitted by the Jordanian Parliament's energy committee, the committee cited the German experience as a major reason for showing how the world is moving away from nuclear energy towards more sustainable alternatives. Many writers and activists used the German example as a case study of a country which managed to implement a vision of a secure and sustainable energy future. This example could be followed by Jordan, which has a much bigger potential for harnessing solar energy due to its suitable weather conditions and large number of sunny days. It can also do this at much lower costs than Germany has done, because prices for renewable technologies have dropped drastically over the last decade and will continue to do so.

When nuclear experts like Mycle Schneider presented Germany's path towards renewables, those impressive facts and figures were used extensively by anti-nuclear and pro-renewable advocates in Jordan. It is also worth noting that the main political party in Jordan, the Islamic Action Front, also cited the German example in its numerous statements against the Jordanian nuclear program.

Room for Diplomacy and Civil Society

Jordan and Germany enjoy a mutually-trusted political and diplomatic relationship which has been strengthened with decades of economic and development cooperation. The German government has always kept a "low-profile" approach towards influencing internal policies in Jordan, and thus has not raised the issue of renewables vs. nuclear to the Jordanian government. This is different from other countries that "support" the Jordanian nuclear program hoping to gain access to the Jordanian market (i.e. France, Russia, Korea, etc.). Germany has worked to demonstrate best practices in renewable energy technology without influencing the development of energy policy. German NGOs have been more active in pursuing a pro-renewables approach with their development partners in Jordan and have succeeded in raising awareness at the community and society levels but not within decision-making circles.

The transition to renewable energy in Jordan is not an option as much as an economic and environmental necessity that is still subject to political marginalization, especially by the pro-nuclear lobby. The German model of transitioning to renewables is the most effective tool that Jordanian advocates can use to convince their government of the economic and environmental feasibility of such a transition. More exchange of knowledge, experiences and even direct influence should be accelerated to facilitate the energy transition process in Jordan.

E – Transatlantic Take-Away: Political Will is more important than Pure Resources

By Christopher Flavin, President Emeritus, Worldwatch Institute February 2013

Some 30 years ago German energy experts were intrigued by the boom in renewable energy then underway in the United States. Today, it's the other way around. The German Energiewende began modestly, but has gained political and economic momentum that is now fueling technological innovation. How is it that a country about as sunny as Alaska could become a world leader in a business that now attracts over $250 billion of capital worldwide each year?

In the mid-1980s, I was occasionally visited in Washington by German energy experts who were intrigued by the boom in renewable energy then underway in the United States. As I explained the policies that had led to the booming use of wind power, solar energy, and other new energy sources, my German guests could only shake their heads sadly. Such a thing, they assured me, could never happen in Germany. The nation's electricity law was one of the few that had survived from the 1930s, and the country's business and political leaders were implacably committed to nuclear power.

What a difference three decades can make. The U.S. renewable energy industry collapsed in a wave of bankruptcies in the late 1980s, while Germany has become the undisputed world leader in the technologies and economics of a new energy economy. It is now the only major economy in which solar, wind, and biomass energy contribute a substantial share of the country's electricity, and heat, even while heavy investment in energy efficiency has reduced the country's energy needs. If hydropower and biomass are included, fully 27 percent of Germany's electricity is coming from renewable resources today – compared with 18 percent from nuclear power.

Democratizing Energy Production

The transformation of Germany's electricity system began in 1990 with the introduction (under a conservative Christian Democrat government) of a new law designed to ensure grid access and fair prices for those who generate renewable power and feed it in to the nation's electricity grid. This law, lobbied for by Bavarian farmers who wanted to sell their small hydropower to the utilities, was awkwardly called a "feed-in tariff" in English (translated from the German word "Einspeisegesetz"). Within a few years, it had broken the monopoly of the nation's electric utilities, and generated an unprecedented wave of entrepreneurial development, investment by German citizens, and decisions by dozens of communities to generate their own electricity.

Over the past two decades, these changes have gathered momentum, with wind power providing most of the new installations in the early years, and solar power growing most rapidly since 2010. The number of "power plants" in Germany has gone from several hundred in 1990 to several hundred thousand today – a thousand-fold increase.

Any possibility of letting up on the accelerator of energy transformation was obliterated on March 11, 2011 with the destruction of two Japanese nuclear reactors. In the days that followed, the German public watched with horror as much of eastern Japan was threatened with radioactive fallout; within 24 hours, Chancellor Angela Merkel had, without informing any of her European neighbors, permanently closed 8 of the country's 17 reactors. (If she had not, there could well have been a million Germans in the streets by the next weekend.) Three months later, the German Parliament had reversed the decision made just five months before Fukushima to delay decommissioning of the country's aging nuclear plants and to instead accelerate the drive to energy efficiency and renewable energy.

The new plan reflected for the first time a consensus across Germany's political parties: all nuclear plants are now required to be closed by the end of 2022 – and replaced largely by renewable energy. Marking the occasion, Germany's government for the first time gave its energy strategy a new name – one freighted with historical reverence. The Energiewende (Energy Transition in English), is based on the same word (Wende) that was assigned to the changes that occurred during German reunification and the fall of the Berlin Wall in the 1990s.

Making Room for Innovation

How is it that a country with about as much annual sunlight as Alaska, and a second-rate wind resource (compared, for example, with the United States), could become a world leader in a business that now attracts over $250 billion of capital worldwide each year?

The forces behind Germany's Energiewende are in some ways easy to understand. The country has a strong technological base both in basic science and advanced mechanical and electrical engineering, supported by a public-private partnership that nurtures young talent from universities to technical schools, and supports them with government assisted research and development. In addition, Germany's governments have over the past two decades created a framework of energy policies, including significant subsidies, which have provided an attractive and steady investment climate, and led to the creation of hundreds of small companies specializing in various parts of the new energy economy. In the process, Germany has become a sort of Silicon Valley for the energy industry – something that surprises German cynics who used to say that if Bill Gates had been born in Frankfurt, he would today be a mid-level engineer at Siemens.

But why were all of these policies implemented? The mystery is sharpened when you ask why a similar energy transformation has not taken shape in countries that not only share most of the advantages that Germany brings to the new energy game, but that in many cases are blessed with far more abundant renewable resources. Progress to a new energy future has, for example, been far slower in Germany's neighbors in Europe, most of which have a common Western economic and political history – even in the northern tier of countries that share many of its cultural and economic values.

Political Will is More Important than Pure Resources

The contrast in energy trajectories is even starker when one compares Germany with Japan. The (so-called) "Land of the Rising Sun" sits on islands that are blessed with a vast resource of on-shore and off-shore wind, some of the world's most abundant and accessible geothermal heat, and enough sun to make even southern Germans envious. And like Germany, Japan is a modern democracy and technology powerhouse. Although Japan like Germany committed to heavy reliance on nuclear power in the 1960s, the Japanese public has shifted gradually against nuclear power since the 1980s. But the Japanese establishment (government and industry joined at the hip) has remained wedded to the nuclear dream.

This sentiment became overwhelming after the Fukushima catastrophe, but the Japanese citizenry has always had a limited role in the country's decision making, most of which is done behind closed doors by the country's elite. Even today, the country's power companies – supported by many politicians and government bureaucrats – are fighting to delay the replacement of nuclear power with renewable energy. Japan's political system now faces an intractable stalemate (including weekly protests outside the Prime Minister's residence) delaying any clear decision on the country's energy future. In the meantime, renewable energy's share of Japanese electricity is at 4 percent – unchanged since 1990. Wind and solar combined provide a fraction of 1 percent of the power.

The tragic political story of Japanese energy failure may hold the key to understanding Germany's success. The roots of the country's energy transformation lie in politics, and behind that, in the cultural norms and values that are expressed through its democratic system of government. Germans are well known for their deep love of nature and their efficient, disciplined approach to getting things done. By the mid-eighties, clear evidence emerged that coal-fired power plants were producing acid rain that was sickening the country's southern forests. Fallout from the Chernobyl disaster in 1986 contaminated some of the country's vegetable crops and dairy products and ignited opposition to nuclear power.

By the end of the 1980s, the threats of global climate change and ozone depletion had begun to solidify many Germans' view that a new energy direction was needed. The German Green Party, which first entered the German Bundestag in 1983, rode the new wave of environmental and energy concern to power, joining the Social Democrats in a coalition government in 1998. But it was not only the Greens who decided the country's energy economy was headed in the wrong direction. Repeated assaults on the German core values of order, risk aversion, and ecological protection have (over two decades, and under four different governments) propelled Germany toward a new energy vision – and more importantly, to its implementation.

A Transition that is Here to Stay

There has, to be sure, been opposition to these new energy plans, particularly to their alleged high cost. Even today, the German media is full of controversies about the country's energy policies. But these frequent political and legal challenges have been repeatedly beaten back by public support for the new energy vision. When the Greens were in government, they accelerated the transition, and when they were out of government, the Christian Democrats maintained the momentum – in part to ensure that the Greens would not once again displace them in the government.

Political differences will almost certainly continue, particularly between the utilities and the increasingly powerful renewable energy industries. The most recent debate on Germany's energy plans is particularly remarkable: the opposition Social Democrats are now criticizing the current government, not for the direction of its energy policy, but for the "chaotic" way in which it's being carried out, in particular the slowness with which the electricity grid is being strengthened to accommodate the new energy sources. In response, the Chancellor called an emergency meeting with state governors on November 1 this year in order to reconcile the fact that the cumulative state plans are even more ambitious than the national plan.

The outcome of the meeting was a decision to explicitly recognize that the states are permitted to go at their own pace so long as they coordinate their plans for assuring that the electricity grid is strengthened to accommodate the new energy sources. If history is any guide, what has been called the latest "crisis" by some in the media, is more likely to accelerate the German energy transition than to delay it.

This is a story the world needs to hear – and to be inspired by. Energy transformation is one of the greatest challenges our generation faces. Will we have the wisdom – and the courage – to follow the trail that has been so improbably blazed by one mid-sized country in the heart of Europe?

F – The Energiewende – blueprint for the energy transition in Japan?

By Kimiko Hirata, Director, Kiko Network

Like in Germany, people in Japan support to shutdown nuclear reactors and switch to renewables. But under a new government, Japan is maintaining its reliance on nuclear. Meanwhile, Germany has firmly committed to replacing nuclear and fossil fuel power with renewable technologies. How can Germany's experience help kick-start a Japanese energy transition?

The increase in Germany's renewable energy production has been featured in Japanese news for more than a decade. Many Japanese consider Germany to be the world leader in promoting renewables. After the Fukushima nuclear accident in March 2011, Germany had also gotten attention because of its rapid political response to the incident.

Debate over Germany's Renewable Energy in Japan

A stable and fast increase of renewables is particularly in Japan's interest. This has attracted many Japanese policy makers and experts who wish to do the same.

Japan introduced the feed-in tariff (FIT), similar to Germany's system, in July 2012. In the decades' long process to establish the FIT, its revision and the policy effects, such as job creation and reduced costs for renewable technologies, were carefully studied and discussed. On the other hand, negative aspects, such as an increase of financial burden and too generous industry exemptions, were also pointed to as potential failures of the FIT. The recent solar tariff cuts in Germany provided Japan's conventional industries with arguments to lobby for lower tariff rates. The typical critiques, such as claims that Germany imports French nuclear electricity or protects its coal industry, were brought up, too.

Situation in Japan

Japan's renewables are only around 10% of overall electricity production (excluding large hydro, it only accounts for 1%). Japan has so far no renewable target for 2020 and 2030, although target level of 25-35% is being discussed. The challenge is how smoothly the country can operationalize the FIT and firmly increase renewables. Many questions now arise, such as: whether the surcharges under the FIT are the right size; how electricity fluctuation is dealt with; if more renewable energies on the grid are technically feasible; what the costs and benefits for ratepayers, the industry, and the economy as a whole would be; how the grid system should be strengthened; and how electricity market liberalization could be realized. These issues need to be addressed properly. In that regard, examining Germany's best practices will be a great help to subsequent countries, such as Japan.

Nuclear Policy Discussion after Fukushima

The overall response to the Fukushima accident was different in Germany and Japan. The German Ethics Commission Report in May 2011 and Chancellor Angela Merkel's quick decision to shut down the oldest nuclear reactors in 2011 and phase-out nuclear by 2022 was seen surprising in light of the boldness of the decision and the way to respond to the accident.

Japan hasn't made any decisions to shut down the old and dangerous reactors, which were kept in operation until the periodical safety check, which is obligatory in Japan. Only two Hamaoka plants, which had very high risk from earthquakes, were shut down in May 2011.

As regards nuclear policy, the Japanese government has begun a "cost analysis" of each type of energy (coal, gas, and oil, nuclear, and various sources of renewables), including calculated economic impacts, and has proposed several energy mix options. The results highlighted comparisons of the economic burden of each option and outcomes showed that maintaining nuclear was cheapest. Unlike Germany, the aspects of ethics and philosophy from the perspective of Fukushima victims had not been discussed in the process.

Challenge for the Future

Many Japanese are skeptical about Germany's ability to realize its ambitious goals. Renewables are still considered to be unreliable and expensive in Japan. Thus, the idea of an economy running on 100% renewable energies is not yet being discussed in Japan. Germany's path to higher shares of renewable energies would motivate Japan's discussion toward 100% renewable future.

In addition, another big challenge for Japan is to reduce greenhouse gas emissions while reducing reliance on nuclear. Germany keeps its ambitious climate target in the course of its nuclear phase-out. How feasible is this? We want to hear more on this from Germany, and I hope Germany can prove it in practice.

Lessons from Japan?

What lessons can Japan provide to Germany? Above all, the Fukushima accident was the most tragic lesson of the dangers of nuclear power being part of the mix. And from now on, Japan's FIT will take a different path from Germany's, and Japan's own experiences, such as bringing down the costs of PV panels and geothermal development, may provide new lessons to other nations in the future.

Four months after the FIT's introduction, 2560MW of renewable capacity (mainly solar) are approved under the system and more are expected to come from wind and geothermal.

In 2013, Japan now has a new government after election of December 2012. The Liberal Democratic Party took a vast majority again, and the direction of nuclear and renewable policies is not yet clear. Though, Prime Minister Abe has suggested he is considering building new nuclear plants. There are concerns around that. However, public opinion is clear: Japanese people support renewables, not nuclear. That will hopefully change the political landscape.

G – India's Opportunity to Leapfrog into the Renewable Age

By Srinivas Krishnaswamy, Chief Executive Officer, Vasudha Foundation March 2013

India is poised to show the value of renewable energies to developing economies. Distributed solar and wind generation has the chance to bring reliable electricity to many communities for the first time. Renewables are not just the environmentally responsible alternative to fossil fuels, they are now being seen as ever-more affordable means to development and social equity.

The demonstration by Germany that even a thriving industrial economy can switch from a conventional energy system, fueled primarily by nuclear and fossil fuel, to an energy efficient, renewables-based one without compromising on industrial energy has definite lessons for all the countries in the world, particularly developing economies.

Some of the key lessons from Germany that are relevant for a number of countries, particularly energy starved countries like India, are:

1. The ambitious renewable energy targets and firm commitment to achieve them
2. Appropriate policy measures which mix market-based instruments and regulation
3. The transition being driven by citizens and communities
4. Breaking the myth that only conventional power can ensure the retention and growth of industry.

Taking the specific case of India, a snap shot of the electricity and energy scenario indicates:

1. The current total installed electricity generation capacity for India stands at 200 GW
2. Coal is still the dominant source of energy and accounts for 56 percent of India's total installed electricity generation capacity
3. Renewable energy has seen a modest growth from 2 percent of India's total installed electricity generation capacity in 2003-04 to 12 percent in 2011-12, a growth of 10 percentage points in the last 8 years
4. India has a huge power deficit, ranging from 7.5 percent to 8 percent of the total electricity requirement
5. 44 percent of India's households do not have access to modern electricity
6. India has a low annual per-capita energy consumption of 778.63 kWh as against the world average of 2596 kWh.

Therefore, in this context, the priority for India is to address:

- Energy security
- Access to energy for all

In the backdrop of the above, let us look at the reasons that it is important for India to take key lessons from Germany and also embark on a pathway of transition from a conventional electricity model to one which is green, sustainable, and has the ability to provide crucial energy security for India.

1. From the Point of Energy Security:
   A. With a business as usual dependence on coal being the dominant fuel for electricity and with India's ambitious 12th five year plan target of adding 88GW, of additional electricity generation capacities, for the period of 2013–2018, with close to 50 plus GW coming from coal, India has to rely on increasing imports of coal. The Planning Commission estimates it to be in the region of 42 percent of the total coal required
   B. Hydroelectric resources are proving to be increasingly unpredictable and with increasing threats of the impacts of climate change on river systems and water resources, energy experts are now looking at hydro sources as more balancing power sources, rather than a base load power source
   C. India does not have its own gas or oil reserves and with the subsidies for oil being close to 9.46 rupees (17 US cents) per liter, the estimated cost of subsidies for power generation alone is in the region of 130 billion rupees ($2.39 billion) annually

2. From a Balance of Payments perspective:
   A. Very clearly, if India has to import oil, gas and coal and with the rising prices of these fossil fuels, India's already skewed balance of payment situation will worsen
   B. We have also seen a trend of increasing prices of coal in the international market and with the recent move of Indonesia to hike its price of coal by almost four times, a number of proposed coal fired power plants have had to defer their operations, the most noteworthy among them being Tata Power's super-critical coal fired power plant in Mundra.

3. From Energy Access Point of view:
   A. With 44 percent of India's households still not connected to the grid and with poor quality grid supply, there are increasing evidences and cases of how only decentralized renewable energy can ensure 100 percent reliable and affordable energy to a large number of remote villages of India

4. Price and Cost Issues:
   A. The cost of solar generation has come down fairly steeply from a tariff of 18 rupees (33 US cents) per kWh in 2010-11 to almost 9 rupees (17 US cents) per kWh in 2012–13 and it is said that there are likely to be bids for solar generation which could even be in the region of 6–8 rupees (11–15 US cents) per kWh.
   B. The price of wind generation has been on an average of 3.50 rupees (6 US cents) per kWh
   C. In comparison, the price of generation of electricity from coal has been steadily going up, particularly with increased dependence on imported coal and with prices of imported coal in the international market seeing a steep rise. The increase in cost of generation from new coal fired power plants which use imported coal is expected to be in the region of 3.50 rupees (6 US cents) per kWh to as much as 6 rupees (11 US cents) per kWh. Looking at the trend of global price of coal, and the trend of falling price of solar, the grid price parity between coal and solar could be in the next 3–4 years itself.

In view of all the above, it makes perfect sense for India to reexamine a shift in its energy generation policy, with an increased focus on renewable energy solution, with fossil fuels and hydro being considered as supplements. This would primarily mean a complete reverse in its current generation paradigm.

India definitely has more potential for renewable energy solutions and can opt for a basket of options and also opt for a basket of hybrid options. Amongst the various renewable energy resources, solar energy potential in India is perhaps the highest and has been estimated to be in the region of 6,000 million GWh of energy per year.

Recent studies to look at wind potentials in India, has completely de-bunked the earlier estimate of 49 GW and has now pitched the potential for wind generation to be in the region of 200 plus GW. There are studies which even quote a much higher potential.

Concentrated solar power (CSP) systems have a bright future for India and to a lesser extent potential run of the river systems and bio-mass generation plants.

Further, there are also a number of hybrid options such as CSP and bio-mass, or CSP and gas, which would ensure that peak demand for electricity is also met.

It is therefore evident that India has perhaps a far higher renewable energy potential, particularly related to some technologies than even Germany and therefore, if Germany has been able to make this switch with a solar and wind based technologies replacing nuclear and fossil fuel based generation capacities, India can definitely not just learn from Germany, but perhaps even leapfrog.

India is right now formulating the policies of the second phase of the National Solar Mission. There is a plan to also create a separate mission for wind generation. The mission would ensure dedicated policy, resources and action plans for wind. The idea of having a wind mission also has the support of the Planning Commission and therefore, it is likely that this mission for wind will be announced very soon.

Further, there is also a discussion happening at the Ministry of New and Renewable Energy to have a mission for bio-energy too.

This would put almost all the sources of clean and green energy in mission mode, with energy efficiency already in a mission mode. With the mission modes in various stages of starting afresh or planning its second phase, the time is ripe for the missions to imbibe some of the lessons from Germany in its energy transition, while formulating its plans.

Energy policy makers in India have started to realize the importance of promoting renewable energy solutions and have also started to realize that conventional power generation systems are not sustainable in the long run. The very idea to pursue renewable energy technologies in a "mission" is with the intent to fast-track its penetration. If these programs are implemented well, which is where the lessons from Germany could help the Indian policy makers in creating the framework necessary for India, it seems likely that our dependence on fossil fuel for electricity generation will fall substantially from the 13th five year plan, which is by 2018.

H – China's Sustainable Energy Development

By Fuqiang Yang,
Senior Advisor of China Program,
Natural Resources Defense Council

Germany has strong renewable energy research and development capabilities and China's manufacturing ability can provide cost-effective renewable power facilities. Sino-German cooperation could decrease tremendously the cost of renewable energy in the future, making renewables fully competitive with fossil fuels, ensuring a secure and affordable price, and facilitating economic growth.

The German energy transition has laid a strong foundation for responding to climate change. The German federal government has proposed an ambitious greenhouse gas (GHG) emissions reduction target, in which by 2020 and 2050 GHG emissions will be reduced from 1990 levels by 40% and more than 80%, respectively. The goal of the German energy transition is to provide secure, affordable and environmentally friendly energy by 2050. The German energy transition provides forward-looking and innovative insights for China's sustainable energy development.

Setting Ambitious Goals

The first important feature of Germany's energy transition is that renewables will become the country's dominant source of energy. By 2050, renewable energy will constitute 60% of primary energy consumption, and 80% of total electricity, as it replaces coal and nuclear energy production. In 2011, coal constituted 70% of China's total energy consumption, while renewables were only about 8%; excluding hydropower, other forms of renewable energy generation – solar, wind, etc. – constituted 1.5% of total electricity generation. Even employing today's most extreme scenario study, China's renewable energy will only reach around 35% of the total energy mix by 2050, and will still not be the leading energy source. China needs innovative and strategic thinking on energy development.

A second important feature of Germany's energy transition is that energy efficiency will increase significantly. By 2050, Germany's annual energy efficiency productivity (the reciprocal of energy intensity) is planned to have increased by 2.1%, decreasing consumption tremendously. Currently, China's energy intensity is up to 1.5 times higher than Germany's. In order to attain Germany's level of energy intensity by 2050, China would have to increase energy productivity by 3.9% annually. Areas for Sino-German cooperation in innovation include renewable power generation, energy efficiency retrofits, electric vehicles, future energy networks, smart grids and smart metering, information and communications technologies, advanced gas and coal power plants, energy storage technologies, cogeneration and other types of energy-saving technologies.

A third important feature of Germany's energy transition is that overall energy consumption will decrease. Primary energy consumption is set to decrease by 50% from 2008 to 2050. In other words, from 2011-2050, Germany's economy and energy consumption will decouple, allowing the economy to grow, while energy consumption decreases. In current Chinese energy demand forecasts and scenario analyses, energy consumption will continue increasing until 2050, and the economy and energy consumption are relatively coupled (although energy consumption growth is slower than the economy's growth). The decrease in German energy consumption is a result of a novel way of thinking, an absolute decoupling that refutes the "zero economic growth" hypothesis, and ensures sustainable development and use of energy resources.

Opportunities for Sino-German Cooperation

Germany currently relies on imports for 88% of its natural gas and 98% of its oil, and in the future will continue to face the challenge of energy supply security. Even if, in 2050 fossil fuels still account for 40% of total German energy production (e.g. in electricity, transportation, and heating), Germany will rely almost entirely on imports for its fossil fuels. As a result, it is in the best interests of Germany, Europe, and countries around the world to develop closer cooperation to safeguard their energy supplies. China's reliance on imported oil and natural gas is increasing significantly, and China continues to face the challenge of energy supply security. China's renewable energy resources are abundant, and could completely satisfy China's energy development needs.

Germany has strong renewable energy research and development capabilities, and China's manufacturing ability can provide cost-effective renewable power facilities. Sino-German cooperation could decrease tremendously the cost of renewable energy in the future, making renewables fully competitive with fossil fuels, ensuring a secure and affordable price, and facilitating economic growth.

Maintaining economic competitiveness is a necessary condition for promoting an energy transition. In the context of economic recession throughout much of the European Union, Germany's economy is thriving. Germany's manufacturing industry is competitive throughout the entire world, and energy consumption indices and productivity in the energy sector rank among the highest in the world. In China, manufacturing accounts for 60% of total energy consumption, and the energy saving potential is great in the industrial sector. China could further benefit from drawing on Germany's experience in productivity promotion, quality control, product design, clean production and recycling in the manufacturing sector. Those are all the more important in the context of China's economic transformation and mandatory requirements for energy savings, environmental protection and GHG emission reductions.

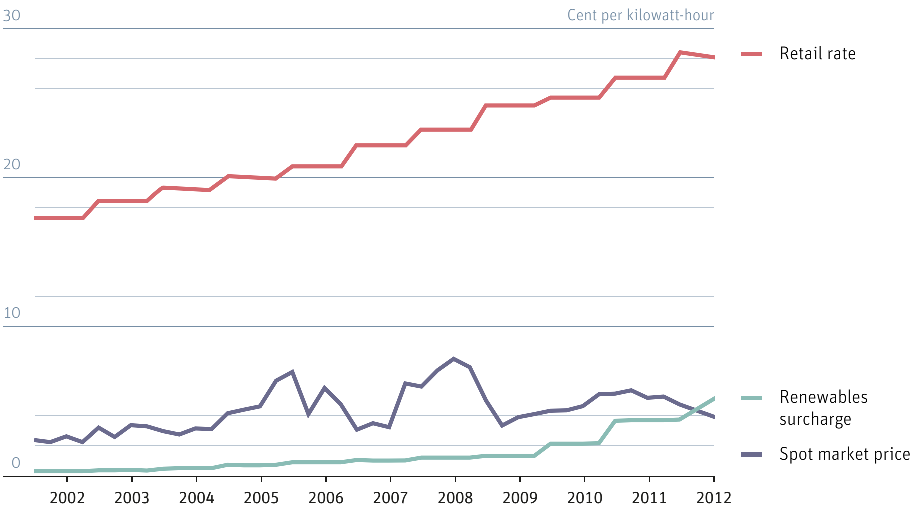
6 Questions & Answers

A – Is the energy transition affordable?	72
B – How will Germany ensure that the poor can still afford energy?	74
C – When will renewables pay for themselves?	74
D – Is the energy payback from wind and solar ever positive?	75
E – Why aren't low-carbon goals enough in themselves?	75
F – Will Germany import more power from abroad after the nuclear phaseout?	76
G – Didn't Germany overreact to Fukushima?	77
H – Aren't renewables a relatively expensive way to lower carbon emissions?	78
I – Won't the nuclear phaseout increase Germany's carbon emissions?	79
J – Wouldn't nuclear power be an inexpensive way to reduce carbon emissions?	79
K – Will the lights go out?	80
L – Will the energy transition kill jobs?	81
M – Do Germans support the energy transition?	82
N – How can Germany be both a green leader and remain an industrial powerhouse?	83
O – How are energy-intensive companies exempted from the surcharge for reneable power?	83
P – What role will shale gas play in the German energy transition?	84
Q – Why did carbon emissions increase in 2013?	85
R – Is Germany undergoing a coal renaissance?	85
S – How much electricity storage will Germany need?	86
T – How could the cost of Germany's energy transition be decreased?	86

Renewables are not the main driver for high power prices in Germany

Trends of retail rates, spot market price and renewable energy surcharge over past 10 years in Germany

Source: www.unendlich-viel-energie.de



A – Is the energy transition affordable?

Yes – in fact, we cannot afford not to do it. Investments made in renewables today will pay for themselves over the usual 20-year service life of the equipment as conventional energy becomes more expensive. Furthermore, renewables only seem the more expensive because some of the cost of fossil and nuclear energy are passed on as taxes and other external costs not included on power bills.

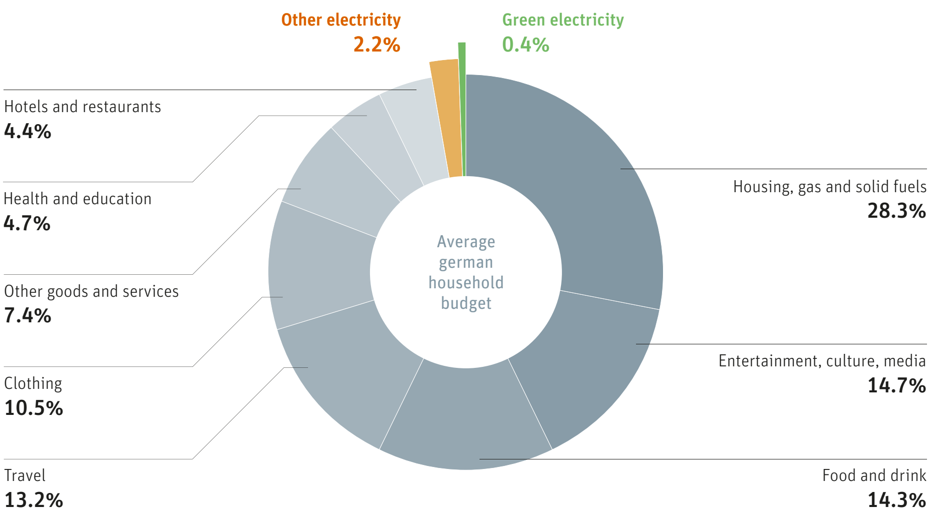
Essentially, the cost of renewables will continue to drop, while the cost of conventional energy – both fossil fuel and nuclear power – will continue to rise. In fact, heating costs in Germany mainly from fossil fuels, reached record levels in 2013.

Germany's leading economic research institute, the German Institute for Economic Research (DIW), estimated the cost of the energy transition at 200 billion euros over the next ten years, but the net effect (some energy costs will be reduced at the same time) would then be around ten euros per month per household – roughly what it is now.

Green electricity less than one percent of average household budget

Expenses of an average household in Germany at a renewables surcharge of five cents

Source: www.unendlich-viel-energie.de



Critics of the energy transition charge that renewable energy is driving up energy prices in Germany, but Germany's Network Agency found that, while retail power prices rose by around 20 percent from 2007 to 2011, the profit margins of power firms also increased significantly during the same timeframe – partly because renewable power was, in fact, lowering wholesale prices, but these cost savings were not being passed on to consumers who pay the retail rate.

When we take a closer look at the surcharge that covers renewable power in Germany, we find that it does not explain two thirds of the increase in the average retail power rate in Germany over the past decade.

Hidden subsidies

Indeed, it is worth noting that Germany ramped up renewables when they were expensive – and, in doing so, helped make them inexpensive. All along, forecasts indicated that the cost impact of the switch to renewables would peak in the first half of this decade, and now it seems clear that German investments in renewables actually peaked in 2010 and will annually be more than one third lower than that record level over the next few decades.

By investing in renewables so soon, Germany may have incurred high costs, but it also positioned itself as a major provider of future-proof technologies. In other words, as renewables become more competitive, the whole world will start switching over – and buying more German products.

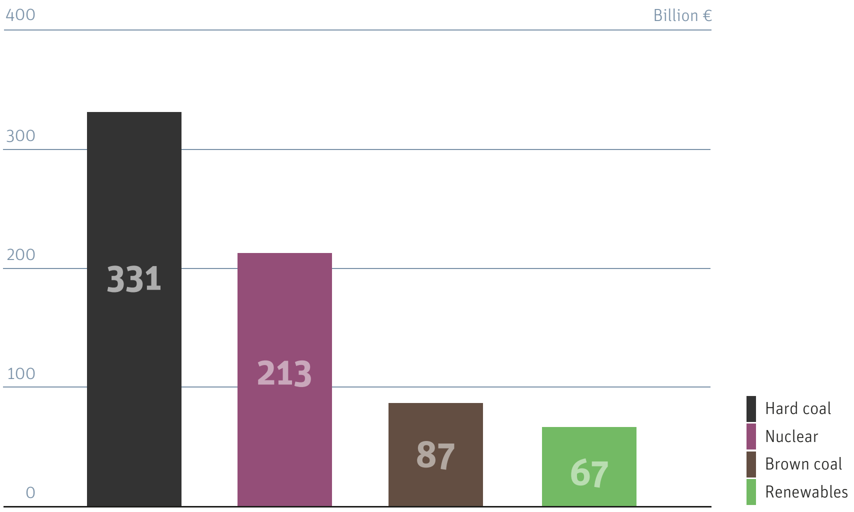
One reason that renewables seem so expensive in Germany is that so much of their full cost is paid immediately as a dedicated item (the EEG surcharge). In contrast, support for coal and nuclear power has largely come in directly as budget items passed on to taxpayers, and because Germany has a budget deficit these costs are being passed on to future taxpayers with interest (source: Green Budget Germany).

Furthermore, the "cost" of the energy transition cannot be seen in isolation. The nonmonetary costs of energy consumption do not appear on consumers' bills for electricity, gas, and oil. Yet, the environmental impact caused by greenhouse gas emissions and pollution quickly adds up to a considerable amount. A study published by Germany's Environmental Ministry in 2012 estimates that some ten billion euros net was avoided in 2011 because people used renewable electricity and heat. These savings, however, are not separately listed on any invoice. Furthermore, Germany is gradually reducing its dependence on energy imports by getting renewable energy from home – and by coming up with more efficient products that will also sell well on the global market.

Fossil and nuclear have received by far more subsidies than renewables

Energy subsidies in Germany, 1972–2012

Source: Green Budget Germany



B – How will Germany ensure that the poor can still afford energy?

In general, Germany can protect the poor by providing jobs with livable wages, which is why one of the main goals of the energy transition is to gear up German industry for future technologies. Furthermore, the cost of electricity is rising more slowly than the cost of motor fuel and heating oil, for instance, partly thanks to renewables.

The energy transition is an answer to rising energy prices, not the cause of higher prices over the long run. The price of conventional energy is expected to go in only one direction: up. Since 2000, the cost of hard coal has more than doubled in Germany, while the cost of natural gas has nearly tripled.

What's more, the price of electricity only increased over the past 12 months by three percent, compared to a five percent increase in the cost of natural gas, a nine percent hike in the cost of gasoline, and a 10 percent increase in the cost of heating oil. The three percent increase in electricity prices is also fairly close to the general inflation rate of two percent in Germany over the past 12 months.

In contrast, the cost of renewable energy, which is still comparatively high, is expected to continue to drop or at least level out, depending on the specific technology. The cost of photovoltaics has fallen by 60 percent over the past four years, and the US Department of Energy's Transparent Cost Database shows that onshore wind power is already roughly on par with natural gas, coal power, and nuclear. Germany's Fraunhofer Institute for Solar Energy Systems estimates that solar power in the country will cost the same as coal power roughly by the end of this decade – even in cloudy Germany.

Concern about energy poverty is increasing, and there were reports in the spring of 2012 that an increasing number of welfare recipients were getting their power cut off because they could not pay their bills – rumors that turned out to be unverifiable.

For the time being, however, energy poverty is an issue, and a number of solutions are being discussed or already implemented. As discussed in the section on social justice, energy audits are already offered to poor households in order to reduce unnecessary energy consumption. At the same time, it should be kept in mind that even low-income homes spend less than ten percent of their income on energy. It is therefore crucial that poverty itself be addressed directly with proper social policy, retirement plans, and wages. Clean power will also help mitigate global warming, which will affect poor countries inordinately. In other words, Germany's commitment to renewables will also help poor countries.

Finally, Germany does not collect statistics on "energy poverty" up to now, so reports of the number of people who cannot pay their power bills are based on rough estimates and lack a comparison with previous years; for all we know, the number of people who cannot afford energy has not risen significantly. Germany needs to start collecting such data – and continue to use social policy to protect the needy.

C – When will renewables pay for themselves?

They increasingly do now. The differential cost of renewables is currently peaking, so renewables are expected to help stabilize power prices within the decade. Other countries face rising energy costs with no end in sight. Only countries that undergo an energy transition – like Germany – will be able to stabilize their energy prices within the foreseeable future.

Concern about the high cost of renewables is increasingly unjustified. By 2030, the ongoing switch to renewables and energy efficiency will look like a very good investment indeed – and an excellent way of protecting the poor. Right now, worries about the cost impact are at their highest because it is peaking – and was expected all along to do so by the middle of this decade. Market research institutes Prognos and Roland Berger estimate that investments in photovoltaics, the most expensive type of renewable power up to this year, will cost the German national economy between six and nine billion euros net in terms of avoided carbon dioxide emissions. But as the steep curve shows, all other options quickly become tremendously more expensive even as the cost of photovoltaics continues to drop, so that by 2030 that cost has become a tremendous benefit of 56 to 75 billion euros per annum.

One thing is clear – the energy transition will not be free. But there is a wide array of factors that determine the cost; it's not just renewables and feed-in tariffs. And while the Renewable Energy Act currently (2013) costs around 20 billion euros (hence the surcharge of 5.3 cents per kilowatt-hour on the retail rate), wind power has long been relatively inexpensive, and the cost of solar continues to plummet. Going forward, the cost increases are expected to taper off, and by 2020 a lot of old systems will no longer be eligible for feed-in tariffs, so green power will start being much less expensive. During the interim, the goal must be to keep costs in check even as we ensure further growth.

The forecast increase in the retail rate in Germany is not unusual. In July 2012, French energy regulator CRE announced that the retail rate in France is expected to rise by nearly 50 percent by 2020 due not only to the greater deployment of renewables, but also to the rising cost of nuclear. It is worth noting that, while the retail rate in France is much lower than in Germany, the French actually have comparable power bills because they waste so much electricity, in part by using electric heating systems. The report put French power bills at 875 euros per year for a typical household, roughly the same level for a typical German household of the same size.

D – Is the energy payback from wind and solar ever positive?

A common question not only among laypeople but, surprisingly, still even among experts occasionally is whether solar arrays and wind turbines ever produce more energy than was consumed for their production and installation. The answer is easy: the payback has been overwhelmingly positive for decades.

Recently, German solar research institute Fraunhofer (PDF) put the payback time at "around 2.5 years" for PV arrays in northern Europe, and that figure even drops to 1.5 years and less in sunnier locations. Keep in mind that solar panels sold over the past few years have had performance guarantees of around 80 percent for 25 years, meaning that, say, a 2.0 kilowatt array is guaranteed to still be able to peak at 1.6 kilowatts after 25 years of operation.

Clearly, the energy payback of PV is tremendous – the energy you get back is an order of magnitude greater than what you put in.

The payback time for wind turbines is even better; it's counted in months, not years. As a British newspaper The Guardian recently put it, "The average wind farm produces 20-25 times more energy during its operational life that was used to construct and install its turbines."

With coal, efficiency always represents a loss, whereas it is always a gain with solar; the coal that consumed is gone for good, so at 33 percent efficiency, two thirds is lost. Had it not been used, it would still be in the ground.

In contrast, the planet gets a certain amount of solar every day. If a solar panel is 16 percent efficient, around 5/6 of the sun's energy is lost, but if a roof doesn't have solar, all of that energy is lost. The 16 percent efficiency rating is a gain. The planet roughly gets the same amount of solar energy every day, but yesterday's solar energy will be gone forever if not harvested.

In other words: coal, use it and lose it; solar, use it or lose it.

E – Why aren't low-carbon goals enough in themselves?

Germany wants to fight climate change and reduce the risks of nuclear power at the same time. Nuclear power is rejected because of the risks, the costs and the unsolved waste issue. In addition, there is no economic case for it to play a major role in the world's energy supply.

In its energy transition, Germany aims to combat climate change, phase out nuclear power, and switch to a reliable, affordable, clean energy supply. Climate targets and emissions trading contribute to some, but not all of these goals, which is why the German government is pursuing a comprehensive, long-term climate and energy strategy with policies addressing different sectors and technologies.

Emissions trading is an important tool, but it will not lead to the goal that Germans want. For instance, cost is the main mechanism in emissions trading, so actions are prioritized according to their cost benefits, with the intended result being that the project that costs the least is the one done next. The unintended outcome is that nothing worth doing gets done unless some investor considers it to be the cheapest option. In the case of renewables, onshore wind power practically always beats out all other competitors, making emissions trading a particularly bad way of ramping up all types of renewables.

For Germans, the goal is to reduce energy consumption to a level that can be provided by renewables even as we ensure ever higher material standards of living. While questions like "When is solar going to be competitive with coal or nuclear?" are popular, solar or wind or any other single source of renewable energy cannot replace conventional power on its own – only a mix of renewables can. And since emissions trading promotes only the cheapest option, it cannot produce that mix, so it cannot get Germans to their goal. Policy-makers in the country are convinced that they need policies that gradually increase efficiency with today's technologies (which emissions trading does) as well as policies that drive innovation for technologies that are initially more expensive, but become competitive in time (which German feed-in tariffs do).

And that's not all – the German policy that promotes renewables also allows the country to reach its climate targets. Without a specific instrument to support renewables, they would never have grown so quickly, and without this dynamic growth, ambitious reduction targets for greenhouse gases would not be feasible. Renewables replace fossil fuels across all energy sectors, offsetting around 146 million tons of greenhouse gas emissions in 2012. In particular, on sunny days, photovoltaics provides large amounts of electricity that is cheaper than "peak demand plants" – old, inefficient power plants that only run when demand is high. By offsetting this peak demand, photovoltaics squeezes out high-carbon electricity.

Renewables and emissions trading

Often, it is claimed that renewables do not really help protect the climate because the emissions trading platform already sets a limit on greenhouse gas emissions. That argument overlooks a crucial fact: the growth of renewables is taken into account when the volume of certificates to be traded is calculated. In other words, renewables allow the cap in cap-and-trade systems to be lowered much more. In this respect, Germany feed-in tariffs and emissions trading do not compete with each other – they complement each other.

Furthermore, it is often charged that insulation is a much less expensive way of reducing carbon emissions than photovoltaics. Seen through the glasses of emissions trading, this comparison does not seem silly – it only becomes so when you realize that the purpose of photovoltaics is to generate electricity, which you cannot get from insulation. In other words, once you have insulated your home, you still have to figure out where you're going to get your power from.

If Germany's only priority was to fight climate change, one could argue that they should keep nuclear power plants online and shut down coal plants first. But in light of the events in Chernobyl, Fukushima, and elsewhere, Germans oppose nuclear power because it is too risky during operation – and unethical for future generations, who will have to manage the waste from electricity they did not use. Germany is convinced it can reach its ambitious climate targets while phasing out nuclear power at the same time.

F – Will Germany import more power from abroad after the nuclear phaseout?

Germany has been a net exporter of power for years and remained so in 2011, even after shutting down eight nuclear power plants within a week. In 2012, the country even returned to a record level of power exports, including to France. A slight reduction in exports in 2011 and 2012 are the temporary effect of the sudden shutdown of all that nuclear capacity. Going forward, Germany will continue to add sufficient power generation capacity – and is likely to remain a power exporter.

The goal is to replace nuclear capacity with renewables, energy efficiency, and – in the interim – fossil fuels.

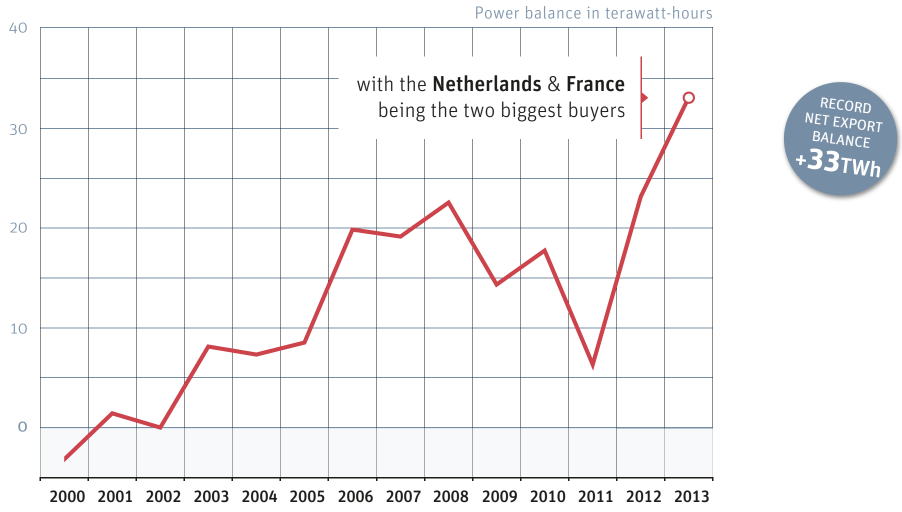
Overall, Germany has generating capacity far exceeding power demand. Even after those nuclear plants were switched off in March 2011, Germany still had around 100,000 megawatts of conventional generating capacity online, compared to only 80,000 megawatts of maximum power demand for the year.

At the beginning of 2011, Germany had a dispatchable (i.e., not including solar and wind) power generating capacity of 93,100 megawatts, and roughly 8,000 megawatts of that was switched off last March. According to the German Association of Energy and Water Industries (BDEW), Germany exported 90,000 megawatt-hours net per day on average in the six weeks leading up to the moratorium on nuclear in mid-March 2011, whereas starting on March 17, 2011, the country began importing an average of 50,000 megawatt-hours net per day.

German power exports continue to rise

Net power exports from 2000–2013 in TWh.

Source: Agora Energiewende, AGEB



Despite the major changes, Germany remained a net exporter of power in 2011. From 2012 to 2014, the German power supply will continue to increase, not only with the addition of numerous renewables systems, but also with more large power plants. Germany's Network Agency expects more than six gigawatts of new conventional plants to go online by 2014.

Working with neighbors

To the east, more power might be imported from the Czech Republic, but not because of any electricity shortage in Germany. Rather, the German power market buys conventional electricity where it is cheapest. Countries like Poland and the Czech Republic are not complaining about having to prop up the German grid after the nuclear moratorium. On the contrary, they are mainly concerned about wind and solar power surges from Germany offsetting their own production of fossil and nuclear power.

To the west, contrary to the numerous claims that France is a major power exporter to Germany, the opposite has been the case for several years now – as official French statistics themselves reveal. In other words, Europe's nuclear powerhouse – France – has been a net importer of power over the past few years from one of Europe's leaders in green power – Germany.

The winter of 2011-2012 proved interesting as an experiment. A long cold spell in Europe caused power consumption in France to reach a new record level exceeding 100 gigawatts, in part because the French often use electric heaters. At one point, France was importing between four and five gigawatts of power – equivalent to the output of around four nuclear plants. Yet, there was still no shortage of power in Germany even though the Germans were also not far from their own peak levels.

In 2013, the German Institute of Applied Ecology published a report on power flows between Germany and its neighbors; see the four-part series in our blog for a summary of the findings.

G – Didn't Germany overreact to Fukushima?

A few pro-nuclear countries did not fundamentally change their stance on nuclear after Fukushima, but Germany was actually in the majority. And its nuclear phaseout dates back to 2000, so the decision in 2011 represents a sudden change in Chancellor Merkel's position, not a fundamental change in general German opinion.

Germany's nuclear phaseout has been a long time in the making, but the government's decision to shut down eight nuclear plants in the week after the accident in Fukushima still came as a surprise.

Overall, however, Germany has a strong political consensus in favor of phasing out nuclear. Since the original nuclear phaseout of 2000, the political discussion in Germany has not been about whether, but about how quickly the phaseout should proceed.

While some countries – such as the US, France, and Russia – did not fundamentally change their policy on nuclear in response to Fukushima, Chancellor Merkel's coalition did an abrupt about-face. In contrast, public sentiment did not change much; the general public in Germany was overwhelmingly in support of Chancellor Schroeder's nuclear phaseout from 2000, with 65 percent of those surveyed stating that they were in favor of it in April 2010 – at a time when newly reelected Chancellor Merkel had indicated she planned to roll back Schroeder's phaseout.

In the wake of the accident at Fukushima, German support for a nuclear phaseout "only" increased by six percentage points to 71 percent, not a great difference; in comparison, a poll taken in the United States nearly a year after Fukushima found that 41 percent of US adults thought the risks of nuclear outweighed its benefits, compared to 37 percent a year earlier – an increase of around ten percent in both cases.

But while the German public can hardly be accused of panicking, Chancellor Merkel certainly did. Had she merely continued the previous nuclear phaseout and decided to speed things up, the effects might not have been so detrimental, but she essentially reversed German energy policy twice within a single year. Two main factors were probably behind Merkel's sudden change of heart in 2011: upcoming elections in the German state of Baden-Württemberg, which Merkel's party lost, and strong anti-nuclear protests in the wake of Fukushima.

The energy sector has heavy infrastructure and can only change with great inertia. Had the Greens and the Social Democrats resolved to shut down nearly half of Germany's nuclear plants within a week, they would have been laughed out of Berlin for being incompetent – and rightly so.

Countries against nuclear

Nor did Germany react more strongly than most other countries. To the north, Denmark already had a goal of 100 percent renewable energy by 2050 when Fukushima happened. To the south, Italy – the world's seventh largest economy – had voted to be nuclear-free in a referendum in 1987, and when then-President Berlusconi attempted to change that policy in June 2011, the Italians managed to successfully conduct a referendum for the first time since 1995 by getting a majority of eligible voters to turn out. Of those who voted, more than 94 percent rejected Berlusconi's nuclear plans, and the event was a major reason for his political defeat a few months later.

In between Italy and Germany, Switzerland took modest steps to ensure that the country would be nuclear-free by 2034, and in 2012, Austria – which had resolved to remain nuclear-free way back in 1978 – went a step further by requiring its utilities to certify that they are not purchasing any nuclear power from abroad starting in 2015.

For a while, Belgium was repeatedly in the news for not having a government, but when it finally got one again, one of the first decisions made in October 2011 was to launch a nuclear phaseout starting in 2015. Germany is not alone in its nuclear position; it stands in the middle of a larger resistance movement.

H – Aren't renewables a relatively expensive way to lower carbon emissions?

If you want to compare apples and oranges, yes. It is often claimed, for instance, that insulation is a much cheaper way. But even if we insulate our homes better (incidentally, another field that Germany is already a leader in), we still have to decide how we are going to make electricity.

But although renewables have been expensive in the past, they are increasingly the cheapest option. All estimates going forward are that renewables will be the least expensive source of low-carbon electricity in Germany within this decade (see chart). These prices are for new plants, not decades-old central power stations that have already been completely written down.

I – Won't the nuclear phaseout increase Germany's carbon emissions?

It didn't in 2011, when the nuclear phaseout was put into law and carbon emissions went down even further. And going forward, carbon emissions from the power sector can only go down, not up, because of the ceiling imposed by emissions trading.

Germany has emissions trading, so its carbon emissions from the power sector cannot increase. Furthermore, it will overshoot its already ambitious Kyoto target for 2012, having already achieved a 27 percent reduction in 2011 – with the goal being just 21 percent by 2012. The country is also on track to reach its 2020 target of a 40 percent reduction. The nuclear phaseout is embedded in a comprehensive, long-term climate strategy following the IPCC's (the UN's International Panel on Climate Change) recommendations to reduce emissions by at least 80 percent by 2050. Scenario studies for the German power plant portfolio show that carbon emissions from electricity production will not rise, but, in fact, fall significantly.

But Germans are concerned not only about climate change, but also about the unnecessary risks of nuclear power, so they want to do both: reduce carbon emissions and phase out nuclear.

J – Wouldn't nuclear power be an inexpensive way to reduce carbon emissions?

Nuclear is not bankable. No nuclear plant is currently being built in any free market without massive state support. Nuclear is currently considered an inexpensive source of power for two reasons: first, all of the currently operating plants in the West were built long ago and have been written down – the longer they stay in operation, the more profitable they become; and second, we do not pay to complete cost of nuclear power in our power bills. Some of the costs are passed on to taxpayers and future generations.

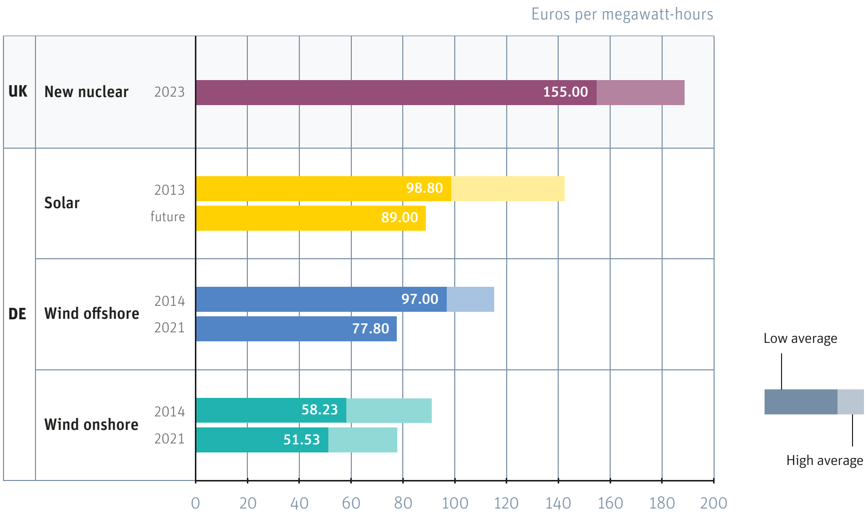
In the UK, French nuclear plant operator EDF is asking for a guaranteed 10 percent return on its investments over a 35-year time frame. Specifically, EDF is asking for 10 pence per kilowatt-hour, whereas the British government is offering eight (as of the beginning of June). In either case, this nuclear power would be far more expensive than onshore wind power currently is – and even more expensive than power from newly installed large ground-mounted arrays. For decades from now, this nuclear power will still cost the same, whereas new solar and wind are likely to have become even less expensive.

In the US, Wall Street has turned its back on financing risky nuclear power. Only the massive subsidy of 8.33 billion dollars in conditional federal loan guarantees keeps Southern Company's dream of building two additional reactors at Plant Vogtle in Georgia alive. Vogtle, however, has a history that should trouble taxpayers. The original two reactors at the Georgia site took almost 15 years to build, came in 1,200 percent over budget, and resulted in the largest rate hike at the time in Georgia.

Price of new nuclear already higher than solar and wind

FITs for current and future solar and wind in Germany with strike price for nuclear at Hinkley

Source: Thomas Gerke, DECC, Agora Energiewende



Decades-old nuclear plants (built with heavy subsidies and governmental support) do indeed produce quite inexpensive power, but all estimates are that the cost of building a nuclear plant today without heavy subsidies would be prohibitive. The only plants currently under construction in the EU (in France and Finland) are both behind schedule and far over budget.

K – Will the lights go out?

Germany has had the most reliable grid in Europe since standardized statistics started being tallied in 2006, and the German grid reached a new record reliability in 2011. Furthermore, other countries that are going renewable, such as Spain and Italy, have also seen grid reliability improve as they pump up renewables.

Within Europe (and probably worldwide), Germany has by far the most reliable power supply (see chart), and it was even more reliable in 2011 than the already world-leading average for 2006 to 2010. Germans have enough capacity for their households, their energy-intensive factories and industry, and their high-speed trains.

Germany (the red line at the bottom starting in 2006) has had by far the most reliable power supply in Europe every year from 2006 to 2010, the last year for which reliable statistics are available.

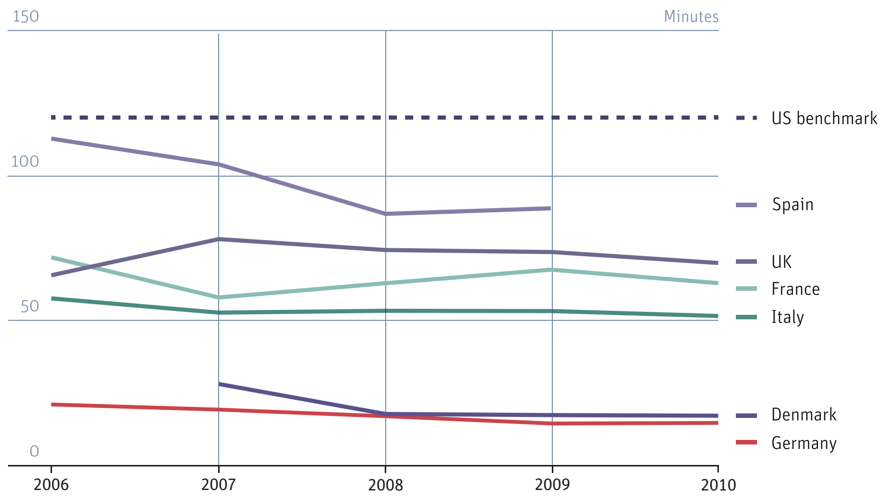
The history of German politicians claiming that the lights will go out in Germany without nuclear power probably begins with Hans Filbinger, former governor of the state of Baden-Württemberg, who said in 1975 that the lights would go out if the power plant in Wyhl was not built (see History). The plant was not built, and the lights stayed on – as they have continued to do, even though opponents of renewables continue to claim that we will not make it through the next winter (German power consumption is greater in the winter than in the summer).

Power outages are always possible, of course, but a systematic shortfall in power supply will only come about if investments in dispatchable power are not sufficient to replace aging conventional plants scheduled for decommissioning. Technically, the solutions are there: a combination of national and international grid extension and optimization, a power plant mix combining a variety of renewables, flexible backup capacity, a strategic reserve of power plants, demand management, and, ultimately, storage. The challenge is more financial. For the future, the power sector is calling for capacity payments to ensure that enough backup generating capacity remains in service. Chancellor Merkel's coalition has yet to say how that would happen, but most industry insiders agree that the market's current design will work for the next few years but is incompatible with the growth of renewable power in the midterm; the wholesale rate drops as more wind and solar electricity is produced, making investments in conventional generators increasingly unprofitable. At the same time, power companies are not penalized if there is a power outage, so there is currently no market instrument to provide either a carrot or stick that would ensure conventional backup capacity.

Grid reliability and renewable growth seem to go hand in hand

Minutes of power outages per year (excl. exceptional events), based on Saidi

Source: CEER and own calculations



Germany has generating capacity far exceeding power demand. Even after eight of its old nuclear plants were switched off in March 2011, Germany still had around 100,000 megawatts of conventional generating capacity online, compared to only 80,000 megawatts of maximum power demand for the year.

However, that does not mean that there is sufficient capacity everywhere on the grid. In the summer of 2011, Germany's Network Agency found that, under worst-case conditions (a cold winter day without solar power, little wind power, and maximum power demand), online failure on the transit grid and the sudden failure of a nuclear plant in southern Germany could cause a problem.

When it comes to power imports, the question is generally not a lack of power plant capacity, but rather cost. In 2011, Germany exported a total of six billion kilowatt-hours of power more than it imported. During the cold winter month of February 2012, Germany was also able to export to its neighbors. In the process, solar arrays in southern Germany helped prevent a power outage in France.

2012 that turned out to be a record year for power exports in Germany, and power exports increased even further by nearly 50 percent in 2013. The Netherlands are now the biggest net importer of German electricity followed by France.

L – Will the energy transition kill jobs?

Per megawatt-hour generated, renewables create more jobs than the fossil and nuclear sectors, and most of those jobs occur at home, not abroad. Germany already has twice as many people employed in the renewables sector than in all other energy sectors combined.

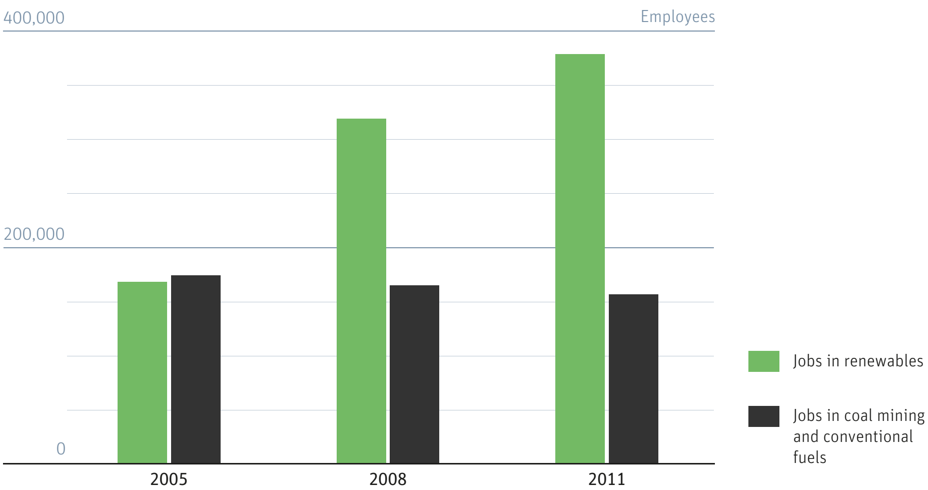
The transition to renewable energy is a job engine. An estimated 377,000 jobs had been created in the renewables sector in Germany by 2012, far more than the 182,000 people working in all of the country's other energy sectors combined. By 2020, more than 600,000 people are expected to work in the renewables sector – roughly as many as are currently employed in the automotive industry. These figures do not include countless jobs in the construction sector and related trades working on energy efficiency. An ambitious efficiency strategy could step up this trend, leading to the creation of more than 250,000 additional new jobs by 2020.

Simply put, renewables and efficiency replace oil and uranium imports with local added value, keep jobs in Germany, and have a net job creation effect.

Renewables create more jobs than conventional energy does

Employment in Germany in renewable and conventional energy sectors, 2005–2011

Source: BMU, BMWI

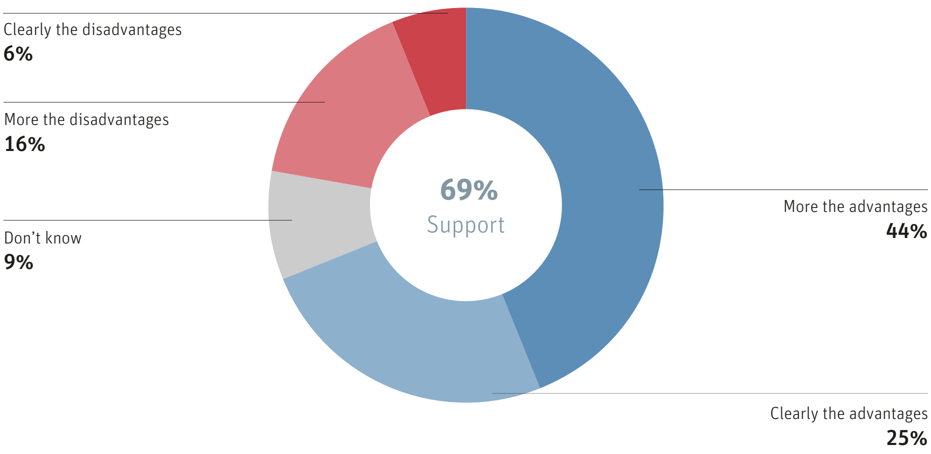


These figures represent "gross job creation," meaning the absolute number of jobs that have been added. A thorough study of the German market estimates a net job creation of around 80,000, rising to 100,000 – 150,000 in the period from 2020 to 2030. One reason why renewables have such a tremendous positive impact on net job creation is that renewable power directly offsets power from nuclear plants, and very few people work in those sectors.

Two thirds of Germans support Energiewende

Share of Germans who said advantages/disadvantages prevail in Energiewende. August 2013

Source: VZBZ



M – Do Germans support the energy transition?

Yes, and they have done so for much longer than Chancellor Merkel's coalition has.

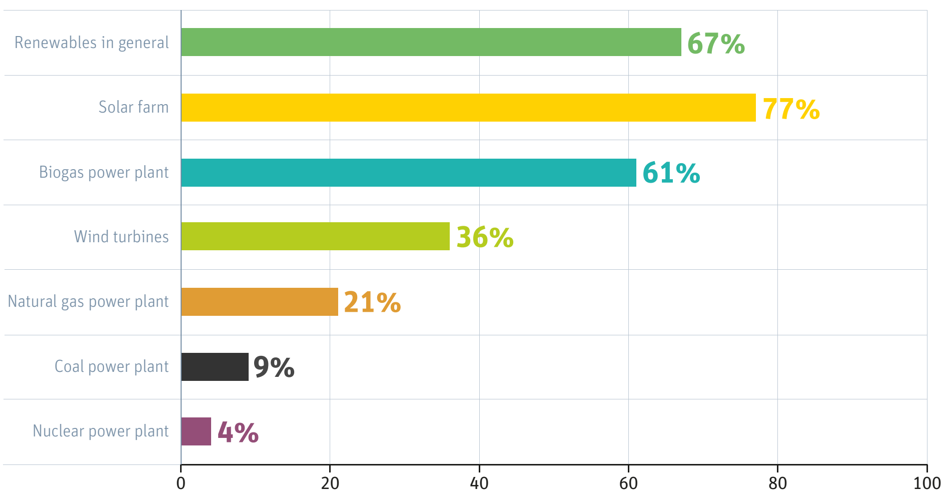
In July 2011, 54 percent of those surveyed stated that the current surcharge to cover the cost of renewable power was at an "acceptable" level; it made up around 14 percent of the retail power rate at the time. Another 25 percent said it was actually too low, so an overwhelming 79 percent had no problem with the surcharge in 2011.

The same survey found that 65 percent of Germans support renewables in general, with 76 percent supporting solar, 60 percent supporting wind power, and 51 percent supporting biomass. In contrast, only three percent supported nuclear, nine percent coal, and 22 percent natural gas. Not surprisingly, 94 percent stated that the growth of renewables was important or very important for them.

Renewables have broad support in Germany

Share of Germans who "like" or "like a lot" living close to power generation. October 2012

Source: www.unendlich-viel-energie.de



These figures were not unnaturally high as a result of the recent nuclear accident in Japan. In June 2012, BDEW – an organization representing power and water providers – conducted a survey that found that 90 percent of Germans believed the energy transition was important or very important. At the same time, 58 percent said the transition was "not progressing enough," and 61 percent felt that renewables were growing "too slowly." While 59 percent felt that the energy transition would be "generally beneficial" for Germany, only 35 percent believed they would personally benefit; 27 percent felt detrimentally affected.

Clearly, there are some obstacles. For instance, another study published by German weekly Focus found in 2012 that 51 percent of Germans did not want to have new power lines built near them.

N – How can Germany be both a green leader and remain an industrial powerhouse?

Renewables are lowering the wholesale power rate, which firms pay, and energy-intensive firms are largely exempt from the surcharge for renewable power. Energy-intensive industries therefore benefit from the cheaper electricity that renewable energy provides.

Heavy industry also benefits from renewables in a number of other ways. Technologies like wind, solar, biogas, and geothermal power provide economic opportunities for traditional industries. For instance, wind turbine manufacturers are now the second largest purchaser of steel behind the automotive sector. A number of struggling ports in Germany are also positioning themselves for the offshore wind sector. The solar sector will support industries ranging from glass to ceramics, and farming communities will benefit not only from biomass, but also from wind and solar. The copper sector is also poised to benefit from the switch to renewables. Thus, switching to renewable energy does not only result in developing new industries like solar manufacturing. These technologies also provide opportunities for traditional industries to become part of the transition to a renewable energy future.

Overall, Germans believe that high-tech green technologies are an industry for the future and see no contradiction between ecology and economics.

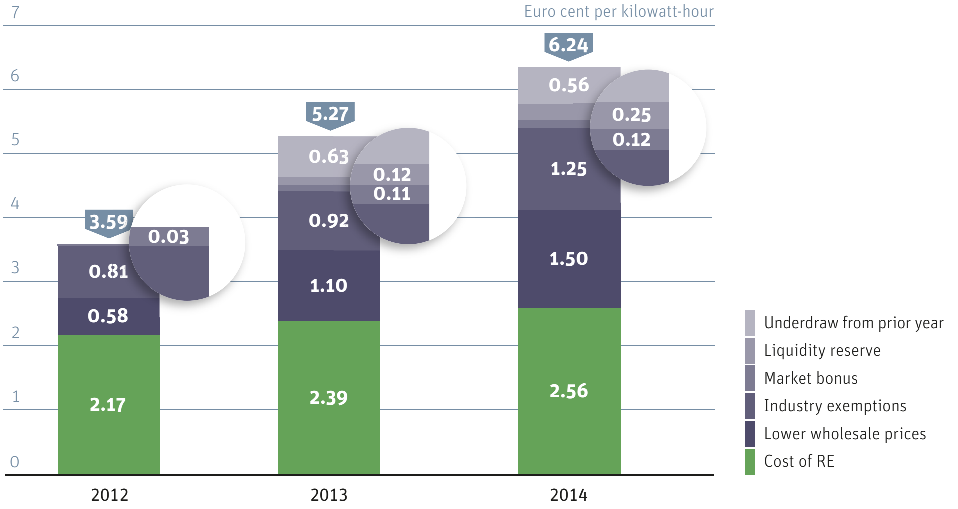
O – How are energy-intensive companies exempted from the surcharge for renewable power?

In 2000, when the original Renewable Energy Act became law, the Social Democrats in the Greens agreed that energy-intensive industry that faces international competition should be exempted from the surcharge to cover the cost of renewable power. The goal was to ensure that such firms do not "go offshore." But Chancellor Merkel's government has unnecessarily expanded those exemptions to cover firms that do not face international competition, thereby unfairly concentrating the cost burden on consumers and small and medium sized companies.

Renewables are not the main reason for rising surcharge

Calculation of renewable energy surcharge in Germany. 2012-2014

Source: BEE



Energy-intensive industry is widely exempt from the surcharge to promote renewables. While almost everyone basically paid 5.27 extra cents per kilowatt-hour in 2013, energy-intensive firms only paid the full 5.27 cents on ten percent of what they consume if their power costs make up more than 20 percent of their total production costs and they consume at least ten gigawatt-hours per year. They then pay 0.05 cents per kilowatt-hour for the remaining 90 percent of the power they consume.

It was estimated for 2012 that the exempt firms consumed 18 percent of German power supply but only covered 0.3 percent of the surcharge for renewable electricity. Chancellor Merkel's coalition has increased the number of industrial firms exempted from the surcharge from less than 600 to more than 2,000. Critics point out that many of these firms do not face international competition (such as public transportation providers) and therefore should not be exempt.

Overall, energy makes up a relatively small part of production costs in Germany's processing industry.

P – What role will shale gas play in the German energy transition?

International onlookers sometimes wonder when shale gas will get going in Germany. Americans in particular think, based on their own shale boom, that the Germans could reduce their carbon emissions and lower their energy prices with shale gas. The situation looks much different within Germany.

In Europe, shale gas is unpopular (see this overview). France has already banned it outright. The German government says that shale gas production can proceed "as soon as environmental concerns are assuaged" – which could be a diplomatic way of saying "never." In February 2013, then-Environmental Minister Peter Altmaier said:

"I do not see fracking being used anywhere in Germany in the foreseeable future ... To everyone who thinks I'm too careful about fracking: I don't know any town or community that would accept it."

The coalition agreement of November 2013 between the CDU and the SPD did not change that stance.

German shale gas reserves are estimated to be large enough to cover 13 years of the country's gas supply. Of course, the country would not shut down all imports of gas for 13 years, nor would it make sense to do so. Rather, domestic reserves would be stretched across decades, offsetting imports in the process.

During that time, we would run the risk of contaminating ground water and the environment. In the US, dozens of families have been affected by individual wells. Because Germany is so much more densely populated, thousands could be affected in single cases. Germans therefore wonder why they should take the risk just for 13 equivalent years of slightly more energy independence.

One reason could be lower prices. In the US, gas prices dropped, but only in parts of the country; the US does not have not a contiguous gas network. Germany, in contrast, is part of a gas network connecting Russia to the Netherlands; northern Africa is connected to Mediterranean Europe. If shale gas were made available, it could be sold to the highest bidder through a large network of buyers, so prices would not drop.

Indeed, gas prices are currently pegged to oil prices in Germany, so gas prices alone cannot fall independent of oil. But even if this pegging were done away with, gas prices would not fall because the gas could be sold on such as large market; Germans would just be taking risks with their environment so that gas companies could post greater profits.

A recent publication (May 2013) by Friends of the Earth found that the potential of shale gas may also be overstated:

- the five biggest gas wells in the US declined by 63% to 80% in the first year
- industry has downgraded its reserves several-fold in recent years
- firms such as BP, BHP Billiton and Chesapeake reduced the value of their shale gas assets accordingly by billions of dollars

In Europe in particular, FOE sees the aforementioned combination of population density and water scarcity as a general problem. Furthermore, a study conducted by the German KfW bank found that the US industrial sector overall had not become more competitive with the German industrial sector during the shale boom largely because energy prices make up such a small share of total costs (two percent), though the situation is different for a small number of firms that specifically consumer large amounts of natural gas.

Finally, low fossil fuel prices are not a goal of the Energiewende; keeping carbon in the ground is. As laudable as the efforts are to curb carbon emissions by switching from coal to shale gas, in the end we just take more carbon from the ground when we extract shale gas. What the world needs is an energy alternative that allows us to leave both fossil reserves in the ground. Germany is working on the most promising alternative now: renewables in combination with efficiency.

Q – Why did carbon emissions increase in 2013?

As of this writing (January 2014), no official figure for carbon emissions from German energy consumption had been released for 2013, but total energy consumption increased by an estimated 2.6 percent, and at one expert forecast an increase of "at least two percent" in November.

The main reason why emissions from energy consumption increased is unrelated to the power sector, however. According to the AGEB, the working group consisting of utility and finance experts that collate energy data for the country, the cold first half of 2013 was the main factor. Here, demand for heating energy was up, 80 percent of which is fossil fuel.

To address the heat and transport sectors, which make up roughly 4/5 of German power consumption, the German Energiewende would have to truly become an "energy" transition, not just an electricity transition. Only then can German carbon emissions from energy consumption truly be addressed.

In the heat sector, there has been a gradual shift from heating oil and coal to natural gas, which has lower specific carbon emissions, but in the power sector, natural gas is more expensive in Germany as a source of electricity, where coal is still less expensive. A European-wide carbon price from emissions trading was to facilitate the transition from emissions-heavy coal power to more environmentally friendly natural gas, but the carbon price has remained far too low.

Within the power sector, the increase in coal power production is mainly due to the record level of power exports, especially to the Netherlands and France. In 2013, German electricity exports to other countries rose at the same level as coal power production, which renewable electricity – which has a priority on the grid – would otherwise have offset. Coal plants are generally inflexible and cannot ramp up and down quickly to meet demand, so they prefer to sell power at very low cost. Likewise, the low carbon price in Europe means that coal power remains economically competitive. The solution here would be a much higher carbon price.

R – Is Germany undergoing a coal renaissance?

At present, a number of new coal plants are being built, and net generation capacity is expected to increase this decade. These plants were planned starting in the first phase of emissions trading, which failed to provide a shift from coal power to power from natural gas. But increasingly, renewables are offsetting demand, so this additional capacity is likely to be unprofitable. The firms are now scrambling to shut down capacity.

One of the main concerns about Germany's energy transition is the role of coal power. In the first half of 2013, the share of German coal power in total supply increased by five percentage points to 52 percent. The recent reports of new coal plants going online have also drawn a lot of attention.

As Germany phases out its nuclear plants up to 2022, more space will indeed be created on the power grid for coal plants, which would otherwise be squeezed out by renewables. At present, renewable electricity primarily offsets power from natural gas, which is currently more expensive than coal power. Natural gas combustion emits only about half as much CO2 as the burning of coal. Though it would be better for the climate, a switch from coal power to natural gas will be a tough sell politically. Germany imports almost all of its gas, 40% of it from Russia, and is the world's largest brown coal producer. An estimated 35,000 jobs could be at stake in the Garzweiler region, less than a tenth of the jobs in the renewables sector.

Depending on how quickly renewables grow in power supply, however, new plants may increasingly run for fewer hours per year. A study published in 2013 for the British government found that the "apparent surge" in new coal plant construction in Germany was the result of a favorable market environment in 2007/2008 and concludes that "there will be no major new unabated coal or date night projects in Germany for the foreseeable future beyond those currently under construction."

Indeed, since the nuclear phaseout of 2011, plans to build new coal plants in Germany are down. In democracies, coal plants are not built in a couple of years, so the ones that went online in 2012 and 2013 were not a result of energy transition.

A chart (PDF in German) published by German environmental NGO Deutsche Umwelthilfe in 2013 shows that, as a reaction to the nuclear phaseout, Germany has not started building any coal plants and has even stepped away from six.

S – How much electricity storage will Germany need?

In 2013 Germany demonstrated that it could get nearly 14 percent of its power from wind turbines and photovoltaics without an any additional power storage. Going forward, demand for power storage will depend partly on the extent to which power demand can be shifted to accommodate intermittent green power production. In general, power storage is not expected to become a major issue until the end of this decade.

In the short term, not much. Based on statistics for actual power generation from the first half of 2012, energy expert Bernard Chabot has estimated that a combined future output of 46 gigawatts of wind and 52 gigawatts of PV (the current targets) would generally not peak above 55 gigawatts, meaning that this level of generating capacity – which Germany is only a few years away from – would not require a lot of power to be stored because almost all of the electricity generated could be consumed. The bad news is that moving beyond that limit will increasingly require power storage.

On the other hand, his statistics also show that combined wind and solar power production would still peak at a mere five to six gigawatts around seven days a year. At power consumption levels ranging from 40-80 gigawatts, Germany will therefore still need nearly a full 80 gigawatts of dispatchable capacity even if these goals are met. The problem is that an increasing amount of this dispatchable capacity will be idled almost all the time, making such systems unprofitable. One solution proposed is capacity payments and the creation of a strategic reserve – but it is unclear what policy will be implemented and what the details will be. There are, however, several solutions.

T – How could the cost of Germany's energy transition be decreased?

A number of steps have to be taken to ensure that the cost of renewable electricity is equally spread across power consumers, and the benefits of distributed power have to be utilized. Overall, Germany needs to start focusing on the cost impact of individual actions on the overall power supply.

A number of decisions have made Germany's energy transition unnecessarily expensive; some solutions are on the drawing board.

To begin with, feed-in tariffs have become unnecessarily expensive with the "market bonus," which is estimated to have cost an additional 500 million euros in 2011 without having increased renewable power production.

Second, the German electricity market needs to be redesigned so that lower wholesale prices brought about by renewable power are passed on to consumers. Furthermore, German industry needs to pay its fair share in the switch to renewables; it already benefits from lower wholesale prices, so the exemption from the surcharge for renewables is a second benefit – and industries that do not face international competition do not need to be exempt.

Finally, a focus on distributed technologies would reduce the need for – and hence the cost of – grid expansion.

The government is focusing on offshore wind, which is currently much more expensive than onshore wind and even more expensive than ground-mounted solar arrays. Within just a few years, even small solar roofs will be cheaper than offshore wind – and offshore wind requires the most grid expansion of all types of renewable power.

Distributed power should require far less grid expansion than large, central projects, especially offshore wind, but some experts say a well designed focus on sites with the best resources could indeed be the least expensive option. Furthermore, the wind sector has already implemented its own ideas about how the grid can be inexpensively expanded, but the government has yet to provide a proper policy framework.

Key findings

German Energy Transition – Arguments for a renewable energy future

1. The German energy transition is an ambitious, but feasible undertaking.

A lot of people outside Germany, including environmentalists, are skeptical. But even the skeptics like Germany's goal of demonstrating that a thriving industrial economy can switch from nuclear and fossil energy to renewables and efficiency. The German can-do attitude is based on the experience over the last two decades, when renewables matured much more quickly, become more reliable and much cheaper than expected. The share of renewable electricity in Germany rose from 6% to nearly 25% in only ten years. On sunny and windy days, solar panels and wind turbines now increasingly supply up to half the country's electricity demand, which no one expected just a few years ago. Recent estimates suggest that Germany will once again surpass its renewable electricity target and have more than 40% of its power from renewables by 2020. Furthermore, many German research institutes and the government and its agencies have run the numbers and developed sound scenarios for a renewable economy.

2. The German energy transition is driven by citizens and communities.

Germans want clean energy, and a lot of them want to produce it themselves. The Renewable Energy Act guarantees priority grid access to all electricity generated from renewables and is designed to produce reasonable profits. In 2013, more than half of investments in renewables had been made by small investors. Large corporations, on the other hand, have invested relatively little so far. The switch to renewables has greatly strengthened small and midsize businesses, and it has empowered local communities and their citizens to generate their own renewable energy. Across Germany, a rural energy revolution is underway. Communities are benefiting from new jobs and increasing tax revenues, which has become even more important after the debt crisis in the euro zone.

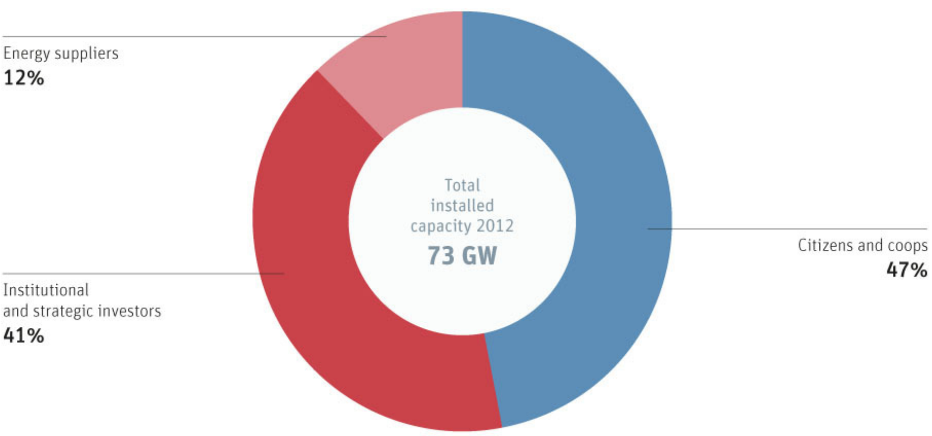
3. The energy transition is Germany's largest post-war infrastructure project. It strengthens its economy and creates new jobs.

The economic benefits of the transition already today outweigh the additional cost over "business as usual". The switch to a highly efficient renewable energy economy will require large-scale investments of up to 200 billion euros. Renewables only seem to cost more than conventional energy, but they are getting cheaper, while conventional energy is getting more expensive; furthermore, fossil fuel remains highly subsidized, and the price of fossil fuel does not include environmental impacts.

German energy transition is a democratic movement

Ownership of renewables in 2012

Source: AEE, www.unendlich-viel-energie.de



Renewables create more jobs than conventional energy does

Employment in Germany in renewable and conventional energy sectors, 2005–2011

Source: BMU, BMWI

These figures represent "gross job creation," meaning the absolute number of jobs that have been added. A thorough study of the German market estimates a net job creation of around 80,000, rising to 100,000 – 150,000 in the period from 2020 to 2030. One reason why renewables have such a tremendous positive impact on net job creation is that renewable power directly offsets power from nuclear plants, and very few people work in those sectors.

By replacing energy imports with renewables, Germany's trade balance will improve and its energy security will strengthen. Already, more than 380,000 Germans work in the renewables sector – far more than in the conventional energy sector. Unemployment has reached an all-time low since reunification in 1990. While some of these are manufacturing jobs, many others are in installing and maintenance. These jobs for technicians, installers, and architects have been created locally and can't be outsourced. They already have helped Germany to come through the economic and financial crisis much better than other countries.

4. With the energy transition, Germany aims to not only keep its industrial base, but make it fit for a greener future.

German climate and energy policies are designed to maintain a strong manufacturing base at home. On the one hand, industry is encouraged to improve its energy efficiency. On the other, industry benefits from exemptions to regulations (some of them probably too generous) to ease the burden on industry. Contrary to one common misconception, renewables have turned Germany into an attractive location for energy intensive industries. In 2012, wind and solar energy have driven down prices on the wholesale power market by more than 10%. Since 2010, they are down by 32%. Cheaper electricity means lower business expenses. Industries from steel to glass and cement benefit from these low energy prices. But the benefits of the energy transition extend beyond today. The demand for solar panels, wind turbines, biomass and hydro power plants, battery and storage systems, smart grid equipment, and efficiency technologies will continue to rise. Germany wants to gain a first-mover advantage and develop these high-value engineering technologies "Made in Germany". The focus on renewables and energy conservation is part of that forward-looking approach to business investments. When the world switches to renewables, German firms will be well positioned to deliver high quality technology, skills, and services for these markets.

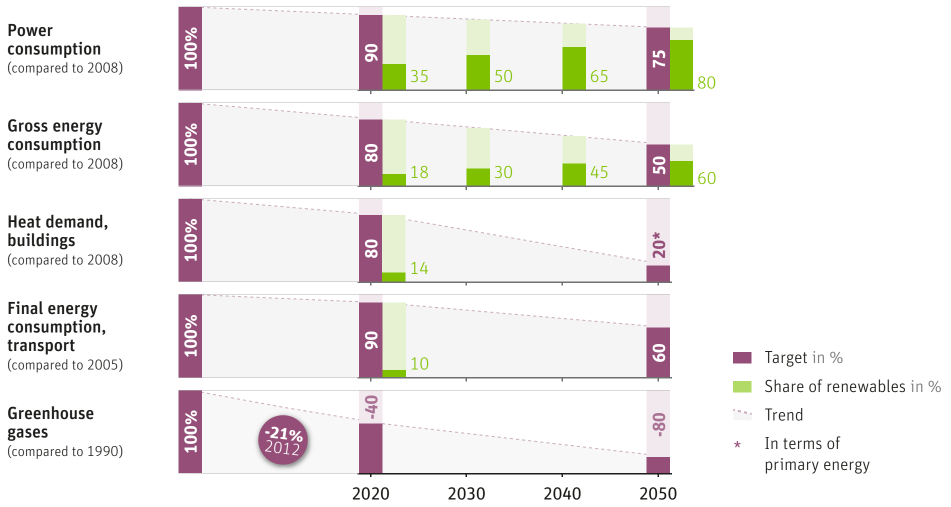
5. Regulation and open markets provide investment certainty and allow small business to compete with large corporations.

Germany's energy policy is a mix of market-based instruments and regulation. Under the Renewable Energy Act, renewable electricity has guaranteed grid access to provide investment certainty and allow family businesses and small firms to compete with large corporations. The policy enables producers of green electricity to sell their power to the grid at a set rate. The rates are "degressive," meaning they decline over time to drive down future prices. Unlike coal and nuclear power, the costs for renewables are not hidden and passed on to future generations, but transparent and immediate. The government sees its role as setting targets and policies; the market decides how much is invested in renewables and how the price of electricity develops. Consumers are free to choose their power provider so they can buy cheaper electricity or switch to a provider with a 100% renewable portfolio.

German energy transition: high certainty with long-term targets

Long-term, comprehensive energy and climate targets set by the German government in 2010

Source: BMU



6. Germany demonstrates that fighting climate change and phasing out nuclear power can be two sides of the same coin.

A lot of countries are struggling to fulfill their climate commitments. The decommissioned nuclear capacity was replaced with more renewables, conventional back-up power plants, and greater efficiency. Renewables reduce Germany's GHG emissions by around 130 million tons annually. Overall, Germany will overshoot its Kyoto target of a 21% reduction for 2012. By the end of 2011, Germany had reduced its GHG emissions by 27% and is now moving towards reaching its 2020 target of 40% reductions (relative to 1990).

7. The German energy transition is broader than often discussed. It not only includes renewable electricity, but also changes to energy use in the transportation and housing sectors.

Germany's energy transition is not only about switching from nuclear and coal to renewables in the electricity sector. Electricity only makes up roughly 20 percent of German energy demand, with roughly 40 percent devoted to heat and 40 percent to transportation. Most public attention has focused on the power sector, with the nuclear phase-out and the switch to wind power and solar power making headlines. But in fact, Germany is a leader in "passive houses," which make heating systems in homes largely redundant. Unfortunately, however, renovation rates are too low for the tremendous efficiency gains from passive house construction to be fully effective. In addition, Germany has not expanded its district heating networks, which allow waste heat from power generators to be used productively, as fast as its neighbors in Austria and Denmark. But perhaps the greatest challenges lie in the transportation sector, where a number of options are being looked into worldwide – from electric mobility to hybrid vehicles. Germany is not a leader in such technologies. But the greatest efficiency gains will come about when we switch from individual mobility to public transport – and from large cars to small vehicles, such as electric bicycles, when we have to resort to individual transportation.

8. The German energy transition is here to stay.

It is very unlikely that Germany will reverse its course. The transition away from nuclear power has been long in the making. Of course the Big Four utilities (E.ON, RWE, Vattenfall, EnBW) once fought hard to defend their incumbent interests by delaying the switch to renewables, but Eon and RWE have publicly announced their plans to stop building nuclear plants internationally, and EnBW is now owned by the State of Baden-Württemberg, which has a Green governor who is unlikely to instruct the company to support nuclear more. Industrial giant Siemens has also stepped away from nuclear in its global portfolio and now wants to focus on wind power and hydropower. The public strongly supports extending renewables, even in light of rising retail power rates. Germans expect their political leaders to take on the challenge of the energy transition. There are disagreements across the political spectrum about which strategies are the best, but in general all German political parties today support the energy transition because the German public overwhelmingly does.

9. The energy transition is affordable for Germany, and it will likely be even more affordable for other countries.

Germany has benefited economically from its international leadership role in going renewable – similar to Denmark and other pioneers moving to renewables. Germany has created the world's largest domestic solar PV market. German commitment and Chinese mass scale production has helped to drive down the cost of renewables worldwide. In Germany, installed system prices for solar PV plummeted by 66% from 2006 to mid-2012. It will be much cheaper for other countries to invest in renewables now that the costs are lower. On top of that, many countries have much better solar resources than Germany; some of them with the capability of producing up to twice as much power from the same solar panel, because of more sunshine.

Back-up power

Backup power is not a clearly defined term. In general, it indicates that certain power plants need to be maintained on standby in case other generators failed to produce power. In the case of wind and solar, dispatchable backup power will always be required, though this could soon increasingly, in the form of stored excess renewable power. Conventional plants occasionally malfunction themselves and have therefore always required some kind of backup capacity; countries that do not rely heavily on our imports all have a part of their generating capacity on standby almost all the time. In addition, many countries, including Germany, have "reserve capacity" – power plants that only rarely run in case of emergencies. For the German grid, oil-fired power plants are generally reserve capacity.

Baseload / medium load / peak power

Baseload power plants are those that cover the minimum amount of power a country needs around-the-clock. For instance, German power consumption rarely drops far below 40 gigawatts (link to kilowatt) even in the middle of the night, so the baseload would be considered roughly the first 40 gigawatts. Power plants that serve this load generally run around the clock when in operation. The medium load is then the load that is generally reached every day. On a normal workday, power consumption in Germany easily reaches 60 gigawatts reliably, so the medium load might be considered the area between 40-60 gigawatts. Power plants that serve this load run regularly but also ramp up and down on a daily basis. The peak load is everything above the medium load. In Germany, power demand rarely rises above 80 gigawatts, so the peak load can be considered from 60-80 gigawatts. Peak power plants run rarely, must be able to ramp up quickly, and may often be idle for days and weeks at a time.

Brown coal / lignite

See hard coal.

Carbon emissions / greenhouse gases / heat-trapping gases

One main reason why the planet Mars is so much cooler than the Earth is that Mars has no atmosphere. Essentially, the Earth's atmosphere acts as a blanket; sunlight that reaches the Earth bounces around in the atmosphere a bit before leaving. In the process, heat builds up instead of quickly dissipating. A number of gases intensify this insulation effect more than others, but to keep things simple, experts express everything in terms of equivalent carbon emissions, with carbon dioxide being the largest factor by volume. Essentially, civilization is taking carbon that has been trapped underground (in coal, gas and oil) and pumping it into our atmosphere, thereby making the atmospheric blanket more effective. These gases are also collectively referred to as "greenhouse gases," a term that has too positive connotations for some – after all, dramatically rising temperatures are expected to have drastically negative consequences, not the pleasant ones suggested by the term "greenhouse." The term "heat-trapping gases" is therefore also used, as is the "overheating of the climate" instead of the more positive-sounding "global warming."

Capacity factor

The relationship between a generator's rated capacity (measured, say, in kilowatts) and the amount of energy produced (measured, say, in kilowatt-hours). For instance, a wind turbine with a rated capacity of 1.5 megawatts could theoretically produce a maximum of 36 megawatt-hours a day (1.5 MW x 24 hours) under ideal conditions, equivalent to a capacity factor of 100 percent – the turbine then generates its maximum output all the time. In practice, an onshore wind turbine has a capacity factor closer to 25 percent in good locations, so a 1.5 MW turbine would run at 0.375 megawatts on the average, producing nine megawatt-hours a day. In Germany, the capacity factor of onshore wind turbines is below 20 percent, whereas the capacity factor of offshore wind turbines is estimated to be in the mid-30s. The capacity factor of solar likewise largely depends upon the amount of sunlight and is generally estimated to be between 10 percent and 20 percent. See "full-load hours." Full-load hours: Whereas capacity factor is an indication of capacity utilization as a percentage, one also speaks of "full-load hours," an especially useful term for dispatchable generators, which can be switched on and off – such as biomass, coal, natural gas, and nuclear. There are 8,760 hours in a normal year. The number of full-load hours can be used, say, as an indication of how many hours a particular generator needs to run each year to be profitable. For instance, a particular power plant may need 4,000 full-load hours of operation to be profitable, equivalent to a capacity factor of 4,000 / 8,760 = 45.7 percent. If it runs at 50 percent capacity, it would need to run for 8,000 actual hours to achieve 4,000 full-load hours.

Cogeneration / trigeneration

When the waste heat of electricity generator is recovered for useful applications, we speak of the "cogeneration" of heat and power. "Trigeneration" indicates that the waste heat is partly also used to provide cooling. Not to be confused with combined-cycle gas turbines, where the waste heat (steam) is recovered to drive a second, downstream generator that produces more electricity, but does not directly provide waste heat as an application. In cogeneration, the waste heat is not recovered to produce additional electricity, but to provide space heating, process heat, etc.

Demand Side Management (DSM)

Also known simply as "demand management." Electricity cannot easily be stored, so the exact amount consumed generally has to be the same as the amount generated. Until recently, our power supply systems were designed so that the supply side was managed to meet demand; our central-station power plants ramp up and down as electricity demand increases and decreases. With intermittent renewables (see dispatchable), however, power supply will no longer be able to be adjusted so easily, so demand will have to be managed. For instance, when there is enough power, refrigerators and freezers could cool down a bit more so they can "ride through" a few hours of lower power production. In this way, peak power demand can be shifted slightly.

Dispatchable
Dispatchable power plants are simply those that can be switched on and off and ramped up and down to meet power demand. Gas turbines are the most flexible, though modern coal plants also ramp up and down well. Older coal plants prefer to be switched on and left running near full capacity, as do nuclear plants. Like gas turbines, generators running on biomass are generally quickly dispatchable, but they are the only type of new renewable source that can be considered dispatchable in Germany. Wind and solar are considered "intermittent," meaning that they do not produce power all the time, though power production can be reliably predicted at least a day ahead. Most importantly, wind turbines and photovoltaics cannot be "dispatched," i.e. switched on and off. Aside from hydropower, the only other renewable sources of electricity that are dispatchable are geothermal and concentrating solar power, which Germany does not have in large quantities.

Distributed power
Electricity produced by a large number of small generators (solar roofs, wind turbines, etc.), as opposed to a centralized power supply based on a large power stations (not only nuclear and coal plants, but also utility-scale photovoltaic power plants and large wind farms).

Efficiency
The amount of useful energy output relative to the amount input. Not to be confused with the capacity factor. For wind power and solar power, efficiency measures something fundamentally different than for non-renewable resources. For instance, an old coal plant may have an efficiency of 33 percent, meaning that a third of the energy in the coal is converted into electricity, with the other two thirds being lost as waste heat. Nonetheless, 33 percent may sound better than the 15 percent efficiency of an off-the-shelf solar panel. But there is a difference: the coal is lost forever when consumed, so it makes sense to use it as efficiently as possible; in other words, we lose what we use. While it obviously also makes sense to use sunlight as efficiently as possible, with solar and wind we lose what we do not use – the Earth gets roughly the same amount of energy from the Sun every day. Whatever we do not harvest with wind turbines and solar panels is lost forever. This distinction becomes clearer when we keep in mind that the volume of coal power is different depending on whether we count primary energy or useful energy, but the amount of wind and solar power is the same in terms of primary/useful energy.

Energy
Here, distinctions are made in the type of application (electricity, motor fuel, and heat) as well as between energy as an amount (measured, for instance, in kilowatt-hours) and power as potential (see kilowatts).

Energy crop
A plantation whose sole purpose is to provide energy. A crop of corn planted to provide food, for example, is not an energy crop if its waste residue is also recovered and used to generate energy. To stick with the example of corn, an energy crop used to produce biogas is actually harvested before the ears become ripe enough to eat, and the entire plant is used in the process. In contrast, only the fruit – the edible part – is used to make ethanol.

Energy-intensive
In Germany, firms that consume a lot of energy and face international competition are largely exempt from the surcharge to cover the cost of renewable power. To be eligible, companies have to consume at least 10 GWh per year to fall into the category of "privileged industry." In 2011, some 300 energy-intensive firms paid 0.05 cents per kWh to cover the cost of German feed-in tariffs for 90 percent of their power and only paid the full surcharge of 3.52 cents for the first 10 percent; everyone else paid 3.52 cents per kilowatt-hour extra for all of their power. Furthermore, if a firm consumes at least 100 GWh per year and power costs make up more than 20 percent of total production costs, it does not even have to pay the full surcharge for the remaining 10 percent of its consumption.

Full-load hours
Whereas capacity factor is an indication of capacity utilization as a percentage, one also speaks of "full-load hours," an especially useful term for dispatchable generators, which can be switched on and off – such as biomass, coal, natural gas, and nuclear. There are 8,760 hours in a normal year. The number of full-load hours can be used, say, as an indication of how many hours a particular generator needs to run each year to be profitable. For instance, a particular power plant may need 4,000 full-load hours of operation to be profitable, equivalent to a capacity factor of 4,000 / 8,760 = 45.7 percent. If it runs at 50 percent capacity, it would need to run for 8,000 actual hours to achieve 4,000 full-load hours.

Generation capacity aka rated capacity
The maximum output a generator can produce under specific conditions.. For instance, a single wind turbine may have a rated capacity of 1,500 kilowatts (1.5 megawatts), but it will only produce that much power under strong winds. See "capacity factor."

Grid access
One obstacle to the growth of renewables is a lack of grid access. German law specifies that renewable electricity has a priority on the grid, meaning that conventional power generators have to ramp down production. Other countries more easily allow wind turbines and solar arrays to be disconnected to protect the profitability of conventional plants. Furthermore, German law specifies the conditions under which grid operators must expand the grid to provide a connection for wind turbines, biomass units, and solar arrays. Otherwise, investments made in renewables could come to naught if the grid operator fails to provide a connection.

Gross energy / final energy
Gross energy includes energy consumption within the energy sector along with distribution losses; final energy is the energy that reaches your doorstep as fuel or electricity. In other words, losses in production and transport are not included. For instance, gross electricity consumption in Germany was nearly 600 terawatt-hours in 2011, whereas net power consumption was reported at around 535 terawatt-hours. The "missing" 60 terawatt-hours were consumed by power plants themselves or lost in power lines. See also primary energy.

Hard coal / anthracite

Anthracite is basically another way of saying "hard coal," just as lignite is another term for "brown coal." Brown coal, which Germany has in large quantities, is the dirtiest kind of coal; it has relatively high water content and hence relatively low energy content; it is therefore not generally shipped over long distances. In contrast, hard coal is more compact with higher energy content, which make it affordable to ship around the world. Hard coal is generally what we imagine as a "lump" of coal. Brown coal is softer. But in practice, there is no clear distinction between lignite and anthracite, which are perhaps best seen as two ranges on a spectrum. Indeed, most of the coal used in the United States is called "bituminous" and has a slightly lower energy content than what Germans would call hard coal.

Kilowatt vs. kilowatt-hour

1,000 watts is a kilowatt. Likewise, 1,000 kilowatts is a megawatt; 1,000 megawatts, a gigawatt; and 1,000 gigawatts, a terawatt. A hair dryer that has "1,000 watts" written on its label consumes a kilowatt of electricity when it is on full blast. If it runs for an hour, it has consumed a kilowatt-hour. Likewise, an appliance that consumes 2,000 watts when it is on will consume 1,000 watt-hours (or a kilowatt-hour) when it runs for 30 minutes. The terms "kilowatt" and kilowatt-hour are commonly confused, but the terms refer to completely different things. If you need a memory aid, think of kilowatts as horsepower – the amount of power your car's engine can provide. Horsepower is then equivalent to kilowatts – the engine/appliance's potential. But your car rarely runs at full horsepower, and most of the day it stands around doing nothing to. So think of kilowatt-hours – the work done, as opposed to the potential – as, roughly, the number of kilometers driven.

Merit order

Indicates the order in which power is bought from power plants on the market. The merit order means that the most expensive plants currently producing determines the price of power on the power exchange. Power plants are ranked and switched on in the order of their "marginal price," which is basically the cost of operation (especially fuel); it specifically does not include the cost of plant construction, for instance. In the case of coal and nuclear, a plant is expensive to construct but relatively inexpensive to operate, so such plants have relatively low marginal prices and therefore run for a large number of full-load hours. In contrast, natural gas turbines are relatively inexpensive to build, but natural gas is expensive in many parts of the world, so gas turbines run for a fewer number of hours when natural gas is more expensive than coal, as is the case in Germany – but not, for instance in the UK. Renewable electricity has a priority on the grid and therefore is not ranked by price. The effect of renewables is therefore the same as lower consumption; the most expensive peak power plants run less often, thereby lowering the price on the exchange.

Passive house

A building (residential or otherwise) that "passively" uses solar heat (sunshine) to drastically reduce the need for "active" heating and cooling, such as from an air conditioner and heating system. In Germany, new homes are already able to do without central heating systems, with only small backup heaters used for a few days a year. Increasingly, old buildings can also be renovated to fulfill the standard. In warmer climates, passive houses can also be built largely to offset cooling demand.

Primary energy

The amount of energy put into a supply system, as opposed to the "useful energy" that the supply system outputs to consumers. For instance, the tons of coal fed to a coal plant are considered primary energy, whereas the electricity that leaves the plant is considered secondary energy. For instance, a coal plant with an efficiency of 40 percent consumes 2.5 times more primary energy (coal) than it produces in the form of electricity (secondary energy). For wind and solar, there is no difference between primary and secondary energy. See efficiency.

Spot / day-ahead market

Power can be bought and sold in long-term agreements, the most common model for the bulk of electricity in free markets like Germany. But because actual power demand cannot be exactly estimated 18 months in advance – the term sometimes applicable for power purchase contracts in Germany – the remainder is purchased on the power exchange, which consists partly of a spot market for relatively immediate purchases and the day-ahead market, for purchases the next day. The day-ahead market is especially interesting for renewables like solar and wind, which depend on the weather – and that can only be reliably predicted within 24 hours.