

# The silent Energy [R]evolution

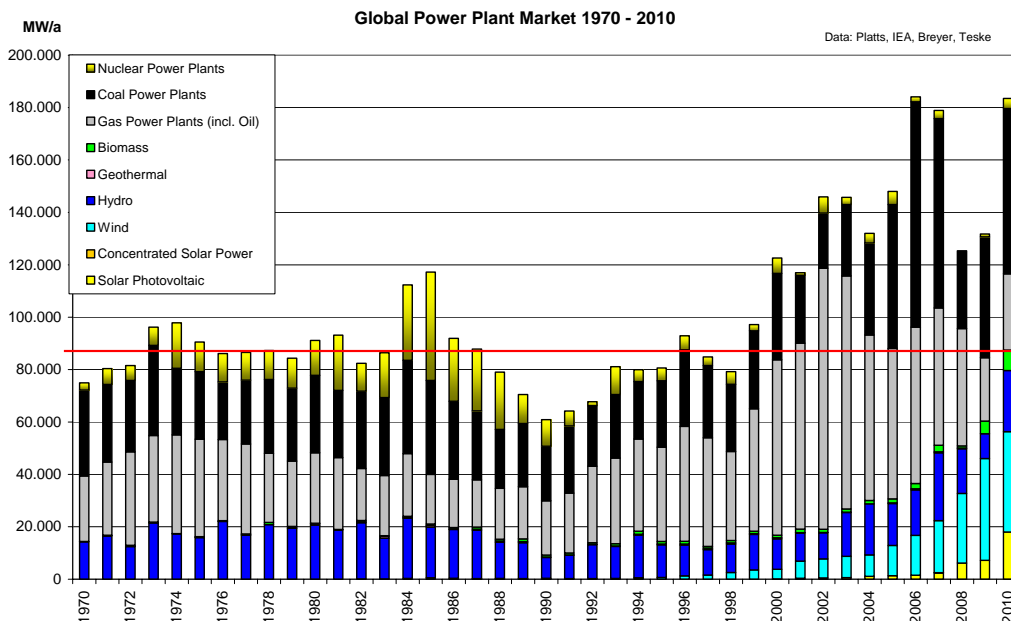
20 years in the making

The bright future for renewable energy is already underway. This new analysis of the global power plant market shows that since the late 1990s, wind and solar installations grew faster than any other power plant technology across the world - about 430,000 MW total installed capacity between 2000 and 2010. However it is too early to claim the end of the fossil fuel based power generation, as at the same time more than 475,000 MW new coal power plants, with embedded cumulative emissions of over 55 bn tonnes CO<sub>2</sub> over their technical lifetime.

The global market volume of renewable energies in 2010 was on average, as much as the total global energy market volume each year between 1970 and 2000. The window of opportunity for renewables to both dominate new installations replacing old plants in OECD countries, as well as ongoing electrification in developing countries, closes within the next years. Good renewable energy policies and legally binding CO<sub>2</sub> reduction targets are urgently needed.

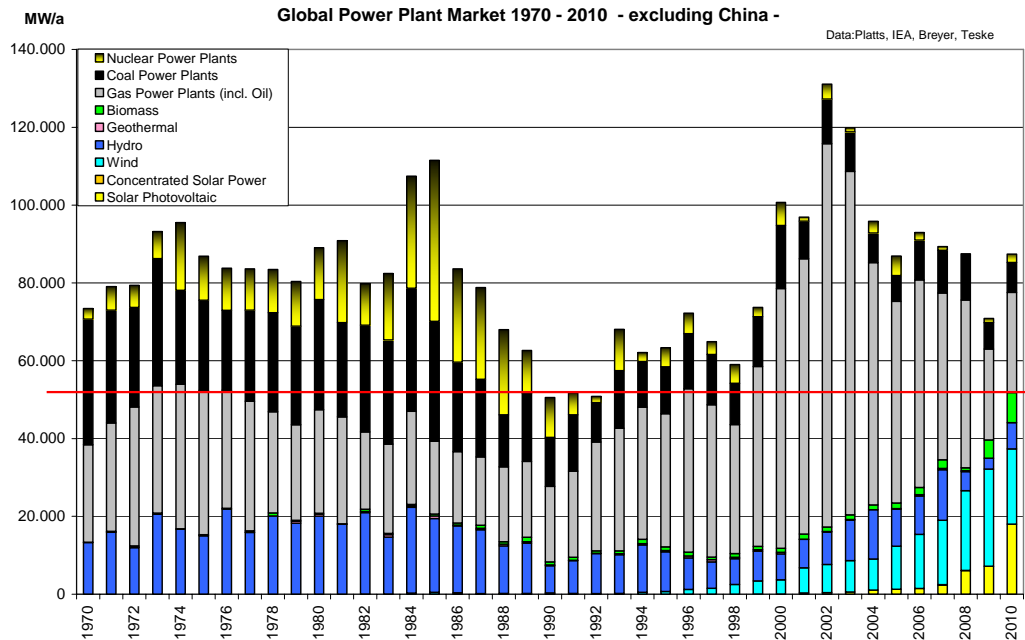
This briefing provides an overview of the global annual power plant market of the past 40 years and a vision of its potential growth over the next 40 years, powered by renewable energy. Between 1970 and 1990, OECD<sup>1</sup> countries that electrified their economies mainly with coal, gas and hydro power plants dominated the global power plant market. The power sector, at this time, was in the hands of state-owned utilities with regional or nationwide supply monopolies. The nuclear industry had a relatively short period of steady growth between 1970 and the mid 1980s - with a peak in 1985, one year before the Chernobyl accident - while the following years were in decline, with no sign of a 'nuclear renaissance', despite the rhetoric.

Between 1990 and 2000, the global power plant industry went through a series of changes. While OECD countries began to liberalise their electricity markets, electricity demand did not match previous growth, so fewer new power plants were built. Capital-intensive projects with long payback times, such as coal and nuclear power plants, were unable to get sufficient financial support. The decade of gas power plants started.



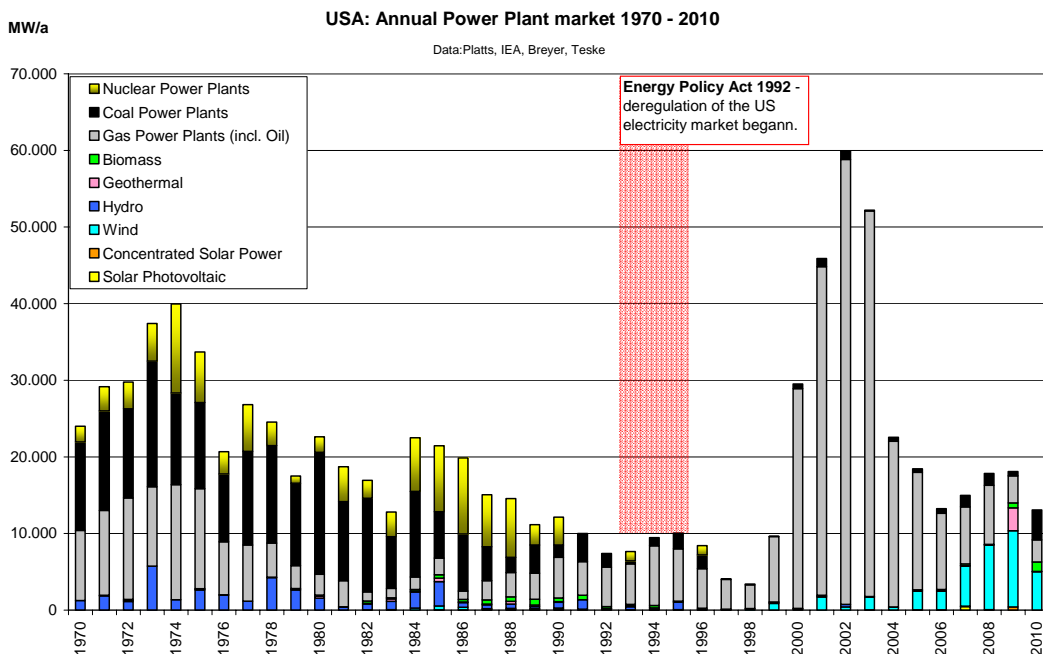
<sup>1</sup> Organisation for Economic Co-operation and Development

Economies of developing countries, especially in Asia, started growing during the 1990s, and a new wave of power plant projects began. Similarly to the US and Europe, most of the new markets in the 'tiger states' of Southeast Asia partly deregulated their power sectors. A large number of new power plants in this region were built from Independent Power Producer (IPPs), who sell the electricity mainly to state-owned utilities. The dominating new built power plant technology in liberalised power markets are gas power plants. However, over the last decade, China focused on the development of new coal power plants. Excluding China, the global power plant market has seen a phase-out of coal since the late 1990s; the growth is in gas power plants and renewables, particularly wind.



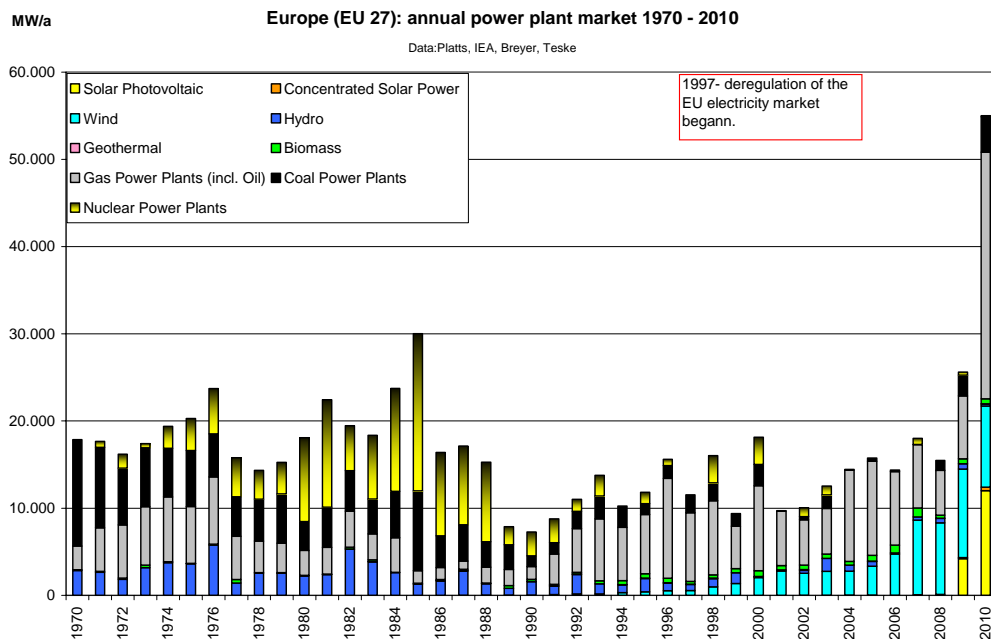
### Power plant markets in the US, Europe and China

Electricity market liberalisation has a great influence on the chosen power plant technology. While the power sector in the US and Europe moved towards deregulated markets, which favour mainly gas power plants, China added a large amount of coal until 2009, with the first signs for a change in favour of renewables in 2009 and 2010.

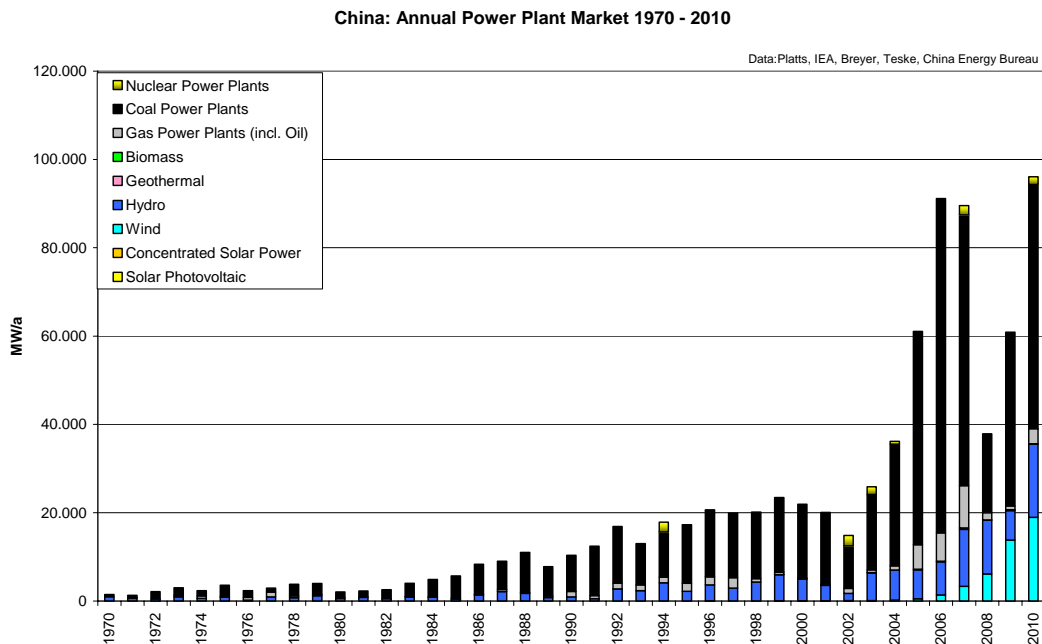


**US:** The liberalisation of the power sector in the US started with the Energy Policy Act 1992, and became a game changer for the entire power sector. While the US in 2010 is still far away from a fully liberalised electricity market,

the effect on the chosen power plant technology has changed from coal and nuclear towards gas and wind. Since 2005, a growing number of wind power plants make up an increasing share of the new installed capacities as a result of mainly state based RE support programmes. Over the past year, solar photovoltaic plays a growing role with a project pipeline of 22,000 MW (Photon 4-2011, page 12).



Europe: About five years after the US began deregulating the power sector, the European Community started a similar process. Once again, the effect on the power plant market was the same. Investors backed fewer new power plants and extended the lifetime of the existing ones. New coal and nuclear power plants have seen a market share of well below 10% since then. The growing share of renewables, especially wind and solar photovoltaic, are due to a legally-binding target for renewables and the associated renewable energy feed-in laws which are in force in several member states of the EU 27 since the late 1990s. Overall, new installed power plant capacity jumped to a record high, due to the repowering needs of the aged power plant fleet in Europe.

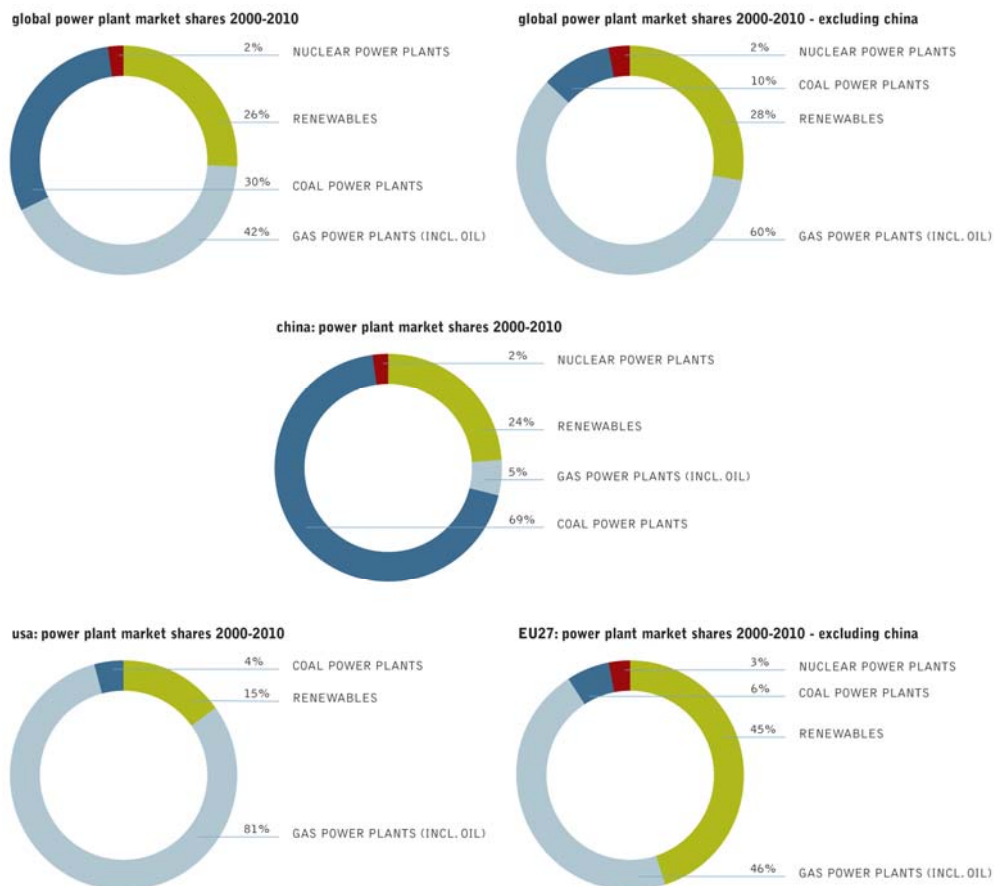


China: The steady economic growth in China since the late 1990s, and the growing power demand, led to an explosion of the coal power plant market, especially after 2002. In 2006 the market hit the peak year for new coal power plants: 88% of the newly installed coal power plants worldwide were built in China. At the same time, China is trying to take its dirtiest plants offline, within 2006~2010, total 76,825MW of small coal power plants were phased out under the “11<sup>th</sup> Five Year” programme. While coal still dominates the new added capacity, wind power

is rapidly growing as well. Since 2003 the wind market doubled each year and was over 18,000 MW<sup>2</sup> by 2010, 49% of the global wind market. However, coal still dominates the power plant market with over 55 GW of new installed capacities in 2010 alone. The Chinese government aims to increase investments into renewable energy capacity, and during 2009, about US\$ 25.1 billion (RMB162.7 billion) went to wind and hydro power plants which represents 44% of the overall investment in new power plants, for the first time larger than that of coal (RMB 149.2 billion), and in 2010 the figure was US\$26 billion (RMB168 billion) – 4.8% more in the total investment mix compared with the previous year 2009.

### The global market shares in the power plant market: Renewables gaining ground

Since the year 2000, the wind power market gained a growing market share within the global power plant market. At this time only a handful of countries, namely Germany, Denmark and Spain, dominated the wind market, but the wind industry now has projects in over 70 countries around the world. Following the example of the wind industry, the solar photovoltaic industry experienced an equal growth since 2005. Between 2000 and 2010, 26% of all new power plants worldwide were renewables – mainly wind – and 42% gas power plants. So, two-thirds of all new power plants installed globally are gas power plants and renewables, with close to one-third as coal. Nuclear remains irrelevant on a global scale with just 2% of the global market share. About 430,000 MW of new renewable energy capacity has been installed over the last decade, while 475,000 MW of new coal, with embedded cumulative emissions of more than 55 bn tonnes CO<sub>2</sub> over their technical lifetime, came online – 78% or 375,000 MW in China.



source PLATTS, IEA, BREYER, TESKE, GWAC, EPIA.

The energy revolution towards renewables and gas, away from coal and nuclear, has started on a global level already. This picture is even clearer, when we look into the global market shares excluding China, the only country with a massive expansion of coal. About 28% of all new power plants have been renewables and 60% have been gas power plants (88% in total). Coal gained a market share of only 10% globally, excluding China. Between 2000 and 2010, China has added over 350,000 MW of new coal capacity: twice as much as the entire coal capacity of

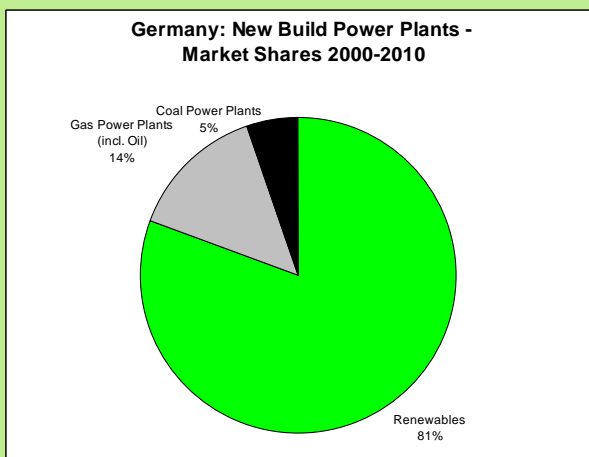
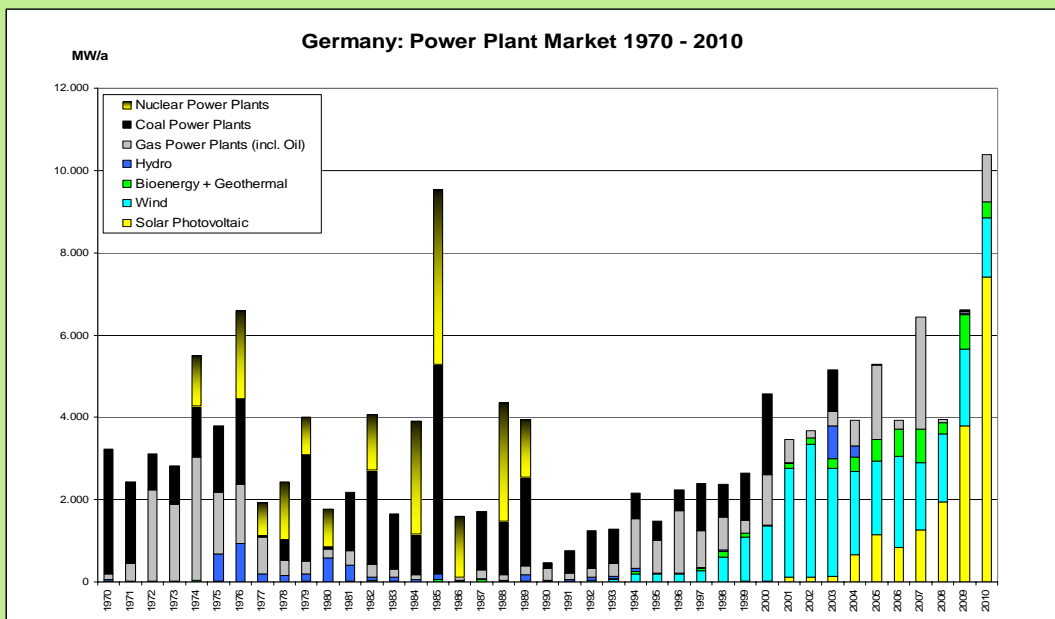
<sup>2</sup> While the official statistic of the Global and Chinese Wind Industry Associations (GWEC/CREIA) adds up to 18,900 MW for 2010, the National Energy Bureau speaks about 13,999 MW. Differences between sources as due to the time of grid connection, as some turbines have been installed in the last months of 2010, but have been connected to the grid in 2011.

the EU. However China has recently kick-started its wind market, and solar photovoltaics is expected to follow in the years to come.

### Country Analysis: Germany

Between 1970 and 1990, the majority of new power plants built were coal, nuclear and gas fired power plants. The nuclear expansion stopped just after the Chernobyl accident in 1985, while installations of new coal power plants – mainly lignite power plants to replace old plants from the former GDR – came to an almost complete halt just after 2000.

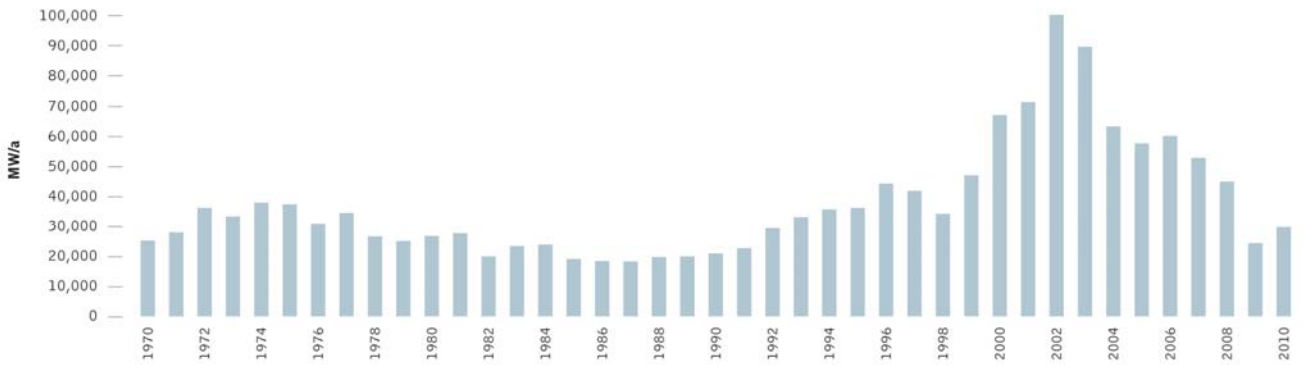
Germany introduced a feed-in law – which guarantees access to the electricity grid and a fixed price per kilowatt-hour over 20 years – in January 1991. This first renewable energy act laid the foundation of the country’s renewable energy industry. Due to the liberalisation of the electricity sector in 1998, this renewable energy act has been changed significantly and a new and far more efficient law came into force in April 2000. Within one decade the German renewable energy industry grew to one of the largest worldwide to over 380,000 employees. Germany has been a global trendsetter for the wind and solar photovoltaic industry development.



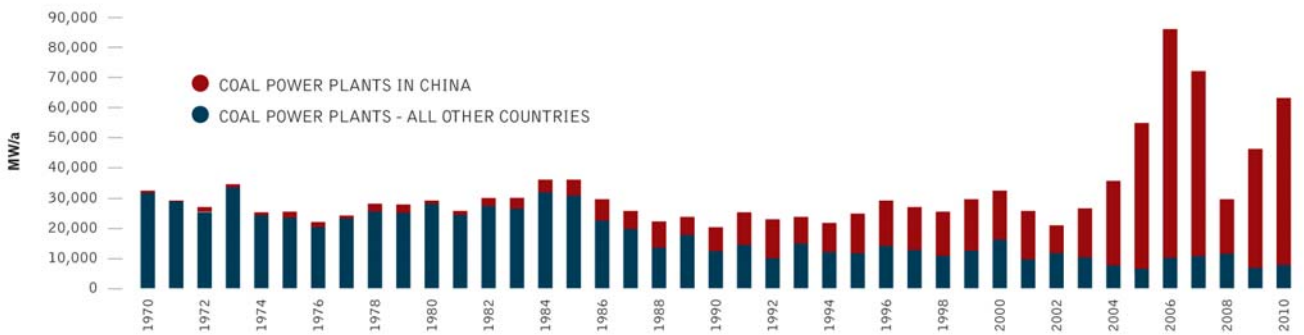
In the past decade, over 80% of all new power plants are from renewable energy technologies – mainly wind – and 14% are gas-fired power plants<sup>1</sup>. Only 5% of the installations are coal fired power plants. With the renewed nuclear phase-out decision of the German government in May 2011, the future development will be very likely in favour of renewables. The future role of coal however remains unclear.

## Historic developments of the global power plant market by technology

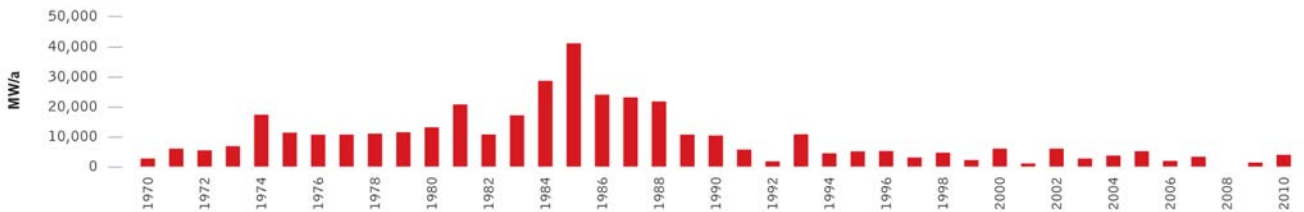
### global annual gas power plant market (incl. oil) 1970-2010



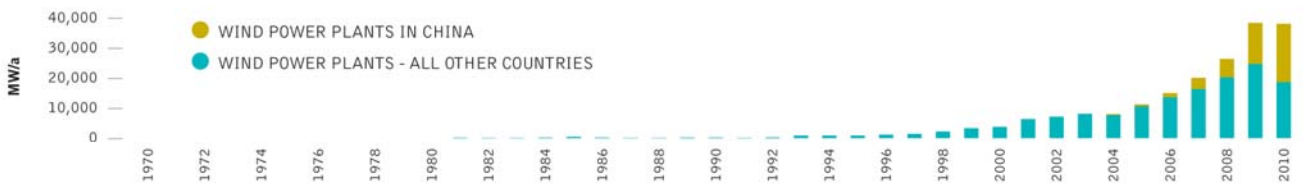
### global annual coal power plant market 1970-2010



### global annual nuclear power plant market 1970-2010



### global annual wind power market 1970-2010



### global annual solar photovoltaic market 1970-2010





## The future of the Energy [R]evolution

While the trend of the renewable energy markets – especially for wind, solar photovoltaic and concentrated solar power – are very promising and a double digit growth has been maintained over the past decade, the next years will decide whether the world will move towards a 100% renewable energy supply.

For seven years, Greenpeace, the European Renewable Energy Council and the German Space Agency (DLR) have published global, regional and national energy scenarios – the Energy [R]evolution - which uses the International Energy Agency's (IEA) World Energy Outlook business as usual scenario as a reference scenario. In the first global edition published in 2007, a global renewable energy installed capacity of 156 GW by 2010 was projected, a figure that was already reached by the wind sector alone in 2009. It is evident that the energy revolution is underway and this will form a major role in combating climate change. The economics of renewables will further improve as they develop technically, as the price of fossil fuels continues to rise and the saving of carbon dioxide emissions is given a monetary value.

The Energy [R]evolution Scenario has a key target for the reduction of worldwide carbon dioxide emissions down to a level of around 10 Gigatonnes a year by 2050. The Advanced Energy [R]evolution Scenario takes a much more radical approach to put the emergency brakes on global emissions. It therefore assumes much shorter technical lifetimes for coal-fired power plants - 20 years instead of 40 years. To fill the resulting gap, the annual growth rates of renewable energy sources, especially solar photovoltaic, wind and concentrating solar power plants, have therefore been increased. The advanced scenario also considers population and economic growth from the basic version, as well as most of the energy efficiency roadmap. In the transport sector, it includes a faster uptake of efficient combustion vehicles and, after 2025, a larger share of electric vehicles. Within the heating sector, there is a faster expansion of CHP<sup>3</sup> in the industry sector, more electricity for process heat and a faster growth of solar and geothermal heating systems. Combined with a larger share of electric drives within the transport sector, this leads to a higher overall demand for power. Even so, the overall global electricity demand in the advanced Energy [R]evolution scenario is still lower than in the reference scenario.

In the advanced scenario, the latest market development projections of the renewable industry<sup>4</sup> have been calculated for all sectors. The speedier uptake of electric vehicles, combined with the faster implementation of smart grids and expanding super grids (about 10 years ahead of the basic version) allows a higher share of fluctuating renewable power generation (photovoltaic and wind). The threshold of a 40% proportion of renewables in global primary energy supply will therefore be passed just after 2030 (also 10 years ahead). By contrast, the quantity of biomass and large hydro power remain the same in both Energy [R]evolution scenarios, for sustainability reasons.

## The Energy [R]evolution in the IPCC Special Report Renewable Energy (SRREN)

The IPCC Special Report Renewable Energy (SRREN) provides a comprehensive overview of the status of renewable energies, the economics, policy, market and technical potentials by source and region. Over 160 global energy scenarios were analysed to get a comprehensive overview about the possible future role of renewable energies to reduce CO<sub>2</sub> emissions on a global and regional level. It is therefore the most complete scientific analysis currently available. Out of these 160 scenarios – three mitigation scenarios have been chosen for a deeper analysis. The Energy [R]evolution scenario is one out of these three and the only scenario which does not rely on a nuclear expansion and unproven CCS technology.

In addition, these three mitigation scenarios have been compared to a baseline scenario, the IEA's World Energy Outlook 2009, equal to the reference scenario used in the Energy [R]evolution scenario. This analysis puts the deployment potential of renewable energy sources into the context of the technical potential by region and globally. While the Energy [R]evolution Scenario has the most ambitious renewable energy expansion on a global level, it became clear that only 2% of the global technical renewable energy potential need to be utilised to achieve a global RE share of 77% by 2050. Under the Energy [R]evolution scenario, 95% of the global electricity generation would come from renewable energy sources.

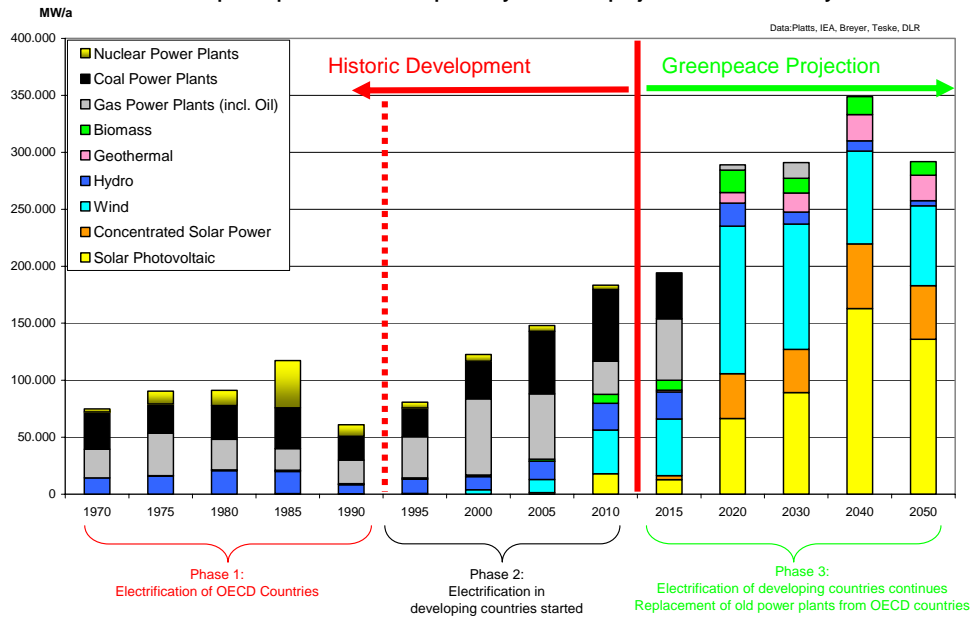
In conclusion, there are neither technical nor economical barriers to achieving a renewable energy supply on a global level. The only barriers exist at the energy policy level.

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<sup>3</sup> Combined heat and power

<sup>4</sup> See EREC, RE-Thinking 2050, GWEC, EPIA et al

Global annual power plant market - the past 40 years and a projection of the next 40 years



Global annual power plant market – the past 40 years and how it could develop in the next 40 years

	Average Annual Growth rates	Annual Market Volume
	[%/a]	[GW/a]
<b>PV 2005 - 2010</b>	87%	18 (2010)
2011 - 2020	42%	36
2021 - 2030	14%	124
2031 - 2050	15%	211
<b>CSP 2005 - 2010</b>	not available	< 2 (2010)
2011 - 2020	62%	12
2021 - 2030	17%	45
2031 - 2050	14%	66
<b>Wind 2005 - 2010</b>	27%	36 (2010)
2011 - 2020	26%	101
2021 - 2030	8%	229
2031 - 2050	7%	202
<b>Geothermal (incl. CHP) 2005 - 2010</b>	4%	not available
2011 - 2020	24%	5
2021 - 2030	13%	23
2031 - 2050	12%	25
<b>Bioenergy (incl. CHP) 2005 - 2010</b>	not available	approx. 8
2011 - 2020	18%	17
2021 - 2030	6%	35
2031 - 2050	10%	29
<b>ocean 2005 - 2010</b>	not available	< 1
2011 - 2020	70%	4
2021 - 2030	15%	12
2031 - 2050	19%	27
<b>hydro 2005 - 2010</b>	not available	approx 20
2011 - 2020	2%	21
2021 - 2030	1%	127
2031 - 2050	2%	67

Average growth rates and annual market volumes by renewable technology in the past, and a future projection under the advanced Energy [R]evolution scenario.

### Policies to maintain and expand the Energy [R]evolution<sup>5</sup>

Although a small number of countries developed renewable energy policies in the late 80s and early 90s, subsequent years have seen a huge increase in uptake, particularly from 2005 to 2010.

Over 85 countries had a policy target by 2009, up from 45 countries just four years before. Electricity production dominates many national targets, typically 5–30%, but as high as 90% in some. Other targets include shares of total primary or final energy supply (typically 10–20%), specific installed capacities of various technologies, or total amounts of renewable energy production. Most recent targets aim for 2020 and beyond. Europe’s target (20% of

<sup>5</sup> Source: REN 21 – Renewable Status Report 2010



final energy by 2020) is key among OECD countries. Brazil leads developing countries with (75% of electricity by 2030), China (15% of final energy by 2020), India (20 GW solar by 2022), and Kenya (4 GW of geothermal by 2030). Many countries also have regional and local level targets.

Renewable power generation policies currently exist in at least 83 countries. Of these, the feed-in tariff is most prevalent. In 2010, at least 50 countries and 25 states/provinces had feed-in tariffs, and more than half of these were just five years old. Support for feed-in tariffs continues to grow, and is increasingly being adopted at a state and provincial level. Globally, renewable portfolio standard (RPS) policies or quotas are currently supported by 10 national governments and 46 state/provincial governments. Most RPS policies require renewable power shares to meet 5–20%, with many targets extending beyond 2020.

Policies are often adopted in combination with direct capital investment subsidies, grants, or rebates offered in at least 45 countries. Other tax incentives, such as investment tax credits, import duty reductions, are also popular. Solar PV markets in particular have been backed by capital subsidies and tax credits. Energy production payments or 'premiums' also exist in a few countries. Public competitive bidding for fixed quantities of renewable power capacity is now common practice, and net metering laws for distributed generation have been adopted in at least 10 countries and 43 states in the US.

Financing renewable power projects differs from financing coal or nuclear projects. While most of the RE projects are in the range of a few kilowatt and a double digit Megawatts – the finance volume is much smaller and the number of projects are far bigger compared to a few but very large scale (1000 MW and more) coal power plant projects. However the policy requirements are similar: The RE project developers need to have confidence that the entire electricity which can be generated from a project eg a wind farm, can be sold at a certain (minimum) price and that the access to the grid is guaranteed over the entire financing time of the power plants. This is on a par with the coal power plant finance concept for Independent Power Producer (IPPs), which requires a power purchase contract over the given timeframe to finance it and a guarantee for grid connection. Power plants cannot be financed on the basis of stock market prices, or on the basis of tradeable CO<sub>2</sub> or RE certificates, if there is no guaranteed minimum price fixed, as this is not bankable. Multi-million dollar investments need reliable and secure income projections.

Therefore, Greenpeace demands a feed-in tariff system – with a guaranteed buy back tariff in combination with a guaranteed and priority access to the grid. The only difference between the power purchase contract for IPPs is that the tariff is not negotiated between the IPP and the grid operator and/or utility, but 'standardised' as small business cannot negotiate with grid operators. Feed-in tariffs are by far the most cost effective mechanisms to phase in renewables, which has been proven since the start of the wind industry in the early 1990s in Germany. Trading systems always lead to higher costs, as they add an additional 'layer' – the traders - between the grid operator and the project developer and/or power plant operator. Traders add additional costs to the project that are not needed to implement RE and only represent an unnecessary burden for electricity bills.

#### Conclusion from the UNEP – Bloomberg – Chatham House Publication 'Private financing of renewable energy - a guide for policymakers' (2009)

- Financial institutions operate on a risk and return basis evaluating each potential investment opportunity on its merits. Project assessment, documentation and due diligence are conducted in a manner consistent with investments in other sectors.
- The range of RE risk profiles can be well matched to the spectrum of financial institutions from banks, pension funds, private equity and VC. However, the RE sector requires clear policy environment to deliver the project economics to attract private debt and equity.
- RE projects in emerging markets and developing countries face additional challenges presented by a number of factors including unstable political regimes, volatile local currencies or lacking infrastructure. Mitigation of these risks can be achieved through local partnering and application of public funding in the form of soft loans, grants and insurance programmes.

*"Policy and regulation continue to be central to ensuring the long term stability of projects from a revenue and operation perspective. It is imperative that both regulation and policy be clear, of a long duration, and legally based in order to deliver growing volumes of private funds into the RE sector."*

## The Energy [R]evolution invests in jobs, not fuels

If the Reference scenario becomes reality, the amount of jobs in the power sector would remain on today's level until 2030. This is despite an increase in electricity generation from coal to 40% by 2030 under the reference case. The main reason is that as prosperity and labour productivity increase, jobs per MW decrease. This is reflected in the 'regional adjustments', which model how electricity generation tends to be more labour intensive in poorer countries than in wealthier ones. This change, based on increasing living standards in the developing world, accounts for two thirds of the reduction in coal jobs in developing countries.

China is responsible for one third of worldwide energy sector jobs in 2015, more than three quarters in coal power. The change in China's regional adjustment accounts for about 200,000 of the coal job losses projected in the reference scenario. A small expansion of the renewables sector would not counteract these losses. Jobs would not return to their 2010 levels, even combined with a 50% expansion in gas capacity.

The Energy [R]evolution scenario also has job losses in coal generation, because growth in capacity is almost zero. However, employment growth in renewable energy is so strong that there is a net gain of 4.1 million jobs by 2030, relative to the 2015 reference case. The advanced case will lead to 8.5 million jobs in the renewables sector, compared to only 2.4 million in the reference case. In both Energy [R]evolution scenarios we have been cautious in the calculations and applied 'decline factors' to represent how jobs per unit of energy can decrease over time, making the Greenpeace projections lower than in other studies. It may be the case, for example, that job creation per GWh (gigawatt hours) in energy efficiency could increase as energy efficiency options are all 'used up'. While the Energy [R]evolution Scenarios have higher investment volumes than the reference scenarios, the actual power generation costs are on an equal level until 2030, and drop sharply after that as the majority of the power plants are written off and produce marginal costs – with no fuel costs involved. However the ER is more labour intensive than the reference scenario, as the ER invests in people, not fuel.

	REFERENCE SCENARIO			ENERGY [R]EVOLUTION			ENERGY [R]EVOLUTION		
	2015	2020	2030	2015	2020	2030	2015	2020	2030
<b>Jobs (millions)</b>									
Construction and installation	1.6 m	1.7 m	1.3 m	3.0 m	2.8 m	2.0 m	3.8 m	3.4 m	3.1 m
Manufacturing	0.6 m	0.5 m	0.3 m	1.8 m	1.7 m	1.2 m	2.5 m	2.2 m	1.7 m
Operations and maintenance	1.6 m	1.7 m	2.0 m	1.9 m	2.6 m	3.3 m	1.9 m	2.7 m	3.6 m
Fuel supply	3.9 m	4.0 m	4.4 m	3.9 m	3.8 m	3.7 m	3.8 m	3.7 m	3.1 m
Coal and gas export	0.5 m	0.5 m	0.7 m	0.5 m	0.5 m	0.5 m	0.5 m	0.4 m	0.4 m
<b>Total jobs</b>	<b>8.0 m</b>	<b>8.4 m</b>	<b>8.7 m</b>	<b>11.1 m</b>	<b>11.4 m</b>	<b>10.6 m</b>	<b>12.5 m</b>	<b>12.4 m</b>	<b>11.9 m</b>
<b>Global</b>									
Coal	3.9 m	4.1 m	4.2 m	3.4 m	3.1 m	2.7 m	3.2 m	2.8 m	2.1 m
Gas, oil & diesel	1.5 m	1.6 m	1.7 m	1.7 m	1.6 m	1.4 m	1.6 m	1.5 m	1.2 m
Nuclear	0.3 m	0.3 m	0.3 m	0.2 m	0.1 m	0.0 m	0.2 m	0.1 m	0.0 m
Renewable	2.3 m	2.4 m	2.4 m	5.9 m	6.6 m	6.5 m	7.5 m	8.0 m	8.5 m
<b>Total jobs</b>	<b>8.0 m</b>	<b>8.4 m</b>	<b>8.7 m</b>	<b>11.1 m</b>	<b>11.4 m</b>	<b>10.6 m</b>	<b>12.5 m</b>	<b>12.4 m</b>	<b>11.9 m</b>
<b>Global - Jobs</b>									
Coal	3.93 m	4.15 m	4.20 m	3.43 m	3.13 m	2.74 m	3.22 m	2.82 m	2.11 m
Gas, oil & diesel	1.51 m	1.59 m	1.74 m	1.67 m	1.63 m	1.40 m	1.59 m	1.49 m	1.23 m
Nuclear	0.33 m	0.29 m	0.29 m	0.17 m	0.10 m	0.04 m	0.17 m	0.10 m	0.04 m
Biomass	0.48 m	0.59 m	0.86 m	0.96 m	1.51 m	2.11 m	0.96 m	1.52 m	2.14 m
Hydro	0.90 m	0.95 m	0.91 m	1.00 m	0.67 m	0.59 m	0.88 m	0.68 m	0.60 m
Wind	0.52 m	0.39 m	0.38 m	1.70 m	1.55 m	1.40 m	2.28 m	2.01 m	1.73 m
PV	0.32 m	0.40 m	0.25 m	1.85 m	2.40 m	1.71 m	2.67 m	2.99 m	2.77 m
Geothermal	0.02 m	0.02 m	0.02 m	0.07 m	0.09 m	0.12 m	0.10 m	0.18 m	0.27 m
Solar thermal	0.02 m	0.02 m	0.02 m	0.23 m	0.31 m	0.49 m	0.54 m	0.51 m	0.85 m
Ocean	0.00 m	0.00 m	0.00 m	0.05 m	0.04 m	0.06 m	0.12 m	0.12 m	0.16 m
<b>Total jobs</b>	<b>8.04 m</b>	<b>8.40 m</b>	<b>8.68 m</b>	<b>11.13 m</b>	<b>11.43 m</b>	<b>10.65 m</b>	<b>12.51 m</b>	<b>12.43 m</b>	<b>11.90 m</b>

**Methodology:** The analysis is based on databases from UDI WEPP Platts, the IEA, Global Wind Energy Council, European Photovoltaic Industry Association, and research paper from Dr. Christian Breyer and Marzella Amata Görig. Please note that the different statistical database use different fuel categories and some power plants run on more than one fuel. In order to avoid double counting, different fuel groups have been established. National data might differ from the international data basis.

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