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The Future Role of Coal: International Market Realities vs Climate Protection?

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Impressum

Editorial

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Foreword

It is our pleasure to introduce the sixth EUCERS Strategy Paper. So far, we have looked in previous issues at the topics of unconventional gas, carbon capture and storage, green energy and sustainable growth, the impact of the Arab Spring on global markets and the international implications of the U.S. Shale Revolution. The present Strategy Paper now turns to the future of European coal power plant technologies in light of current developments in climate protection policies and coal's strategic role in the global energy mix.

As this Strategy Paper shows, the debate about the role of coal is conducted very differently in Europe and elsewhere. However, all serious global energy scenarios predict that coal will continue to comprise a significant share of the global energy mix in the middle and long term. The International Energy Agency (IEA) predicts that by 2019 world demand will break the nine million tonne level, with China being responsible for the majority of growth in this period and offsetting only slight declines in Europe. One might like it or not, coal is here to stay.

As a consequence – particularly as we can register a renaissance of coal in electricity production – both increased consumption and stricter climate protection policies will boost demand for cleaner coal technologies in Europe and worldwide. New coal power plants are being built around the world, but notably in emerging markets. Therefore, it is in particular technological advancements – such as highly efficient coal power plants and carbon capture and storage – that could contribute to reducing greenhouse gas emissions. Consequently, our analysis critically and non-ideologically looks at the interplay of efficient coal power plant technologies and international climate protection policies. It also stresses the key role that carbon capture and storage could play in this context.

I would like to take the opportunity to thank our Research Director of the European Centre for Energy and Resource Security (EUCERS) Dr Frank Umbach for writing this very important and insightful study. I also thank Professor Theo Farrell at King's College London for supporting our work at EUCERS. A special thank you goes to Alstom Deutschland AG for financially supporting this research study. Last, but not least, I would also like to thank Carola Gegenbauer, EUCERS Operations Coordinator, and Arash Duero, EUCERS Research Associate, for their support.

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Summary

The use of coal for energy generation is currently subject to growing criticism in light of international climate protection efforts. Nevertheless, globally coal as a raw material is inexpensive and available in the long term, and it will also be used in the future in many ways.

Despite coal's crucial importance for global – and European – energy supply, both demands for a German and European coal phase-out, as well as announced bans and restrictions on export credit support for clean coal technologies remain part of different climate protection programs. In this context, it is worth exploring to what extent regional or national policy provisions and energy policy preferences are conducive to a realistic and sustainable climate protection policy at the global level, considering that:

- On the one hand, a coal-free and independent world is unthinkable in the medium-term, as the use of this resource will grow globally – and particularly in Asia – through 2040.
- On the other hand, there exists a global need for modernising already existing or planned coal power stations in order to increase their efficiency and reduce their emission of greenhouse gases, which would contribute significantly to global climate protection efforts.

Against this background, countries inside and outside the EU should not regard renewable energy and coal-fired power stations as mutually exclusive factors. On the contrary, renewable energy sources and coal should both be part of a pragmatic and more realistic energy strategy, given that it is pivotal to reconcile the world's growing energy needs and supply security with climate change mitigation goals.

The following analysis will examine the strategic implications of different restrictions on and bans of export credit finance for coal power station and clean coal technologies, including whether such an export ban may prove counterproductive to global, German, and EU climate protection efforts. In addition, it will examine the overall question of whether coal has a future in the German and European energy mix in the medium-term – i.e. through 2040.

Based on this analysis, the study will shed light on the global, European and German energy policy dimensions in the context of the energy triangle – or 'trilemma' – and its three objectives: strengthening (a) energy (supply) security, (b) economic competitiveness, and (c) environmental protection. The study comes to the following observations and conclusions:

Climate Policy Framework

- Climate protection policies cannot exclusively determine EU or German energy policies and economic competitiveness; instead, all three factors of the so-called trilemma need to be balanced.
- In the absence of a 'silver bullet' solution, governments have favoured a mix of policies and low-carbon technological solutions and regulations in order to comply with global climate protection targets and, at the same time, guarantee both economic stability and energy supply security. For example, higher natural gas consumption has been favoured over coal – as in the United States -, and there has been a rapid introduction of an increasing number of CCTs – including boosting the energy efficiency of coal-fired plants, coal-to-gas gasification (GTG), carbon capture and storage (CCS) and carbon capture, use, and storage (CCUS).
- While the joint U.S.-China declaration of November 2014 may be deemed politically historic, it lacks new, more ambitious energy-related climate mitigation efforts to reach the 2°C-target. All in all, the prospects for a binding global agreement on climate change are still limited, as highlighted at the December 2014 UN COP 20 climate summit in Lima, Peru.
- Current global energy policies and climate mitigation efforts are still insufficient for reaching the 2°C target – forecasts currently point to a 3.6°C rise in world temperature by 2100. Without a widespread introduction of CCS, coal-related CO_2 emissions might be one-third higher than those of gas.
- Coping with climate change involves not only new investments in cleaner energy sources, but also addressing high emission assets that are already in place, such as coal-fired plants.[1]
- **Carbon Leakage:** The Kyoto protocol calls for CO_2-reductions to be counted at the point of production and not of transport and use. Estimates suggest that at least seven per cent of the EU's CO_2 emissions between 1990 and 2008 were simply outsourced to the developing world in the form of manufacturing imports. These production facilities often produce more emissions, and more distant shipping routes need more energy and produce more greenhouse gas emissions (GHGE). Any unilateral and overly ambitious climate change policy will merely drive out energy-intensive industries from Europe and Germany, leading to considerable de-industrialization – with losses in economic competitiveness and often higher levels of global emissions.

1 These include, phasing-out existing power plants, enhancing their energy efficiency of power plants, and retrofitting them with CCS-technologies.

Global Dimensions of Coal as a Key Energy Resource

- Plans for building new coal plants – around 1,200 in 50 countries, with 75 per cent of those in China and India Alone – are not in line with the 2°C target, and they instead highlight the need for CCTs, including CCS. The new plants would join the current 2,300 operating worldwide and bring the world's coal-fired power capacity up to 1,400 GW – the equivalent of another China as the world's biggest emitter.
- Coal is, after oil, still the second most important energy resource in the world for energy consumption. It has longer availability than conventional gas and oil resources, is cost-competitive, widespread, and plentiful. Hard coal, together with lignite, accounts for not less than about 55 per cent of all fossil energy resources. Moreover, it is used to make steel, cement, fertilisers, and as feedstock for the chemical industry.
- Continuing a 20-year trend, growth in coal-fired generation since 2010 has been greater than that of all non-fossil-fuel sources combined. The share of fossil fuels in the total primary energy mix will only slowly decrease from 82 per cent in 2012 to 60-80 per cent by 2040. At 30.1 per cent, coal's share in the global primary energy consumption in 2013 reached its highest level since 1970.
- The proved global coal reserves in 2013 are sufficient to meet 113 years of global production, and thus far more than the ratio of reserves versus production (R/P) for oil and natural gas – 53.3 and 55.1 years, respectively. Yet coal reserves have been halved during the last decade. At the same time, coal resources are 20 times larger than coal reserves and could be exploited with slightly higher prices and/or future technological innovations.
- According to the International Energy Agency (IEA), coal will rival oil as the world's top energy source as early as 2017. Global coal consumption is expected to grow by another 15 per cent through 2040.[2] Its share of global energy demand will decline from 29 per cent in 2012 to 24 per cent by 2040, but will still remain the world's second most important energy source just ahead of natural gas. Yet a world without coal is unrealistic even beyond 2040, and new production and transformation technologies – e.g. liquefaction and gasification – are expected and already underway.
- **China** is the world's largest energy and coal consumer, using nearly as much coal as the rest of the world combined. It is also the largest coal producer, providing more energy to the world's economy than the whole Middle Eastern oil production. Over 50 per cent of global coal consumption will be absorbed by China's coal demand over the next ten years. While China's coal share of its primary energy and generation mix will decline from the current 70 per cent to around 55 per cent by 2040, China's coal consumption cannot be replaced entirely by gas or renewables.
- **India** will already overtake the United States as the world's second-largest coal consumer by 2020, and surpass China's import demand around 2025. Between 2012 and 2040, India's import levels will more than triple to 30 per cent of global coal trade. Its coal import dependence will rise sharply from 25 per cent in 2012 to 40 per cent by 2040.
- In the **United States**, the newly proposed Clean Power Plan of June 2014 foresees additional regulations and standards for the U.S. power plant industry in order to reduce 30 per cent of the country's CO_2 emissions by 2035 compared with 2005. In turn, these reductions will require less reliance on coal, with renewables expected to enjoy a significant boost.[3] Yet coal may remain the largest source of electricity generation until 2035 and then be surpassed by gas. The U.S. government estimates that coal will still meet about 30 per cent of U.S. power demand under the new regulations by 2030, compared with 39 per cent in 2013.

European Dimensions of Coal: Phasing Out of Coal Threatens Energy Supply Security and Economic Competitiveness

- In Europe, coal has enjoyed a renaissance since 2010 thanks to the current oversupply of cheap coal in international markets. Furthermore, the price of carbon allowances of the Europe's carbon market have significantly declined from €30 in 2008 to the current €6. The American shale gas revolution has also contributed to cheaper U.S. coal exports to Europe, which have in turn also replaced Russian gas on the continent.
- In 2012, the EU reached a new record of spending on fossil energy imports of €548 billion – 4.2 per cent of EU-GDP, in contrast to just 1.5 per cent in 2002 – compared to just €180 billion on average during the timeframe of 1990-2011. By contrast, the U.S. import bill for fossil fuels had already decreased to US$340 billion in 2012 by maximizing its own indigenous fossil-fuel resources. Current EU import levels are expected to remain at around €500 billion through 2035. The EU is already the world's largest importer of energy, which casts doubt on both its future economic competitiveness and the security of its energy supply.
- European energy and climate change mitigation policies threaten to affect its own ambitions for an industrial renaissance. In 2012, the EU announced goals increasing

2 This represents an annual growth of just 0.5 per cent compared with 2.5 per cent during the last decade, with almost two-thirds of this growth is taking place within the next decade.

3 Many older coal-power plants will likely neither be replaced nor modernized; instead, they will face closure and replacement by gas-fired power plants. Lower production and exports are expected after 2020. Coal is expected to lose more market share and will also be overtaken by renewables in the 2030s due to more ambitious decarbonisation and CO_2 emissions reduction efforts, as well as new energy efficiency regulations in the transport sector.

its industry's share of GDP to 20 per cent by 2020; in 2013, however, this share further declined to 15.4 per cent.

- EU targets for enhancing energy efficiency cannot compensate for the comparative costs advantages that the United States will enjoy over the next years or even decades. The October 2014 40 per cent target for reducing CO_2 emissions by 2030 implies cutting in just one decade – 2020 to 2030 – the same amount of emissions that the EU is currently struggling to cut in three – 1990 to 2020. Together with Japan, the EU is already the least energy-intensive economy in the world. The IEA estimates that, because of high-energy prices and ambitious climate mitigation policies in Europe, European energy-intensive exports stand to lose a third of global market share over the next two decades.
- At this point, conditions in international coal markets make a switch from coal to gas seem unrealistic – despite an early reform of the EU Emissions Trading System (ETS) in 2017/18 and given the aforementioned 40 per cent target.
- Coal remains an important energy source in the Commission's view, particularly because of energy security concerns. In the context of the EU decarbonisation strategy, coal plants need to boost energy efficiency and apply new clean coal technologies, including CCS. Current fossil-fired generation capacity is, additionally, quite old.[4] Replacing Europe's ageing coal-fired plants with more efficient modern ones would decrease GHGE by 30-40 per cent.
- Realistically, the EU cannot phase out coal before 2035 or 2040 because of the following facts:
  - Coal represents 88 per cent of all EU energy reserves and is present in almost all EU countries.
  - Globally, Europe is still the third-largest coal consuming region after China and North America, and the second-largest importer after China; 60 per cent of EU coal consumption comes from indigenous sources.
  - Although EU coal consumption fell by 40 per cent between 1990 and 2009, 18 per cent of primary energy demand still came from coal in 2012, while 27 per cent of power generation was dependent on coal.
  - The EU cannot remain competitive vis-à-vis the United States without using coal; in fact, coal prices would have to double to make gas competitive enough to replace coal in the power sector.
  - Keeping coal in the EU's energy mix ensures interfuel competition, which ultimately is an essential protection against the pricing power and still existing risks related to the oligopoly of gas suppliers in Europe.
  - Giving up coal affects not only the coal industry, but has wider implications for the entire EU value chain – up to the integrated manufacturing sector.
  - Europe produces around 50 per cent of global brown coal (lignite), 95 per cent of which is used in power stations.
- The EU's current Seventh Framework Programme (FP7) also promotes projects for increasing energy efficiency of power plants to more than 50 per cent through further research and development programmes, as well as a better integration of new technology and infrastructure components. Improving energy efficiency of Europe's older coal-fired power plants to more than 45 per cent has been estimated to cost no more than €5-10 billion across the EU.[5]
- The new EU energy security and diversification strategy of May 2014 promises not just to increase energy efficiency measures as a short-term crisis supply response, but also the possibility that the EU could switch from gas to coal in order to ensure energy supply, especially during times of conflict.

The Need for Carbon Capture, Use and Storage (CCUS): Failing Alternatives

- CCS and CCUS are considered a key and cost-effective technology both for achieving larger emission reductions from fossil-fuel use – not just coal –, and enhancing energy efficiency and expanding renewables.[6] Meanwhile, even the Intergovernmental Panel on Climate Change (IPCC) has stressed the strategic importance and need of CCS as worldwide climate mitigation technology in its Fifth Assessment report of November 2014.
- Several technological solutions are currently tested for reducing the loss of electrical output and to make CCS-projects in the power sector more competitive.[7] A key solution could be seeing CO_2 as a valuable product instead of just waste, but research in this regard is only at an early stage.
- The United States and China agreed in the summer of 2013 to jointly develop CCS-technologies for power plants and also to implement large-scale pilot projects, in addition to collaboration in other areas. China is

4 More than 40 per cent of all fossil-fired generation capacity is more than 30 years old, and over 45 per cent of the existing one in OECD countries will retire by 2040. In the EU, this is equivalent to some 630 GW.

5 For comparison, Germany alone spends €20-30 billion of subsidies for renewables each year.

6 The IEA has estimated that equipping 3,400 power plants and industrial facilities with CCS could provide 19 per cent of the total CO_2 reduction required by 2050. Currently, there is no alternative, realistic mitigation technology other than CCS.

7 The world's first large-scale CCS-project in the power sector has been operating since October 2014 at the 110 MW Boundary Dam coal-fired power station in Saskatchewan, Canada that will capture 90 per cent of the CO_2 and 100 per cent of sulfur dioxide. Two additional large-scale U.S. CCS-projects will come into operation in 2015 and 2016 respectively.

promoting CCS-projects not just for coal-fired plants, but also for energy-intensive industries such as oil and chemicals. CCS in industrial applications could represent almost 50 per cent of the CCS-induced emission reductions by 2050. Overall, CCS in all sectors can reduce 17-19 per cent to all cumulative CO_2 emissions reductions by 2050.

- Globally, 22 large-scale CCS projects are in operation or being constructed – twice as many as at a decade ago. The total CO_2 capture capacity of these projects is around 40 million tonnes per year. Another 14 projects are in an advanced stage of planning, with nine in the power sector. Many of them are expected to make a final investment decision in 2015. Altogether, the Global CCS Institute has identified 55 large-scale CCS projects on a global scale.
- European and German public discussions have largely ignored the fact that CCS technologies are not necessary just for coal-fired power plants, but also for energy-intensive industries. Otherwise, Germany and the EU will be unable to achieve their CO_2 emissions targets for 2050, with negative economic consequences and increasing carbon leakage effects. CCS projects need to be part of a wider strategy reducing CO_2-emission and implementing realistic climate mitigation targets.
- The EU lags behind countries like Canada, the United States, Australia, and China in adopting these key technologies; in so doing, it risks losing industrial competitiveness for its energy and entire energy-intensive industries.

The Germany *Energiewende* vis-à-vis Coal's Importance for Domestic Jobs and Energy Supply Security

- Germany's energy supply security has declined during the last decade – in 2013, for example, Germany's energy import dependence increased by another 2.7 per cent up to 61 per cent of its primary energy consumption and was higher than the EU-28 average of 53 per cent. As a result of the double phase-out of domestic hard coal production by 2018 and nuclear power by 2022, Germany now depends primarily on Russia as a supplier of gas, oil, diesel and even hard coal, with Moscow now covering almost 25 per cent of total German primary energy consumption.
- While Germany's 2006 decision to phase out hard coal mining and production by 2018 may reduce its national CO_2 emissions more drastically by 2020, it has directly led to carbon leakage in Russia as a result of higher gas and coal exports to Germany and expanding domestic coal-fired electricity generation.
- In the German *Energiewende*, coal has been downgraded to a swing and reserve supplier to balance the ever-increasing power generation from intermittent RES. But since 2012, German utilities have turned to cheaper hard coal and lignite instead of the more environmentally friendly natural gas in light of much higher raw material costs. Hard and brown (lignite) coal still contribute towards around 44 per cent of Germany's electricity generation mix, but, at the same time, in 2012, following fierce opposition, Germany gave up plans to subsidize CCS-equipped plants.
- In 2013, coal-burning emissions soared to their highest level in more than 20 years. While that increase might be temporary, Germany cannot simultaneously phase out nuclear power and coal based power generation if the country is to safeguard energy supply security and economic competitiveness.

Strategic Implications of German and European Bans on Export Credit Finance of Coal-Fired Power Technologies

- Currently, even with further expansion of renewables, coal remains the most viable option to enable economic growth and meet growing demand for energy in the near future – a key target of the 2010 Copenhagen accord to tackle the needs of around 1.4 billion people with no electricity supply and another 2 billion little or inadequate access to power.
- An increased consumption of inefficiently burned coal is incompatible with proclaimed climate goals such as the 2°C target. CCS technologies will remain vital as long as renewables cannot totally replace all fossil-fuelled power plants and nuclear power as an alternative and affordable option, and as long as clean and affordable technological solutions for storing electricity do not exist.
- Energy efficiency is a critical key factor in mitigating the global challenges of energy security and rising energy consumption. In this context, the need to replace no less than 40 per cent of the world's existing power plants offers huge export opportunities for German and European producers as technology leaders in this field.
- The present worldwide average energy efficiency of coal power plants is around 33 per cent, but even the newest coal-fired plants do not reach ultra-supercritical energy efficiency levels of 45 per cent or more. Globally, if all coal-fired power plants would operate at such levels by 2040, worldwide coal-fired emissions would be 17 per cent lower.[8]
- Around 60 per cent of the existing coal capacity built in the past is subcritical – the least efficient class of commercially available coal-fired efficiency technologies. European and German power and other technology companies could make strategic contributions to the modernization and retrofitting of existing coal-fired plants with a range of CCTs enhancing their energy efficiency and reducing significant amount of GHGE as part of Europe's climate protection policies.

8 Relative to the IEA's so-called New Policy Scenario.

- If Europe replaced its old power plants with high-energy efficient coal-fired power plants, CO_2 emissions could drop by around 25-30 per cent. In this regard, the limits in the power plant sector prescribed in the European Strategy Energy Policy 2020 could be easily reached and surpassed. The United States has cut its CO_2 emissions by over 400 million tonnes by its cost-effective coal-to-gas fuel switching
- It is also pivotal to consider the geopolitical consequences of international coal divestment efforts, which have only fuelled further Asian frustration with the West and its development institutions. In this context, the newly launched Asian Infrastructure Investment Bank (AIIB) – to be established by the end of 2015 with China as its largest stakeholder – stands to offer a non-Western funding option for future energy infrastructure projects (i.e. coal power plants and coal mining as it has already been announced), with potentially wide-ranging geopolitical implications.
- There is no contradiction between, on the one hand, supporting the export of highly efficient coal power plants and CCTs and, on the other, EU or German climate protection policies. In the absence of European production and exports of CCT equipment, competitors in other regions would supply these key technologies – often without comparable energy efficiency advantages and GHGE reductions.
- An export ban on CCTs for European companies would also prevent a worldwide application of CCS as a future key technology for reducing GHGE emissions not just for coal-fired power plants, but also for the oil and gas sector and other energy-intensive industries such as cement, steel, and chemicals.

Introduction: A Europe Without Coal?

In the summer of 2014, the German Environment Ministry announced its decision to end all financial support for coal power plants technology exports. Yet, after further consultations with the German Ministry for Economic Affairs and Energy, authorities reached a compromise by significantly decreasing support for these exports, allowing them only in particularly poor countries with no real energy alternatives.[9] France followed suit in late 2014 with a similar announcement, though French coal projects based on public guarantees and funds in developing countries would be still possible if they include carbon capture and storage (CCS) technology.[10]

In so doing, the German and French governments are drastically reducing their coal-related investments[11] by following the steps of the U.S. government. In 2013, the Obama Administration announced that it would no longer support coal-fired power plant projects in developing countries financed by the World Bank and other international development banks, unless they are the only option for poor developing countries or if coal projects abroad include technologies that reduce greenhouse gas emissions (GHGE). Officials have also left open the possibility of financing coal plants that meet strict U.S. emissions standards.[12]

Coal is often seen as the dirtiest or least clean fossil fuel, as it produces much more carbon dioxide (CO_2) than oil or gas. In light of international efforts for limiting average global temperature from rising above 2°C – the so-called *Kyoto target* –, environmental organizations have increasingly criticized coal as a major problem for any successful climate protection policies, particularly in Europe and Germany.

These new divestment strategies for coal power plant technologies are not exclusive to government circles. In July 2013, both the World Bank and the European Investment Bank put an end, de facto, to any lending to greenfield coal power projects, except in "rare circumstances". Those banks have supported coal power plants in developing countries with more than US$10 billion in the past five years. In December 2013, the European Bank for Reconstruction and Development (EBRD) followed suit.[13] At the same time, World Bank President Jim Yong Kim has warned his own institution against ignoring the role of coal as a cheap energy source for economic development.[14] Even Yvo de Boer, former head of the UN Framework Convention on Climate Change recently stressed the importance of coal for developing countries and warned against "ban[s] on any single fuel source."[15]

These export bans are only part of a wider trend of a fossil fuel disinvestment promoted by environmental NGOs, cities, and investors, which collectively account for at least US$50 billion in investment.[16] They demand an end to all support for fossil fuel projects, more climate-friendly business models and more investment in renewable energy sources (RES).[17] Given coal's image as the dirtiest or least clean fossil fuel – it produces more carbon dioxide (CO_2) relative to oil or gas –, environmental NGOs – particularly in the developed world – have portrayed coal as a major problem for any successful climate protection framework seeking to limit the world temperature rise to no more than the 2°C target agreed upon in Kyoto.

Having reached a significant victory in Germany's announced nuclear phase-out by 2022, these NGOs have now focused their efforts on coal-fired power plants – particularly on putting a ban on new plants and on exports of coal technologies. These organizations – with some exceptions[18] – have increasingly demanded a complete elimination of the use of coal and the phase-out of all subsidies to the coal industry in order to achieve EU climate targets. Their campaign in Germany has intensified

9 'Streit um Kohleförderung. Umweltministerin will Technologieexport erschweren', Frankfurter Allgemeine Zeitung (FAZ), 18 September 2014, p. 16.

10 See EurActiv, 'France To Axe Coal Subsidies While EU Stalls', 6 February 2015.

11 Between 2006 and 2013 the German government-owned KfW-Bank had supported these technology exports with around €2.8 billion. For its part, the French export credit agency Coface has guaranteed over €1.2 billion of coal projects since 2011 and was the fifth largest subsidizer of coal energy exports from the OECD between 2007 and 2013.

12 See Michael D. Shear, 'U.S. Says It Won't Back New International Coal-Fired Power Plants', New York Times, 29 October 2013.

13 See 'European Investment Bank to Stop Financing Coal-Fired Power Plants', The Guardian, 24 July 2013 and Pawel Smoleri, 'Message from the President: in Euracoal, 'Annual Report 2013', Brussels, December 2013, p. 5.

14 See 'Davos 2013: World Bank Head Says Don't Shun Poor Coal-Using Nations', BBC-News, 26 January 2013.

15 Quoted following Michael Bastasch, 'Former UN Global Warming Chief: Coal Is 'Essential', Daily Caller, 14 April 2015.

16 This group includes, among others the Rockefeller Standard Oil Fortune, the board of trustees at California's Stanford University, the University of Glasgow, and the World Council of Churches.

17 See Pilita Clark, 'Climate Change Groups Split on Fossil Fuel Divestment ', Financial Times (FT), 5 January 2015; Jesse Riseboroughj/Thomas Biesheuvel, 'Coal Seen as New Tobacco Sparking Investor Backlash: Commodities', Bloomberg, 20 November 2013; Mark Drajem,'Coal at Risk as Global Lenders Drop Financing on Climate', Bloomberg, 6 August 2013; 'Could Oslo's Decision to Divest from Coal Inspire Bigger Cities to Do the Same', EurActiv, 23 March 2015; Raja Jayaraman, 'Kohle ist unmoralisch!', IPG, 25 February 2015, David J. Hayes, 'The Real Cost of Coal', New York Times (NYT), 24 March 2015.

18 'Government Coal Subsidies Must be Stopped', EurActiv, 5 December 2014; Pilita Clark, 'Climate Change Groups Split on Fossil Fuel Divestment', FT, 5 January 2014..

in the wake of Berlin's increased coal consumption,[19] as coal use has in part compromised the country's 2020 climate targets.[20] As a result, calls for phasing out coal-fired electricity generation have only grown stronger, as coal-power plants are responsible for around a third of the country's total CO_2 emissions.[21]

Efforts against coal appear to be supported by a new study on meeting the Kyoto target. It concluded that 88 per cent of the world's known coal reserves, 35 per cent of known oil, and 52 per cent of gas reserves need to stay in the ground and cannot be burned, while drilling in the Arctic is equally out of question. As for Europe, the study calls against using around 89 per cent of known coal reserves and 21 per cent of oil, whereas allowing for the use of about 94 per cent of European gas reserves.[22]

At the same time, coal still enjoys political backing. In November 2014, for example, German Economy and Energy Minister Sigmar Gabriel defended the country's lignite industry and coal-fired plants by arguing that Germany cannot phase out both coal and nuclear power simultaneously. In addition, he criticized the 2013 decision that makes it possible for Germany to finance CCS projects in other European countries, but not on its own soil. In his view, any closing of coal-fired power plants would fail to take into account energy supply security, the implications for the industry's economic competitiveness, and rising electricity prices for both private and industrial consumers.[23]

In order to tackle the hurdles for reaching the 40 per cent reduction target, the German Economy and Environmental Ministries adopted a new action program for climate protection at the end of November 2014. The programme plans to remove an additional 62 to 100 million tonnes of CO_2 every year through a series of measures, including shutting down more coal power plants.[24] Nonetheless, it may ultimately lead to the gradual phase-out of lignite mining and coal-fired power generation. These measures are to be enshrined in an energy law to be adopted in the summer or autumn of 2015.[25] Yet Minister Gabriel has denied that the plan would forcefully close outdated coal-fired power plants, pointing out that the emission cuts would not require any forced closings of coal-fired power plants towards Germany's total CO_2 emissions of 341 million tonnes per year.[26]

These new developments are, overall, in conflict with the role of this resource in the past, present, and future global energy mix:

- According to the World Coal Association and the World Resources Institute, more than 2,300 coal-fired plants are currently operated worldwide – 620 in China alone.[27]
- Continuing a 20-year trend, growth in coal-fired generation since 2010 has been greater than that of all non-fossil-fuel sources combined. Since 2000, coal-fired electricity generation increased by 52 per cent up to 9,100 Terrawatt hours (TWh).
- Fossil fuels still make up 68.4 per cent of global electricity generation. During the past two years, coal has remained the largest contributor (43.9 per cent in both years) of worldwide GHGE. Oil followed as the second-largest source with 35.3 per cent and gas with 20.3 per cent.[28]
- China is the world's largest energy consumer in general and coal consumer in particular, using nearly as much coal as rest of the world combined. In 2012, it added alone 48 Gigawatt (GW) of new coal capacity. China's total coal capacity accounts for almost 50 per cent of global coal consumption.[29] It is also the largest coal producer, providing more energy to the world's economy

19 See Germanwatch/WWF, 'Klima oder Kohle? Reduktion des Kohlestroms zur Erreichung des deutschen 40%-Klimaschutzziels bis 2020', Berlin 2014.

20 In the autumn of 2014, it became clear that Germany would miss its 2020 climate target of a 40 reduction of CO_2 emissions – (compared with 1990s levels) by 5-8 per cent – around 87 million tonnes of CO_2. See also Daniel Wetzel, 'Bundesregierung scheitert beim Klimaschutz', Die Welt, 2 September 2014, p. 9; Wendel Trio, 'Government Coal Subsidies must be Stopped', EurActive, 5 December 2014; the interview with Regine Günther, Head of Climate and Energy Policy at WWF Germany – 'Es geht nicht um das 'ob' – sondern die Geschwindigkeit', BIZZenergy today, 12 November 2014; 'Germany Unlikely to Meet Carbon Reduction Targets for 2020 and 'Global Comparison Reveals Germany's 'Energiewende-Dilemma', EurActiv, 9 December 2014.

21 See Pao-Yu Tei, Claudia Kemfert/Felix Reitz/Christian von Hirschhausen, 'Coal Power Endangers Climate Targets: Calls for Urgent Action', DIW-Weekly Report, Vol. 4, No. 8, 15 August 2014.

22 See Christophe McGlade/Paul Ekins, 'The Geographical Distribution of Fossil Fuels Unused when Limiting Global Warming to 2°C', Nature, No. 517, 8 January 2015, pp. 187-190. See also 'Fossil Fuels Must Stay in Ground – But Be Realistic , Chris Smith Says', EurActic, 30 March 2015.

23 See Andreas Mihm/Henrike Roßbach, 'Gabriels willkommene Abrechnung mit Kohlegegnern', FAZ, 13 November 2014, p. 26 and 'Germany's Says Can't Exit Coal-Fired Energy at same time as Nuclear', Reuters, 13 October 2014.

24 In the power sector, it envisages decreasing emissions by around one-third or another 22 million tonnes by 2020. A further eight coal-fired power stations might be closed down. The emission reductions will be shared equally between Germany's power companies. They would be allowed a maximum of flexibility to determine themselves which of their power plants will be decommissioned. See also 'Germany May Shut Down Eight More Coal Power Plants', EurActiv, 24 November 2014.

25 See Martin Greive/Daniel Wetzel, 'Gabriel zielt auf die sanfte ‚Kohle-Wende', Die Welt, 25 November 2014, p. 9; 'Germany Plans to Withdraw from Binding 2020 Climate Targets', Spiegel-Online, 16 November 2014, and 'Klimapaket soll Milliarden an Investitionen anschieben', Die Welt, 4 December 2012.

26 See 'Germany Denies Plans to Close Old Coal Plants in Sprint to 2020 Targets', EurActiv, 25 November 2014.

27 See Ailun Yang/Yiyun Cui, 'Global Coal Risk Assessment: Data Analysis and Market Research' (Washington D.C.: World Resource Institute, November 2012).

28 See IEA, 'Energy Climate Change and Environment – 2014 Insights' (Paris: IEA/OECD, 2014), p. 12.

29 See IEA, 'Energy Technologies Perspectives 2014. Harnessing Electricity's Potential' (Paris: IEA/OECD, 2014)', p. 74.

than the whole of Middle Eastern oil production.[30] In addition, it has also become the world's largest importer of coal. Beijing has huge impact on both the world energy and coal markets as well as on any successful international and European climate protection policies, as already highlighted in 2009 by an International Energy Agency (IEA) study.[31]

- In Germany, 2.2 GW of lignite capacity became operational in 2012. Recently it reduced this output by 1.4 GW and plans to retire an additional 1.5GW.[32]
- The IEA has forecasted that coal will rival oil as the world's top energy source as early as 2017.[33] Coal is not only currently the world's most important source of electricity generation, but may also be the "fuel of the future" for many developing countries because of its availability and cost competitiveness.[34]

Around 60 per cent of the existing coal capacity is subcritical – the least efficient class of commercially available coal-fired efficiency technologies.[35] The need for modernization – by retrofitting existing coal-fired plants with a range of CCTs to enhance their energy efficiency – offers huge future export chances for the European and German power companies, which are amongst the world's leaders in clean coal technologies (CCTs).

Potential for cleaner coal technology is significant in Europe, which has witnessed a coal renaissance since 2010. A major contributor to this coal surge has been the U.S. shale gas revolution, which has ultimately boosted cheap U.S. coal exports that have replaced Russian gas in European markets.[36] American coal has found a ready market in countries in Europe and Asia, where gas is three to five times more expensive. The current oversupply in international coal markets has made coal more competitive in European power generation, in direct contradiction to the EU's officially agreed climate protection policies. All in all, the European power mix will be the product of "the dynamics of global, rather than local, gas and coal supply."[37]

Complicating the outlook for the use of coal and the development of coal technology are global efforts to reach a GHGE reduction deal. In November 2014, China and the United States announced a joint landmark agreement to cut emissions. In addition, China declared a peak of its GHGE around 2030, and that it would switch to non-fossil fuel sources for 20 per cent of its energy needs. The landmark commitment has raised new hopes of a new global deal on a post-2020 GHGE reduction at a UN summit in Paris in December 2015.[38] If the Paris summit reached a global binding climate change agreement, it would have wide-ranging implications for the global energy policies.

But, according to most energy experts and international energy organizations, a world without coal-fired plants is unrealistic through 2040. In the absence of a 'silver bullet' solution, governments have favoured a mix of policies and low-carbon technological solutions and regulations in order to comply with global climate protection targets and, at the same time, guarantee both economic stability and energy supply security.[39] For example, higher natural gas consumption has been favoured over coal – as in the United States -, and there has been a rapid introduction of an increasing number of CCTs – including boosting the energy efficiency of coal-fired plants to more than 45 per cent, coal-to-gas gasification (GTG), CCS and carbon capture, use, and storage (CCUS).[40]

Meanwhile, in Europe views on the future of coal are also complicated by the decline in European hard coal production during the past 30 years – contrary to global energy trends. In contrast to oil and gas supplies from oftentimes unstable regions and countries outside Europe, coal has been seen as a guaranteed and affordable supply source lacking major interruptions and related high price and supply risks. During the last decades, coal has failed to be considered a strategic resource, although individual European countries such Poland and those of South Eastern Europe, as well as China and India, have recognized its role as an indigenous resource for enhancing national supply security.[41]

The following analysis will examine the strategic implications of a German and European ban on export credit finance of coal-fired power technologies and

30 See IEA, 'Cleaner Coal in China' (Paris: IEA/OECD, 2009, p. 3.

31 See ibid., p. 17.

32 See IEA, 'Energy Technologies Perspectives 2014., p. 74.

33 See IEA, 'Coal's Share of Global Energy Mix to Continue Rising, with Coal Closing in on Oil as World's Top Energy Source by 2017', IEA-News, 17 December 2012, and Javier Blas,'IEA Expects Coal to Rival Oil by 2017', FT, 18 December 2017.

34 'Coal: The Fuel of the Future, Unfortunately', The Economist, 19 April 2014, Henry Foy, 'Several Factors Conspire to Increase Fossil Fuel Use', FT, 22 October 2014, and Brian Ricketts, 'Coal Industry Stands for Progress and Prosperity', EurActiv, 27 February 2015.

35 See IEA, 'Energy Technologies Perspectives 2014., p. 9.

36 See Keith Johnson, 'U.S. Coal Finds Warm Embrace Overseas', The Wall Street Journal, 6.2.2013;

37 David Price/Catherine Robinson/Shankari Srinivasan, 'The Coal Connection. Impact of the US Market on Europe', IHS-CERA, 29 August 2013, p. 1.

38 See Li Xin, 'Next Five Years Crucial for Chinese Climate Pact', Interfax-NGD, 14 November 2014, p. 4.

39 The chair's statement of the tenth Asia-Europe Meeting (ASEM), for instance, stated the necessity of diversifying energy sources and phasing out fossil fuels, while also calling for the adoption of clean coal technologies. Council of the European Union, 'Chair's Statement of the Tenth Asia-Europe Meeting', Milan, 16-17 October 2014, Press Release ST 14134/14, Presse 541, Milan, 17 October 2014, here p. 6.

40 See also Xunpeng Shi/Brett Jacobs, 'Clean Coal Technologies in Developing Countries', East-Asia Forum, 25 September 2012.

41 See Euracoal, 'An Energy Strategy for Europe. Importance and Best Use of Indigenous Coal', Brussels 2009 and idem, 'Guaranteeing Energy for Europe – How Can Coal Contribute?', ibid., and Sandro Schmidt/Sönke Rehder/Benhard Cramer, 'Quo vadis Kohle?', Commodity Top News, No. 32, BGR, Hannover 13 November 2009.

CCTs, including whether such an export ban may in reality negatively affect global, German, and EU climate protection efforts. It will also analyse the overall question of coal's future in the European and German energy through 2040.

In answering these questions, the analysis will first address the global energy developments and the forecasted role of coal in the worldwide energy mix in the medium term. In this context, it will also take a look on newly emerging coal options, which are often overlooked in the European and German energy discussions. It will also pay particular attention to China's energy policies for the next decades as it is the world's largest energy and coal consumer, producer, and importer. In addition, it will examine U.S. energy and coal policy, as the shale gas revolution and rising cheap U.S. coal exports to Europe and Asia have also had a significant impact on international coal markets. Moreover, any discussion on the future of coal should include a review of the progress and remaining challenges of CCS, as this key technology needs to be adopted by the oil and gas sectors and all energy-intensive industries, having no alternative technology available for reducing considerable GHGE as part of the worldwide efforts to cope with climate change.

Next, the analysis will examine the EU's integrated energy, climate, and coal policies. Special attention will be given to the European Commission's view on the future role of coal, CCTs and CCS.

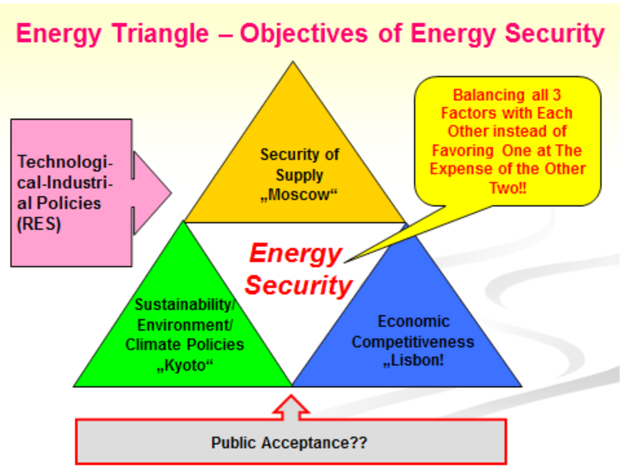
Finally, the study will review the German energy policy of *Energiewende,* as well as whether a third phase-out for coal-fired power generation – i.e. lignite – may happen after the phase-outs for Germany's hard coal production by 2018 and nuclear power by 2022 – adopted in 2006 and 2011, respectively. Against this background of global, European and German energy and related climate change policies, this paper will address the question of whether a German and European ban on export credit finance for coal-fired technologies and CCTs makes sense both for mitigating climate change and for keeping economic and industrial competitiveness

Global Dimensions: Coal in the Global Energy Mix and International Forecasts on Energy Megatrends

The Interrelated Twin Challenges of Global Energy Security and Climate Change Policies and the 'Energy *Trilemma*'

Since the end of 1990s, international energy experts have stressed the increasing strategic importance of energy supply security[42] in relation to economic competitiveness and environmental and climate sustainability. According to energy security experts, the biggest challenge is maintaining the balance between all three objectives instead of favouring one at the expense of the other two. Nevertheless, more emphasis has been given to the environmental and climate sustainability factor, especially in European and German debates on energy strategies.

Figure 1: The 'Energy *Trilemma*'

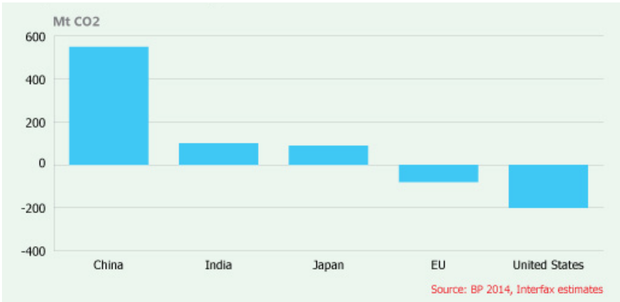


Source: Dr. Frank Umbach

Throughout the world, integrated solutions to the energy-climate nexus are needed in order to balance energy security priorities with economic and environmental objectives. While energy security may often be defined as a national priority, there are very different ideas about the best ways of achieving it. Although the EU sees a threat in its rising gas import dependence on Russia, it has relied primarily on market-based solutions for its energy needs. Until the first Russian-Ukrainian gas crisis in January 2006, many EU member states had often separated energy questions from political factors and strategic developments.

Additionally, energy policies have generally been left to the private sector to determine, even as the EU has recognised the need to develop a common energy foreign policy, and, increasingly, to speak with one voice. This is a significant fact because business interests have been primarily guided by short-term economic concerns and revenues in an increasingly competitive environment. As a result, before 2006 both energy companies and national companies had often overlooked longer-term national interests and energy security issues.[43]

Figure 2: Changes of CO_2 Emissions by Major Countries in 2012



Source: www.interfaxenergy.com

A number of recent events and geopolitical developments – e.g. the current Ukraine conflict, falling oil prices, and instability in North Africa and the Middle East – have dramatically highlighted the importance of energy to the global economy and the vulnerability of individual states and consumers to changes in supply and new energy price shocks. On the one hand, this appears simply a function of the growing imbalance in the supply of, and demand for, energy worldwide. On the other hand, energy supply problems reflect the dependence of much of the industrialised world on potentially unreliable suppliers.

In contrast to energy security and its vulnerabilities, climate change has been a concern only since the 1990s, but it is closely linked to energy policies and energy security. Four major factors shape the new energy-climate nexus:

- Firstly, the energy sector accounts for around two-thirds of global GHGE, reaching 31.6 gigatonnes (Gt) in 2012 –

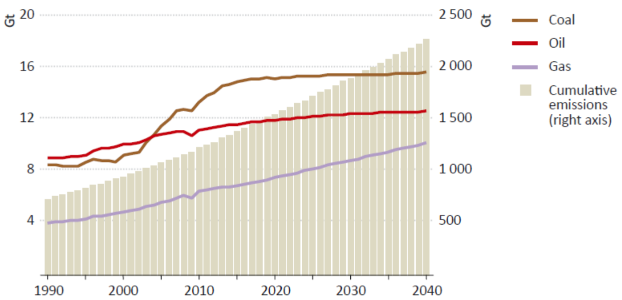
42 So the IEA definition of energy security: http://www.iea.org/subjectqueries/ keyresult.asp?KEYWORD_ID=4103 and IEA, 'Energy Supply Security. Emergency Response of IEA Countries', Paris. OECD/IEA 2014, p. 13 f.

43 See also N.Elhefnawy, The Impending Oil Shock, Survival, Vol. 50, No. 2, April-May 2008, pp. 37-66 and F.Umbach, "Energy Security and World Politics", in: M.Beeson/N.Bisley (Eds.) 'Issues in 21St Century World Politics' (Houndmills-Basingstoke-Hampshire-New York: Palgrave McMillan, 2010), pp. 202-213.

an increase of 400 MT or 1.2 per cent. The international focus towards GHGE is directed towards CO_2 emissions, which represent some 80 per cent of all GHGE, whereas all non-CO_2 GHG emissions cover just 20 per cent.

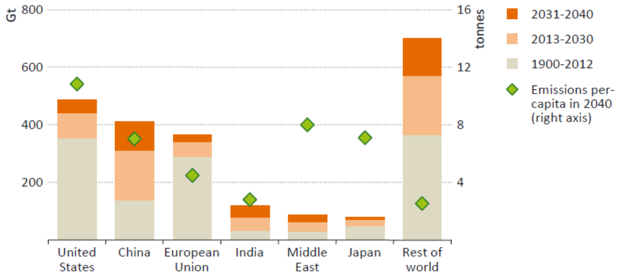
- The most carbon-intensive fuels are coal, oil, and gas – 44, 35, and 20 per cent of all energy-related CO_2 emissions, respectively. Only in the United States and Europe (-CO_2 emissions fell in 2012 – by 4.1 and 1.2 per cent, respectively –, whereas elsewhere they increased – including by 3.1 per cent in China and 6.8 per cent in India. In both cases and many others, the further rise of coal consumption has been identified as the major reason for increases in emissions.[44]
- Even by taking into account the newest energy policies – i.e. enhancing energy efficiency and conservation efforts – and climate mitigation initiatives, these worldwide measures and policy initiatives are not sufficient to reach the 2°C target. On the contrary, they indicate that by 2100 the world temperature may increase up to 3.6°C. Without a widespread introduction of CCS, CO_2 emissions from global coal consumption might be one-third higher than those of gas due to its lower carbon content.[45]
- Hence, mitigating climate change can only be successful when a more far-reaching transformation and decarbonisation of energy production and use takes place worldwide, particularly in China and India. Three-quarters of the projected increase in energy-related CO_2 emissions until 2030 will originate in China, India, and the Middle East, and 97 per cent in non-OECD countries as a whole. OECD countries alone – even if they were to reduce their emissions to zero – are unable to reduce the world's GHGE to a level that limits the rise in global temperature to just 2°C.

Figure 3: Global Fossil-Fuel Energy Related CO_2 Emissions and Total Cumulative CO_2 Emissions in the New Policy Scenario



Source: © OECD/IEA (2014), 'World Energy Outlook 2014', Paris: IEA-Publishing. Licence: www.iea.org/t&c/termsandconditions

Figure 4: Cumulative Energy-Related CO_2 Emissions by Regions in the New Policy Scenario



Source: © OECD/IEA (2014), 'World Energy Outlook 2014', Paris: IEA-Publishing. Licence: www.iea.org/t&c/termsandconditions

Due to the inter-relationship between improving energy – supply – security and mitigating climate change, both policy objectives can conflict with each other: the expanded use of domestic coal, for instance, strengthens national energy supply security by reducing fossil fuel imports, but increases CO_2 emissions. Achieving only a 5 per cent reduction in emissions, through a switch from coal to gas – in particular pipe-based –, on the other hand, has already had negative impacts on energy supply security and the economic competitiveness of economies and national enterprises.[46]

The recent U.S.-China announcement of November 2014 has been praised as a 'watershed moment' in the fight against climate change and in efforts to reach the Kyoto target.[47] The declaration has indeed historical political value, as for the first time the world's two biggest emitters, responsible for 44 per cent of worldwide CO_2 emissions, developed a joint plan ahead of the Paris global climate conference in December 2015. At the same time, the joint declaration is neither binding nor enforceable, but just a political declaration of intent. Likewise, it did not announce any further energy-related climate mitigation efforts to reach the Kyoto target.

Moreover, China announced that its GHGE will peak around 2030. Given China's higher GDP growth rates and more energy-intensive industries, the scope for a significant rise in emissions is high. Indeed, during the last five years, its emissions have grown by 40 per cent. Likewise, its annual per-capita CO_2 emissions are already higher than those of the EU. Moreover, Beijing's target to expand its

44 See IEA, 'WEO 2014' (Paris: OECD/IEA 2014), p. 86 f.

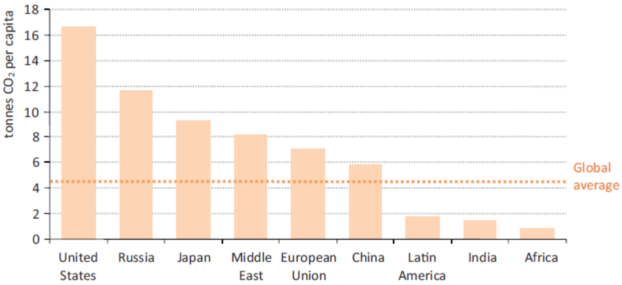
45 See ibid., p. 88.

46 See IEA, 'Energy Security and Climate Policy', pp. 18, 102 ff.

47 The White House, 'U.S.-China Joint Announcement on Climate Change', Office of the Press Secretary, Washington D.C., 11 November 2014; William Mauldin, 'U.S., China Reach Deal on Limiting Emissions', Wall Street Journal, 13 November 2014, p. 15.Johnny Erling, 'China will sauberer werden', Die Welt, 26.11.2014; Coral Davenport, 'Climate Deal Wins Praise, as Landmark with Caveats', New York Times, 13 November 2014, pp. 1 and 4; Mark Landler, 'Differences Arise Despite U.S.-China Deal', ibid., p. 4; Edward Wong, 'China's Plan on Emissions Raises Hopes, and Queries', ibid., and Annemarie Botzki, 'China-US-Climate Pledges Will Set the Scene for Paris', Interfaxenergy.com-NGD/European Policy Weekly, 20 November 2014, p. E3.

total energy consumption coming from zero-emission energy sources – includes hydro- and nuclear power – up to around 20 per cent by 2030 and building an additional 800-1,000 GW of nuclear, wind, solar, and other zero emission generation, is not new. On the contrary, the Chinese goal is based on its present policies, targets, and adopted energy plans – as is the case with the planned U.S. reduction of CO_2 emissions following its Climate Action Plan of 2013 –, and it is therefore not more ambitious.

Figure 5: Worldwide CO_2 Emissions per Capita by Countries and Regions (in tonnes)

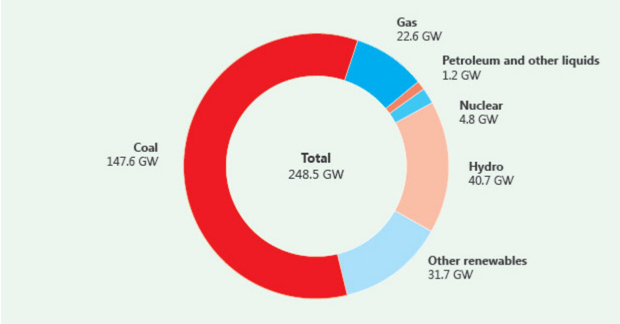


Source: © OECD/IEA (2014), 'World Energy Outlook 2014', Paris: IEA-Publishing. Licence: www.iea.org/t&c/termsandconditions

With these energy and climate mitigation policies in place and even by taking into consideration that China's GDP and industry growth will slow and shift towards less polluting services, Beijing is still set to emit 50 per cent more emissions by 2030. Nevertheless, India will soon replace China as the world's largest coal consumer after 2030. At present, Delhi's CO_2 emissions per capita are eight times lower than Beijing's, which vastly limits the Indian government's appetite to agree to a voluntary cap on its emissions. All in all, even the 3.6°C increase in temperature would become unrealistic if India, for example, were to follow China's example by adopting ambitious energy policies and climate mitigation efforts, albeit at a higher per capita emissions cap along the lines of China's emission commitments vis-à-vis Europe's.[48]

Furthermore, U.S. pledges in the joint declaration to cut GHGE by 26 to 28 per cent from 2005 levels by 2025 are in line with the U.S. Climate Change Action Plan of 2013. Nevertheless, these pledges themselves may be in jeopardy

Figure 6: India's Installed Power Capacity (May 2014)



Source: www.interfaxenergy.com

in light of the U.S. legislative branch's control and oversight over the U.S. federal budget. The new Republican Party majority in Congress has announced its intentions to withhold funding for the U.S. Environmental Protection Agency and has also criticized the joint U.S.-China climate change declaration as detrimental to American economic interests.

A variety of factors complicate the prospects for a binding climate change agreement at the global level, as highlighted at the December 1-14, 2014 UN 20th Session of the Conference of the Parties (UN COP 20)[49] – despite the joint U.S.-China declaration and some progress at other fronts.[50] These factors include some uncertainties about the exact degree of human effects on climate change, the overall unwillingness of many countries to sign legally binding agreements, and the concrete impact and severity of climate change at the regional level.

The divisions between richer and poorer countries seem still difficult to overcome because national interests often outweigh global climate change objectives.[51] For example:

- The U.N. Green Climate Fund (GCF), meant to ease the transition to climate change mitigation policies with up to US$100 billion a year, has merely received US$9.7 billion in financial pledges;
- Australia has abolished its carbon tax system;
- Japan has given up on the Kyoto process in the aftermath of the Fukushima catastrophe, after which it closed almost all nuclear power stations;

48 See also 'New Delhi Says 'No' to Emission Cap Deadline', the Hindu, 6 December 1014; Robert Wilson, 'The Historic' US-China Climate Change Deal Confirms that We Are Failing in the Fight against Climate Change', Energy Post, 20 November 2014 (http://www.energypost.eu/historic-us-china-climate-change-deal-confirms-failing-fight-climate-change/), Matt Hope, 'What Are We to Make of the U.S. and China's 'Historic' Climate Deal?, ibid., 17 November 2014 (http://www.energypost.eu/detailed-look-us-chinas-historic-climate-deal/), Andrew Bolt, 'China, US Deal on Global Warming a Load of Hot Air', the Australian, 17 November 2014, Pilita Clark/Richard McGregor, 'China and US Deal to Curb Emissions Draws Mixed Response, FT, 12 November 2014; John Kemp, 'U.S.-Climate Statement Is No Breakthrough', FT, 12 November 2014 and Pilita Clark, 'Q&A: the U.S.-China Plan on Climate Change', ibid.

49 See also Andreas Walstad, 'Lima Let-Down Poses Risk to Global Carbon Dioxide Deal', Interfaxenergy.com-NGD/Energy Policy Weekly, 18 December 2014, E1-2; Pilita Clark, 'UN Climate Agreement Reached in Marathon Session', FT, 14 December 2014; 'Lima Climate Accord: Positive Steps on the Road to Paris', IISS-Strategic Comments, Vol. 20, Comment 47, December 2014; Mat Hope, 'What Came Out of Lima; Energy Post, 14 December 2014; Giles Parkinson, 'Lima: A Trillion Reasons Why Climate Talks May Still Fail', 4 December 2014

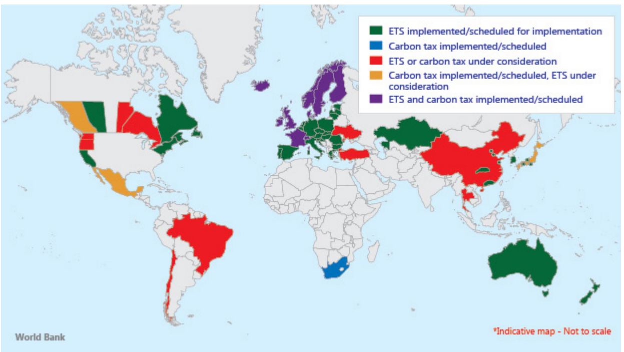
50 See also Stratfor, 'A Binding Global Agreement on Climate Change Will Remain Elusive', 30 December 2014.

51 See 'When It Comes to Climate Change, National Interests Outweigh International Mandates', Strafor, 2 January 2015.

- China and India are unwilling to risk their economic growth by committing to too overly ambitious and costly environmental and climate change policies;[52]
- Even the EU and the United States do not agree on legally binding emissions targets – while Brussels is willing to adopt these targets, Washington favours some legally binding elements, but with the option of allowing countries to determine the scale and pace of their emissions reductions.[53]

Complicating matters even further, the last few years have witnessed several setbacks in plans to link carbon-trading schemes and emission trading systems (ETSs) in order to create larger and more liquid markets, harmonise emission prices, and reduce price volatility. Nevertheless, such a linkage would be a pre-condition to reverse the sharp decline of the carbon price allowances since 2008, which has given coal a competitive advantage over gas in power generation. Since 2008, Europe's carbon prices have fallen by more than €30 (US$33) per tonne to around €6 per tonne as a result of the global recession and a coal oversupply.[54]

Figure 7: Global Carbon Policies and Linkages of Carbon Markets



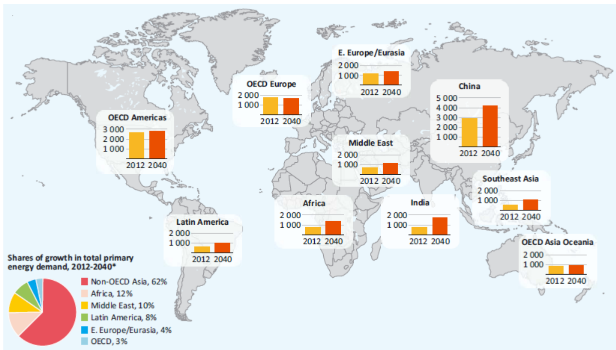
Source: www.interfaxenergy.com

Forecasts and Scenarios of the Global Energy Megatrends by 2040

The IEA's World Energy Outlook (WEO) had already warned in 2010 that since 2008 the world has faced "unprecedented uncertainty" due to the worldwide economic crisis and the twin challenges of climate change and global energy security – the latter the result of huge energy demand in Asia, mostly by China and India.[55] The latest WEO edition of November 2014 warns against mounting hopes and expectations because of several factors. For one, the era of "cheap oil" is coming to a close, with the Middle East and the Persian Gulf as the only remaining sources of inexpensive oil supplies. Likewise, regional instability in North Africa and the Middle East is having a more serious effect than the oil shock of the 1970s. Furthermore, the Ukraine conflict has destabilized European gas supply security, whilst the future of nuclear power is uncertain despite its strategic importance in many countries. In addition, almost one-third of the worldwide population – with an estimated 620 million in sub-Saharan Africa alone – has no access to electricity.[56]

Nonetheless, the IEA had to re-define its oil demand and production forecasts at the end of 2014 in light of rapidly falling oil prices from US$115 to just less than US$70 a barrel in December 2014 – and even just US$44 in January 2015. Consequently, it appears that, at least for the next two to three years, the global oil supply security can be guaranteed at a considerably lower price.[57]

Figure 8: Primary Energy Demand by Region in the New Policy Scenario (Mtoe)



This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries, and to the name of any territory, city or area.

*Growth in primary demand excludes bunkers. Note: Values in the pie chart do not sum to 100% due to rounding.

Source: © OECD/IEA (2014), 'World Energy Outlook 2014', Paris: IEA-Publishing. Licence: www.iea.org/t&c/termsandconditions

In 2013, global primary energy consumption increased and accelerated by 2.3 per cent compared to the previous year (over 1.8 per cent), but remained below the 10-year average

52 'China Says Climate Aid Inadequate, Especially Australia', Reuters, 4 December 2014; Alex Morales/Reed Landberg, 'China Broadens Pollution Pledge in Call for More Climate Funding', 4 December 2014; 'Developed Countries Should Compensate Emissions: India', The Economic Times, 4 December 2014; 'India Says Won't Sacrifice Growth at Climate Talks', The Straits Times, 5 December 2014; 'China Rejects US-Sought Carbon Pledge Review at UN Climate Talks', South China Morning Post, 8 December 2014; 'AP Interview: Australia Won't Pay to Climate Fund', Mail Online, 15 December 2014; and Penny Peiser, 'Climate Blowback: Hostility to the West's CO_2 Crusade', Financial Post (Canada), 9 April 2008.

53 See Dan Collyns, 'Lima Climate Talks: EU and US at Odds over Legally Binding Emissions Targets' The Guardian, 2 December 2014.

54 See Annemarie Botzki, 'Global Linkage of Carbon Markets Remains a Challenge', Interfaxenergy.com-NGD/EnergyPolicy Weekly, 18 December 2014, E4.

55 IEA, 'WEO 2010', p. 45.

56 IEA, 'WEO 2014', pp. 23 ff.

57 See also F. Umbach, 'The Geopolitical Impact of Falling Oil Prices', Geopolitical Information Service (GIS - www.geopolitical-info.com), 19 November 2014.

Figure 9: Global Primary Energy Demand 2012-2040 (in Mtoe.; IEA New Policy Scenario)

	2012	2020	2025	2030	2035	2040	2012-2040*
Coal	**3,879**	**4,211**	**4,293**	**4,342**	**4,392**	**4,448**	**0.5%**
Oil	4,194	4,487	4,612	4,689	4,730	4,761	0.5%
Gas	2,844	3,182	3,487	3,797	4,112	4,418	1.6%
Nuclear Power	642	845	937	1,047	1.137	1,210	2.3%
Hydro	316	392	430	469	503	535	1.9%
Bioenergy	1,344	1,554	1,675	1,796	1,911	2,002	1.4%
Other	142	308	435	581	744	918	6.9%
Total	**13,361**	**14,978**	**15,871**	**16,720**	**17,529**	**18,293**	**1.1%**

* average annual growth rate in per cent.
The numbers in brackets for 2020-2035 are those of the ambitious 450-Scenario linked with Kyoto's climate policies and its "2° C"-target.

Source: F.Umbach based IEA, 'World Energy Outlook (WEO) 2014'. Paris 2014, p. 606.

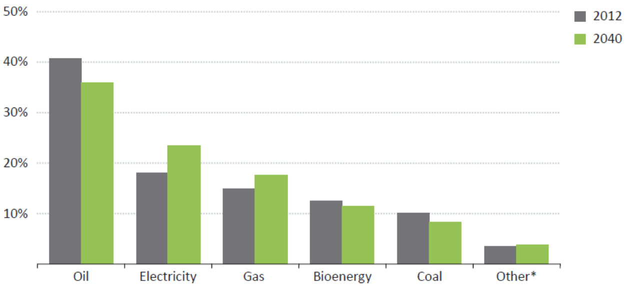
of 2.5 per cent. That same year and during the last decade, respectively, 80 per cent and nearly 100 per cent of global energy demand growth stemmed from emerging economies.

According to the IEA's central scenario – the so-called *New Policies Scenario*[58] –, world primary energy demand will increase by 37 per cent between 2013 and 2040. Yet its growth will significantly decrease from above two per cent during the last decade to just one per cent annually after 2025. Rising energy consumption will still occur mainly in Asia – over 60 per cent. In fact, China is expected to become the largest oil-consuming country around 2030. Growth in primary energy demand growth from fossil fuels will only slightly decrease and still be almost three-quarters by 2040. It will lead to a further rise of energy-related CO_2 emissions by another 20 per cent in the New Policy Scenario with an average increase of up to 3.6°C instead of Kyoto's 2°C target.[59] Also through 2040, almost all growth in primary energy demand will come from non-OECD countries, with Asia accounting for 60 per cent of that growth. Indeed, Asia will shift the energy centre of gravity away from the Americas and Europe, with wide-ranging geo-economic and geopolitical implications. Moreover, China already is and will intensify its role as the determining factor in the rise of global energy demand over the next decades. The IEA expects that China alone will be responsible for more than one-third of the world's increase in primary energy demand.

As for nuclear power, it is set to remain another key option to reduce CO_2 emissions and an important pillar in national energy security strategies, in contrast to Germany and some other European countries. Global output of nuclear energy will increase by almost 60 per cent from 392 GW to 620 GW, though its share of global electricity generation will grow by just one per cent to 12 per cent of the global electricity mix. China alone will account for 45 per cent of worldwide nuclear generation growth, followed by a collective 30 per cent from India, Korea, and Russia. As for OECD markets, nuclear generation is forecasted to decline by 10 per cent in Europe, while it will rebound in Japan – albeit on lower levels prior to the Fukushima catastrophe in 2011 – and in the United States by over 16 per cent.[60]

With regard to renewables, by 2040 their share of the primary energy mix is expected to increase from 13 per cent in 2012 to 19 per cent, and in global power generation to one-third. Its output will increase more than coal and gas combined by 2040, accounting for 48 per cent of all incremental electricity generation in the projected mid-term timeframe. In the EU, the share of renewables in total electricity generation is expected to double from the present level up to 46 per cent by 2040.

Figure 10: Fuel Shares in Global Final Energy Consumption in the New Policy Scenario



* Includes heat and renewables except bioenergy.

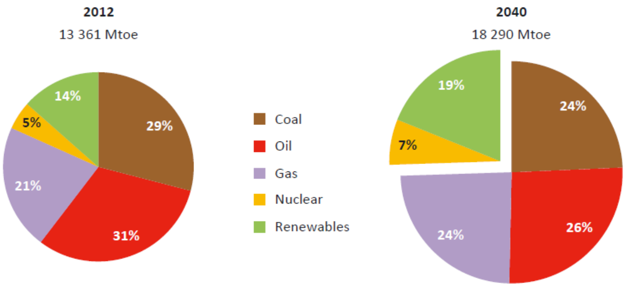
Source: © OECD/IEA (2014), 'World Energy Outlook 2014', Paris: IEA-Publishing. Licence: www.iea.org/t&c/termsandconditions

58 In contrast to the traditional "Reference Scenario", the New Policies Scenario of the IEA takes into account the broader policy commitments and energy plans that have already been announced by the national states around the world, including pledges to reduce GHGE and plans to phase out fossil-energy subsidies. This scenario is being place between the traditional Reference Scenario (business-as-usual) and the ambitious 450 Scenario that is consistent with the 2° C goal of the global climate policy efforts.

59 See IEA, 'WEO 2014', pp. 53 ff.

60 See ibid. p. 27.

Figure 11: Fuel Shares in World Primary Energy Demand in the New Policies Scenario



Source: © OECD/IEA (2014), 'World Energy Outlook 2014', Paris: IEA-Publishing. Licence: www.iea.org/t&c/termsandconditions

The IEA also expects that renewables will account for almost 50 per cent of the increase in total electricity generation by 2040. Wind power, followed by solar PV, will become the second-largest of all power technologies after gas-fired capacity.[61] But the expansion of RES is dependent on adequate price signals for timely investments and on their relative competitiveness vis-à-vis other energy resources.

The expansion of renewables has considerable effects on electricity generation and the power sector. It creates unprecedented challenges for baseload security and electricity supply stability, as it can be observed in the German Energiewende. For instance, wind and solar power are not available on a regular basis, yet currently there are no technical and affordable solutions for storing electricity. In this context, keeping the lights on and avoiding large-scale electricity blackout pose serious challenges for energy companies and governments in industrialized countries. The daily functioning of the entire electricity system faces complications such as rapid increases and decreases or insufficiently coordinated deployment of various renewables. Very flexible demand-side management capacities are necessary in order to avoid abrupt swings in the availability of electricity supply and other unpredictable changes in power generation and electricity supply. For the time being, only nuclear power and fossil-fuel power plants can guarantee stable electricity supply.

Electricity generation will remain the fastest growing final form of energy demand worldwide. Global installed electricity generation capacity will grow from about 5,950 GW in 2013 to more than 10,700 GW in 2040 thanks to capacity increases – over 7,200 GW – as well as replacement of retired plants – over 2,400 GW. At the same time, almost 40 per cent of existing power generation capacity and 200 GW of renewable capacity need to be replaced. In the EU alone, almost 60 per cent of the retired power generation capacity is in need of replacement.[62]

Figure 12: World Electricity Generation by Source in the New Policy Scenario

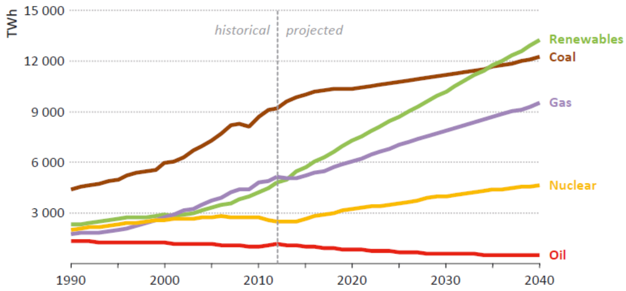
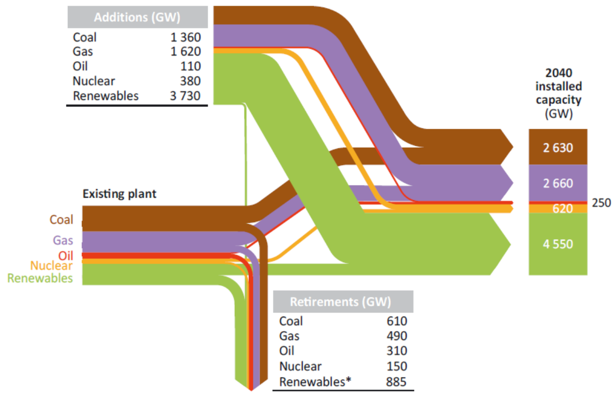
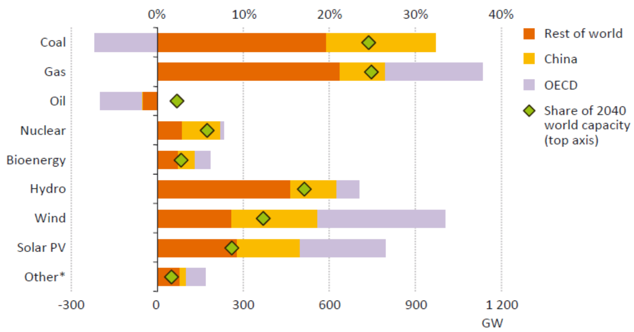


Figure 13: Power Generation Capacity Flows by Source in the New Policy Scenario (2014-2040)



*Note: Over the projection period, a portion of renewable additions is retired, consistent with the average lifetime assumption for wind and solar PV of 25 years.

Figure 14: Net Change in World Power Generation Capacity by Fuel Type and Region in the New Policy Scenario (2013-2040)



* Includes geothermal, concentrating solar power and marine.

Source for figures 12 to 14: © OECD/IEA (2014), 'World Energy Outlook 2014', Paris: IEA-Publishing
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61 See IEA, 'WEO 2014', p. 25 f. and 239 ff.

62 See ibid, here p. 201 ff.

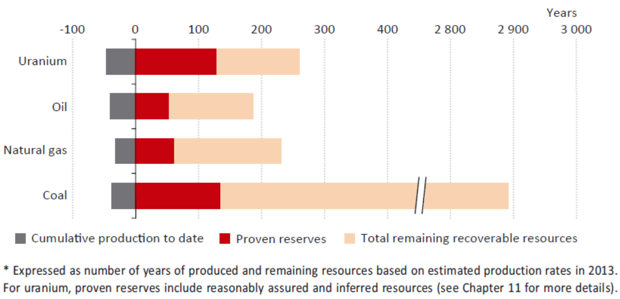
Figure 15: Comparison of Standard Sub-divisions and Classifications of Coal in Accordance with the Coalification

Subdivisions and classifications	Increasing coal rank →			
Internationally Conventional Classification	lignite	hard coal		
Germany and Countries to the East	brown coal		hard coal	anthracite
English Speaking Area	lignite	sub-bituminous coal	bituminous coal	anthracite
Internationally Classification of In-Seam Coals (UN-ECE 1998)	lignite	sub-bituminous coal	bituminous coal	anthracite
Commercial Classification according to intended use			steam coal	steam coal
			cooking coal	anthracite
			PCI-coal	PCI-coal

Source: F.Umbach based on Federal Institute for Geosciences and Natural Resources (BGR), Energy Resources 2009 – Reserves, Resources, Availability, Hannover, 10th November, 2009.

Nonetheless, depending on the IEA policy scenarios, the share of fossil fuels in the total primary energy mix will only slowly decrease from 82 per cent in 2012 to 60 to 80 per cent by 2040, with wide uncertainties for both coal and renewables – in the New Policy Scenario, for example, this reduction reaches 74 per cent.[63]

Figure 16: Lifetimes of fossil-fuel and uranium resources



Source: © OECD/IEA (2014), 'World Energy Outlook 2014', Paris: IEA-Publishing. Licence: www.iea.org/t&c/termsandconditions

63 See ibid, p. 55.

Perspectives of the Role of Coal in the Worldwide Energy Mix by 2040

Coal is expected to remain a key source of energy generation for the next several decades.[64] The different types of coal vary depending on their intended use. In general, coal can be sub-divided into energetic and coking coal.[65] Energetic coal comprises lignite or brown coal as well as different types of hard coal, depending on the different international classifications:

Energetic hard coal is called steam coal or thermal coal and used more commonly for transportation because of its higher energy content. Steam coal is used, above all, for three purposes:

1. as an input in the power sector to produce electricity and heat – and then sold to third parties mostly as district heat –,
2. as fuel in the final consumption sectors for the production of heat and/or steam – i.e. industry, agriculture, transport, residential and commercial and public services –, and

64 According to the Japanese energy expert Shoichi Itoh from the Institute of Energy Economics Japan (IEEJ), "ignoring the inevitable role" of coal as an abundant and competitive resource is "a fundamental mistake" and the world "will continue to depend it for decades to come. See Shoichi Itoh, 'A New Era of Coal: The 'Black Diamond' Revisited', Pacific Energy Forum Working Paper, The National Bureau of Asian Research (NBR), p. 1.

65 See Federal Institute for Geosciences and Natural Resources (BGR), 'Energy Resources 2009 – Reserves, Resources, Availability', Hannover, 10 November 2009, p. 115 f. and IEA, Coal Information 2010 (with 2009 data), Paris 2010, pp. 11 ff.

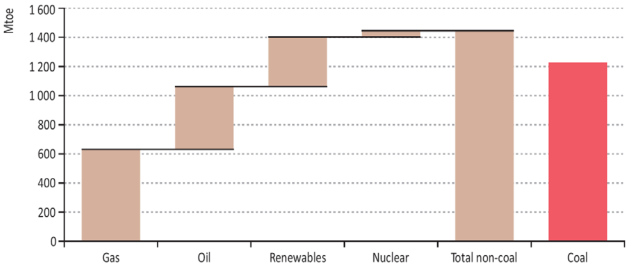
3. small amounts as pulverised coal injection – so-called PCI coal.

In contrast to steam coal, coking coal is of a significant higher quality – e.g. it has low sulfur content. It is used in coke plants and sometimes as an input in the power sector to produce electricity, and it is indispensable for steel production. From a global perspective, hard coal production – primarily steam coal – plays the dominant role towards the production of lignite/brown coal, which has lower energy content. In contrast to lignite, hard coal is an internationally traded commodity, whereas lignite is not affected by maritime transport costs. Instead, lignite/brown coal is mostly used in vertically integrated processes with power being generated in power plants that are mostly close to surface mines.

While both global oil and gas consumption increased by 1.4 per cent individually in 2013, global coal consumption was again the fastest fossil fuel, growing by another three per cent, whilst the 10-year average was even higher at 3.9 per cent.[66] China and India combined accounted for 88 per cent of the world's coal consumption increase – with China alone accounting for 67 per cent.

During the last decade, global coal demand grew by more than 50 per cent – almost half of the increase of the worldwide total primary energy use.[67] Between 2000 and 2010, global coal consumption grew globally almost as much as the whole increase in world demand for primary energy.

Figure 17: Incremental World Primary Energy Demand by Fuel, 2000-2010



Source: © OECD/IEA (2011), 'World Energy Outlook 2011', Paris: IEA-Publishing. Licence: www.iea.org/t&c/termsandconditions

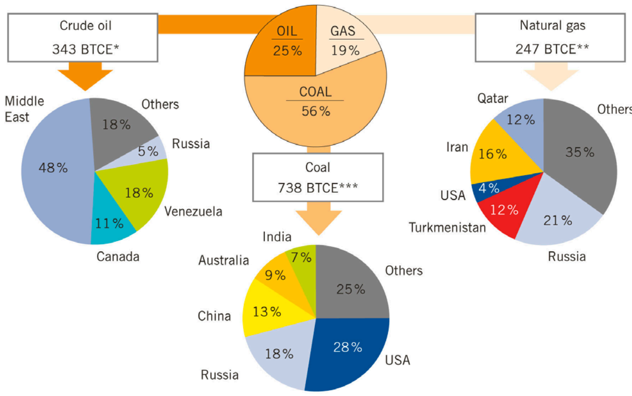
At 30.1 per cent, in 2013, coal's share of the global primary energy consumption reached its highest point since 1970. Renewables continued to fasten its increase, but accounted for just 2.7 per cent of global energy consumption – compared to just 0.8 per cent ten years ago. In power generation, renewables increased by 16.3 per cent and reached a new record of 5.3 per cent of worldwide power generation.[68]

66 BP, 'BP Statistical Review of World Energy 2014', June 2014.

67 See IEA, 'WEO 2014', p. 178.

68 See ibid.

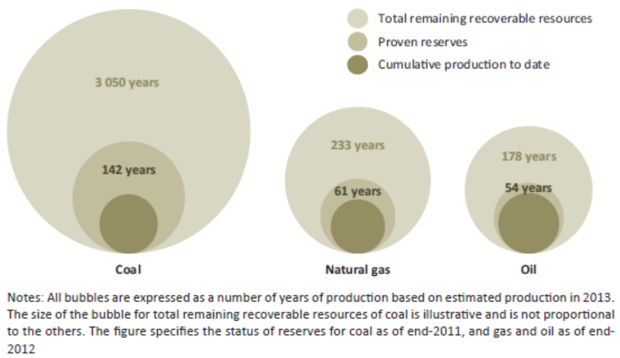
Figure 18: Global Reserves of Energy Sources



Source: World Energy Council (WEC)-Germany 2013.

As of 2013, proved global coal reserves were sufficient to meet 113 years of global production – far more than the ratio of reserves versus production (R/P) for oil and natural gas – 53.3 and 55.1 years, respectively.[69] At the same time, it is often overlooked that these coal reserves have been halved during the last decade.[70] Nonetheless, coal resources are 20 times larger than coal reserves and could be exploited with slightly higher prices or future technological innovations.[71] Only 30 per cent of global coal reserves are located in non-OECD Asian countries.[72]

Figure 19: Global Fossil-Fuel Reserves and Resources



Source: © OECD/IEA (2013), 'World Energy Outlook 2013', Paris: IEA-Publishing. Licence: www.iea.org/t&c/termsandconditions

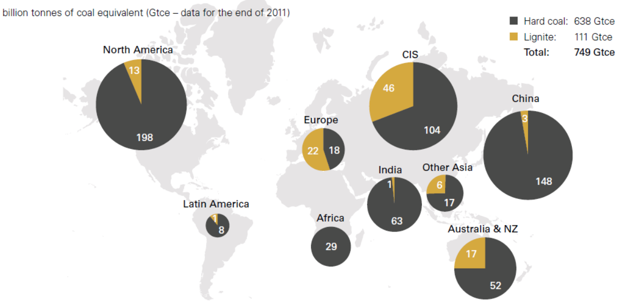
69 See BP, 'BP Statistical Review of World Energy 2014', London 2014, and BGR, 'Energiestudie 2014: Reserven, Ressourcen und Verfügbarkeit von Energierohstoffen', Hannover, December 2014

70 In 2001, the R/P ratio of the worldwide coal reserves were still 216 years according to BP, 'BP Statistical Review of World Energy 2002', June 2002, p. 30.

71 Reserves versus resources: reserves are those defined quantities of fossil fuels which are considered as commercially recoverable by the present application of exploration projects and technologies; resources are those defined quantities of fossil fuels which are contingent and prospective, estimated to be potentially recoverable from known accumulations; but projects are not yet considered mature enough for commercial development.

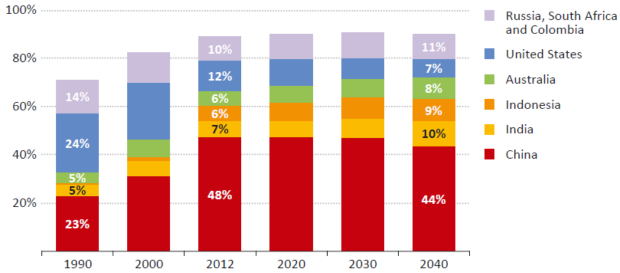
72 See BP, 'BP Statistical Review of World Energy 2014', p. 30 f. and IEA, 'WEO 2014', p. 181.

Figure 20: Global Hard Coal and Lignite Reserves



Source: BGR, Euracoal 2013.

Figure 21: Share of World Coal Production by Key Country in the New Policy Scenario



Source: © OECD/IEA (2014), 'World Energy Outlook 2014', Paris: IEA-Publishing. Licence: www.iea.org/t&c/termsandconditions

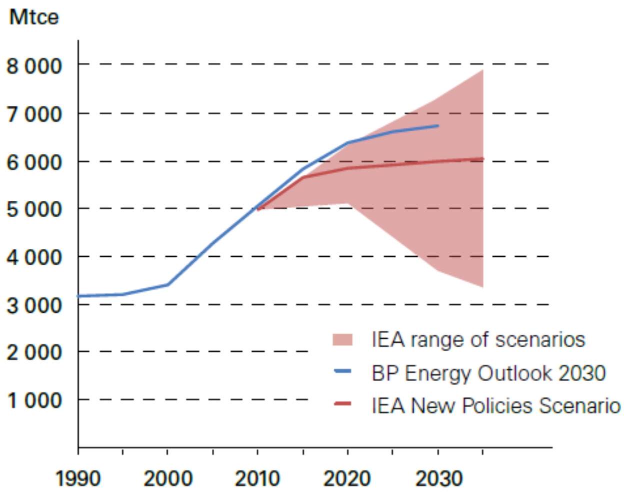
Three of the largest countries by territory – the United States, Russia, and China – also hold the largest proven coal reserves in the world. By region, however, Europe and Eurasia have the largest proven coal reserves at an R/P ratio of 254 years, compared to 250 years in the United States.[73]

Global coal production is dominated by eight countries – see below –, accounting for 90 per cent of global production. By 2040, China, India, Indonesia, and Australia alone are expected to account for more than 70 per cent of global coal output. India and Indonesia may overtake the falling U.S. production around 2030 and become the second- and third-largest coal producers after China.

According to the IEA, until 2040 global coal consumption will grow by another 15 per cent – annually just 0.5 per cent compared with 2.5 per cent during the last decade –, with almost two-thirds of this growth taking place within the next decade. Nevertheless, coal's share of global energy demand will decline from 29 per cent in 2012 to 24 per cent by 2040, but it will still remain the world's second most important energy source just ahead of natural gas. At the same time, it must be noted that the IEA's and other scenarios differ by a wide margin in light of different uncertainties and conditions.[74]

Currently, around 1,200 coal plants are being planned across 59 countries, with almost 70 per cent planned in China and India alone – 363 and 455 respectively. The total capacity of these new plants will increase the world's coal-fired power capacity up to 1,400 GW – the equivalent of another China.[75] At the same time, a recent study found

Figure 22: Future Global Coal Demand scenarios to 2030 and 2035



Source: Euracoal 2013.

that more coal power plants are being cancelled than built.[76] Regardless, even considering that not all of them will come to fruition, the vast building programme is out of line with 2°C target and instead highlights the need for CCTs, including CCS. In this regard, Japan's approach to coal use with cutting-edge CCTs could provide an interesting roadmap for the future.[77]

73 See BP, 'BP Statistical Review of World Energy 2014', p. 31, 8 and 20.

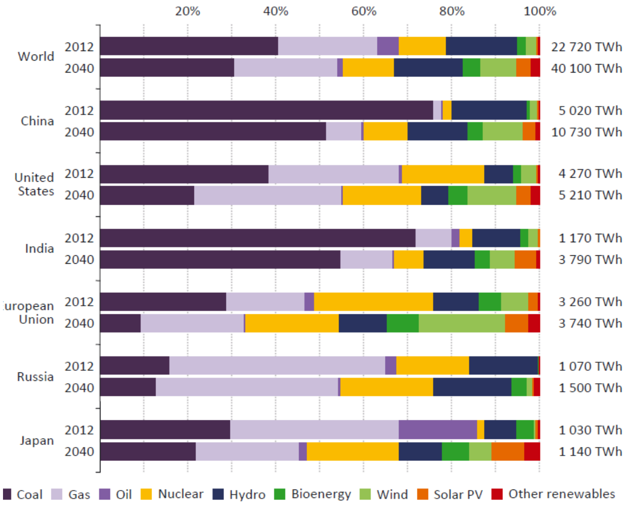
74 The new BP-report 'Energy Outlook 2035', for instance, has forecasted that coal will remain the dominant fuel for power generation with more than a third of the inputs as part of a stronger growth of fossil fuels compared with the IEA's 'New Policy Scenario' 'Energy Outlook 2035', January 2015 (http://www.bp.com/content/dam/bp/pdf/Energy-economics/Energy-Outlook/Energy_Outlook_2035_booklet.pdf).

75 See also Ailun Yang/Yiyun Cui, 'Global Coal Risk Assessment'; Damian Carrington, 'More than 1,000 New Coal Plants planned Worldwide, Figures Show', The Guardian, 20 November 2012.

76 Between 2010 and 2014, some 356 GW of new coal capacity had been added to the world's existing fleet of coal power plants with a total capacity of 1,805 GW in 2012. But 493 GW or 624 individual power plants were shelved. See Sophie Yeo, 'More Coal Plants are being Cancelled than Built', Energy Post, 17 March 2015.

77 As a result of the shut-down of its nuclear reactors, Japan has also been forced to increase its coal share in its electricity generation from around 25 per cent before the nuclear accident to some 30 per cent today. Its new blueprint for its energy future also seeks to increase its coal consumption, albeit on cutting-edge technology for highest energy efficiency. See 'Japan's New Coal Plants Threaten Emission Cuts, Group Says', Bloomberg, 9 April 2015 and Keith Johnson, 'Japan Bets on Nuclear, and Coal, for Future Power', Foreign Policy, 8 April 2015.

Figure 23: Share of Electricity Generation by Source and Selected Region in the New Policy Scenario



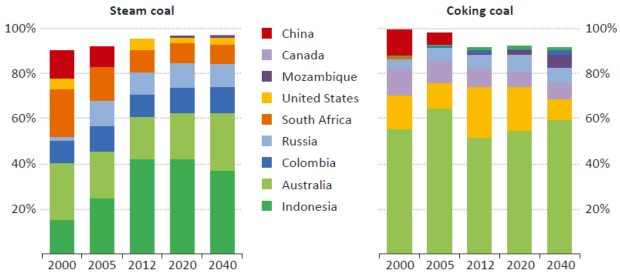
Source: © OECD/IEA (2014), 'World Energy Outlook 2014', Paris: IEA-Publishing. Licence: www.iea.org/t&c/termsandconditions

Over 50 per cent of global coal consumption will be absorbed by Chinese coal demand over the next ten years. Some 80 per cent of the increase in net coal trade will be absorbed by steam coal given the strong growth in demand from coal-fired power plants in Asia. After 2030, however, China's coal use will begin to decline.

At the same time, before 2020, India will have already overtaken the United States as the world's second-largest coal consumer, and by around 2025 it will surpass China's import demand. [78] Between 2012 and 2040, India's import levels will more than triple to 30 per cent of global trade. Likewise, its coal import dependence will sharply rise from 25 per cent in 2012 to 40 per cent by 2040.[79] Currently, coal accounts for 67 per cent of India's total power generation.[80] India's dependence on goal for meeting its development coals could even "tip the balance on global climate change."[81]

While current low coal prices are threatening investments on the production side, global growth in demand is expected to lead to price increases sufficient to attract new investments in the next decades. China, India, and Australia alone are forecasted to account for over 70 per cent of global coal production by 2040, highlighting Asia's strategic importance in world coal markets. Hence, the adoption of clean coal technologies and high-efficient coal-fired generation technologies, as well as of CCS, will be key factors in containing a further dramatic rise of CO_2 emissions, and also to ensure a realistic transition to a low carbon power system. The use of coal in the EU-28 is expected to drop by more than 50 per cent in light of Europe's ambitious climate mitigation and local anti-pollution policies. For its part, Australia – today the second-largest coal exporter – is forecasted to surpass the United States as the largest OECD coal producer by 2035.[82]

Figure 24: Share of World Coal Trade by Type and Key Countries in the New Policy Scenario



Source: © OECD/IEA (2014), 'World Energy Outlook 2014', Paris: IEA-Publishing. Licence: www.iea.org/t&c/termsandconditions

By 2040, global trade in coal will grow by 40 per cent due mainly to rising coal imports in China and India. It will increase the share of global coal trade relative to world coal demand from 18 per cent in 2012 to 23 per cent by 2040. Trade of global coking coal production will increase from 30 per cent in 2012 to 40 per cent by 2040 and steam coal production from 17 per cent to 21 per cent, respectively.[83]

Although present coal production has the highest CO_2 emissions of all fossil fuels, almost all international energy organisations and experts assume that it will continue to play a major role in world energy supply – at least through 2040. But a world without coal appears unrealistic even through 2050. Most public energy debates ignore the fact that new coal production and coal transformation options for liquefying or gasifying coal are underway for the development of commercial operation. Another 'silent revolution' – as in the case of U.S. unconventional gas resources and new drilling technologies – of 'coal cannot be excluded – i.e. underground coal gasification, or UCG – in the years to come.[84]

Furthermore, Europe has overlooked another strategic development – the European and EU market share is continuously declining as power shifts to the new consumer centres in the Asia-Pacific region. Indeed, China, India, and others will restructure the overall international trade patterns and structures of the international coal markets. Thus, European coal prices are already being increasingly

78 See 'India to Overtake China as Biggest Thermal Coal Importer', Hellenic Shipping News, 17 April 2015 and Neil Hume, 'Indian Coal Import Growth Outstrips China', FT, 6 October 2014..

79 See IEA, 'WEO 2014', p. p. 184.

80 See Rosemary Marandi/Kiran Sharma, 'Modi Looks to Double Coal Production by 2020', Nikkei Asian Review, 3 April 2015; James Crabtree, 'Coal India Digs Deep in Pursuit of Tough Goals', FT, 24 March 2015 and idem, 'India: At the Coalface, FT, 31 March 2015.

81 Coal Rush in India Could Tip Balance on Climate Change', New York Times, 17 November 2014.

82 See ibid.

83 See IEA, 'WEO 2014', p. 173.

84 See also Henry Foy, 'Several Factors Conspire to Increase Fossil Fuel use', FT, 22 October 2014.

influenced by rising coal demand in China and India.[85] Furthermore, China – together with Australia, the world's largest exporter of hard coal – has itself become a leading nation in promoting clean coal technologies, and is supporting new technology options such as CCS, coal-to-liquids (CTL), coal-bed methane (CBM), and UCG.

New Coal Options

In addition to evolutionary coal-fired power generating technologies – see also pp. 37 ff. – that enhance energy efficiency, new coal transformation options that convert fossil fuels into higher value end-use products are entering the world's energy markets. With rising oil prices in recent years, and conventional oil remaining available just for another 50 years at current production levels, CTL transformation is becoming a more attractive option and an important growth sector. At the same time, CTL is only realistic in combination with CCS due to its large energy needs and higher CO_2 emissions in comparison with conventional oil production. However, on a 'well-to-wheels' basis, the difference of CO_2 emissions is much smaller – see picture below – given that those emissions already occur at the point of use.

In contrast to oil shales, CTL technology is more experienced, less risky and the environmental impact less controversial, because the plants are located near active coal mines that are already being exploited. Thus, land-use is likely to be more acceptable to the local communities, including more densely populated Europe.[86]

CTL has a long history and is based on the German *Fisher-Tropsch* catalysis technique used during World War II. Furthermore, the gasification of coal (CTG) into 'syngas' – a mixture of hydrogen, carbon dioxide, and methane – had previously been used as old 'town gas' before natural gas became available worldwide. The same gasification process is being used today in highly modern integrated gasification combined cycle (IGCC) power plants. With the second step of turning syngas into a liquid hydrocarbon, it is possible to produce high quality diesel as in World War II.

Oil derived from processing coal with CTL (and from gas through to gas to-liquids/GTL87) can serve as a means of reducing dependence on oil imports. Currently only two large-scale CTL – *Sasol II* and *III* – plants are operating in South Africa, with a capacity of 150,000 b/d of synthetic liquids, which accounts for 20 per cent of the county's total liquid fuel supply. For the country's CTL production, around 25 per cent of its total coal consumption is needed.[88] Given the manifold experiences with the key components of the gasification and *Fischer-Tropsch* processes, syngas can be

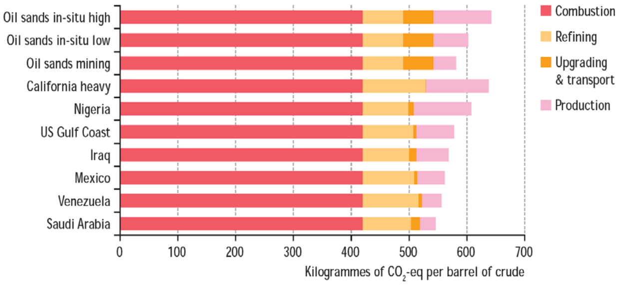
85 See also Federal Institute for Geosciences and Natural Resources (BGR), 'Annual Report 2010 – Reserves, Resources, Availability', Hannover 2011, p. 30.

86 See IEA, 'WEO 2010', pp. 170 ff.

87 See ibid., pp. 174 ff.

88 See ibid., p. 65.

Figure 25: 'Well-to-Wheels' Greenhouse-Gas Emissions of Various Oils



Note: Transport emissions are based on delivery to the United States. The bottom seven bars are examples of specific conventional crudes; they do not imply an average value for the countries of origin. The range of values for in-situ production of oil sands is indicated by the high and low cases.

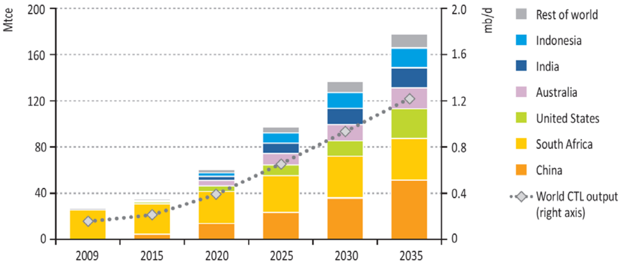
Source: © OECD/IEA (2010), 'World Energy Outlook 2010', Paris: IEA-Publishing. Licence: www.iea.org/t&c/termsandconditions

used for power generation, as well as a chemical feedstock, and to produce methane. Moreover, biomass can be mixed with the coal-and-biomass-to-liquids (CTBL) and biomass-to-liquids without major changes to the existing equipment, offering a useful diversification of the investment risks.

The IEA's New Policy Scenario forecast an increase in CTL production by about 125 Mtce or around 1.1 mb/d – equivalent to 1 per cent of global oil demand by 2040. In recent years, ten CTL projects have been announced in the United States, six in China, one in Canada, and a second one in Australia. Of the 20 CTL projects announced during the last years, the largest projects have a capacity of 60-80 kb/d. Most of the newly announced larger projects are expected to start operating around 2020. The Monash Energy project in Australia is due to start in 2015. China commissioned its first large-scale commercial CTL-plant in Inner Mongolia at the end of 2008 and plans to expand its production, for which 120-150 MT coal are needed, up to 30 MT of which by 2020.[89] The equivalent oil price required for CTL-plants is conservatively estimated between US$60 and US$100/barrel. These prices already include CCS, whose prices represent only a small share of the higher total CTL costs. Most of the CCS costs involved are generated primarily from the produced hydrogen. Theoretically, RES, too, can be used for generating hydrogen, but for now they are too expensive. For CTL, CCS is rather inexpensive because CO_2 is already produced as a byproduct of syngas and the bulk of CO_2 needs to be captured anyway. Thus, only transport and storage costs need to be added in the overall cost assessment.

89 See BGR, Energy Resources 2009, p. 136 and IEA, WEO 2011, p.372 f.

Figure 26: Coal-to-Liquids-Production (CTL) by Country in the New Policy Scenario



Source: © OECD/IEA (2011), 'World Energy Outlook 2011', Paris: IEA-Publishing. Licence: www.iea.org/t&c/termsandconditions

Another option is gas-to-liquids (GTL), whose production jumped in 2011 with the start of the Pearl-GTL plant in Qatar with a capacity of 140 thousand barrels per day (kb/d). It also uses the Fischer-Tropsch process, producing diesel, gasoline, and lubricants. Another GTL plant started in Nigeria in 2014, two new ones are planned in Uzbekistan and the U.S. and some more are considered in Canada, Algeria, and Russia, which may increase global production up to 400 kb/d by 2025.[90]

CBM

Alongside the U.S. shale gas revolution, there is also worldwide attention on CBM due to lower capital requirements, technological entry barriers compared with tight or shale gas exploration and production, and the involvement of many more players. But, while CBM production capacity was just 2.5 bcm in 2009, production volumes are even lower at 0.7 bcm. At present, production targets for CBM were 5 bcm by the end 2010, and are 30 bcm by 2020 and 50 bcm by 2050. Present production costs are about 50 per cent higher than conventional natural gas.[91] Global resources of CBM alone amount to 135.5 tcm-372.5 tcm.[92] The IEA's New Policy Scenario expects a CBM production of almost 200 bcm, which is equivalent to 15 per cent of the global incremental production of gas by 2035.

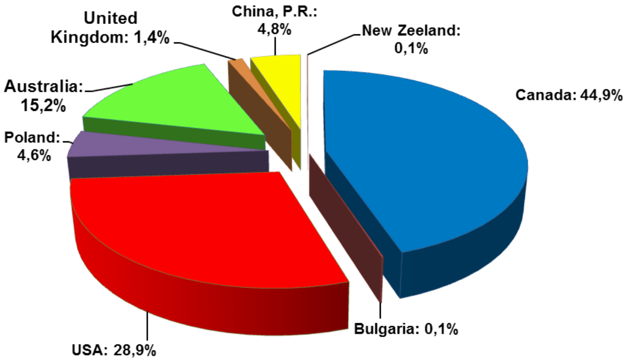
At the global level, CBM may become more attractive by extracting methane from unmined coal-beds in light of their depths or poor quality. This may happen given the perspective of a global revolution of unconventional gas and the similarity between coal gasification technologies and those used for shale gas production. These factors, however, may also be a boon to UCG.

90 See IEA, 'WEO 2014', p. 70.

91 'China Gas Sector. Key Takeaways from the Asia-Pacific Unconventional Gas Summit', Yuanta-Industry Update, 1 April 2010.

92 BGR, "Reserves, Resources and Availability of Energy Resources 2009", p. 95.

Figure 27: CBM Reserves by Countries in 2007



Source: Frank Umbach based on BGR (2009), "Reserves, Resources and Availability of Energy Resources". Hannover/Germany, p. 96.

UCG

An interesting and promising CTL-project, for instance, is Linc-Energy-Chincilla in Australia because the production of syngas is combined with UCG. Aiming at a capacity of 20 kb/d of liquid hydrocarbons, UCG offers a much lower cost option for the production of syngas and allows deeper, traditionally 'unmineable' coal-beds to be exploited.[93] Compared against CBM, UCG has also has a much greater potential to recover energy at 'non-mineable' coal deposits with conventional technologies. UCG could also significantly increase the world's classified recoverable coal resources. UCG exploration techniques involve an injection borehole through which air oxygen – and possibly steam – is injected, and a production well from which gas – mainly hydrogen and carbon monoxide – j is exploited to the surface for further treatment and use.

Historically, this technique goes back to England as early as 1868, and later in the former Soviet Union, while tests have taken place in the United States, continental Europe and China. Yet it was only testing with new emerging technologies – i.e. horizontal drilling – at a demonstration site in Spain between 1992 and 1998 that spurred new development around the world.

Reportedly, more than 60 pilot projects in various stages are currently being tested in Australia, Canada, China – Beijing alone accounts for around 30 projects – and South Africa for directionally drilling and computer modeling. But the experiences with UCG and new drilling technologies are still limited and mixed, and it is thus difficult to reach detailed conclusions for concrete projects and cost assessments. According to the IEA, however, successful results could lead to new projects in coal-rich countries like India, Russia, the United States, Poland, and Great Britain. It will be particularly competitive in regions that offer access to low-cost coal reserves, such as Xinjiang in China.[94]

93 See IEA, 'WEO 2010', p. 173.

94 See ibid., p. 205 f.

The most advanced projects are both in Queensland, Australia. Efforts are being made at the testing sites to prove to government regulators that these UCG-projects can be safely decommissioned before allowing commercialization, as the key element in the process is not water, but rather underground fire.

Using UCG gas as a substitute for natural gas in combined-cycle gas turbines (CCGTs) for power generation is an economically sound option. As new cost analysis suggest, it is especially economically competitive, for example, vis-à-vis feeding conventional natural gas to CCGTs or any other low-carbon power generation. And it may be even more so when combined with a carbon capture technology – pre- or post-combustion carbon capture to remove an overall 90 per cent carbon.[95]

In addition, UCG has the considerable advantage of leaving a much smaller surface footprint, allowing waste and ash to stay underground, and preventing the emission of methane or contaminated water because no fracturing drilling technologies are used, unlike in shale gas exploration.[96] In contrast to conventional coal mining, UCG requires no comparable processing and transportation or other logistical chains, which call for the consumption of additional fuel and energy. Syngas is processed and used on site, which markedly reduces the overall CO_2 and other GHGE compared with conventional coal utilisation. Thus, CO_2 emissions are reduced by more than 50 per cent at power stations.[97] Those UCG projects need to integrate CCS-technologies at the extraction site. Proponents, however, have argued that it would be less expensive and more efficient in terms of reducing CO_2 from coal at a UCG site than at a coal power plant. The opportunity both to produce hydrogen and to capture carbon might make UCG-projects more attractive as a potential CCT.[98]

Europe lags behind other countries – such as China, India, Australia, and others – in promoting UCG projects, even if UCG may become a key technology and high-tech industry in future coal mining, especially from deeply-bedded seams and thin seams.[99] Globally, more than 100 USG projects are underway. Currently, eleven project partners finance a PPP UCG project in Poland called HUGE, and they gasified an underground panel of coal at the Barbara coal mine in April 2010.[100]

In July 2014, the Polish Ministry for the Environment granted an Australian company an approval for the development of a UCG project near Krakow. The site could provide 800 bcm of pipeline gas for the next 80 years at an annual rate of 10 bcm. In addition to Poland's slowly developing shale gas projects, it could secure Poland's entire present annual gas consumption of around 15 bcm per year. UCG may even have the potential of changing the European energy landscape by creating gas self-sufficiency.[101]

Most efforts are taking place in the United Kingdom, where the North Sea domestic gas production peaked in 2000. It has resulted in increasing gas imports of up to 47 per cent of its present gas demand, which could rise further to 75 per cent by 2030. The country may have up to 18.7 billion tonnes of deep seam coal reserves suitable for UCG and about 300 years of supply. The UK Coal Authority has issued 24 conditional UCG permits to undertake exploratory investigations. Although 13 conditional permits have already expired, eight new applications are currently pending. Currently, a demonstration project is in the works for what may become the first offshore-UCG project on the Firth of Forth off the Scottish coast, which could pave the way for much larger investment for unlocking considerable coal reserves.[102] But similar to several shale gas projects in the UK, local opposition has slowed down the developments of UCG-projects, with environmental NGOs demanding that a fracking moratorium be extended to UCG-projects.[103]

Carbon Capture, Use and Storage (CCUS)

Three factors profile CCS and CCUS as a vital, cost-effective technology both for achieving larger emission reductions from fossil-fuel use, as well as for enhancing energy efficiency and expanding renewables. First, fossil

95 See Kenneth J. Ferguson, 'A Cleaner, Cheaper, Indigenous Fuel for Combined Cycle Plants', Modern Power Systems, August 2009, pp. 24-26, here p. 24 (http://www.modernpowersystems.com).

96 See idem, 'Underground Coal Gasification', presentation at the international conference "New Energy Frontiers: What Role for Hydrocarbons in Global Energy Security?, organized by Wilton Park in association with the Federal Government of Canada and Alberta Government, 15-17 June 2011.

97 See also Fred Pearce, Could Burning Coal Underground Take Clean Coal Ltd. In too Deep?, The Guardian, 4 March 2010. See also the website of Clean Coal Ltd. – http://www.cleancoalucg.com.

98 See Thomas K. Grose, 'New Energy Frontier: Drilling into Coal for Gas', National Geographic, 8 April 2014 (http://news.nationalgeographic.com/news/energy/2014/04/140408-new-energy-frontier-underground-coal-gasification/) and Michael Green, Underground Coal Gasification – A Clean Indigenous Energy Option (http://ucgengineering.com/publishedarticleonucg.html.

99 See also Sara Stefanini, 'India Offers Blocks for UCG Projects', Interfaxenergy.com-NGD, 12 March 2013, p. 7; and idem, 'First Aussie UCG Project Struggles with State Rules', ibid., 13 August 2013, p. 4.

100 HUGE is co-funded by the Research Fund for Coal and Steel and the Polish Ministry of Science and Higher Education. The consortium partners come from research centres in Poland, the Netherlands, Great Britain, Germany, Czech Republic, Belgium, and Ukraine as well as companies from the energy sector. See the presentation by Dr Eng. Mirosław Kugiel (President, Kompania Węglowa S.A.), 'Hard Coal Mining in Poland, 2009' and IEA, Poland – 2011 Review. Energy Profiles of IEA Countries, Paris 2011, p. 152.

101 See Joshua Posaner, 'Poland Approves UCG Test that Could Produce 10 bcm/y', Interfax-NGD, 8 July 2014, p. 4.

102 See Dominic Jeff, 'Cluff Heards New North Sea Offshore Coal Project', The Scotsman, 28 September 2014 and 'Britain See Putting Off Subsea Coal Gasification Projects', Reuters, 1 October 2013..

103 See Thomas K. Grose, 'New Energy Frontier: Drilling into Coal for Gas', p. 4 and BBC-News, 'Fracking Moratorium 'Should be Extended' to Underground Coal Gasification', 22 February 2015.

fuels are still expected to account for between 70 and 75 per cent of the global energy mix; second, by 2020 electricity generation from coal will double twice as much as generation from renewables; and, third, by 2035 another 19 per cent increase of energy-related CO_2 emissions is expected to take place.[104] The IEA has estimated that equipping 3,400 power plants and industrial facilities with CCS could provide up to 19 per cent of the total CO_2 avoidance required by 2050. It has also been calculated that absent investment in CCS-projects, total mitigation costs in the energy sector would increase by US$2 trillion by 2050.[105] Given the huge increase in energy demand in non-OECD countries, around 70 per cent of CCS deployment needs to take place in these countries by 2050 to achieve the 2˚C target.[106]

A new study on the necessity of leaving fossil fuels unused for achieving the Kyoto target, however, also concluded that CCS would have only limited impact on the proportion of fossil fuels that can be burned. In this scenario, CCS would allow only six per cent of the world's known coal reserves to be burned and even a lower percentage for oil and gas. The study reached this conclusion given "the expense of CCS, its relatively late date of introduction (2025), and the assumed maximum rate at which it can be built."[107]

Nonetheless, as the IEA and many Intergovernmental Panel on Climate Change (IPCC) members have admitted, the Kyoto target has already become hardly realistic as the large majority of CO_2 emissions for the 2˚C scenario has already been 'locked in' and only limited emissions can be added until 2017. Furthermore, there is currently no realistic alternative climate warming mitigation technology available to the fossil-fuel energy sector and other energy intensive industries without CCS in the mid- and longer-terms.

At the Hokkaido Toyako Summit in 2008, G8 government leaders committed themselves to the following CCS-related actions:

- promoting 20 large-scale CCS test projects globally by 2010, taking into account various national circumstances, with a view toward beginning broad deployment of CCS by 2020;
- establishing an international initiative with the support of the IEA to develop CCS technology roadmaps and enhance global co-operation through existing and new partnerships;
- initiating various policy and regulatory measures to provide incentives for commercialising CCS technologies.[108]

104 See Kevin Bullis, 'Grasping for Ways to Capture Carbon Dioxide on the Cheap', MIT Technology Review, 30 May 2013.

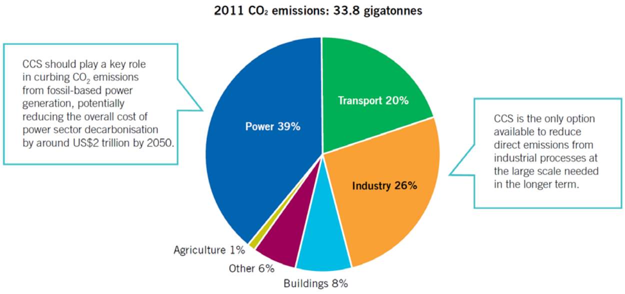
105 See IEA, 'Energy Technology Perspectives', Paris 2012.

106 See Global CCS Institute (GCCSI), 'The Global Status of CCS 2014', Melbourne/Australia, September 2014.

107 See Christophe McGlade/Paul Ekins, 'The Geographical Distribution of Fossil Fuels Unused when Limiting Global Warming to 2˚C'.

108 See IEA, 'Carbon Capture and Storage. Full-Scale Demonstration – Progress Update', Paris 2009, p. 3.

Figure 28: CO_2 Emissions by Sector in 2011



Source: GCCSI, 'The Global Status of CCS 2014', Melbourne/Australia, September 2014.

CCS is the only technology that achieves large reductions in CO_2 emissions – not just for coal power plants, but for oil, gas extraction, and also for the iron, steel and cement industry.[109] Given the huge potential and use of commercialisation of CCS for the energy sector and energy-intensive industries, most major economies have announced ambitious plans and associated funding for large-scale demonstration projects. Meanwhile, even the IPCC has stressed the strategic importance of CCS as worldwide climate mitigation technology in its Fifth Assessment report of November 2014.[110]

At the same time, CCS faces a major barrier to its commercial application – namely, the loss of 15 to 20 per cent of its net power output in a context where coal power plants already average an energy efficiency level of between 33 and 44 per cent at the global level. Combined with coal power plant's high capital and CO_2 capturing costs, which can use up to 25 per cent of their total electrical output, the net result could be an increase in the levelised cost of electricity of 40 to 75 per cent.[111] Yet, several technological solutions are currently tested for their ability to reduce the loss of electrical output and to make CCS projects in the power sector more competitive. A key solution could be to consider CO_2 as a valuable by-product instead of just waste.

109 See also IEA, 'Global Action to Advance Carbon Capture and Storage' (Paris: IEA/OECD, 2013) and Annemarie Botzki, 'Gas Needs to Become Part of the CCS Discussion – IEA', Interfaxenergy.com-NGD, 25 July 2013.

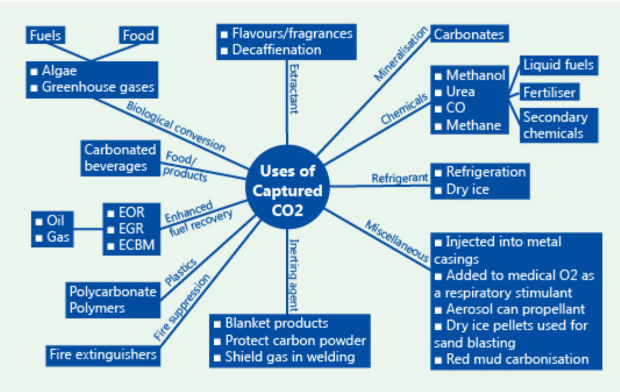
110 The report stated that "zero- and low-carbon energy supply includes renewables, nuclear energy, and fossil energy with carbon dioxide capture and storage (CCS), or bioenergy with CCS (BECCS)" on page 26; "The availability of CCS would reduce the adverse effects of mitigation on the value of fossil fuel assets" on page 27; and that "many models could not limit likely warming to below 2˚C if bioenergy, CCS, and their combination (BECCS) are limited" on page 31 – see IPCC, 'Fifth Assessment Report. Climate Change 2014. Synthesis Report: Summary for Policymakers', 2 November 2014.

111 See also IEA, 'WEO 2014', p. 175 f.

At the same time, research into possible industrial uses of CO_2 is still in its infancy.[112]

In 2010, government worldwide made commitments to support the launch of between 19 and 43 large-scale CCS integrated demonstration projects by 2020. In 2010, some 80 large-scale demonstration projects at various stages of development were identified globally – see figure below –, mostly in developing countries in Europe, the United States, Canada, Australia, and Korea.[113] At the time, two-thirds of these projects were in the power generation sector. Importantly, more than 40 per cent of all global CCS large-scale projects wanted to use CO_2 for an industrial purpose.

Figure 29: Potential Uses of Captured CO_2



Source: Interfax-Energy Policy Weekly, 3 April 2014, p. E4.

In order to launch the projects mentioned above, governments have pledged US$ 26 billion. According to original estimates by IEA and the U.S. Energy Information Administration (EIA), about 100 projects are needed globally by 2020 – roughly half of them in developing countries –, and 850 commercial CCS projects should be in operation by 2030 and 3,400 by 2050.114 But progress is very slow and the financial state of many European utilities has caused another setback for CCS projects, as four large utilities dropped out of European Technology Platform for Zero Emission Fossil Fuel Power Plants (ZEP), the CCS-promoting organization.[115] The present international situation is as follows:[116]

- According to the IEA, overall, CCS could contribute by around 17 to 19 per cent to all cumulative CO_2 emissions reductions between now and 2050. Half of these emissions reductions will need to come from industrial applications.[117] Around 72 per cent of CO_2 captured from the industrial sector by 2050 might take place in developing countries, in which CCS-projects might be implemented at costs lower than those in OECD countries.[118]
- Currently, CCS appears to be more cost-efficient for natural gas than for, as it has a greater potential to yield a lower cost per kWh. The cost per tonne of CO_2 captured from a coal CCS power plant is likely to be lower, but gas plants with CCS only produce about half as much CO_2 per MWh when capture, transport, and storage are taken into account. Ultimately, however, price considerations are dependent on annual operating hours and fuel-price relation, which currently favors coal.[119]
- The world's first large-scale CCS project in the power sector has been operating since October 2014 at the 110 MW Boundary Dam coal-fired power station in Saskatchewan, Canada. It will capture 90 per cent of the CO_2 and 100 per cent of sulphur dioxide. Two additional large-scale U.S. CCS projects – the Kemper County Energy Facility in Mississippi and the Petra Nova Carbon Capture project in Texas – will come into operation in 2015 and 2016.[120]
- The world's first large-scale CCS project in the iron and steel sector is under construction in Abu Dhabi.[121]
- In February 2015, Qatar launched one of the largest regional CCU projects with its US$80 million carbon dioxide recovery plant. The project will capture 500 tonnes of CO_2 per day from its methanol reformer stack

112 CO_2 could not only be used for enhanced oil recovery (EOR) as in the United States or Norway, but also as feedstock for chemical processes, algae cultivation and the production of a precursor for the synthesis of plastics or for many other industrial uses. See also. F. Umbach, 'The Future of Coal, Clean Coal Technologies and CCS in the EU and Central East European Countries. Strategic Challenges and Perspectives, EUCERS-Strategy Paper, London, Vol. 2, 12 December 2011, and Annemarie Botzki, 'Breakthrough Technology Could End Opposition to CCS', Interfax-Energy Weekly Policy, 3 April 2014, p. E4.

113 The overview of these 80 projects identified by the GCCS-Institute can be found at IEA, 'Carbon Capture and Storage. Progress and Next Steps'. IEA/CSLF Report to the Muskoka 2010 G8 Summit, Paris 2010, pp. 30 ff.

114 See ibid.

115 See Annemarie Botzki, 'Financial Decline of Utilities Slows European CCS', Interfax-NGD, 22 January 2015 and Bob Burton, 'FutureGen's Demise: Another Blow to CCS', Energy Post, 9 February 2015.

116 See GCCSI, 'The Global Status of CCS 2014', Melbourne/Australia, September 2014 and IEA, 'Energy Technology Perspectives 2014', p. 76 f.

117 See IEA, ', 'Global Action to Advance Carbon Capture and Storage', p. 5.

118 See ibid., here p. 17.

119 See also Annemarie Botzki, 'CCS 'More Cost Efficient' for Natural Gas than Coal', Interfaxenergy.com-NGD, 20 June 2013, p. E4.

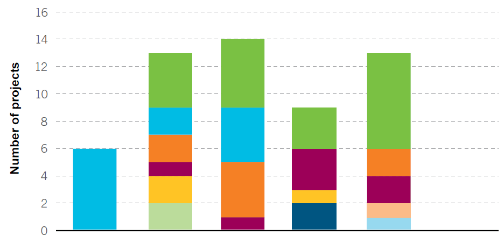
120 See also Pilita Clark, 'SaskPower to Launch C$1.4 billion Carbon Capture and Storage Project', FT, 1 October 2014 and James Batty, 'Boundary Dam Pioneers CCS for Power Plants', Interfax-NGD, 2 October 2014, p. 8.

121 The United Arab Emirates' industry accounts for nine per cent of global CO_2 emissions. See GCCSI, 'The Global Status of CCS 2014' and its website information: http://www.globalccsinstitute.com/project/esi-ccs-project.

and will be injected back into the existing process to enhance the production capacity of methanol.[122]

- The Gorgon LNG plant, worth US$2 billion, is the largest in the world, though its operation has yet to begin. The Australian government has insisted on CCS for this site and has supplied US$60 million to this effect.[123]
- Washington and Beijing agreed in the summer of 2013 to jointly develop CCS technologies for power plants and also to implement large-scale demonstration projects in addition to other collaborations – among others, energy efficiency of buildings, and improving GHGE data collection.[124] China is promoting CCS projects not just for coal-fired plants, but also for its entire energy-intensive industry, including oil and gas.[125]
- In India, a CCS project developed in 2013 for treating industrial emissions has successfully completed commercial testing.[126]
- Altogether, there are 55 large-scale CCS projects at the global level, of which:
  - 22 are in operation or in construction – globally, double the number at the beginning of the decade –, with a total CO_2 capture capacity of around 40 million tonnes per year.
  - 14 are in advanced stages of planning, with nine in the power sector; many of them are expected to make a final investment decision in 2015.
  - Nevertheless, no large-scale CCS-project is currently planned in the cement industry, which accounts for six per cent of worldwide CO_2 emissions.
- All projects in operation using separation technology as part of an already established industrial process either use CO_2 to generate revenue through enhanced oil recovery (EOR) or have access to lower cost storage sites.
- Major challenges are the higher construction, operating and maintenance costs, as well as the reduced thermal efficiency of power plants fitted with CCS. At present, incorporating CCS into power plants raises the levelised costs of the produced electricity by 39 to 64 per cent, depending on the available technologies and fuel sources. Many projects have been beset by delays, a failing market, and large cost over-runs due to difficulties in making the projects economically viable.[127]
- Nonetheless, costs will decline with further technology innovations underway and the expansion of Carbon Capture and Use (CCU) research and development programmes.
- Given global climate mitigation policies and the 2°C target, CCS needs to be implemented not just for future coal-fired power plants, but also for oil and gas-fired plants and exploration as well as for energy-intensive industries, including cement, iron and steel, chemicals and refining. These industrial sectors present one-fifth of all globally produced CO_2 emissions, which will further increase with the industrialization of non-OECD countries. CCS in industrial applications could represent almost 50 per cent of the CCS-induced emission reductions by 2050. It is still the only option for decarbonizing many global industrial sectors.[128]
- At the same time, focus on CCS has shifted from Europe to the United States, as Washington is increasingly using CO_2 for EOR projects that promise revenue stream and enhanced efficiency of oil drilling projects themselves.[129]

Figure 30: Large-Scale CCS-Projects by Lifecycle and Region/Country (Status 2014)



	Identify	Evaluate	Define	Execute	Operate	Total
United States	0	4	5	3	7	**19**
China	6	2	4	0	0	**12**
Europe	0	2	4	0	2	**8**
Canada	0	1	1	3	2	**7**
Australia	0	2	0	1	0	**3**
Middle East	0	0	0	2	0	**2**
Other Asia	0	2	0	0	0	**2**
South America	0	0	0	0	1	**1**
Africa	0	0	0	0	1	**1**
Total	**6**	**13**	**14**	**9**	**13**	**55**

Source: GCCI, 'The Global Status of CCS 2014', Melbourne/Australia, September 2014.

122 See IZ-Klima Newsletter, CCS-Kurzmitteilungen, No. 2/2015.

123 Se ibid.; and 'Gorgon Fact Sheet: Carbon Dioxide Capture and Storage Project' (http://sequestration.mit.edu/tools/projects/gorgon.html).

124 See Kasia Klimasinska, 'China to Join U.S. in Carbon-Capture Projects', Bloomberg, 10 July 2013

125 See also Li Xin/Colin Shek, 'Carbon Capture on the Cards for China's Gas', Interfaxenergy.com-NGD, 23 May 2013, p. 5.

126 See 'CCS Announces Successful Demonstration of CO_2 Capture Technology for Industrial Scale', Carbon Clean Solution, Press Release, 8 August 2013.

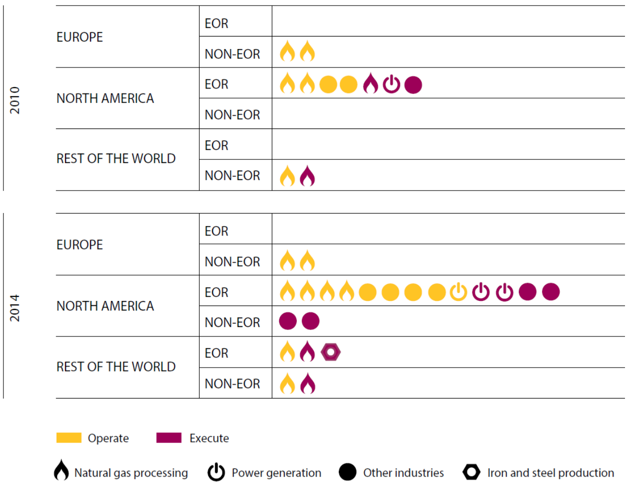
127 See also Pilita Clark, 'Carbon Capture Faces Viability Struggle', FT, 23 November 2014; Howard J. Herzog, 'Why is CCS Stuck in Second Gear? We Need It to Fight Climate Change', Energy Post, 19 March 2015; 'The Carbon Capture Conundrum. Is CCS an Essential Climate Mitigation technology? Or a Dangerous Distraction?, World Energy Focus, No. 10, April 2015 and Jeffrey Michel, 'CCS: Why the High Hopes Cannot be Fulfilled', Energy Post, 14 June 2013.

128 See IEA, 'Global Action to Advance Carbon Capture and Storage', p. 3.

129 See 'CCS Projects Spread from Europe to US', Euractiv.com, 10 March 2011.

During recent years, global knowledge-sharing networks have been greatly expanded between the IEA, EIA, the GCCS-Institute in Australia and the Carbon Leadership Forum (CSLF), which is a Ministerial-level international climate change initiative, and ZEP.[130] International discussions are also underway to include CCS in the Clean Development Mechanism (CDM), or any post-2012 climate change arrangements. Such a step would be very important because it would include a financial mechanism to speed up deployment of resources, particularly in developing countries.

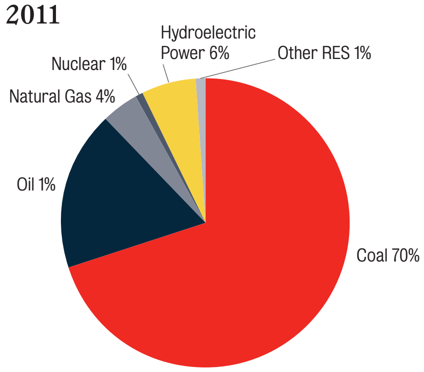
Figure 31: Large-Scale Projects in the Operate and Execute stages by Storage Type (Status 2014)



Source: GCCSI, 2014.

Much more government and public support for CCUS is needed, however. Given present energy and CCS-policies, IEA's New Policy scenario expects that not more than about 70GW of coal-fired power generation, accounting for just three per cent of total coal-fired power, will be equipped with CCS and good access to CO_2-storage sites by 2040.[131] Industry has also voiced its scepticism that CCS will play a larger role before 2035.[132] Against this background, experts have called for a clear role for CCS in the EU Energy Union strategy – including the ZEP, which has estimated that, absent CCS, it would cost between 20 and 50 per cent more to decarbonise the European power sector by 2050.[133]

Figure 32: China – Total Energy Consumption by Type in 2011



Source: F.Umbach based on EIA, 'China'. Analysis Briefs, 4 February 2014.

China's Coal Policies in Change

Given its growing energy needs and high GDP growth, Beijing is one of the most important and influential actors in international energy markets. During the past years, China has not only surpassed Germany as the world largest export nation, but also the United States as the world's largest economy. In 2000, Beijing's energy demand was only half that of Washington. Between 2000 and 2008, its energy consumption was rising at a rate of four times that of the previous decade.

As the world's most populous country with a fast-growing economy, China is already the largest energy producer, consumer, and oil importer. It is also the world's largest consumer, producer, and importer of coal, despite having the third largest coal reserves in the world – after Washington and Moscow –, it became a net-importer of coal already in 2009 which increased at more than 30 per cent in 2012. In 2012, it consumed more than two times as much as coal as in 2000.[134] By 2040, Chinese energy demand is projected to rise by 44 per cent – at that point, China will consume about 80 per cent more than the United States. China has to cope with a dual challenge: first, an energy demand projected to rise by almost 50 per cent by 2035 and at the same time, and, second, shifting its energy mix from coal to gas as well as non-fossil fuels like nuclear power and renewables. China will be unable to shift its energy completely to renewables by 2050 because it would be too expensive and unrealistic.[135]

China consumes today more than half of the globally produced coal. In 2005, the Chinese government established a coal-production limit of 2.6 billion tonnes for 2010. Beijing's actual coal output, however, reached 3.24

130 ZEP is a unique coalition of stakeholders united in their support for CCS, and serves as an advisor to the European Commission on the research, demonstration and deployment of CCS – See ZEP web-site: http://www.zeroemissionsplatform.eu/about-zep.html.

131 See IEA, 'WEO 2014', p. 174.

132 See Tom Hoskyns, 'CCS to Play 'Very Limited Role' to 2035 – BP', Interfax-NGD, 10 February 2035.

133 ZEP Chairman Graeme Sweeney places this figure at up to €4 trillion. 'Europe's Energy Union Needs Carbon Capture and Storage', EurActiv, 25 February 2015. See also EurActiv, 'EU Paper Calls for Binding CCS Targets by 2030', 27 January 2015.

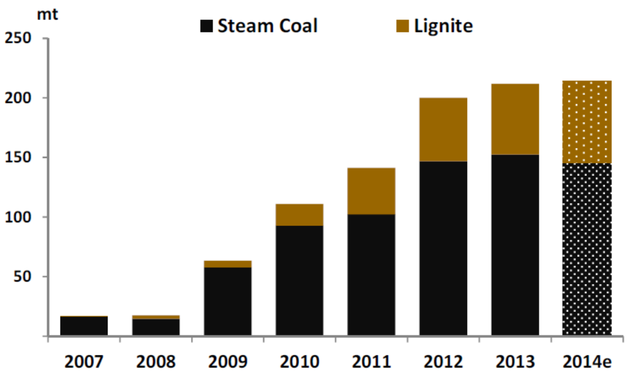
134 See EIA, 'China'. Analysis Briefs, p. 29.

135 See again IEA, 'WEO 2014', pp. 171 ff. and F.Umbach, China's Growing Hunger for Energy Resources", Geopolitical Information Service (GIS – www.geopolitical-info.com), 5 September 2014, and idem, 'The EU-China Energy Relations and Geopolitics: The Challenges for Cooperation', in: M.Amineh/Y.Guang (Eds.), The Globalization of Energy. China and the European Union' (Koninklijke Brill NV: Leiden-Boston 2010), pp. 31-69.

billion tonnes in the same year.[136] In 2012, it surpassed the EU as the world's largest net importer of coal, while in 2013 it imported a record 326.8 million tonnes of coal – accounting for more than 8 per cent of the country's coal supply. In 2012, its primary energy mix was still, at 68 per cent, based on high coal consumption,[137] but the government wants to reduce it to below 65 per cent by 2017 and some 53 per cent by 2035, as well as to raise the share of non-fossil fuel energy to 15 per cent by 2020.[138]

China has an estimated 114,500 Mtoe of recoverable coal reserves in 2013 – equivalent to 12.8 per cent of the world's total, and the third largest behind the United States and Russia. At the same time, its production-reserve ratio is just 31 years compared to 266 years in the United States and 452 years in Russia.[139] Coping with about 10,000 small, local, and often inefficient coal mines, Beijing has pushed for major structural reforms through mergers and acquisitions in order to create ten large coal companies, accounting for about 60 per cent of the country's total coal production, and reducing the number to 4,000 mines.[140]

Figure 33: China Thermal Coal and Lignite Imports 2007-2014



Source: Alstom 2014.

By 2040, its national energy demand is projected to consume about 80 per cent more than the United States. Its demand for oil, gas, hydro, wind, solar, and electricity generation is projected to grow faster than in any other country. China will account for around 40 per cent of the world energy demand rise between 2011 and 2025 and by some estimates for 31 per cent between 2011 and 2035. Its electricity demand is projected to double between 2012 and 2040.[141] While China's share of global energy demand was just 12 per cent in 2002, it almost doubled to 22 per cent in 2012, and is forecast to rise further to 24 per cent in 2025. The annual growth rate of coal-fired power will fall from more than 11 per cent in the decade prior to 2012 to just 0.6 per cent between 2030 and 2040, yet Beijing will remain by far the largest coal producer throughout 2040. The IEA has projected that China needs to import eight per cent of its huge domestic demand.[142] Yet Beijing's energy consumption is not just fuelled by its own mostly state-owned companies, but also by foreign-funded firms, which account for 55 per cent of China's exports.

The rise in Chinese coal demand by 2020 will surpass growth in the rest of the world combined, despite a decrease in its demand growth. Coal-fired power plant capacity is projected to further rise by some 420 GW by 2040.[143] Beijing's rising coal consumption is forecast to peak around 2030 and then decline sharply. Even if China might be able to reduce the coal share in its national energy mix to less than 53 per cent by 2040, its absolute coal consumption might increase by over 50 per cent relative to today.[144] By 2040, China will account for half of the global coal production and install around 600 GW of new coal-fired power generation capacity – the total combined coal-fired generation capacity of the United States, the EU and Japan. China will also need to further enhance the energy efficiency of its existing coal-fired fleet, which, at 37 per cent, is already higher than the world's average of 33 per cent.[145] Beijing also plans to build 50 additional modern coal plants, which may produce an estimated 1.1 billion tonnes of CO_2 per year. But while its new plans will reduce CO_2 emissions in China's largest cities, it may ultimately shift the pollution just to other regions.

To be sure, the Chinese government aims to reduce the country's dependence on fossil fuels. At present, fossil fuels cover about 80 per cent of China's power generation and more than 70 per cent of installed capacity in its power sector.[146] The Chinese government hopes to raise its non-fossil fuel share – nuclear, hydropower, and other renewables – to 15 per cent of its national energy mix by 2020 and reduce its CO_2 emissions by at least 40 per cent between 2005 and 2020.

China will also account for around half of the global increase of nuclear power generation by 2035. It will become the largest producer of 'climate friendly' nuclear power after 2030. It will increase more nuclear power capacity than the total installed in the United States at present. It currently

136 Seee Kevin Jiangjun Tu, 'Chinese Goal: Key to a Global Climate Solution', East Asia Forum, 7 January 2013

137 See IEA, 'WEO 2014', p. 178.

138 See U.S. Energy Information Administration (EIA), 'China'. Analysis Briefs, 4 February 2014 (http://www.eia.gov/countries/analysisbriefs/China/china.pdf), p. 2.

139 See BP, 'BP Statistical Review of World Energy 2014', p. 30.

140 See EIA, 'China'. Analysis Briefs, p. 30.

141 See IEA, 'WEO 2014', p. 206, and 'China: A Potential Opportunity to Consolidate the Coal Industry', 19 July 2013.

142 See IEA ibid., p. 182 and 192.

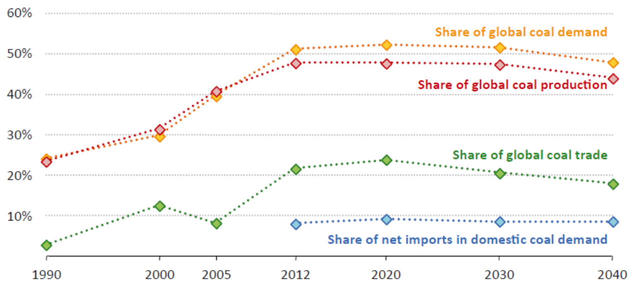
143 See ibid., p. 180.

144 See IEA, 'WEO 2014', pp. 171 ff. and 'Coal Use in Chinese Power Below 62 per cent by 2020', Interfax-NGD, 22 September 2014, p. 6.

145 See IEA, 'Energy, Climate Change and Environment', p. 20.

146 See EIA, 'China'. Analysis Briefs, p. 33.

Figure 34: Share of China in Global Coal Markets and China's Coal Import Dependence in the New Policy Scenario



Note: China was a net exporter of coal in 1990, 2000 and 2005.

Source: © OECD/IEA (2014), 'World Energy Outlook 2014', Paris: IEA-Publishing. Licence: www.iea.org/t&c/termsandconditions

has 21 nuclear reactors in operation and another 28 are under construction.[147] China needs to build up additional electricity generation from coal and nuclear sources in levels equivalent to the total U.S. capacity in 2012. Yet, after the Fukushima accident in 2011, China has slowed down the building of new plants and temporarily suspended new constructions due to a safety review. It has only recently restarted its construction programme for four new reactors.

At the same time, China is already the world's largest producer of renewable electricity. In 2011, it accounted for 28 per cent of worldwide growth – more than the combined growth of the EU, the United States and Japan. It is projected to triple its renewable generation by 2035 and will account for almost 50 per cent of the net increase of renewables in the worldwide electricity generation. China has plans to expand the share of renewables in its national energy mix from 9.9 per cent in 2009 to at least 15 per cent in 2020. Their share in China's generation mix will shift from one fifth in 2011 to one-third in 2035. Its wind power capacity will cover around 30 per cent of the worldwide total, which is largely concentrated in three major regions – China, the EU and the United States – that account for some 70 per cent of the global total.

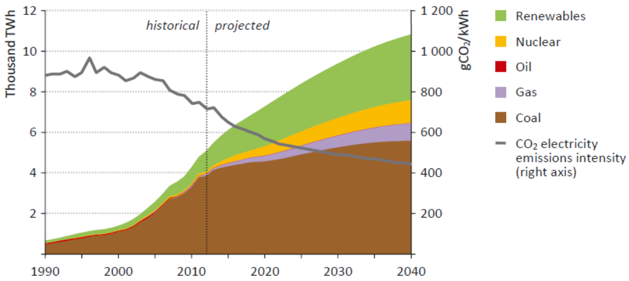
China's electricity demand has grown faster than in any other country in the world during the last decade, but the past average increase of electricity demand by almost 12 per cent will decline to 4.8 per cent between 2012 and 2020 and just two per cent annually between 2021 and 2040.[148] Nonetheless, China must double the entire U.S. electricity generation between now and 2030.[149]

147 By 2020, it will have raised its nuclear power capacity from the present 10 GW to at least 70-80 GW, while the Chinese State Council Research Office (SRCO) has recommended that this should be expanded to as much as 100 GW by 2020, 200 GW by 2030, and 400 GW by 2050.

148 See IEA, 'WEO 2014', here p. 234.

149 See Keith Johnson, 'Dirty Pretty Rock', Foreign Policy, 29 January 2015.

Figure 35: China – Electricity Generation by Source and CO_2-Intensity in the New Policy Scenario



Source: © OECD/IEA (2014), 'World Energy Outlook 2014', Paris: IEA-Publishing. Licence: www.iea.org/t&c/termsandconditions

In 2006, China surpassed the United States and became the world's largest carbon polluter. Given the poor quality of its air,[150] in the spring of 2014, China declared a "war against air pollution" and announced plans to cut its CO_2 emissions per capita by 40 to 45 per cent by 2020 relative to 2005 levels. In 2013, China's per capita-emissions declined by 28.5 per cent from 2005 levels.[151] But in 2012, Beijing emitted in total 60 per cent more than Washington. In 2014, for the first time, China produced more CO_2 emissions per capita than the EU. Despite national efforts to increase energy efficiency and rein in pollution,[152] all in all, Beijing will remain the largest emitter through 2035, and its emissions will be more than twice those of the United States by that year.

At present, every individual Chinese citizen consumes, on average, just 3,300 kw/h of electricity per year – still much less than Germany, South Korea, and the United States at 7,000, 10,000, and 13,000 kw/h, respectively.[153] Over the next twenty years, however, Beijing will require total energy investments of US$4 trillion in order to keep its economy running and to avoid electricity blackouts and power shortages. By 2040, the majority of its energy and electricity generation mix will still be based on fossil fuels on even higher demand levels.

150 At the beginning of 2013, northern and eastern China had been plagued by an extreme haze covering around 1.3 million square kilometers and affecting 800 million people. The highest daily average concentration of fine particulate was more than 20 times higher than the World Health Organisation (WHO) has recommended – see Yuan Jiahai, 'Capping Coal Consumption is the Correct Choice for China', East-Asia Forum, 7 April 2015. According to the Natural Resources Defence Council estimates, China's air pollution kills almost 700,000 people a year – see also Keith Johnson, 'Dirty Pretty Rock'.

151 See Li Xin, 'Next Five Years Crucial for Chinese Climate Pact', Interfax-NGD, 14 November 2014, p. 4.

152 These new initiatives for controlling environmental pollution have been the result after a self-financed documentary film "Under the Dome" by former state television news reporter Chai Jing has caused new after new heated national debates, unnerving China's central government – see Colin Shek, 'Calling Time on Coal in China', Interfaxenergy.com-NGD, 27 March 2015, p. 3 and Yuan Jiahai, 'Capping Coal Consumption is the Correct Choice for China'.

153 See Keith Johnson, 'Dirty Pretty Rock'.

Figure 36: The World's Largest CO_2 Emitter in 2014

Country	% of the global emissions
China	28%
U.S.	14%
EU-28	10%

Although China surpassed Japan as the third-largest natural gas consumer already in 2009, its gas share in its national energy mix was just 5.9 per cent in 2013. It is projected to increase to 7.5 per cent in 2015 and 10 per cent in 2020. Its future gas demand growth is expected to be an annual six per cent on average, by far the largest one in the world. Its gas consumption of 169.2 bcm in 2013 is projected to quadruple by 2035. This growth in demand for gas comes amid Chinese efforts to diversify its energy mix, to reduce its air pollution levels and reliance on heavy coal for its annual energy demands from the current 68 per cent to 53 per cent in 2035, and to the fact that gas supplies a growing share of electricity generation.

China's gas demand of 530 bcm by 2035, however, will be just 50 per cent that of the United States, which remains the world's largest gas consuming country. China's gas-fired power generation capacity will grow to 60 GW by the end of the current five-year plan in 2015, which alone demands an additional gas demand of around 50 bcm. By 2035, the gas use in the power sector alone is expected to grow six-fold to around 160 bcm. The IEA has forecast that Beijing's total gas demand will rise from 110 million tonnes in 2011 to 442 Mtoe by 2035.

Figure 37: China's 12th Five Year Plan for Natural Gas (2011-2015) – Production Targets for 2015

Demand	230 bcm
Total conventional and unconventional gas production	176 bcm
Conventional Gas production	138.5 bcm
Shale Gas	6.5 bcm
CBM	15 bcm (originally 30 bcm)
CTG	15-18 bcm
LNG import terminal capacity	25.3 bcm

China's own gas production may triple from 121 bcm in 2013 to 320 bcm in 2035. Of that 121 bcm demand, 117 bcm came from conventional gas reserves, but production from conventional gas fields has struggled to keep up with demand. Consequently, since 2007 China has been a net natural gas importing country. In 2013, its natural gas imports dramatically increased to more than 30 per cent of its gas demand, which is forecast to increase further to 50 per cent by 2020. Its future gas import dependence will further rise to 154 bcm by 2020 and may exceed 210 bcm by 2035.

Yet this rise itself could be even higher because the projected gas production will considerably depend on several factors: further progress in China's unconventional gas production – shale gas, coal-bed methane/ CBM and tight gas –, widespread reforms, and timely investments in its wholesale gas sector as announced by China's government in 2011. Coal-bed methane is already been commercially produced with a level of 10 bcm per year. The Chinese government is set to tripe CBM production up to 30 bcm by 2015, but may only be reached by 2020.

Alongside its CBM programme, China also has a very ambitious plan for expanding its CTG production, still in early stages of development, by using its abundant low-cost coal reserves and building the world's largest synthetic natural gas (SNG) industry in order to reduce its energy imports. Its first CTG plant just began operations at the beginning of 2014 and will expand to an annual production target of 16 bcm by 2015. Beijing has 18 CTG projects under construction and another 50 planned with a combined annual capacity of 225 bcm. But the production of SNG through CTG is energy and water-intensive and will ultimately also increase China's coal consumption, though CTG for city heating can also reduce air emissions and pollution.[154] Accordingly, the Chinese National Energy Administration (NEA) warned in July 2014 against a "blind development."[155]

Figure 38: China's technically recoverable unconventional gas reserves

Type of reserve	tcm
Shale gas resources	31.9 tcm
CBM	11 tcm
Tight Gas	12 tcm

On 23 July 2014, the NEA established limits on its CTG-projects. Originally, it only wanted to allow larger projects, but ban those CTG-projects producing less than two bcm of gas per year, and those coal-to-oil project producing annually less than one million tonnes. Critics have argued that emissions from planned coal-to-chemicals plants could increase China's emissions by four to 11 per cent. But in December 2014, China revised its CTG plans further by excluding an additional CTG projects in its next Five-Year Development Plan, but deciding to complete the construction of approved CTG plants in order to keep its CTG production capacity to 15 bcm around 2020.[156]

Despite China's expansion of gas projects and its share in the national energy mix, China's government would like to avoid larger import dependence on an additional energy source, particularly given its rising gas pipeline and maritime LNG import supply risks. Instead, Beijing

154 See Lucy Hornby, 'Coal Conversion Plants Sap China's Emissions Targets', FT, 30 November 2014.

155 Quoted following Li Xin, 'China's Coal-to-Gas Output to Disappoint Next Year', Interfax-NGD, 22 September 2014, p. 6.

156 See 'China Plans Major Slowdown of New Coal-to-Gas Projects in Bid to Cut Emissions', Ukraine Energy News, 18 December 2014.

is interested in having a balanced and diversified national energy mix with a lower coal share and a rising non-fossil fuel shares – nuclear and renewables – in order to reduce its heavy GHGE. Otherwise, Chinese LNG and coal imports could increase even further once the country can no longer rely on its indigenous oil reserves – particularly at a time of perceived geopolitical rivalries with Japan, the United States and India, and of rising anxiety about Beijing's dependence on maritime oil and LNG imports.

On June 13, 2014, Chinese President Xi Jinping called for an "energy revolution" and an expanded role for gas and diversification into non-coal energy sources. Already in April 2014, the government announced a plan to increase its gas supplies – domestic production and imports – from 174 bcm in 2013 up to 420 bcm by 2020, as it is the most realistic energy option for achieving its 2020 carbon reduction goals. In November 2014, China's State Council released a draft of a new energy strategy and 'Action Plan' for 2014-2020 that envisages capping coal consumption at 4.2 billion) tonnes by 2020 – after new estimations suggest to soon reach 5.1 billion tonnes from 3.6 billion tonnes in 2013 – and a coal mix of no more than 62 per cent of the primary energy mix by that year. It also highlights that China will be self-sufficient in energy by 85 per cent by 2020.[157]

As a result, China will have to upgrade its coal-fired plants to use ultra-low emission technologies and other CCTs to cope with gas-fired power.[158] Furthermore, the present global over-supply of coal has pushed down global and Chinese coal prices by 40 per cent following a peak in 2008. It has led to a situation when some 70 per cent of China's coal producers do not make profits any longer. Thus, the pressure for a comprehensive structural reform of China's coal industry has significantly increased after the closing down of especially old, small, unprofitable and inefficient mines as well as implementing a coal tax reform to improve the overall efficiency of coal-use in the country.[159] However, low coal prices have strained the power supply chain and hindered more fundamental structural reforms. Therefore, the government might be willing and able to implement only new gradual pricing reforms in its coal sector.[160]

While China's coal share of its primary energy and generation mix will decline, China's present annual consumption of 2 billion tonnes of coal cannot be replaced entirely by gas or renewables as. All in all, renewables still face financial, technological, and safety challenges, while coal will remain the country's most or at least one of the most reliable resources to guarantee base-load-stability and energy supply security.[161] In addition, despite the much celebrated new Chinese 'decarbonisation strategy' of 2014 in the West, the new coal production capacity added to China's grid in 2014 exceeded new solar energy by 17 times, new wind energy by more than four times, and new hydro by more than three times.[162]

U.S. Energy Policies, its Coal-to-Gas Switch and Rising Coal Exports in Perspective

For its part, the U.S. shale gas revolution has caused unprecedented changes in the country's energy landscape and in global gas and coal markets. In 2009, Washington overtook Moscow as the world's largest gas producer. In 2012, U.S. natural gas production increased to 20.4 per cent of global production, whereas Russia's was just 17.6 per cent. American shale gas production is expected to increase from 34 per cent of total U.S. natural gas production in 2011 to 49 per cent in 2035 and more than 50 per cent in 2040. The share of coal use for electricity generation has already fallen by more than one-third from almost 50 per cent in 2007 to just 39 per cent in 2013, and in the U.S. primary energy demand mix from 22.5 per cent in 2007 to just 18.1 per cent in 2012. In the same time period, total U.S. energy consumption has been reduced by 6.4 per cent relative to 2007.[163]

In the past five years, U.S. carbon dioxide emissions decreased by 13 per cent to the lowest levels since 1994 due to the coal-to-gas switch, new energy saving technologies, and a doubling of renewable energy production. It is even more impressive if one takes into account that the real GDP in 2012 was 55 per cent higher and the U.S. population 17.5 per cent larger than in 1994.

These dramatic changes since 2006 will continue through 2040. The oil share in U.S. primary energy mix is expected to decline by 10 per cent down to 27 per cent by 2040. Natural gas will become the most important energy resource before 2030. Coal is expected to lose more market share and will also be overtaken by renewables in the 2030s due to more ambitious decarbonisation and CO_2-emsissions reduction efforts as well as new energy efficiency regulations in the transport sector, but may remain the largest source of electricity generation until 2035, at which point it will be surpassed by gas.[164]

157 See Edward Wong, 'In Step to Lower Carbon Emissions, China Will place a Limit on Coal Use in 2020', NYT, 20 November 2014; Zhang Yiping, 'China's Latest Energy Blueprint Raises Eyebrows, Interfax-Natural Gas Daily, 27 November 2014, p. 8 and Yuge Ma, 'China's Energy Strategy in the 'New Normal' Economy', Geopolitical Information Service (GIS), 9 February 2015.

158 See for the background of the need for rapidly increasing the introduction of CCTs also IEA, 'Cleaner Coal in China'.

159 See Alstom Power – GPS Marketing, 'China Takes Steps to Revive its Coal Industry', Fuel Intelligence Special Report, November 2014.

160 See also Stratfor, 'Cheap Coal: Enabling Power Price Reform in China', 17 February 2015.

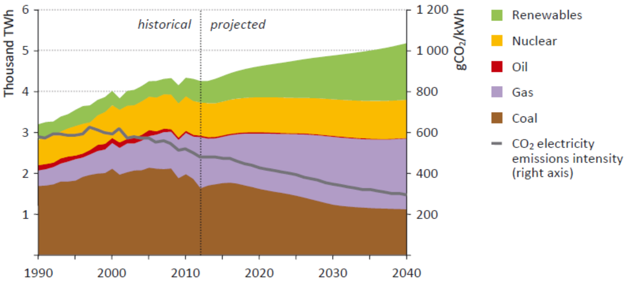
161 See also Li Xin, 'China's Clean Coal Hopes May Affect Gas Outlook', Interfax-NGD, 23 October 2014, p. 4.

162 See 'No China Coal Peak in Sight; Carbon Capture Will be Necessary to Tame Emissions in this Country', Clean Air Task Force, 18 February 2015.

163 See also F.Umbach, 'The Intersection of Climate Protection Policies and Energy Security', Journal of Transatlantic Studies, Vol. 10, N. 4, December 2012, pp. 374-387.

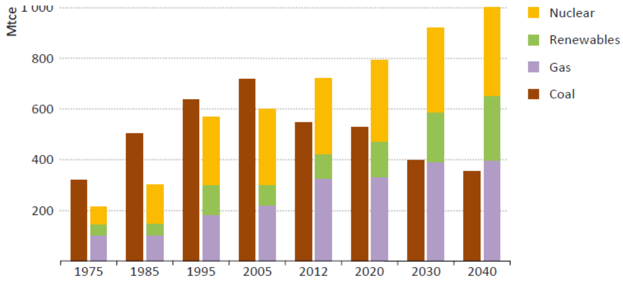
164 IEA, 'The United States. 2014 Review'. Energy Policies of the IEA Countries (Paris: IEA/OECD, 2014), p. 231.

Figure 39: U.S. Electricity Generation by Source and CO_2 Intensity in the New Policy Scenario



Source: © OECD/IEA (2014), 'World Energy Outlook 2014', Paris: IEA-Publishing. Licence: www.iea.org/t&c/termsandconditions

Figure 40: U.S. Power Generation Fuel Mix in the New Policy Scenario



Note: Oil is not shown due to its minor contribution.

Source: © OECD/IEA (2014), 'World Energy Outlook 2014', Paris: IEA-Publishing. Licence: www.iea.org/t&c/termsandconditions

In contrast to Europe's long-term contracts with Russia, the terms of U.S. coal contracts have no real impact on protecting coal producers against developments in natural gas markets. This has to do with the fact that almost 60 per cent of the gas used in power generation is purchased at spot markets, and the typical duration of a coal contract is short – some 40 per cent of all coal purchases contract in 2013 expired within the same year.[165]

Almost no coal-fired power plants have been built in the United States since 1994. In fact, nearly half of all existing coal-fired plants were built in the 1950s and 1960s and are consequently comparatively inefficient. The combination of cheap shale gas and environmental regulations has accelerated and may further fasten the retirement of U.S. coal plants, though it will remain dependent on the coal policies of the next U.S. governments.

The IEA expects U.S. coal demand to fall by a third between 2012 and 2040. Its coal share will decline to just nine per cent of its national energy mix by 2040, while the share of renewables will grow to more than 25 per cent and may double in electricity generation to 46 per cent by 2040. It is estimated that up to one-fifth of the present coal capacity could retire, but by 2030 coal will still meet about 30 per cent of U.S. power demands under the new regulations compared to 39 per cent in 2013.[166]

The newly proposed Clean Power Plan of June 2014, – opposed by the coal and power industries – sets out additional regulations and standards for the U.S. power plant industry in order to reduce 30 per cent CO_2 emissions by 2035 vis-à-vis 2005. Regarded as the most robust U.S. effort to date to combat climate change, the four identified provisions are (1) improved efficiency in coal-fired plants; (2) emphasis on combined-cycle gas-fired power; (3) more nuclear and renewable energies, and (4) improved end-use energy efficiency. It is expected that many older coal-power plants will be closed and replaced by new efficient gas-fired power plants. Similarly, many high-cost mines in the Appalachian region will face an end to their operations, leading to lower production and exports after 2020.[167] Between 2011 and 2013, at least 264 coal mines were already closed, as the coal industry had to implement seven major EPA regulations since 2008.[168] Yet even before the new regulations some 163 coal-fired generating units with a net summer capacity of almost 23,000 MW were scheduled to close between 2014 and 2017. The EIA expects that about 60 GW of coal generation will be shut down between 2012 and 2018.[169]

While the Act provides the federal states with a long transition period to come into compliance, it ensures the long-term switch from coal to cleaner-burning gas and renewables even if the economics of gas become less competitive in the future. At the same time, more coal plants will be closing than initially anticipated, with possibly problematic consequences. In fact, stable electricity supply at regional levels might be at risk during peak demand periods, as new gas-fired generators may not replace coal plants fast enough.[170]

The future of coal in the United States largely depends also on the uncertain implementation of CCUS. The U.S. federal government is committed to developing CCTs and is also investing into CCS-technologies with US$3.4 billion from the Recovery Act. Furthermore, a new interagency Task Force on CCS is developing new ways for a widespread, cost effective deployment of CCS-technologies within the next decade.[171] Currently, the United States has 19 large-scale CCS projects in operation or in

165 See ibid., here p. 195.

166 See IEA, 'WEO 2014', p. 65 f. and Keith Johnson, 'Dirty Pretty Rock'.

167 See ibid., 196 f.

168 See also Karl Mathiesen, 'US Coal Sector in 'Structural Decline', Financial Analysts Say', The Guardian, 24 March 2015.

169 See also Ed Crooks, 'Cheap Natural Gas and Emission Rules Darken Future of US Coal', FT, 9 December 2014.

170 Some 42 GW – 13 per cent of the U.S. coal capacity – has been or will be retired by 2035; 15 GW has already been shut, and an additional 13 GW might be closed in 2015 alone. See Margaret Ryan, 'US Coal Shutdown too Fast, too Soon – Experts', Interfax-NGD, 22 September 2014, p. 7.

171 See IEA, 'The United States. 2014 Review', p. 234.

various stages of development, including eight major CCS test projects.[172]

The decline in domestic coal consumption has boosted Washington's profile as a leading coal exporter in the short and medium term. Between 2005 and 2012, U.S. coal exports increased from 45.3 MT to a record 114.1 MT in 2012 – topping the previous record set in 1981 –, before decreasing slightly to 106.7 MT in 2013. American hard coal exports have continuously grown from 3.6 per cent of national production in 2009 to 11.6 per cent in 2013 and from 45 MT in 2009 to a record of 114.1 MT in 2012.[173] In 2014, however, coal exports already declined by 16 per cent relative to 2013 and reached 52.3 million short tonnes in 2014.[174] Going forward, U.S. coal exports are nonetheless expected to remain high, while coal prices will only slightly increase, as they will be able to draw from stocks.[175] Some estimates suggest that U.S. coal exports may reach an annual 500 MT to Europe, Asia and other regions by 2030. Nevertheless, protests by environmental NGOs and local residents against new coal export terminals have also grown – particularly against exports to Asia, as critics see the export boom to Europe as a short-term phenomenon. Of six proposed coal export facilities on the West Coast in 2013, three projects have already been abandoned due to those protests.[176]

These developments in the U.S. coal industry notwithstanding, the Obama-Administration announced in 2013 that it would no longer support coal-fired power plant projects financed by the World Bank and other international development banks – unless they were the only option for poor developing countries or included technologies that reduces GHGE. At the same time, officials have also left open the possibility of financing coal plants that meet strict U.S. emissions standards.[177] Meanwhile, the U.S. Congress has tried to block the executive branch's export ban on financing for coal-fired power plants abroad.[178]

'King Coal' in the Global Power Sector and the Potential for Enhancing Energy Efficiency and Decreasing CO_2 Emissions

Coping with climate change not only requires new investments towards clean energy sources, but also measures to address high emission assets that are already in place, such as coal-fired plants. Such measures can include operational phase-outs, enhancing energy efficiency, and retrofitting with CCS-technologies. They are all the more necessary considering that more power-generating capacity than the entire current capacity will be added by 2040.[179] Against this background and despite the expansion of RES, boosting the overall energy efficiency of the global coal-fired power plant fleet through CCT retrofitting is a major pre-condition for any successful climate mitigation strategy.

Energy efficiency will play a key role in tackling energy security and rising energy consumption. In this context, German and European producers, as technology leaders in the field of highly efficient power plant technologies, can make significant contributions to the replacement of no less than 40 per cent of the worldwide fleet of power plants in need of a phase-out. As the IEA itself has argued, the rapid and widespread adoption of highly efficient coal-fired generation technologies and CCS is pivotal for reaching the Kyoto target in the medium and long-terms.[180]

Boosting energy efficiency is also crucial in light of the on-going inefficiency of both new and old power plants. For instance, the average worldwide energy efficiency for power plants is currently around 33 per cent, but many European power plants still apply old technologies. New technologies can reach energy efficiency levels of 45 per cent and more – see below -, which in turn reduces CO_2 emissions by some 25 per cent per MWh vis-à-vis the world average. Each percentage point gain in energy efficiency leads to GHGE reductions of around two to three per cent.[181] Going further, if the world's coal-fired power plants could operate at optimal efficiency levels of around 45 per cent by 2040, emissions would be 17 per cent lower than in the IEA's New Policy Scenario. With these efficiency measures, CO_2 emissions would drop by almost 0.8 Gt per year on average or by 17 Gt through 2040.[182] Nevertheless, not even the newest coal-fired plants in the world reach optimal energy efficiency levels of 45 per cent. In China, for instance, around one-third of the newly built power plant capacity reaches no more than 30 to 40 per cent.[183]

In Europe itself, CO_2 emissions would drop between 25 and 30 per cent if the continent's plants were replaced with highly efficient ones. In this regard, the limits in the power plant sector prescribed in the European Strategy Energy Policy 2020 could be easily reached and

172 See ibid., p. 237.

173 See IEA, 'Coal Information 2013' (Paris: IEA/OECD, 2013) and IEA, 'The United States. 2014 Review', p. 230 f.

174 See EIA, 'U.S. Coal Exports Fall on Lower European Demand, Increased Global Supply', Washington D.C., 3 October 2014.

175 See David Price/Catherine Robinson/Shankari Srinivasan, 'The Coal Connection. Impact of the US Market on Europe', p. 1.

176 See also Keith Johnson, 'U.S. Coal Finds Warm Embrace Overseas'; Patrice Hill, 'AS U.S. Scales Back, 'King Coal' Reigns as Global Powerhouse', Washington Times, 4 March 2013; Richard Martin, 'In the West, Big Coal Makes a Stand', Forbes, 20 May 2013;

177 See Michael D. Shear, 'U.S. Says It Won't Back New International Coal-Fired Power Plants', New York Times, 29 October 2013.

178 See Jared Gilmour, 'Congress Puts Obama's Overseas Coal Ban on Chopping Block', The Christian Science Monitor, 11 July 2014.

179 Electricity will be the fastest-growing final form of energy and is expected to increase from 5,950 GW in 2013 to over 10,700 GW by 2040. By replacing 2,450 GW of retired plants, the world needs to add around 7,200 GW of cumulative power generation capacity to keep the worldwide electricity demand-supply balance stable. See IEA, 'WEO 2014', pp. 201 ff.

180 See the IEA's latest "World Energy Outlook" report of November 2014.

181 See IEA, 'The Global Value of Coal' (Paris: IEA/OECD), p. 24.

182 See IEA, 'WEO 2014', p. 180.

183 See ibid.

Figure 41: Unlocking Actions for Existing Coal Plants and the Range of Policy Options

	Policy Options		
Unlocking Action	**Direct Regulation of Plants**	**Regulated Change in Supply/ Demand Balances**	**Influence Markets via Price**
Retirement of coal plant	• Ownership decision to shut down • Regulated lifetime limits • Regulated phase-out	• Fleet wide GHG emissions performance standard • Regulated increase in renewable capacity • Demand reductions	• Fuel price changes • Carbon pricing • Preferential pricing for renewables
Change dispatch of the existing power plant	• "Clean-first" dispatch • Priority dispatch of renewables	• Fleet-wide GHG emissions performance standard	• Fuel price changes • Carbon pricing • Removal of fossil fuel subsidies
Rerofit of coal plant to increase efficiency	• Targets for plant retrofit rates	• Fleet-wide GHG emissions performance standard	• Carbon pricing • Removal of fossil fuel subsidies
Retrofit of coal plant for carbon capture and storage (CCS)	• Regulated lifetime limits • CCS retrofit mandates	• CCS trading schemes • Fleet-wide GHG emissions performance standard	• Carbon pricing • Removal of fossil fuel subsidies • Preferential pricing for CCS generation
Biomass co-firing or conversion	• Ownership decision to convert	• Renewable generation quota • Fleet-wide GHG emissions performance standard	• Carbon pricing • Preferential pricing for renewables

Source: F.Umbach based on IEA, 'Energy Climate Change and Environment – 2014 Insights' (Paris: IEA/OECD, 2014), pp. 9 and 18.

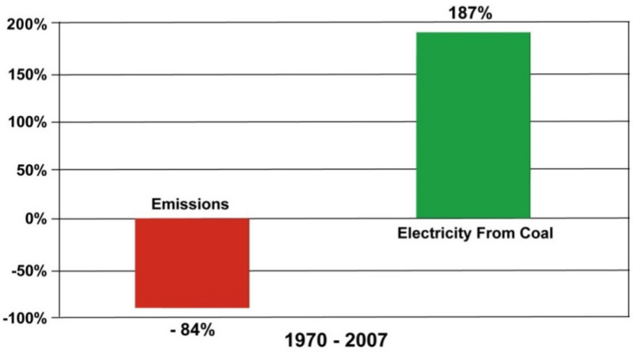
Figure 42: Four Critical Coal-Fired Power Generating Technologies

Type	Technology Description
Sub-critical	Conventional boiler technology, the most commonly used in existing coal-fired plants, in which water is heated to produce steam at a pressure below the critical point of water. A water separator (or drum) must be installed in order to separate water and steam. Thermal efficiency is typically under 40%.
Super-critical	Steam is generated at a pressure above the critical point of water, so no water-steam separation is required (except during start-up and shut-down). Super-critical plants are more efficient than sub-critical plants (normally above 40%), but generally have higher capital costs.
Ultra-Supercritical	Similar technology to super-critical generation, but operating at even higher temperature and pressure, achieving higher thermal efficiency (>45%, but can exceed 50%). Although there is no agreed definition, some manufacturers classify plants operating at a steam temperature in excess of 566°C as ultra super-critical.
Integrated Gasifi-cation Combined-Cycle (IGCC)	Involves the production of a flue gas by partially combusting coal in air or oxygen at high pressure. Electricity is then produced by burning the flue gas in a combined-cycle gas plant. Thermal efficiency can exceed 50%.

Source: Frank Umbach based on IEA, WEO 2011, Paris 2011, p. 365.

surpassed.[184] For comparison, the United States has cut its CO_2 emissions by over 400 million tonnes thanks to its coal-to-gas fuel switching. Germany, by contrast, has spent more than €100 billion on substituting just solar panels since 2000, but has seen a reduction of only 67 million tonnes in CO_2 emissions.[185]

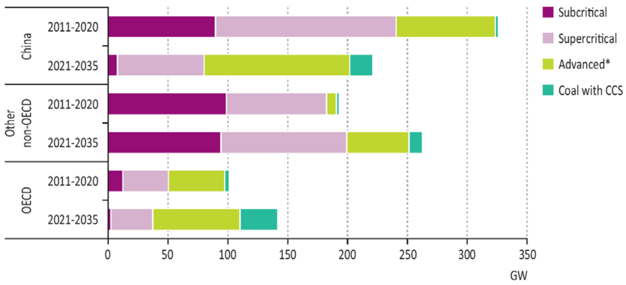
Figure 43: Clean Coal Technologies Have Reduced Regulated Emissions in the U.S.



Source: © OECD/IEA (2012), 'Global Value of Coal', Paris: IEA-Publishing. Licence: www.iea.org/t&c/termsandconditions

At present, four types of coal-fired power generation technologies are in operation and under development. The most modern ones raise the efficiency of coal-fired power generation, but have different characteristics and costs. In 2010, around 75 per cent of the worldwide coal-fired capacity was "sub-critical" – against 85 per cent in 1990 – , 20 per cent was "super-critical" and only three per cent corresponded to advanced technologies such as "super-critical" or Integrated Gasification Combined-Cycle (IGCC) plants.[186] Further advances in material development are underway which will boost power plant efficiency to between 50 and 60 per cent.[187]

Figure 44: New Additions of Coal-Fired Electricity Generating Capacity by Technology and Region in the New Policy Scenario



*Includes ultra-supercritical and IGCC.
Note: Excludes coal-fired generation from CHP plants.

Source: © OECD/IEA (2011), 'World Energy Outlook 2012', Paris: IEA-Publishing. Licence: www.iea.org/t&c/termsandconditions

184 See also F. Umbach, 'The Future of Coal, Clean Coal Technologies and CCS in the EU and Central East European Countries: Strategic Challenges and Perspectives'.

185 See Robert Price, 'Not Beyond Coal. How the Global Thirst for Low-Cost Electricity Continues Driving Coal Demand', p.12. See also Bogdan Janicki, 'Have the Cards Already Been dealt in Climate Policy and CO_2?, CEEP-Report 9/2014, pp. 10-15.

186 See IEA, 'WEO 2011', p. 365.

187 See also Giancarlo Benelli/Massimo Malavasi/Giuseppe Girardi, Innovative Oxy-Coal Combustion Process Suitable for Future and More Efficient Zero Emission Power Plants, ID 194; Jongsup Hong et. al., 'Analysis of Oxy-Fuel Combustion Power Cycle Utilizing a Pressurized Coal Combustor'; Marco Gazzino/G.Riccio/ N.Rossi/G. Benelli, 'Pressurised Oxy-Coal Combustion Rankine-Cycle for Future Zero Emission Power Plants: Technological Issues', Proceedings of ES2009, Energy Sustainability 2009, 19-23 July 2009, San Francisco, CA, USA; and Marca Gazzino and Giancarlo Benelli, 'Pressurised Oxy-Coal Combustion Rankine-Cycle for Future Zero Emission Power Plants: Process Design and Energy Analysis', ibid. 2008, 10-14 August 2008, Jacksonville/Florida, USA.

European Coal Policies

The Evolution of the EU's Integrated Energy and Climate Policy until 2010, and the Energy Roadmap to 2020 and 2050

In order to strengthen its future energy security, the European Commission's energy demand management strategy has emphasised the broadest possible energy mix, diversification of energy supply and imports, promotion of renewable energies, and a neutral policy towards the nuclear option. Its 20-20-20 per cent formula in its Energy Action Plan (EAP) of March 2007 aims to reduce GHGE, to raise the share of RES, and to improve energy efficiency and conservation. At the same time, the EU has recognised that it cannot achieve its energy and climate change objectives on its own. By 2030, the EU may consume less than 10 per cent of global energy and will emit just five to six per cent of all global GHG emissions.

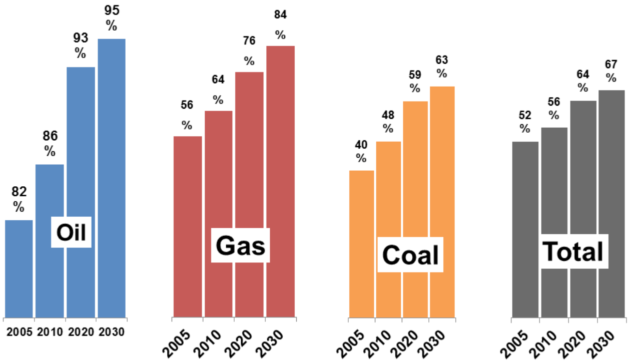
Despite progress in the integration and Europeanization of national electricity and gas markets, Europe – unlike the United States – is becoming more energy import-dependent. In fact, the EU's overall energy import dependencies will rise further from 55 per cent to more than 60 per cent by 2035; especially, its dependency on gas and oil imports will rise, respectively, from 60 to more than 80 per cent and from 80 to more than 90 per cent. At the same time, the Commission is hoping that a fully integrated, liberalised and competitive energy market could save 40 to 70 billion Euro through 2030.

The European Council's March 2007 EAP – valid for 2007 to 2009 – favours a liberalised internal market for gas and electricity, enhanced measures for security of supply, and a common approach to an external energy policy with a global dimension.188 The EU's energy policy aims at a careful balance between all three parameters: security of supply, competitiveness, and environmental sustainability.

The EU sees itself as the international leading political actor in efforts to contain climate change effects, and it hopes to benefit from this role politically and economically by becoming the technological leader of the future 'green economies'. The EU Council itself has accepted the policy that developed countries should collectively reduce their emissions by 60 to 80 per cent by 2050, compared to 1990 levels. In this context, under the German Presidency in the first half of 2007, the EU agreed to implement by 2020 the world's most comprehensive action plan – 17 individual measures – on climate protection and energy supply. If the EU achieved these goals, in 2020 it would be by using 13 per cent less energy than today – equivalent to a saving

188 See European Council, 'Presidency Conclusions'. 7224/1/07 REV 1, CONCL 1, Brussels, 8-9 March 2007.

Figure 45: Increase of the EU's Import Dependency throughout 2030



Source: Dr. Frank Umbach, based on Euracoal, An Energy Strategy for Europe: Importance and Best Use of Indigenous Coal, Brussels 2009, p. 1.

of more than 100 billion Euro and a reduction in CO_2 emissions of about 780 million tonnes per year.[189]

The EU-27 agreed on a set of tasks and the following three precise, legally-binding 20 per cent targets:

- Energy efficiency should be increased by 20 per cent across the EU;
- The goals of the Kyoto protocol should be exceeded and carbon emissions should be reduced by 20 per cent by 2020, compared to 1990;[190]
- Additionally, a 20 per cent share of the energy-mix should be generated from renewable energy sources.[191]

Despite these commitments, the EAP has failed to reach its overall energy balance, supply security, and environmental objectives. For example, natural gas was originally expected to grow in the EU-28 in order to balance coal and nuclear power, but there are several factors limiting a surge in demand – namely, gas's higher operational costs relative to those of coal, and a feared further increase of overall demand for Russian gas imports from Russia. Likewise, the strategy alone was not sufficient to meet the self-declared target of reducing CO_2 emissions by 80-95 per cent 2050. Therefore, EU emissions must be reduced by approximately 120 MT per year.[192]

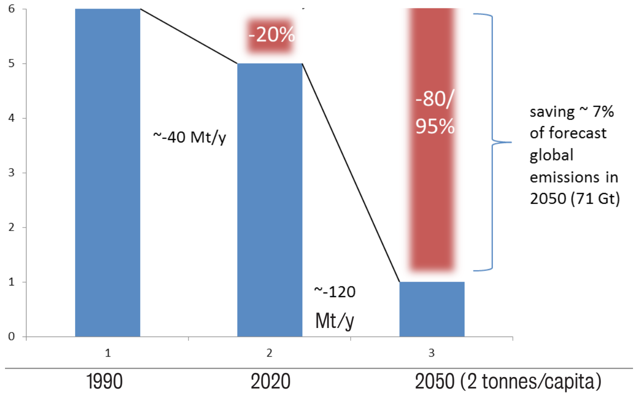
189 See European Council, 'Presidency Conclusions 2007', p. 13.

190 Emission reductions would go up to 30 per cent if other countries like the United States, India, and China followed suit.

191 Latvia, Sweden, Finland and Austria have already attained this target, although the Swedish and Finnish successes are due to the use of nuclear energy.

192 See also Euracoal, 'Coal Industry Across Europe 2011', p. 25.

Figure 46: Mitigation of Climate Change in the EU: Two Stages – Two Speeds (to reduce GHGE from 5.8 Gt/y in 1990, to some 4.6 Gt/y in 2020, and to some 1 Gt/y in 2050)



Source: Euracoal, 'Coal Industry Across Europe 2011', Brussels 2011, p. 25.

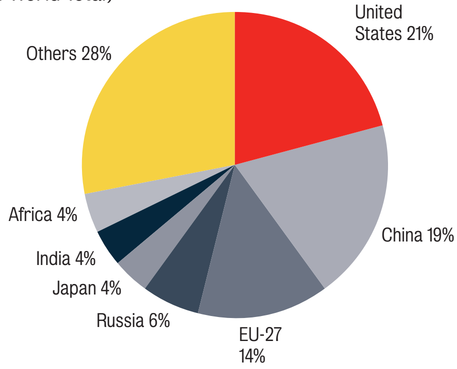
In general, the implementation of the 20 per cent reduction in GHGE by 2020 is still uncertain. Furthermore, between 1990 and 2005, EU energy intensity improvements had been accelerated to 19 per cent. In this regard, the target of reducing GHGE by 20 per cent did not seem overly ambitious until around 2012. Nevertheless, the need to determine national targets for the EU's declared GHGE reductions is difficult to achieve, given the very different energy situations and the economic prowess of the 28 member states for modernising their energy sectors and reducing GHG-emissions. Consequently, the share of RES, for instance, in the EU's final energy consumption is currently around 14 per cent.

In order to increase this share by another six per cent by 2020, major investments across the EU are required, but on a very different scale and with new initiatives to raise the recent rapidly declining carbon price and costs of allowances of the EU's Emissions Trading System (ETS). Although it covers some 10,000 industrial plants across the EU, today it accounts for just 45 per cent of all EU-28 GHGE. Furthermore, the contribution of small and large emitters to the overall emissions covered by the ETS is uneven.[193] Instead of 28 national caps from each EU member state, the Commission has favoured one EU-wide gap towards the existing scheme. Nevertheless, the market-based cap and trade solution needs to be strengthened, updated and extended with the inclusion of GHGE other than CO_2, and all major industrial emitters.[194]

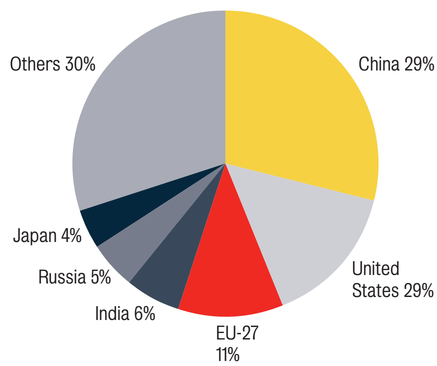
All in all, climate change mitigation has become a strategic goal with far-reaching consequences for the EU's energy and economic policies. The enactment of the 2008 Climate and Energy Package (CEP) and its ambitious targets all but confirm this reality. In addition, climate change mitigation is enshrined in EU law, as it is one of the core environmental goals of the Lisbon Treaty, the constitutional basis of the EU.

Figure 47: EU-27 CO_2 Emissions in the Global Context in 2005 and 2012

World's Largest Emitters of CO_2 in 2005 (Share of World Total)



World's Largest Emitters of CO_2 in 2012 (Share of World Total)



Sources: Dr. Frank Umbach based on data from the European Commission, Joint Research Center.

Since 2011, the EU has sent signals of further commitments. The European Commission has prepared to take new initiatives, while it has also, together with some member states, called for increasing the 20 per cent objective for CO_2 emission reductions to 30 or at least 25 per cent unilaterally. Nevertheless, this unilateral approach carries serious risks

193 Large installations cover only seven per cent of the total number of installations, but produce 60 per cent of total emissions, whereas small installations representing around 14 per cent of all installations emit only 0.14 per cent of all emissions. See ibid., p. 18.

194 See European Commission, 'An EU Energy Security and Solidarity Action Plan. Second Strategic Energy Review 2008'. Commission Working Staff Document: Europe's Current and Future Energy Position. Demand-Resources-Investments. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee of the Regions, COM(2008) 744, Brussels, November 2008.

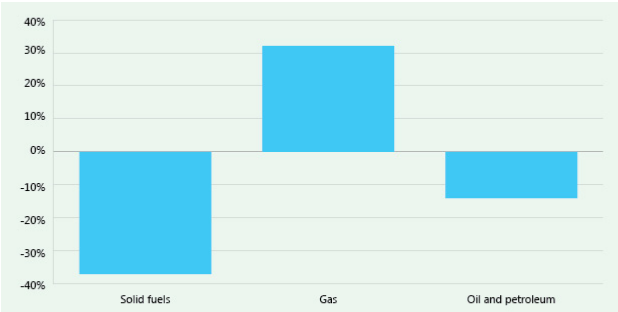
– namely, more free-riding policies by other states, threats to the survival of EU energy-intensive industries, and ultimately the production of more GHGE due to carbon leakage.[195] In addition, the EU's carbon footprint is already quite small compared to other economies.[196]

According to the Commission, its 2007 EAP and the present energy and climate policies have made significant progress to achieve its 20-20-20 targets:

- By 2012, GHGE had already decreased by 19.2 per cent in comparison with 1990 levels, and they are expected to reach a 24 and 32 per cent drop in 2020 and 2030, respectively.
- The share of RES has grown from 8.7 per cent in 2005 to 14.4 per cent in 2012 and was originally expected to increase further to 21 per cent by 2020 – now uncertain – and 27 per cent in 2030 – agreed to in October 2014. At the same time, the EU's consumption of solid fossil fuels – coal and coal products – decreased by 37.1 per cent.[197]
- The EU is – together with China – the largest investor in renewable energy sources. Of the US$100 billion of worldwide subsidies for renewable energies, more than 50 per cent are in Europe.
- It has created various eco-industries with an employment of more than 4.2 million people, becoming a job motor even during the EU's economic recession.
- At the end of 2012, the EU had installed about 44 per cent of the global renewable electricity production – excluding hydro.
- Between 1995 and 2011, the energy intensity of the EU economy was reduced by 24 per cent and even 30 per cent in its industry, though its economy has grown by around 45 per cent in real terms since 1990.
- Subsidies for generation from RES reached €52 billion (US$65 billion) per year in 2013 within the EU-28.
- The EU's energy consumption level had fallen to a 20-year low in 2013, returning to 1990s levels; from its peak in 2006, energy consumption decreased by more than nine per cent in 2013 and 0.2 per cent between 1990 and 2013.[198]

At the same time, several other targets and strategic objectives have not been achieved. The fulfilment of the 20 per cent target for enhancing energy efficiency remains unrealistic Furthermore, despite the achievements towards the EU's targeted 20 per cent reduction in emissions, those emissions have also grown in several EU member states – including in Germany in 2012 and 2013 because of higher and cheaper coal imports and coal consumption. Even the 20 per cent target for renewables has become questionable given disparate levels of implementation across member states.[199] The World Economic Forum has recently also criticised the 'suboptimal deployment' of RES, which has cost the EU approximately US$100 billion more than if each country in the EU had invested in the most efficient capacity according to their natural resource advantages – wind and/or solar power.[200]

Figure 48: Changes in EU Primary Energy Consumption (1990-2013)



Source: www.interfaxenergy.com.

Aiming to reinforce its climate protection goals, in January 2014 the European Commission unveiled an energy strategy for 2030 with new headline targets. The Commission has proposed a binding carbon dioxide emissions reduction of 40 per cent by 2030, which doubles the previous 2020 target.[201] In addition, it adopted a binding 27 per cent share of renewable energies in energy consumption by 2030.

Close analysis of these new strategy and targets indicate a paradigm change and a new set of priorities – namely, a reinvigorated focus on economic competitiveness for a

195 See also Karel Beckmann, 'EU Climate Policies Are Driving Smelters out of Europe'. Interview with Robert Jan Jeekel, Eurometaux, in: European Energy Review, 6 June 2011.

196 In 2013, the EU-28 was responsible for only nine per cent of all worldwide emissions, whereas China and the United States accounted for 24 and 12 per cent of global GHGE, respectively. See also Barbara Lewis, 'EU Pushes for Tough Paris Climate Deal – Draft', Reuters, 23 February 2015.

197 See 'EU Energy Consumption Returns to 1990s Level', Interfax-Natural Gas Daily, 11 February 2015, p. 8.

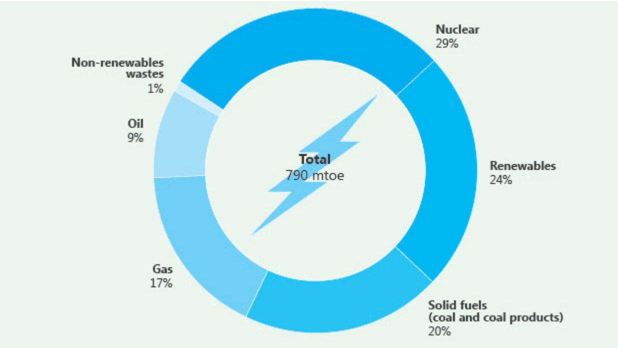
198 See EurActiv, 'EU Energy Consumption Level Falls to 20-Year Low', 10 February 2015 and Eurostat, 'Energy Savings Statistics. Data from February 2015', Statistics explained, Brussels, 10 February 2015 and 'EU Energy Consumption Retruns to 1990s Level', Interfax-Natural Gas Daily, 11 February 2015, p. 8.

199 France and 13 other EU member states are significantly behind their interim national 2012 targets for RES, while Italy and Germany being ahead of their national targets.See European Commission, 'Progress Towards Completing the Internal Energy Market. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, COM(2014) 634 final, Brussels, 13 October 2014 and Andreas Walstad, 'IEA Chief Questions EC's Global Ambition on Renewables', Interfaxenergy.com-NGD/Energy Policy Weekly, 4 December 2014, E1.

200 See EurActiv, 'Europe's Renewable Energy Deployment 'Sub-Optimal', Report Says', 21 January 2015.

201 See European Commission, 'A Policy Framework for Climate and Energy in the Period from 2020 to 2030'. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee of the Regions, Brussels, 22.1.2014 COM(2014) 15 final.

Figure 49: Domestic Production of Energy in the EU



Source: www.interfaxenergy.com

so-called 'industrial renaissance' in the EU.[202] In so doing, the EU has heeded calls to create a policy framework that not only furthers its climate protection goals, but also stimulates its economy.[203]

The EU's new energy security and diversification strategy of May 2014 has also differentiated the needed decisions and concrete actions in the short, medium, and long terms – nine months, one to five years, and more than five years, respectively – to respond to any major energy security

Figure 50: New EU-Energy Security Strategy – Response Options for a Gas Supply Disruption

In the short/medium-term:

- Strengthening emergency/solidarity mechanisms, incl. coordination of risk assessments and contingency plans, and protecting strategic infrastructures;
- Completing the integrated internal market;
- Gas-to-coal switch.

In the Medium-term:

- Moderating energy demand;
- Increasing EU energy production;
- Diversifying external supplies;

In the medium and long-term:

- Improving coordination of national energy policies and speaking with one voice in external energy policy.

Source: European Commission 2014.

202 This paradigm change could be identified at latest as of spring 2013 – see F.Umbach, 'EU's New Climate-Change Targets Will Drive Industry Towards US and China', Geopolitical Information Service (GIS – www.geopolitical-info.com), 10 February 2014; Oliver Geden/Severin Fischer, 'Moving Targets. Die Verhandlungen über die Energie- und Klimapolitik-Ziele der EU nach 2020', SWP-Studie S 1, Berlin, Januar 2014 and Severin Fischer, 'Der neue Rahmen für die Energie- und Klimapolitik bis 2030', SWP-Aktuell Nr. 73, Berlin, December 2014.

203 Fatih Birol, 'Europe's Energy Crossroads Is Dangerously Close', Europe's World, Spring 2013.

Figure 51: EU-Energy and Climate Packages of 2007 and 2014

„20-20-20 Energy Package" (2007)

- RES: Expanding It for Total Primary Energy Consumption (TPEC) from 8% to 20% by 2020 (Binding with Enforcement Plan)
- Energy Efficiency: Strengthening 20% by 2020 (Binding);
- Climate Protection: Decreasing CO_2-Emissions by 20% till 2020 (compar-ed with 1990 levels; Binding);
- Biofuels: 10% Target for Diesel-Fuel-Mix (Non-Binding; later been giving up).

- **RES-target by 2020 uncertain:**
  - RES 2014: 14% of TPEC;
  - 14 Member States may miss 20% target;
- **Efficiency target by 2020 unrealistic:**
  - Forecast by 2020: just 12-14%.

Energy Package 2030 (23/10/2014)

- Climate Protection: Decreasing CO_2-Emissions at least 40% till 2030 (compared with 1990 levels; Legally Binding);
- RES: Expanding to at least 27% for TPEC (doubling of 2014 level) by 2030 (Binding on EU-Level, but not at national levels without an Enforcement Strategy)
- Energy Efficiency: Strengthening by at least 27% (Indicative, Non-Binding);
- Interconnection Target of (Existing Generation Capacity) for Electricity: 15% by 2030 (Non-Binding)

Source: Dr. F.Umbach based on information and data of the European Commission.

challenges.[204] In addition to energy efficiency measures, the EU could switch from gas to coal in order to displace gas imports.

In October 2014, the EU confirmed the binding 40 per cent target for reducing GHGE, which will be broken down to individual member states based on their GDP per capita. It also adopted an energy efficiency target of 27 per cent by 2030 (only indicative), which could be raised to 30 per cent following a review in 2020. In addition, a non-binding 15 per cent interconnection target – of existing generation capacity – for electricity was agreed upon.[205]
The EU's targets also have a geopolitical and energy security angle. The EU hopes that the two 27 per cent targets for increasing energy efficiency and RES – incidentally, binding at the EU level, but non-binding at the national level – will reduce the EU's gas imports from Russia in the 12 most vulnerable EU member states by around 20 per cent.[206] Other analyses point out that a 25 per cent efficiency target could reduce EU gas imports by nine per cent, while a 35 per cent target may decrease the EU's gas imports by 33 per cent by 2030.[207]

204 See European Commission, 'European Energy Security Strategy'. Communication from the Commission to the European Parliament and the Council. SWD(2014) 330 final, Brussels, 28 May 2014 COM(2014) 330 Final.

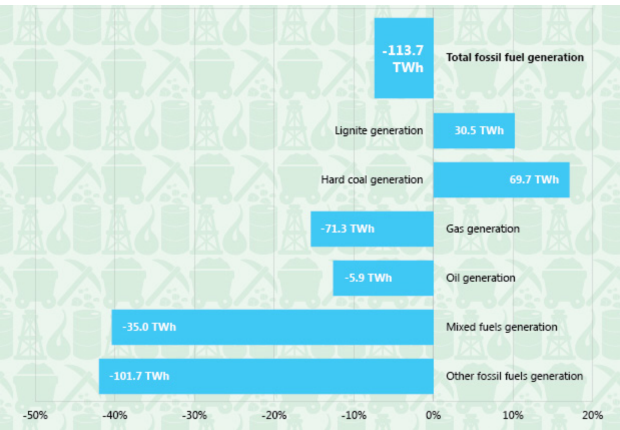
205 See Arthur Neslen, 'EU Leaders Agree to Cut Greenhouse Gas Emissions by 40 per cent by 2030', The Guardian, 24 October 2014; Andreas Walstad, 'EU's 'Soft Target' on Energy Savings Is Blow for Brussels', Interfax.energy.com-Energy Policy Weekly, 30 October 2014, E.2, 'EU Leaders Adopt 'Flexible' Energy and Climate Targets for 2030', EurActive, 24 October 2014; James Kanter, 'E.U. Greenhouse Gas Deal Falls Short of Expectations', NYT, 24 October 2014; Christian Oliver/Peter Spiegel, 'EU Agrees Target to Cut Gas Emissions', FT, 24 October 2014; and Sonya von Renssen, 'The EU's Great 2030 Energy and Climate Compromise', Energy Post, 24 October 2014.

206 See Annemarie Botzki, 'World Leaders Play Carbon Poker', Interfaxenergy.com-NGD, 23 October 2014.

207 See Christian Oliver/Jeevan Vasagar, 'Germany Backs EU Energy Target to Ease Dependence on Russia', FT, 16 June 2014.

Yet, internal divisions within the EU have led to some level of policy re-nationalization and polarization into two camps in their respective energy and climate policies.[208] As a consequence, ETS reform has also become highly controversial.[209] While some countries have favoured an early reform and introduction of the Market Stability Reserve (MSR)[210] by 2017/18, others would like to stick to the agreed upon timetables of 2021 out of fear of further negative impacts on overall economic competitiveness, innovation, carbon leakage, and energy supply security. But even with an early reform in 2017 and given the 40 per cent target for reducing CO_2 emissions, current EU energy policies still, contradictorily, largely favour coal to the detriment of gas. Against this background, the heads of ten of Europe's biggest utilities called on the EU to fundamentally reform its energy and climate policies and to curb subsidies for RES-power generation.[211]

Figure 52: Year-on-Year Changes in Fossil Fuel Generation (2012-2013)



Source: www.interfaxenergy.com.

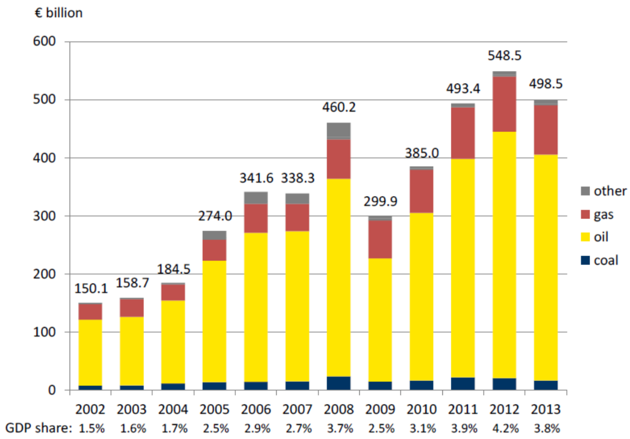
208 For example, Germany and Denmark push for ambitious climate policy targets, while Poland and the Baltic states, heavily dependent on fossil fuels, have largely opposed such moves. See again Oliver Geden/Severin Fischer, 'Moving Targets. Die Verhandlungen über die Energie- und Klimapolitik-Ziele der EU nach 2020', and Severin Fischer, 'Der neue Rahmen für die Energie- und Klimapolitik bis 2030'.

209 See also EurActiv, 'EU Politicians Edge Towards 2018 Start Date for Carbon Reform', 13 February 2015; idem, 'MEPs, Member States at Odds over ETS Reform Start', 23 February 2015 and Barbara Lewis, 'EU Politicians Divided on Eve of Carbon Market Reform Vote', Reuters, 23 February 2015.

210 Carbon prices have fallen almost €25 since their highs in 2008 from about €30 per tonne to just around 6€with a surplus of 2 billion allowances in the market. The MSR envisions taking out 12 per cent of surplus allowances out of the market each year, starting in 2021. The allowances will be handed back to the market if the surplus falls below 400 million. If the plan is approved, carbon prices could rise to nearly 9€ by 2020 and €48 by 2030 – see also Christian Oliver/Pilita Clark, 'EU Plans to Revive Lifeless Carbon Market', FT, 13 October 2014 and Andreas Walstad, 'MEPs Call for Early EU-ETS Reform as Debate Heats Up', Interfaxemergy.com-Energy Policy Weekly, 20 November 2014, E4.

211 In 2013, these market distortions led to 51 GW of the EU's electricity capacity getting mothballed – equivalent to the combined capacity of Belgium, the Czech Republic, and Portugal. See Ewa Krukowska, 'Europe Risks Energy Crisis From Green Subsidies, CEO Say', Bloomberg, 11 October 2013.

Figure 53: The EU's Energy Import Bill for Oil, Gas and Coal, 2002-2013



Source: Euracoal 2014.

The Need for Enhancing EU Economic Competitiveness[212]

As the world's largest energy importer, there are persistent doubts about Europe's future economic competitiveness and energy supply security. In 2012, the EU reached a new spending record for its fossil energy imports of €548 billion – 4.2 per cent of the EU's GDP, against 1.5 per cent in 2002 – compared to just €180 billion on average during the timeframe of 1990-2011.[213] By contrast, the U.S. import bill for fossil fuels had already decreased that year to US$340 billion by maximizing its own indigenous fossil-fuel resources.[214] The present record EU import bill is expected to stay at around €500 billion through 2035, drawing away much needed financial power from industrial innovation, research and development programmes, infrastructures and others.

Its energy conservation and efficiency efforts notwithstanding, the EU's energy costs are expected to rise further by 2030 to a level of 14 per cent of GDP compared with 12.8 per cent in 2010. The Commission reckons that its electricity costs will further rise from 2011 to 2030 by another 31 per cent – before inflation – and, thereby, consume a further increasing share of the EU's GDP. During the last decade, the EU's industry share of GDP has already declined from 20 per cent in 2000 to 15.1 per cent by 2012, pointing to an alarming de-industrialization

212 This sub-chapter is an update of two previous publications by the author – F. Umbach, 'EU's New Climate-Change Targets Will Drive Industry Towards US and China', and idem, 'Energieversorgung als Parameter europäischer Sicherheit (Energy Supply as a Parameter of European Security)', in: Johann Frank/Walter Matyas (Hg.), 'Strategie und Sicherheit (Strategy and Security)'. Eine wissenschaftliche Publikation des Bundesministeriums für Landesverteidigung und Sport, Wien-Köln-Weimar 2014, S. 231-242.

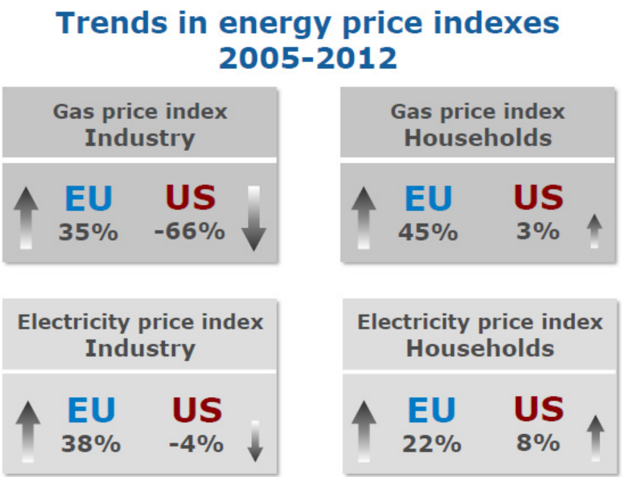
213 See Eurostat DS-018995, 15 January 2014.

214 See also IEA, 'WEO 2014', p. 83.

trend.[215] Consequently, the EU declared a fourth 20 per cent objective in 2012: to push the industrial share of its GDP to that level by 2020. At the end of 2013, however, this share was still stuck at 15.1 per cent.

Meanwhile, the energy price gap between the EU and other economies has widened for a number of reasons – many of them outside of the EU's controls. At the same time, the EU is also facing a significant internal price disparity among 28 member states – at one end of the spectrum, consumers are paying 2.5 times as much as consumers at the other end. Furthermore, some sectors have also experienced different price increases with much more volatility in regard to household electricity prices ranging from -34 per cent to +55 per cent, and gas prices of certain energy intensive industries increasing between 27 and 40 per cent, while EU average industrial gas prices rose by less than 1 per cent annually between 2010 and 2012.[216]

Figure 54: Comparison of US and EU Gas and Electricity Prices



Source: J.M. Barroso at the European Council, 22 May 2013.

The main driver of EU energy costs has not been the rise of raw materials, but rather the taxes or levies and network costs included in energy prices. Another factor is the EU's import dependence on Russia's high cost gas supplies and Russian unwillingness to give up its oil-price indexation and its Take-or-Pay-clauses in its long-term gas contracts. As a Commission study highlighted, within the EU gas and electricity prices – including taxes and charges – for industrial consumers have increased by 3.3 and 15 per cent, respectively, and for households by 13.6 and 18 per cent between 2008 and 2012.

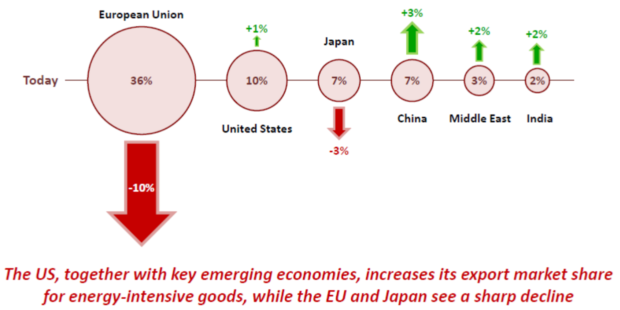
The gap between EU and U.S. energy prices is wide and keeps growing. Industrial gas prices in the United States have dropped by 66 per cent since 2005, while gas prices in the EU have increased by 35 per cent. Worse yet, gas prices in the EU are now three to four times higher than in the United States, Russia and India, as well as 12 per cent higher than in China. The IEA expects this gas price disparity will last much longer than often expected – at least for another 20 years. Correspondingly, this comparative energy cost advantage has boosted foreign investment in the United States and a revival of its manufacturing industry.[217]

Factbox: Industry Forecast of the American Chemical Council (ACC) in 2013

Price of natural gas liquids and ethane has decreased in 2011 from 91 cents per gallon to 26 cents;
Steady expansion of U.S. chemical feedstock supplies such as ethylene and its derivatives (i.e. polyethylene, PVC etc.) in the EU and other global markets, threatening their chemicals industries even in their home markets;
Chemical exports will grow by 45% over the next five years;
More than 135 new chemical production projects have been announced with a value of over US$90 bn;
U.S. Capital investment by the chemical industry will more than doubling to US$61.8 bn over the next five years.

Source: Dr. F.Umbach based on American Chemical Council 2013.

Figure 55: Share of Global Export Market for Energy-Intensive Goods (2012-2035)



Source: © OECD/IEA (2013), 'World Energy Outlook 2013', Paris: IEA-Publishing. Licence: www.iea.org/t&c/termsandconditions

215 See also Institut der deutschen Wirtschaft, 'Die Zukunft der Industrie in Deutschland und Europa'. IW-Analysen 88 – Forschungsberichte aus dem IW, Köln 2013 und BDI, 'Positionspapier Förderung von unkonventionellem Erdgas im Industrieland Deutschland', Berlin, March 2013.

216 See also European Commission, 'Energy Prices and Costs in Europe'. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Brussels, XXXCOM(2014) 21.

217 The U.S. oil industry has also enjoyed major growth. According to forecasts of the IEA, the U.S. may become the world's largest oil producer in 2015. During the last five years, the United States and Canada combined have become the fastest-growing region in the world for new oil supplies, overtaking producers like Russia and even Saudi Arabia. Correspondingly, U.S. oil imports declined from 60 per cent of domestic consumption in 2005 to 46 per cent in 2011 – see IEA, 'WEO 2014'; F. Umbach, 'The Geopolitical Impact of Falling Oil Prices' and idem, 'EU's New Climate-Change Targets Will Drive Industry Towards US and China'.

The declared new EU headline targets for enhancing in energy efficiency cannot compensate for the comparative costs advantages that the United States will enjoy over the next years or even decades. Together with Japan, the EU is already the least energy-intensive economy in the world. The IEA has warned and predicted that Europe will lose a third of its global market share of energy intensive exports of its industry employing almost 30 million people over the next two decades as a result of its comparatively high energy prices.[218] Against this background, former Energy Commissioner Guenther Oettinger repeatedly argued against a unilateral binding 40 per cent GHGE reduction target as long as other major global emitters would not accept a comprehensive and binding UN climate change agreement.[219]

The European Commission's View on the Future Role of Coal, Clean Coal Technologies and CCS

The European Commission's energy demand management strategy has always emphasised diversification in energy supply, promotion of renewable energies and a neutral look at the nuclear option. In this context, the Commission still views coal as an important energy source and a major contributor to the EU's present security of supply – at least in the short- and mid-term perspective. At the same time, it has also emphasized the need to make the use of coal more environmentally acceptable and to decarbonise its future energy mix.[220]

Against this background, coal plants could increase their energy efficiency further and apply new clean coal technologies, including CCS, as over 40 per cent of all fossil-fired generation capacity is more than 30 years old and over 45 per cent of the existing capacity in OECD countries will retire by 2040 – in the EU alone some 630 GW. Replacing Europe's ageing coal-fired plants with much more efficient modern ones could decrease the GHGE by 30 to 40 per cent.[221] To be sure, however, these reduction goals still fall short of some NGOs' demands and those of the divestment movement, which call for shutting down all coal-fired generation.[222]

218 See 'Energy and Competitiveness', in: IEA, 'WEO 2013', pp. 261 ff.

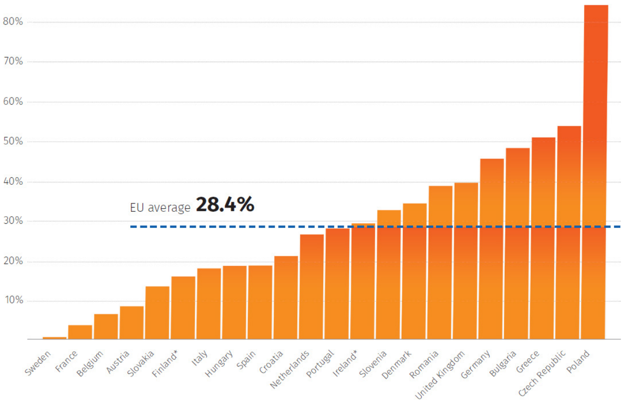
219 See, for instance, Arthur Nelsen, 'Europe's Carbon Cuts Should Be Subject to Paris Climate Deal', The Guardian, 25 September 2014.

220 European Commissioner for Energy Günther H. Oettinger, 'Foreword', in: Euracoal, 'Coal Industry across Europe 2011', p. 1.

221 See Euracoal, 'An Action plan for Coal in the 21st Century', Brussels, 19 March 2014.

222 A Greenpeace study from the summer of 2014 concluded that Europe's lignite reserves would wipe out the EU's entire carbon budget from 2020 until the end of the century. Lignite power plants alone are currently responsible for more than 10 per cent of the EU's total emissions. See Karl Mathiesen, 'New Coal Power Stations Threat to EU's Emissions Target', The Guardian, 27 August 2014.

Figure 56: Share of Coal in EU-Electricity Generation in 2012



Source: Euracoal 2011

The European Commission has recognized that, against the diverse economic development levels of the EU-28, the bloc cannot realistically phase out coal before 2035 or 2040. This recognition is based on the following facts:

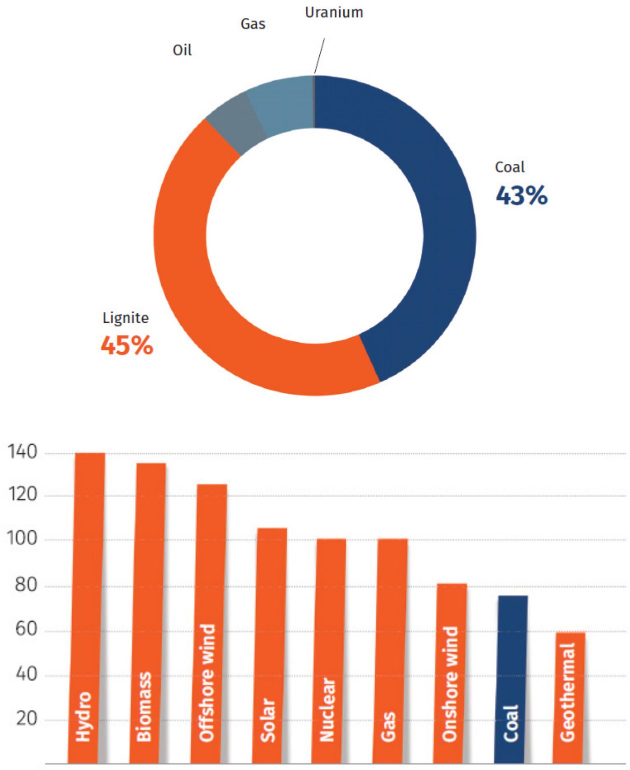
- At 88 per cent of all EU energy reserves, coal is the only one fossil energy resource that is still abundant and available in almost all EU countries.
- Globally, Europe is still the third-largest coal-consuming region after China and North America; it is also still the second-largest coal importer after China.
- In 2014, global coal demand had almost caught up with oil demand, whereas in 2003 the latter was around 45 per cent higher than coal.
- Even though EU coal consumption fell 40 per cent between 1990 and 2009, 18 per cent of primary energy demand was still covered by coal in 2012, while 27 per cent of power generation was dependent on coal.
- While the EU-28 spent more than €500 billion – or four per cent of GDP – on fossil energy imports, 96 per cent was on oil and gas and less than four per cent on coal imports.[223]
- The EU cannot phase out coal if it wants to remain competitive vis-à-vis the United States given the huge gas price differences between both sides of the Atlantic;[224] in fact, international coal prices would have to double in order to make gas competitive enough in the power sector to replace coal.[225]

223 See also Brian Ricketts, 'Coal Industry Stands for Progress and Prosperity', EurActiv, 27 February 2015.

224 See also Henry Foy, 'Several Factors Conspire to Increase Fossil Fuel Use', FT, 22 October 2014.

225 See Jason Torquato, 'Coal Prices Need to Double to Make Gas Competitive', Interfaxenergy.com-NGD, 17 January 2013; 'European Coal Prices Need $80 Rise for Gas to Become Competitive', Reuters, 8 January 2013 and Henry Foy, 'Several Factors Conspire to Increase Fossil Fuel Use', FT, 22 October 2014

Figure 57: EU-Energy Reserves Dominated by Hard Coal and Lignite Reserves and Levelised Cost of Electricity Generation in 2012



Source: Euracoal 2012.

- Given the oligopoly of gas suppliers in the EU, a broad EU energy mix ensures higher interfuel competition, which ultimately is an essential protection against the pricing power and risks inherent to a few gas suppliers.
- Phasing out coal would not just affect the coal-industry, but also the highly integrated value chain.
- The energy-mix in the EU-28 is highly diverse – while France uses only 4 per cent of coal for electricity generation, Poland gets 90 per cent of its electricity from coal.
- RES will unable to replace the approximately 40 per cent of EU power plants that will have to be replaced over the next 15 to 20 years; between 2012 and 2014, around 32 GW of gas- and coal-fired generating capacity was closed within the EU-28.[226]
- Fuel costs for generating electricity from coal are about half those for natural gas; coal prices would have to increase two-fold before gas becomes competitive.[227]
- Europe produces around 50 per cent of global brown coal – lignite –; around 95 per cent of lignite is used in power stations.
- The EU's coal import dependency increased from 22 per cent in 1995 to 46 per cent in 2012; by 2040, they will slightly decline to around 40 per cent.[228]
- In 2012, US coal exports to Europe rose by 23 per cent up to 66.4 MT.[229]
- The projected long-term decline of absolute European import volumes will further weaken the importance of the EU in global coal trade, as its share will decrease from 22 per cent today to just 9 per cent by 2040.
- In 2013, almost 600,000 people worked in the European coal industry.[230]
- Confronted with declining hard coal production – representing 57per cent of total coal supply –, the EU has become more import dependent, in particular from Russia, which has become the largest coal exporter to the EU since 2006[231] – see figure below.
- Around 60 per cent of EU coal consumption is from indigenous sources.
- European concerns over energy security have increased in the last decade. As a result, more than 50 new coal-fired plants were originally planned to go into operation over the next years and would remain in use for the next four decades. Although not all of them will finally be built, new coal power plants will be added to Europe's power generation capacity.

226 See also Andreas Walstad, 'EU Emission Controls Could Close More Plants', Interfax-Natural Gas Daily, 12 February 2015.

227 See also Sylvia Pfeifer, 'Coal Gains a Towering Lead over Gas', FT, 18 November 2013 and Jason Torquato, 'Coal Prices Must be Double to Make Gas Competitive', Interfaxenergy.cm-NGD, 17 January 2013.

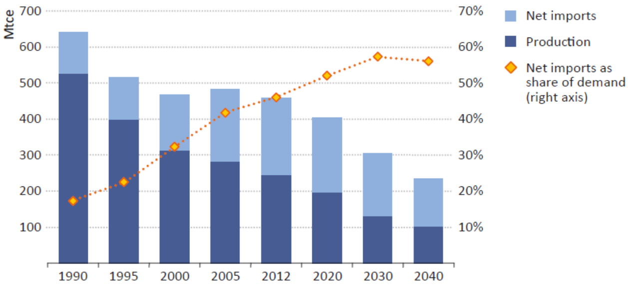
228 During the last two decades, coal imports substantially grew until 2006, reaching a peak of 220 Mtce, and then they declined until 2010, before increasing again, reaching the close historic peak of 2006 in 2012.

229 To rising US coal exports see also Rachel Williamson, 'Coal Comfort for Europe', Business Spectator, 7 June 2013; John W. Miller, 'Green No More, Europe is Desperate for Cheap Coal', The Wall Street Journal, 6 May 2014; Will Nichols, 'UK and Germany See CO_2 Emissions from Energy Rise over 2012', Business Green, 29 May 2013; and Guy Chazan/Gerrit Wiesmann, 'Shale Gas Boom Sparks EU Coal Revival', FT, 3 Februry 2014; Irwin Conway, 'US Gas Boom Pushes Europe Towards Coal', Interfaxenergy.cm-NGD, 28 August 2012, p. 4, Stephen Fidler, 'Rising Coal Use Clouds Europe's Future', The Wall Street Journal, 6 February 2014; Keith Johnson, 'U.S. Coal Finds Warm Embrace Overseas', The Wall Street Journal, 8 Februiary 2013; Michael Birnbaum, 'Europe Consuming More Coal', The Washington Post, 8 February 2013; and Stefan Nicola/LadkaBauerova,'Dirtiest Coal's Rebirth in Europe Flattens Medieval Towns', Bloomsberg Businessweek, 6 January 2014.

230 Figure includes Ukraine and Turkey. See Euracoal, 'Coal Industry across Europe 2013', Fifth Edition, Brussels, November 2013, p. 20.

231 Despite having the largest hard coal reserves in Europe, Poland became a net importer of coal in 2008, for the first time, highlighting the declining hard coal production trend during the last five years

Figure 58: OECD Europe Coal Production, Net Imports and Import Dependency in the New Policy Scenario



Source: © OECD/IEA (2014), 'World Energy Outlook 2014', Paris: IEA-Publishing. Licence: www.iea.org/t&c/termsandconditions

In this context, the EU and its industry have favoured a decarbonisation policy that consists of a three-way strategy:

- Fuel-switching away from coal and oil to gas and RES,
- Energy saving – e.g. reducing transmission losses and insulating buildings –;
- Deployment of new clean-coal technologies – CCS, smart grid, new chlorine processes, and so forth.

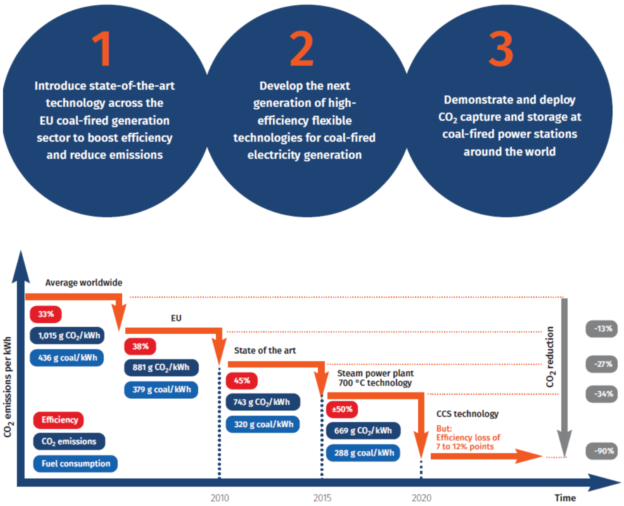
In addition, the European Commission, together with the coal industry and the coal-fired power station operators, has also pursued a so-called Clean Coal Concept based on an integrated approach of modernization. The concept promotes the introduction of state-of-the-art technologies to enhance the efficiency of coal power plants above 50 per cent for new coal-fired plants, and to reduce CO_2 emissions from electricity generation plants with CCS-technologies after 2020.[232]

Furthermore, the EU's current Seventh Framework Programme (FP7) is promoting projects for increasing energy efficiency of power plants to more than 50 per cent through further research and development, as well as better integration of technology and infrastructure components. Improving the energy efficiency of Europe's older coal-fired power plants up to more than 45 per cent has been estimated to cost not more than €5 to €10 billion across the EU – compared with the more than €30 billion that Germany is spending alone on RES each year.[233]

232 See European Commission, 'Supporting Early Demonstration of Sustainable Power Generation from Fossil Fuels'. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, COM(2008) 13 final, Brussels 23 January 2008 and idem, 'Sustainable Power Generation from Fossil Fuels: Aiming for Near-Zero Emissions from Coal after 2020.' Communication from the Commission to the Council and the European Parliament, COM(2006) 843 final, Brussels, 10 January 2007. See also Euracoal, 'A Strategy for Clean Coal', Brussels, November 2012.

233 See Euracoal, 'Why Less Climate Ambition Would Deliver More for the EU', Brussels, 2014, p. 11.

Figure 59: Euracoal's 3-Step Strategy for Clean Coal



Source: Euracoal 2014.

Originally, the European Commission was planning to support 10 to 12 larger CCS test projects, with the goal of launching them commercially by 2020. But these plans have proven to be too optimistic, as the present lack of funding for CCS in EU member states only allows projects in the near future. Nonetheless, the Commission remains committed to the large-scale introduction of CCS before 2030, as a CO_2 emission-free Europe is unrealistic without CCS covering around 19 per cent of the agreed upon emission reductions by 2050.[234] That goal, however, depends ultimately on a global binding agreement on climate change, leading to higher carbon prices under the EU's ETS, as an underlying rational for those expensive commercial projects.

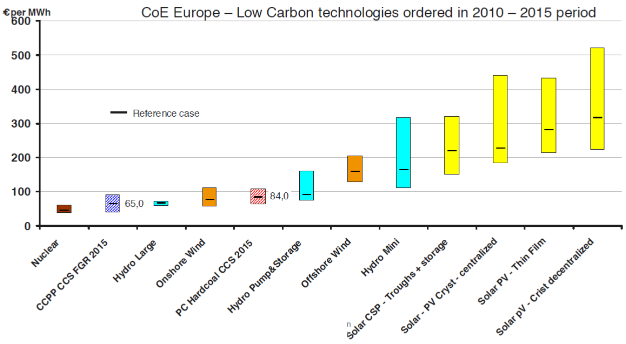
Yet, even after combining all costs of capture, transport and storage, CCS appears actually cheaper than photovoltaics (PV), concentrated solar power, and offshore – comparable to onshore wind. In addition:

- Electricity costs vary between €65 and €85 per MWh for steam plants, depending on fuels and regions. The first large scale CCS units, to be ordered, starting in 2015, will be fully competitive with any other low-carbon power generation solution;
- Compared with other mature technologies, the greater potential learning curve improvement of CCS will increase its competitiveness over time, particularly with the introduction of second- and third-generation technologies;
- Contrary to mainstream assumptions, the relative competitiveness of gas with CCS is slightly improved versus coal, with CCS for the first plants to be ordered in 2015;

234 See also Bellona Europe, 'CCS Needed for Both Climate and Growth, Establishes European Parliament Event', 12 November 2014.

- With the right policy framework, neither the technology nor the costs themselves are obstacles to CCS deployment.[235]

Figure 60: Alstom – Cost Assessment of Fossil Power Plants with CCS versus Other Low Carbon Technologies



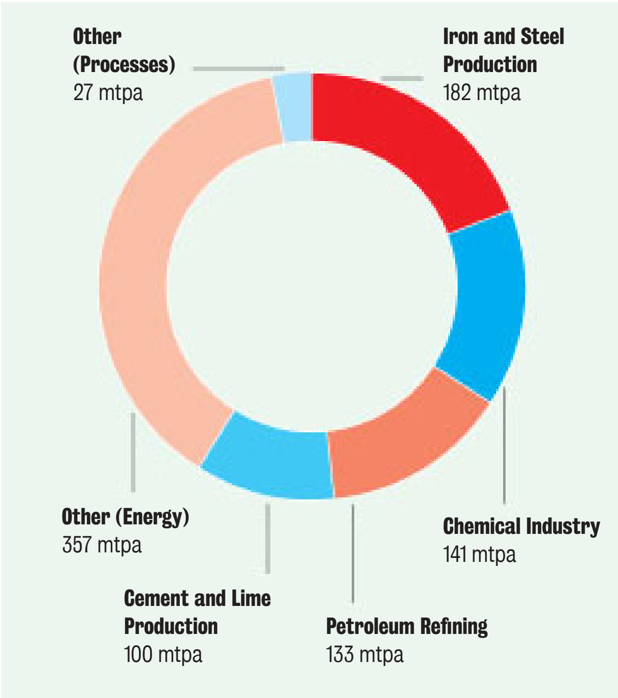
Source: J.-F.Leandri/P.Paelinck/A.Skea/C.Bohtz, 'Cost Assessment of Fossil Power Plants Equipped with CCS under Typical Scenarios, Power-GEN Europe, Alstom, 7-9 June 2011, Milan/Italy, p. 18.

Similar research has concluded that CCS will be cost-competitive with other low-carbon energy powers, including on-/offshore wind, solar power, and nuclear.236 It also re-confirmed that CCS is technically applicable to both coal- and natural gas-fired power plants. The relative economics depend on power plant cost level, fuel prices, and market positioning. Furthermore, all three CO_2 capture technologies – post-combustion, pre-combustion, and oxyfuel – have been analysed, and there is currently 'no clear difference' with regard to the costs between them. They could all be competitive in the future once they have been successfully tested. The main factors influencing total costs come from fuel and investment costs.

Until now, however, the Commission has not offered CCS a clear business case – in contrast to RES, where regulation and feed-in tariffs guarantee a return on investment and have been driving factors for expansion. At current ETS prices and without legal constraint or incentives, there is no real economic rationale for operators to invest in CCS.[237]

Beyond financial and technological challenges, environmental NGOs have opposed the storage of CO_2 on land in countries with a high population density, such as Germany. The German government 2013 abandoned the idea of locating any storage site for CO_2 emissions, which de facto blocked all CCS-projects in Germany. Yet, public debate has focused almost exclusively on CCS for coal-fired power plants and largely ignored oil and gas power stations and energy-intensive industries – all of which will also need CCS for achieving climate mitigation goals and ensuring economic stability. German policy-makers are largely aware of this reality, but still struggle to reconcile the value of CCS technologies with climate mitigation efforts.[238]

Figure 61: Industrial CO_2 Emissions in the EU (2013)



Source: Interfaxenergy.com-NGD 2013.

The EU is increasingly lagging behind other advanced economies in the adoption of CCS, at the risk of losing industrial competitiveness.[239] Only the European Parliament has taken a strategic view by demanding that CCS-projects receive the same level of financial support as RES.[240]

On 23 October 2014, the European Council agreed to boost funding for CCS test projects after 2020. The so-called NER400 programme will be financed with 400 million

235 See J.-F.Leandri/P.Paelinck/A.Skea/C.Bohtz, 'Cost Assessment of Fossil Power Plants Equipped with CCS under Typical Scenarios', Power-GEN Europe, Alstom, 7-9 June 2011, Milan/Italy.

236 See ZEP, 'The Costs of CO_2 Capture, Transport and Storage. Post Demonstration CCS in the EU', Brussels, 2011.

237 See also European Academies Science Advisory Council, 'Carbon Capture and Storage in Europe', Brussels, May 2013; Chris Tighe/Andrew Bounds, 'Energy Groups Pin Hopes on Carbon Capture and Storage', FT, 22 December 2013; Sam Gornersall, 'Is the Door to CCS Closing in the UK?', Energy Post, 25 February 2014; Pilita Clark, 'TUC-Backed Sudy Points to Carbon Capture to Cut UK Energy Bills', FT, 3 February 2014, and Annemarie Botzki, 'No Rationale' for Investment in CCS in Europe' and Jeffrey Michael, 'CCS: Why the High Hopes Cannot be Fulfilled', Energy Post, 5 June 2013.

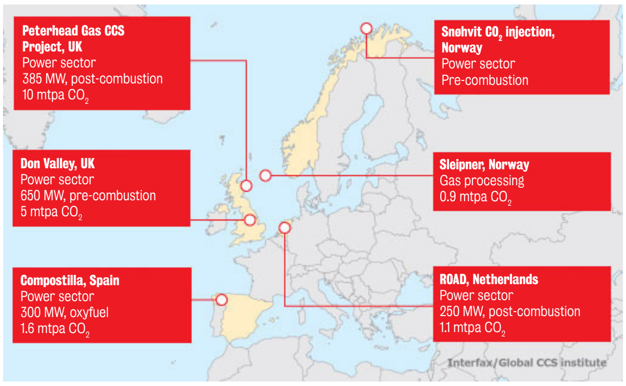
238 See 'Einsatz der CCS-Technologie wieder auf der politischen Agenda', IZ-Klima Newsletter No.2, April 2015 and the interview with Environment Minister Barbara Hendricks: 'Mindestpreise sind nicht nötig', BIZZ Energy Today, March 2015, pp. 22-27, here p. 25 f.

239 See also the interview with Jonas Helseth, director of Bellona Europe and leader of the foundation's work on CCS in – Annemarie Botzki, 'How to Spur CCS Development in Europe', Interfaxenergy.com-NGD, 17 March 2015, p. 4.

240 See John McGarrity, 'EU Parliament Gives Strong Backing to Carbon Capture' (www.rtcc.org), 14 January 2014.

EU ETS-allowances. The previous NER300 programme raised €2.1 billion on the carbon market for RES and one CCS project in the United Kingdom.[241] Only two other CCS projects in the United Kingdom and the Netherlands – the Peterhead and the Rotterdam Capture and Storage Demonstration Project projects, respectively – are currently in development.[242] The UK government has recently reiterated its commitment to support CCS projects and announced to provide £4.2 million for the proposed CCS power station in Grangemouth in Scotland.[243]

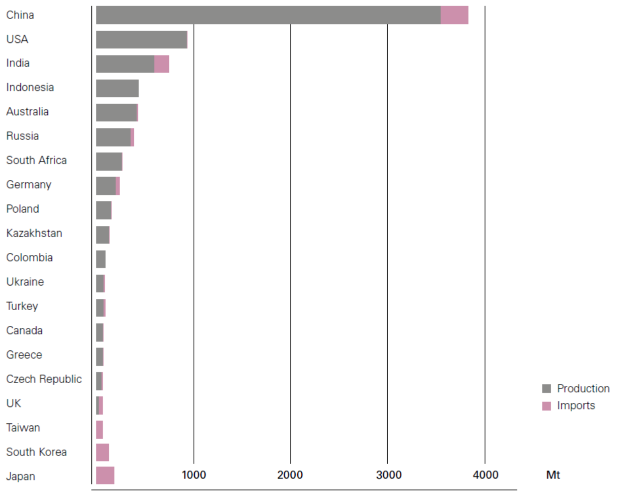
Figure 62: EU – Large-Scale European CCS Demonstration Projects in Development or in Operation



Source: Interfaxenergy.com-NGD 2013.

At the same time, coal and other fossil fuel power plants must become not just clean and efficient, but also 'smart' in order to operate with unprecedented flexibility and backup capacity. Smart coal-fired plants are still important for guaranteeing the base-load security for a stable 24-hour electricity supply, but move into the new role of an "auxiliary" power provider for intermittent RES having priority dispatch for feeding electricity into the grid system. Minimising the cost of decarbonisation and finding timely solutions will become an ever more important task for the future, achieved by implementing more advanced coal technologies such as ultra-supercritical plants, IGCC and UCG technologies to reduce the CO_2 footprint. These steps will be all the more important since the European Commission and member states have solely focused on domestic emissions and failed to account for outsourced

Figure 63: Major Coal Producing and Importing Countries 2012



Source: Euracoal 2013.

ones coming from goods previously produced in Europe or energy resource imports from other countries.[244]

In fact, accounting for outsourced production and any resulting imports provides revealing insights. By some estimates, the EU's carbon footprint may have increased 47 per cent since 1990 if one considers the outsourcing of EU energy-intensive industries to other countries. Life-cycle analyses – which take into account emissions from a) Russia's gas production sites, b) their transport routes to European markets, and c) their end use – similarly conclude that GHGE from domestic European and German coal production are not necessarily higher than Russian pipeline gas. In general, GHGE from indigenous energy production are lower than fossil energy imports via long transport ways with pipelines and ships. Hence, the use of indigenous energy resources may be more effective for global climate protection efforts than energy imports with long-distance transport routes.[245]

As previously mentioned, European coal consumption has surged in the last years despite the EU's ambitious climate protection policies. Even many older and less-efficient coal-fired power plants have been much more competitive than many new gas-fired power plants due to the huge price difference between coal and gas. But, beyond 2020, the current oversupply in global coal markets will decline and international coal prices could rise alongside the prices determined by the ETS and new EU regulations for the power sector. They are also responsible

241 The White Rose project at the UK's Drax power station secured 300 million Euro in funding from the programme last July.

242 See Annemarie Botzki, 'EU Leaders Agree to Boost Financial Support for CCS', Interfaxenergy.com-EPW, 30 October 2014, idem, 'Uncertain Future for CCS in Europe', ibid., 18 August 2014, p. 3 and idem, 'Commission Unlikely to Review CCS Directive in 2015', Interfaxenergy.com-NGD, 13 November 2014,

243 See 'UK to Invest £4.2 Million in Feasibility Studies for CCS in Grangemouth', Natural Gas Europe, 27 March 2015.

244 See for instance A.Brinkley/S.Less, 'Carbon Omissions – Consumption Based Accounting for International Carbon Emissions', Research Note, Policy Exchange, London, October 2010

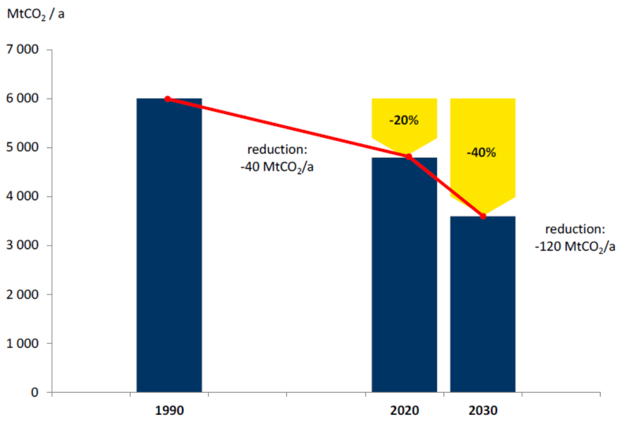
245 Milton Catelin, Coal: A Pillar of Europe's Future, in: EUCERS-Newsletter, No. 7, King's College, London, pp.1-4 (4). See also Greg Pytel, The Future is Clean. The Future is Coal, in: ibid., pp. 5-7 and Andrew MacKillop, Europe's Green Energy Chaos, European Energy Review, 31st October, 2011.

for the expected decrease of the European coal production, particularly lignite, due to the phase-out of subsidies and the closing of many ageing mines as well as sub-critical coal power plants.[246]

Currently, trends are discouraging – not just for coal power plants, but also for gas power plants. In 2014, European utilities shut more coal and gas power plants than in any year since at least 2009 due to the challenging economic and regulatory environment. They turned off 63 per cent more coal and gas power generation than they started by decommissioning five GW – equivalent to about five nuclear power plants. While they added eight GW of new coal and gas-fed generation, they shut 13 GW of fossil capacity.[247]

Following the October 2014 agreement, the EU persuaded member states opposed to the 40 per cent reduction target by creating a funding regime to modernize some of Europe's most-polluting power plants. It also strengthened its support for CCS-projects,[248] which have now also been highlighted in the EU's new Energy Union strategy. In this context, CCS projects and other CCTs have been identified as an important field of research, for which the European Commission will provide new funding options.[249] An EU funding regime to modernize Europe's ageing coal power plants will also be important as part of the planned overhaul of its electricity market as it will highlight the importance of guaranteeing its base-load stability and the need of full open capacity markets, which encourage governments to pay energy companies for idle power stations.[250]

Figure 64: Agreed GHGE-Reduction Path in the EU: Achieving the Same Amount of Emissions Reduction in a Decade (2020-2030) as in the Previous Three Decades?



Source: Euracoal 2014.

246 By implementing the Large Combustion Plant Directive of 2001, 35 GW have already been closed and another 40 GW of the remaining 150 GW of coal-fired capacity could also be phased out by 2023. See 'Pressure on Polluters Increases as Coal Industry Declines across Europe', EurActiv, 17 March 2015.

247 See Bloomberg, 'EU Shutters Most Coal, Natural Gas Power in Six Years', 11 February 2015.

248 See also Andreas Walstad, 'EU Considers Aid to Modernise Coal-Fired Power Plants', Interfaxenergy.com-NGD, 23 October 2014.

249 See also Simon Evans, 'Briefing: What Is the EU's Energy Union?', Natural Gas Europe, 7 February 2015 and Sonya van Renssen, 'The Energy Union: 'A. Holistic Approach to the Energy Transition', Energy Post, 8 February 2015.

250 See also Andreas Walstad, 'EU Considers Aid to Modernise Coal-Fired Power Plants', Energy Policy Weekly, 23 October 2014, and EurActiv, 'Energy Union GTargets Renewables Subsidies, Boosts Idle Coal Plants', 20 February 2015.

Germany's *Energiewende*: Leading by Example?

Germany's *Energiewende* at a Crossroads

The *Energiewende* is the world's most ambitious energy transformation. After the Fukushima catastrophe in March 2011, the German government adopted, unilaterally and with limited prior notice, the challenging task of transforming its entire energy system. Against this background, Berlin decided to phase out nuclear power by 2022, and to break its dependence on fossil fuels and to expand wind, solar and other renewable energies to 50 per cent of all electricity by 2030 and 80 per cent by 2050.

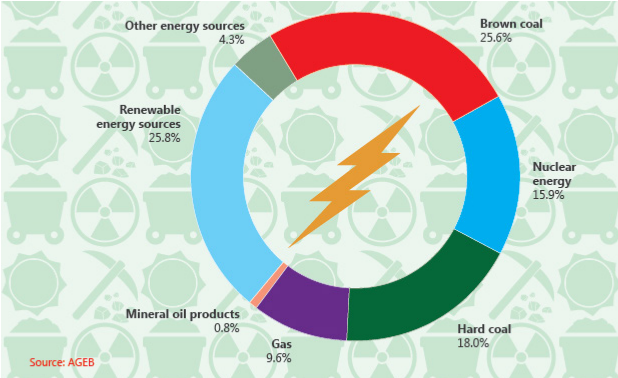
As of 2014, Germany presents a mixed record in electricity generation:

- RES: 26 per cent – up from 24 per cent in 2013 –, with their share in electricity output having risen eightfold since 1990;
- Lignite: 25.6 per cent;
- Hard coal: 18 per cent – the lowest level since 1990, and down from 19.2 per cent in 2013 –;
- Gas: 9.6 per cent – down from 10.7 per cent in 2013.

After increasing in 2013, Germany's GHGE decreased to 301 m tonnes in 2014 and reached the lowest level since 2009. Germany also remains Europe's largest electricity producer of solar panels with more than 35 TWh. The wholesale price for power on the Leipzig power exchange fell to a record low of €33 per MWh – compared with €38 in 2013.[251]

Expanding RES, in particular, has been celebrated as Germany's success story,[252] which in turn ignores the overall costs and problems of implementing the *Energiewende*. Cost estimates of the entire energy transformation policy have constantly increased since 2011 and are due to reach €1 trillion over the next 25 years. Of that figure, €348 billion has already been paid, whilst another €680 billion needs to be spent by 2022.[253] Until now, Germany is on track to meeting only one of its three major targets – one third of renewables in energy generation. Meanwhile, it appears to be failing to meet its second goal – to cut energy consumption by a fifth by 2020 –, which will in turn make it difficult to reach the third target – 40 per cent cut in emissions compared to 1990.[254]

Figure 65: Gross Electricity Production in Germany (2014)



Source: www.interfaxenergy.com

Currently, Germany faces a gap of between 5 and 7 per cent for meeting the *Energiewende*'s third goal. In order to tackle this gap, the German Ministry for the Economy and Energy has adopted a new action programme that calls for decreasing emissions in the power sector by another 22 million tonnes by 2020, which ultimately may lead to the phase-out of lignite mining and coal-fired power generation.[255] A further eight coal-fired power stations might be closed down. The emission reductions will be shared equally between Germany's power companies, which will be allowed maximum flexibility to determine which of their power plants will be decommissioned.[256] An industry study has shown that closing coal-fired power plants with 10 GW capacity would push electricity prices up by around €7 per MWh.[257] German Energy Minister Gabriel, however, has denied that the plan would forcefully close outdated coal-fired power plants, while also arguing that phasing out both nuclear and coal power simultaneously is out of question.[258]

251 See also Agora *Energiewende*, 'The *Energiewende* in the Power Sector: State of Affairs 2014', Berlin, 7 January 2014; 'Renewables Dominate German Energy Mix', EurActiv, 8 January 2015 and Jeevan Vasagar, 'Renewables Take Top Spot in Germany's Power Supply Stakes', FT, 7 January 2015.

252 See Bärbel Höhn, 'Renewables Are 'the Most Important Source of Energy in Germany', EurActiv, 25 February 2015.

253 See also Jeevan Vasagar, 'Clean Energy Proves a Costly Exercise for Germany', FT, 22 October 2014; Rose Jacobs, 'Germany's Burdensome Shift to Renewables', FT, 22 October 2014; and 'Moves Toward Green Energy Hamper Germany's Economy', Stratfor, 1 February 2015.

254 See also Frank Drieschner, 'Schmutziger Irrtum', Die Zeit, No. 50, 4 December 2014, p. 4.

255 See Martin Greive/Daniel Wetzel, 'Gabriel zielt auf die sanfte ‚Kohle-Wende', Die Welt, 25 November 2014, p. 9, 'The Growing Absurdity of German Energy Policy', FT, 25 November 2014, Melissa Eddy, 'Missing Ist Own Goals, Germany Renews Effort to Cut Carbon Emissons', The New York Times, 3 December 2014, and 'Klimapaket soll Milliarden an Investitionen anschieben', Die Welt, 4 December 2012.

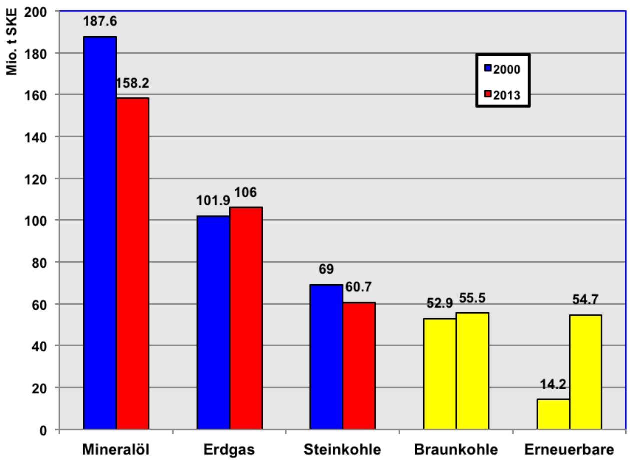
256 See also 'Germany May Shut Down Eight More Coal Power Plants', EurActiv, 24 November 2014.

257 See 'BDI warnt vor Stilllegung von Kohlekraftwerken', Die Welt, 25 November 2014, p. 9.

258 See 'Germany Denies Plans to Close Old Coal Plants in Sprint to 2020 Targets', EurActiv, 25 November 2014.

Reducing additional emissions in the power sector opens up another set of issues. Indeed, such a reduction would further decrease the number of ETS allowances. Under these circumstances, a more fundamental and early reform of ETS would become much more urgent, as the new EU-Energy Commissioner Miguel Canete has already warned the German government.[259] More importantly, however, it is increasing Germany's dependence on energy imports. In 2012, it imported 61 per cent of its overall energy consumption – higher than the EU-28 average of 53 per cent.[260]

Figure 66: Comparison of Shares (in %) of Domestic Energy Production of Germany's Primary Energy Consumption in 2000 and 2013



Source: F. Umbach, based on AG Energiebilanzen e.V.

Rising energy prices for both private and industrial consumers are challenging the future of Germany's economic strength.[261] Germany's feed-in tariff system – the EEG – has made Germany the world's largest, but also the most subsidized, solar market. Experts have increasingly warned that only a drastic policy shift will prevent the *Energiewende* reform from threatening the very international competitiveness of the Germany economy. In this context, German industry is calling for the abolition of feed-in tariffs for new wind and solar installations, as well as for a 'strategic reserve' of fossil fuels in order to ensure the base-load supply of reliable gas and coal-fired power stations for the stability of the national grid.[262]

Admittedly, the overall international risks and vulnerabilities of energy supply security have constantly increased since the September 11 terrorist attacks in 2011,[263] but Germany's own supply security has also declined significantly during the last decade.[264] Germany's double phase-out of domestic hard coal production by 2018 – adopted in 2006 – and nuclear power until 2022 has turned Russia into Berlin's largest gas, oil, diesel and hard coal supplier. Russia now covers almost 25 per cent of Germany's total primary energy consumption.[265] In 2013, Germany's import dependence increased by another 2.7 per cent to 61 per cent of its primary energy consumption.[266] Furthermore, it is often overlooked that green technologies themselves largely depend on critical raw materials from abroad for their production and maintenance. The growing dependence, for instance, on heavy rare earths imports from China for magnets in wind turbines is troubling given that Beijing has a production and export monopoly of rare earths

259 See 'Berliner Klimapolitik macht Emissionshandel witzlos', FAZ, 6 December 2014, p. 21.

260 See also F.Umbach, 'Gasversorgungssicherheit in Deutschland und in der EU. Bedeutung, Herausforderungen und strategische Perspektiven', in: Politische Studien (Political Studies, ed. by the Hanns-Seidel-Foundation), September-October 2014, pp. 28-40; idem, 'Die deutsche Energiewende am Scheideweg" (The German Energiewende at the Crossroads'), BWK-Das Energiemagazin, Nr. 7-8/2014, p. 14, and 'Germany Is Paying the Price of Its Energy Switch to Renewables', Geopolitical Information Service (GIS – www.geopolitical-info.com), 10 March 2014,.

261 See also Institut der deutschen Wirtschaft, 'Die Zukunft der Industrie in Deutschland und Europa' and BDI, 'Positionspapier Förderung von unkonventionellem Erdgas im Industrieland Deutschland'.

262 See F.Umbach, 'Die deutsche Energiewende am Scheideweg', and idem, 'Germany Is Paying the Price of Its Energy Switch to Renewables'.

263 See, for instance, Institute for 21st Century/U.S. Chamber of Commerce, 'International Index of Energy Security Risk. Assessing Risk in a Global Energy Market', Washington D.C 2012; Löschel, Andreas/Moslener, Ulf/Rübbelke, Dirk T.G., Indicators of Energy Security in Industrialised Countries, in: Energy Policy, April 2010, S. 1665-1671.

264 See Daniel Wetzel, 'Teuer, ineffizient, fortschrittsfeindlich?', Welt am Sonntag, Nr. 48, 30 November 2014, p. 34; World Energy Council, '2014 Energy Trilemma Index. Benchmarking the Sustainability of National Energy Systems', London 2014; Buttermann, Hans Georg/Freund, Florian, 'Sicherheit unserer Energieversorgung – Indikatoren zur Messung von Verletzbarkeit und Risiken. Untersuchung im Auftrag des Weltenergierat – Deutschland, Endbericht, EEFA – Energy Environment Forecast Analysis GmbH & Co. KG, Münster-Berlin, April 2010; Frondel, Manuel/Ritter, Nolan/Schmidt, Christoph M., 'Deutschlands Energieversorgungsrisiko – gestern, heute und morgen', in: Zeitschrift für Energiewirtschaft 1/2009, S. 42-48; Bundesnetzagentur, Auswirkungen des Kernkraftwerk-Moratoriums auf die Übertragungsnetze und die Versorgungssicherheit. Bericht an das Bundesministerium für Wirtschaft und Technologie, Berlin, April 2011, S. VI und F.Umbach, 'Global Energy Security and the Implications for the EU', Energy Policy, Vol. 38, Issue 3, March, 1229-1240.

265 See also F.Umbach, 'Gasversorgungssicherheit in Deutschland und in der EU. Bedeutung, Herausforderungen und strategische Perspektiven", in: Politische Studien (ed. by the Hanns-Seidel-Foundation), September-Oktober 2014, pp. 28-40, and Frondel, Manuel/Schmidt, Christoph M. (2009a): 'Am Tropf Russlands? Ein Konzept zur empirischen Messung von Energieversorgungssicherheit', in: Perspektiven der Wirtschaftspolitik, 1/2009, S. 79-91.

266 See also F. Umbach, 'Germany Is Paying the Price of Its Energy Switch to Renewables', Geopolitical Information Service (GIS – www.geopolitical-info.com), 10 March 2014.

of around 90 per cent, which can given Chinese leaders important geopolitical tools.[267]

Despite the broad acknowledgment of the shortcomings of the *Energiewende*, reform is extremely difficult. At the political level, there are 17 different perceptions of the *Energiewende* – one of the federal government and those of the 16 German states. Thus, Germany's northern federal states want to expand offshore wind power farms in order to sell most of their generated electricity to southern Germany, but the South would rather stick to its traditional model of energy self-sufficiency and even to launch joint gas projects with Russia. As for the political parties, both sides of the political spectrum also face diverging interests at the federal and the state levels.[268]

Rising Energy Prices and the Need to Reform the Renewable Energy Sources Act

While it was clear from the outset that the *Energiewende* would be expensive to implement, its total costs have grown faster and greater than anticipated. Since 2002, the ballooning costs of subsidizing feed-in tariffs under Germany's EEG renewable law have increased to more than €120 billion by the end of 2013. By 2022, German consumers will have to pay more than 100 billion for renewables – i.e. solar panels – that have already been installed.[269]

Germany's electricity costs have also increased faster than elsewhere in Europe and are now twice the level of those in the United States. Germany's electricity is 40 per cent more costly for private consumers and 20 per cent more expensive for industrial users than the EU average. The average German household paid €287 per MWh in 2013, with fees, taxes and other levies accounting for more than 50 per cent of this price.

In addition, Germany has to cope with the third-highest electricity prices in the EU due to its EEG feed-in tariff system. The 15-years old subsidy system has been copied around the world and helped Germany turn into Europe's biggest green energy market. But, the total annual costs of Germany's EEG rose from €14.1 billion in 2012 to a considerable €24 billion in 2014. By 2020, costs may reach €35 to €40 billion absent a major reform. The EEG allocation charge was forecast at the end of 2012 to increase to almost 6 cents per kWh (Ct/kWh) in 2013, perhaps 8 cents per kWh in 2014, whereas the government had promised in 2011 a limit of 3.5 cents per kWh in the future. Those costs for funding the shift to renewable power of more than €20 billion annually will last through 2030 because subsidies have been fixed for 20 years.

Germany's subsidies for installed solar panels are, in particular, not cost-efficient. In fact, its currently installed solar panels will ultimately cost taxpayers US$130 billion over the next 20 years through the heavily subsidized feed-in-tariff contracts, compared to US$15 billion for building a state-of-the-art nuclear reactor that will generate more than 50 per cent of the electricity of Germany's entire solar fleet over a similar 20-year period. Even by including external costs for building a nuclear power station, these solar panels have not been cost-competitive thus far. Worse still, despite these heavy subsidies, German solar companies have experienced a wave of insolvencies and a market developing away from Germany since 2012, with a loss of around 60,000 jobs.[270]

Economy and Energy Minister Sigmar Gabriel outlined in his spring 2014 plans that the EEG subsidies might be cut by up to a third by 2015. Nevertheless, he also sought to strike a balance by reducing the support of subsidies for the energy-intensive industry. In addition, he tried to trim benefits for companies that generate their own electricity, which now would have to pay up to 90 per cent of the renewable subsidy. Germany would also be the first country to charge owners of renewable energy plants for their own use of electricity. Yet, Gabriel has opposed a capacity mechanism system that would include all Germany's loss-making conventional power plants, calling it too expensive. The coalition also agreed to reduce targets for offshore wind power from 10 GW to 6.5 GW by 2020 and from 25 GW to 15 GW by 2030.[271] In the summer of 2014, however, it became already clear that Gabriel's original reform proposals had largely failed due to a lack of support from the federal states and opposition from the renewables industry.[272]

Exemptions for Energy-Intensive Industries

Some of the most controversial measures to curb costs are the exemptions that have shielded companies from the cost of transitioning to renewable power. These cumulative costs amounted to €2.3 billion in 2012. In 2013, they rose to €4 billion after the applications for exemptions from grid charges more than doubled from 1,600 in 2011 to 3,400 in 2012. In 2014, another rise to 5.1 billion was forecast. But despite financial support for its energy-intensive industry, German

267 See F. Umbach, 'Islands Dispute Puts Spotlight on China's Rare Earths Strategy", Geopolitical Information Service (GIS – www.geopolitical-info.com), 28 December 2012, 4 pp.; idem, 'How China's Strict Rare Earths Policies Sparked a Backlash', ibid., 19 December 2012, 3 pp., and idem, 'China Moves Closer to a Monopoly in Rare Earths', ibid., 14 December 2012, 3 pp.

268 See F. Umbach, 'Germany Is Paying the Price of Its Energy Switch to Renewables'.

269 See also Andreas Mihm, 'Regierungsberater wollen das EEG abschaffen', Frankfurter Allgemeine Zeitung (FAZ), 26 February 2014; idem, 'Das EEG-Monster', ibid., 28 June 2014, p. 19; 'Teuer, ineffizient und fortschrittsfeindlich?', Welt am Sonntag, No. 48, 30 November 2014, p. 34; 'Germany Feels the Burden of its Shift to Renewable Energy', Stratfor, 4.2.2015;

270 See also Jeevan Vasagar, 'Clean Energy Proves a Costly Exercise for Germany', FT, 22 October 2014.

271 See Bundesministerium für Wirtschaft und Energie, 'Eckpunkte für die Reform des EEG', Berlin, 21 January 2014.

272 See Martin Greive, 'Das Neue EEG-Gesetz ist schon jetzt eine Baustelle', Die Welt, 25 July 2014; Daniel Wetzel, 'Strompreis-Anstieg legt bestenfalls Atempause ein', ibid., 16 October 2014; idem., Ökostromnovelle ist erst der Anfang der Grausamkeiten', ibid., 26 June 2014, p. 9 and Andreas Mihm, 'Das EEG-Monster', FAZ, 28 June 2014, p. 19.

business leaders have warned both the German government and the EU that the unilateral 40 per cent GHGE target may push production out of Germany and Europe and towards other countries and regions with lower energy costs.[273]

Meanwhile, an ever-smaller number of consumers carry the burden of the total costs of the *Energiewende*. On one end of the spectrum, a growing number of poor people need to be subsidized because they can no longer afford their soaring electricity bills. In 2012, between 10 and 15 per cent of Germans were already struggling to pay their monthly electricity bills. Reportedly, 600,000 households had their electricity turned off that year. The rising costs of electricity for an average four-person household paying more than €1,000 annually has become a very sensitive political issue for the German government.[274] On the other end of the spectrum, the number of companies in the energy-intensive sector receiving subsidies has increased, as they are no longer competitive enough in global markets.[275] As a result, it is primarily the German middle class that is financing the bulk of the *Energiewende*, which in turn poses challenges to the policy's future political and financial support.

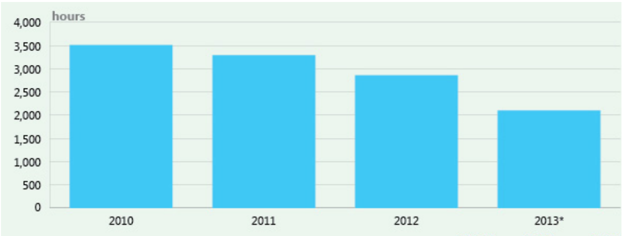
A 'Capacity Market' or 'Strategic Reserve' of Fossil-Fuel Power Stations for Base-Load Stability?

Prior to the immediate nuclear shutdown of 8 nuclear reactors and the removal of 8 GW of nuclear capacity from the market in the aftermath of the Fukushima catastrophe in March 2011, Germany was Europe's largest net exporter of electricity. Within three weeks, it became a net importer of electricity – often from France and the Czech Republic –, which was basically produced in nuclear power stations. In 2012, Germany became a net exporter of electricity again, but now on volatile renewable energy production with rising unplanned loop flows across the German borders, often destabilizing the electricity grids in neighbouring countries. In electricity, 17 out of the 27 national energy markets of the EU have already been coupled by infrastructure networks.[276]

Berlin has still to phase out nine nuclear reactors by 2022. The ambitious transformation of the German energy system seeks to replace 20 GW in nuclear capacity by building at least 10 GW in wind and solar plants, as well as another 10 GW in cleaner and highly efficient modern gas-fired power plants. By 2022, Germany's base-load could face a shortage of around 15 GW, almost equivalent to the output of 15 large gas-fired power plants. But construction of new gas-fired plants is no longer profitable for the private industry, and the share of gas-fired electricity generation has constantly fallen.

In 2012, the German Association of Energy and Water Industries (BDEW), representing some 1,800 utilities, called for some 84 large power projects, each of which will add at least 20 megawatt of generating capacity. It recommended changing the market design for conventional power plants to a more decentralized capacity market, where conventional power plant capacity would be traded in form of 'guarantees of security of supply' and a 'strategic power plant reserve' for a short-term transitional phase.[277] Wind and solar power do provide more than 60 per cent of Germany's electricity production – but only for few short moments when the weather is windy and sunny enough, as a few hours later this proportion can drop to only 20 to 40 per cent. In early December 2013, Germany's solar and wind power production of more than 23,000 wind turbines came to an almost complete standstill. For a whole week, coal, nuclear and gas power plants had to generate an estimated 95 per cent of Germany's electricity supply.[278]

Figure 67: German Gas-Fired Plants Operating Hours



Source: www.interfaxenergy.com.

The grid has to maintain voltage balances by matching supply and demand within about five per cent of each other or risk electricity blackouts. Nevertheless, Germany has far too little storage capacity to serve as a buffer against the fluctuating supply of wind and solar energy. As a result, even larger electricity blackouts cannot be excluded.

Factbox: Original BDEW-Plan of Building 84 large power projects, including:

23 offshore wind farms;
29 gas-fired plants;
17-coal-fired plants;
10 pumped-storage power plants
With a combined capacity of 42 GW;
With a total investment costs of more than €60 bn.

Source: F.Umbach based on BDEW information in 2012.

273 See also 'German Industry Issues Stark Warning ahead of EU Climate Summit', EurActiv, 22 October 2014.

274 See also Florian Diekmann, 'Energiearmut in Deutschland nimmt drastisch zu', Spiegel-Online, 24 February 2014 and P.Gosselin, '17% of all German Households Now In Energy Poverty! Spiegel Writes of an ‚Energy Cost Explosion'', Notrickszone, 24 February 2014.

275 See also 'Germany Feels the Burden of its Shift to Renewable Energy', Stratfor, 4 February 2015.

276 See also F. Umbach, 'Germany's Energy Policy Cost Growth, Jobs and Living Standards, Geopolitical Information Service (GIS – www.geopolitical-info.com), 17 February 2014.

277 See also idem, 'Germany Is Paying the Price of Its Energy Switch to Renewables".

278 See also Daniel Wetzel, 'Stromnetz am Limit', Die Welt, 13 December 2014, p. 9 and idem, 'Sturmfront bringt Stromnetz an die Grenzen, ebda., 31 March 2015, p. 9.

Germany's cross-subsidies of high feed-in tariffs for wind and in particular solar power installations have boosted these RES so much that they are overwhelming the grid. Some utilities have threatened to shut down even the most modern and efficient gas-fired power plants producing 23,000 megawatts. At the same time, 23 new modern and much more efficient coal-fired plants have been originally planned across Germany with a capacity of 24 GW. However, RES advocates have tried to stop the building of these new coal-powered plants, as these plants may block the further expansion of renewables.

The average load factor of combined-cycle gas turbine plants in Germany is around 3,000 hours. Yet, Germany's preference for renewables and its EEG is ensuring that preference is given to green energy to feed in ahead of any electricity generated by fossil and nuclear fuels. As a consequence, fossil-fuel and nuclear plants frequently have to shut down to avoid overloading the grid, which reduces their revenues while increasing costs. Utilities are forced to shut down those fossil plants, as they are unable to recover operating costs, even though these plants are needed to ensure the stability of energy generation, the grid, and base-load capacity. In the autumn of 2013 alone, utilities announced plans to shut down 26 power plants across Germany, with a capacity of about 7,000 MW – 2,000 MW in the South, which is already beset by problems linked the nuclear phase-out.[279]

At the same time, urgent investment is needed, but neither German utilities nor external suppliers can plan and invest in the absence of a clear framework. The IEA has also criticized Germany's energy transition policy and called on the country to increase its support for flexibility-granting gas-fired power plants as part of a predictable and stable regulatory framework. Germany also needs to reduce these costs in order to maintain a balance between sustainability, affordability and competitiveness. The German government still argues that it will not provide any capacity payments for fossil fuel power plants, fearing costs and another expensive subsidy.[280]

Since 2012, German utilities have also turned to cheaper coal and lignite instead of the more environmentally friendly natural gas due coal's relative price competitiveness. This preference for coal caused Germany's CO_2 emissions to rise in contrast to its official climate mitigation policies. In the first half of 2013, Germany's hard coal imports from the United States and other countries increased 3.4 MT up to 25.7 MT. Hard and brown (lignite) coal still contributes around 44 per cent of Germany's electricity generation mix, but at the same time, Germany has given up its plans to subsidize coal-fired power plants with carbon capture and storage facilities in 2012. In 2013, coal-related emissions soared to their highest level in more than 20 years.[281]

Building a New Grid Infrastructure

One of the major problems of the state-subsidised expansion of RES has been the exclusive focus on increasing their production, to the detriment of the connecting grid system. This past disregard has led to an overproduction of RES-based electricity generation that cannot be transported to the consumers due to the lack of a modern grid infrastructure. Thus, German taxpayers are paying for heavy subsidized electricity generation that cannot be supplied to and used by consumers.

Wind farms, now present particularly in offshore waters of the Baltic and North Seas with an originally planned total output of 10,000 MW, are particularly problematic. Most of these generated electricity needs to southern Germany, where most of the nuclear reactors are based and are being phased out in the coming years. The previous German government unveiled plans to build 2,800 km of high voltage power lines across the country, but primarily as an energy highway from north to south. The costs of this super grid have been estimated at around €10 to €12 billion. At the same time, it is necessary to carry out a modernization and upgrading of Germany's existing grid system with another 4,000 km electricity network in order to address capacity and technical shortfalls and to boost flexibility. This effort will cost at least another €32 billion, according to the country's four grid operators. But in 2013, only 300 km had been built, and 15 out of 24 grid expansion projects had been up to seven years behind schedule in mid-2013.[282] These plans, however, face challenges from other German states – particularly from Bavaria, which has even threatened to block the new 800 km long North-South super highway of power lines. Such a block would de facto imperil the future electricity supply security of both Bavaria and Germany and, ultimately, the viability of the entire *Energiewende*.[283]

279 Ultimately, the German government has approve the closure of all or some of these plants. Those rejected have to be compensated by the German state in order to maintain the base-load supply for the expanding volatile renewable energy production. See also '26 Gas und Kohlekraftwerke vor dem Aus', Die Welt, 9 October 2013, p. 14 and idem Wetzel, 'Irrsinn von Irsching', ibid., 31 March 2015, p. 9.

280 See EurActiv, 'Gabriel Rejects 'Senseless' Calls for Surplus Energy Capacity', 21 January 2015.

281 See also 'Global Comparison Reveals Germany's 'Energiewende Dilemma', EurActiv, 9 December 2014; Stefan Wagstyl, 'German Coal Use at Highest Level since 1990', FT; 7 January 2014; Annemarie Botzki, 'German Coal Consumption Continues to Rise', Interfax-NGD, 9 January 2014; Green Revolution? Germany's New Coal Boom Reaches Record Level', The Global Warming Policy Foundation (GWPF), London, 7 January 2014, Mathew Carr, 'Rising German Coal Use Imperils European Emissions Deal', Bloomberg.com, 20 June 2014 and Bundesverband Braunkohle (DEBRIV), 'Braunkohle 2013'. Sonderdruck BWL 4/2014.

282 See F. Umbach, 'Germany's Energy Policy Cost Growth, Jobs and Living Standards'.

283 See also Daniel Wetzel, 'Bayerischer Kurzschluss', Die Welt, 5 November 2014, p. 10; 'Ein neuer Plan für die Stromtrassen', in: ibid. and idem., 'Im Süden drohen 2018 Stromengpässe', ibid., 2 October 2014, p. 9.

The Failing European Dimensions of the German *Energiewende* and its Impacts[284]

In the end, however, the most serious problem with the *Energiewende* was the underlying assumption that policy of such scale could be implemented without taking European and global energy developments into account.[285] Equally problematic was the assumption that fossil fuels would become ever more scarce and expensive.[286] Against this background, it is hardly surprising that the introduction of CCS has failed in light of local resident and political opposition. As a consequence, plans to construct underground storage sites even for scientific tests have been abandoned.[287]

Meanwhile, the German government itself has been more vocal about the economic challenges stemming from the *Energiewende*. Minister Gabriel, for instance, has outlined a much-needed deeper reform of the EEG. In the meantime, evidence of energy supply and pricing problems keep mounting. At the beginning of 2014, Germany's domestic energy prices rose to 48 per cent above the European average. Moreover, regular assessments of the *Energiewende* reveal that the policy is failing to meets its goals and is only worsening industry energy prices. German industry prices are now around 19 per cent higher than the EU average, translating into an increasingly competitive disadvantage for the German industry.[288]

At the same time, Gabriel or the federal government cannot solve many Energiewende problems alone. In fact, only the EU and/or global energy markets could address pressing issues like the needed ETS reform and the necessity to make gas more competitive vis-à-vis coal. While energy within the EU remains a national issue, member states are interconnected and dependent on each other by their declared common EU energy policy and their interlinked energy infrastructures – i.e. gas and electricity. In electricity, for example, infrastructure networks connect 17 of the 28 national energy markets. Thus, any energy policy shifts of in particular the larger member states will have direct and indirect effects upon and implications for the common EU energy policy and in particular the energy security of their neighbouring countries. In this context, strengthening cross-border energy infrastructures and adopting common regulations are all the more necessary.

Against this background, it is hardly surprising that the *Energiewende* has also affected Germany's neighbours. As a result of its expanding volatile wind and solar power capacities, Berlin has been forced to export up to 80 per cent of its wind power electricity to avoid an electricity blackout. Nonetheless, also relatively low-cost coal-based electricity from Germany is being exported and has ousted gas-based power generation in the Netherlands. In fact, utilities in Poland, the Czech Republic, and the Netherlands have been forced to disconnect some coal- and gas-fired plants because of unplanned excess power flowing from Germany. In 2012, Germany imported 44.2 TWh of electricity and exported 67.3 TWh, creating a net export balance of +23.1 TWh. These relatively unexpected exports of surplus volatile electricity production create blackout risks for Germany's neighbours, as electricity, unlike fossil fuels, must be consumed or risk causing a grid collapse.

Between 2005 and 2014, Germany almost doubled its wind power generation to 52.4 TWh. Absent the previously mentioned North-South grid system, the present electricity transport needs to take a detour through Poland and the Czech republic before reaching Germany's South. Neighbouring countries are currently beginning to install expensive phase-shifters in their trans-border areas with Germany in order to regulate flows and protect their transmission networks.[289] But in the next years, Germany's neighbouring countries will also negotiate with Berlin on other short-term solutions and will push for a creation of smaller power trading areas with realistic capacity allocation, because those transformers will only become operable by 2017.[290]

Problems with the implementation of the *Energiewende* have also taken a toll on the policy's image. In fact, some three-quarters of international energy experts do not believe that the *Energiewende* could serve as a blueprint for their own countries. Even the number of those in favour of at least some parts of the *Energiewende* has declined relative to previous years, whereas the share of countries that reject the policy altogether has increased.[291]

284 See also F.Umbach, idem, 'Die deutsche Energie-wende in internationaler Perspektive', in: Johannes Varwick (Hrsg.), 'Streitthema Energiewende. Nachhaltigkeit, Energieeffizienz und ökonomische Aspekte', Schwalbach/Ts. 2013, S. 119-152 und F.Umbach., 'Deutschlands Energiewende. Gesellschaftliche Hypersensibilität und der Verlust strategischer Versorgungs-sicherheit', in: Christopher Daase, Stefan Engert und Julian Junk (Hrsg.), 'Verunsicherte Gesellschaft – überforderter Staat: Zum Wandel der Sicherheitskultur', Frankfurt/M.-New York 2013, S. 235-257.

285 See Bundesministerium für Wirtschaft und Technologie, 'Der Weg zur Energie der Zukunft – sicher, bezahlbar und umweltfreundlich. Eckpunkte für ein energiepolitisches Konzept', Berlin, 6 June 2011, and Bundesministerium für Wirtschaft und Technologie, 'Energiekonzept für eine schonende, zuverlässige und bezahlbare Energieversorgung', Berlin, 28 September 2010.

286 See also F.Umbach, 'The Geopolitical Impact of Falling Oil Prices", Geopolitical Information Service (GIS – www.geopolitical-info.com), 19 November 2014,.

287 See 'Carbon Capture Technology out in Germany', Deutsche Welle, 7 August 2013.

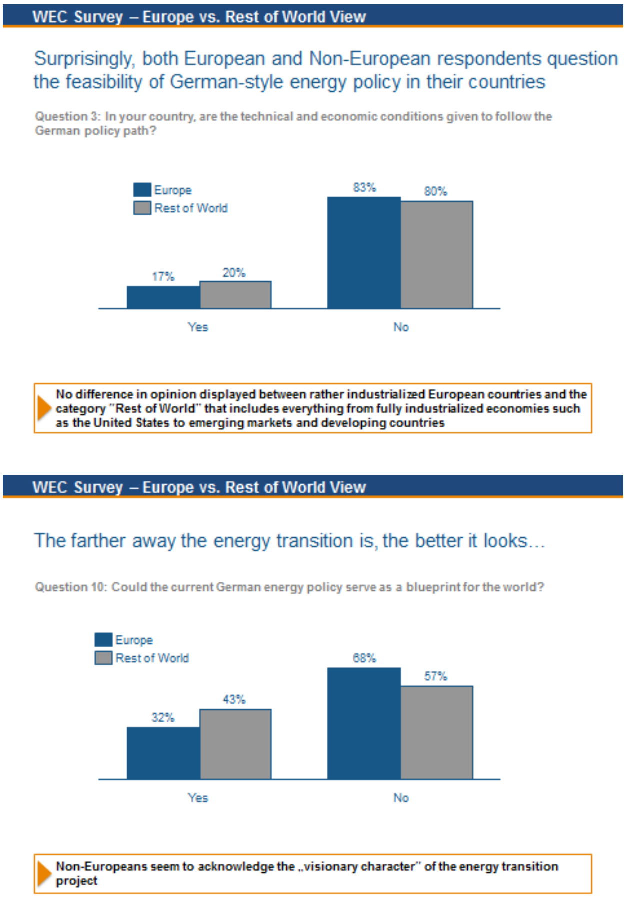
288 See also Daniel Wetzel, 'Ökostrom-Kosten belasten Industrie', Die Welt, 4 February 2014, p. 9.

289 See 'Coal to Dominate Polish Power Supply to End of Decade Despite EU Goals', ICIS, 13 April 2015.

290 See also F. Umbach, 'Germany's Energy Policy Cost Growth, Jobs and Living Standards'.

291 See also World Energy Council, 'German Energy Policy – a Blueprint for the World?', Berlin, January 2015.

Figure 68: Is the German Energiewende a Model for Countries Inside and Outside the EU?



Source: World Energy Council-Germany, January 2015.

A Third-Phase-Out in Germany's Energy Mix: Does Coal Have No Future in Germany's Energy Policies?

The *Energiewende* downgraded the role of coal to a swing and reserve supplier to balance the ever-increasing power generation from intermittent RES. Coal, however, retains a crucial value for the country's power system. Indeed, Germany's nuclear phase-out by 2022 has led not only to a rapidly expansion of RES, but also to higher coal imports and consumption. In 2013, Germany's coal use rose by nearly 2 per cent to about 1.6 million barrels of oil equivalents per day – the highest level since 2007. In addition, German utilities had originally planned to bring some 7.3 GW of new coal-fired generation online by the end of 2015, albeit it is no longer realistic until the end of the year.

Overall, Germany will remain dependent on fossil fuels for decades to come.[292] Berlin depends on energy imports – 98, 87, and another 87 per cent of oil, gas, and hard coal demand, respectively. In 2013 and 2014, Germany's hard coal imports increased up to a record 51 and 50 million tonnes, respectively.[293] In 2012, Berlin became Europe's largest hard coal importer, as well as one of the world's largest coke importer.[294] In addition, Germany has considerable hard coal reserves.[295] In 2012, Germany had an 8,230 MW power capacity on the basis of hard coal with an efficiency rate of up to 46 per cent, and another 2,760 MW power capacity on the basis of lignite with an efficiency rate of up to 43 per cent under construction.[296] Furthermore, it has the world's most flexible lignite-power plants for balancing the increasing share of electricity from RES under the *Energiewende*.[297]

Lignite, in particular, remains a key energy-producing input in lignite-rich Germany. Despite on-going measures for phasing out lignite[298] as part of the 40 per cent reduction target and Berlin's efforts in international climate protection discussions,[299] in 2014, hard coal and lignite still provided 44 per cent of Germany's electricity generation. Lignite is Europe's least expensive fuel for electricity generation and industrial heat, and its overall impact on global warming is arguably limited despite its higher CO_2 emissions.[300] Lignite makes around 12 per cent of Germany's primary energy consumption, but is responsible for over 22 per cent of its CO_2 emissions.

Given German dependence on lignite, a phase-out would have significant energy supply consequences. The country's base-load security, for example, could only be guaranteed by gas-fired power plants, which would significantly raise Germany's already high electricity prices. Southern Germany would be especially affected by a phase-out, as

292 See also EurActiv, 'Germany Far from Giving Up Fossil Fuels Despite Energiewende', 11 December 2014 and Annemarie Botzki, 'Coal and Renewables Dominate German Power', Interfax-NGD, 16 February 2015.

293 See 'Shoaib-ur-Rehman Siddiqui, 'Germany Set for 50 mn T Hard Coal Imports in 2014', Reuters, 5 December 2014.

294 See also Mathew Carr, 'Rising German Coal Use Imperils European Emissions Deal', Bloomberg, 20 June 2014; Annemarie Botzki, 'German Coal Consumption Continues to Rise', Interfaxenergy.com-NGD, 9 January 2014, p. E3; Ezra Levant, 'Germany Out in the Coal', Toronto Sun, 6 January 2014. Stefan Wagstyl, 'German Coal Use at Highest Level Since 1990', FT, 7 January 2014; Stefan Nicola/Tino Andresen, 'Merkel's Green Shift Forces Germany to Burn more Coal', Bloomberg, 24 September 2012.

295 2,500 MT are technically accessible out of 82,961 MT of known resources, but only 37 MT will be extracted before the hard coal production ends by 2018.

296 See IEA, 'The Global Value of Coal' (Paris: IEA/OECD, 2012), p. 24.

297 See Euracoal, 'Coal Industry Across Europe', p. 2.

298 These include a climate package of €80 billion approve in November 2014; see EurActive, 'German Government Approves €80 billion Climate package', 4 December 2014. 'Germany's Climate Targets Unattainable with Dirty Coal Power, Analysts Say', 21 November 2014.

299 See EurActiv, 'Global Comparison Reveals Germany's 'Energiewende Dilemma'', 9 December 214.

300 Lignite plants are price-competitive vis-à-vis their hard coal and gas counterparts – by €20 and €60 MWh, respectively. At the same time, it emits up to 24 per cent more CO_2 than hard coal per MWh, but is devoid of methane. Globally, only a billion tonnes of lignite is burned each year, and it only contributes about three per cent to current global CO_2 emissions. See Jeffrey Michael, 'Wishing Away Lignite – EU Climate Policy Ignores Elephant in the Room', Energy Post, 17 November 2014.

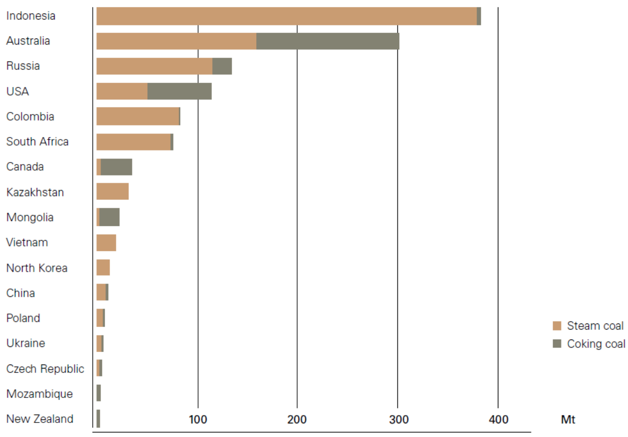
it is facing a supply deficit of 105 Twh – one sixth of total national power generation.

The controversies about the future of lignite notwithstanding, the resource stills enjoy broad political support, especially in lignite-rich states.[301] The German government itself is aware of lignite's economic importance and has directly intervened in order to keep lignite plants open. In fact, the announced reduction of Swedish mining expansion in Germany in 2014 led to the direct intervention of Minister Gabriel, who, in a letter to the Swedish government, warned about the "serious consequences" for electricity supplies and regional employment, as Germany "cannot simultaneously quit nuclear energy and coal-based power generation." Gabriel's warnings have also highlighted Germany's already rising risks of large-scale electricity blackouts.[302]

Against this context, it is hardly surprising that the Economic Ministry has faced opposition to its plans to curb the use of lignite-powered plants through financial penalties in order to cut 22 MT of CO_2 emissions by 2020.[303] Resistance comes not just from the country's coal industry, but also from the affected federal states and trade unions, who fear lasting damage to the integrated lignite mining industry and losing up to 100,000 jobs.[304] Furthermore, the Ministry has faced criticism for arguing that these measures will merely decrease production and not lead to closures, as its calculations appears to be based on unrealistically high electricity prices.[305] Likewise, energy experts have warned that these measures would merely lead to imports of dirtier and cheaper coal-based electricity and nuclear power from neighbouring countries – i.e. Czech Republic, Poland and France.[306]

Prior experience provides evidence for backing up this last point. Indeed, Berlin's 2006 announcement of the phase-out of its domestic hard coal mining and production substantiates the belief that such policies lead to more carbon leakage and free riding. Suffice to consider that the resulting coal and gas exports from Russia to Germany pushed the Kremlin to decrease future domestic gas consumption and to expand nuclear power and coal production instead.[307] Thus, Germany's decision to phase out hard coal mining and production by 2018 has directly led to higher CO_2 emissions from dirtier coal in Russia.

Figure 69: Top Coal Exporting Countries in 2012



Sources: IEA, Euracoal 2013.

Maintaining indigenous coal mining and production not only keeps domestic jobs and strengthens energy supply security, but coal import dependence could also be risky given the relative volatility of international coal markets. At present, coal is available in international markets at relatively stable prices, and is a much cheaper fossil fuel than gas and oil. The growing dependence on coal imports overlooks some important strategic trends, however:

1. Most coal production is being used in the producer countries themselves, and international trade represented only 23 per cent of the entire global coal demand.
2. China and India, the world's largest coal consumers, will meet their coal demand growth largely with their own rapid expansion of domestic coal production, but also use coal as their most important domestic energy source for stabilizing and enhancing their overall energy

301 This is particularly the case in Brandenburg, which had approved plans to mine a further 200 million tonnes of lignite starting in 2026, and North Rhine-Westphalia. See Madeline Chambers, 'German State Allows Vattenfall to Expand Brown-Coal Mining', Reuters, 3 June 2014.

302 See Pilita Clark/David Crouch/Jeevan Vasagar, 'German Plea to Sweden over Threat to Coal Mines', FT, 24 November 2014.

303 See 'Germany May Shut Down Eight More Coal Power Plants', EurActiv, 24 November 2014; 'Germany Denies to Close Old Coal Plants in Sprint to 2020 Targets', ibid., 25 November 2014, and Annemarie Botzki, 'Germany to Cut Emissions from Coal', Interfaxenergy.com-NGD, 21 April 2015, p. 4.

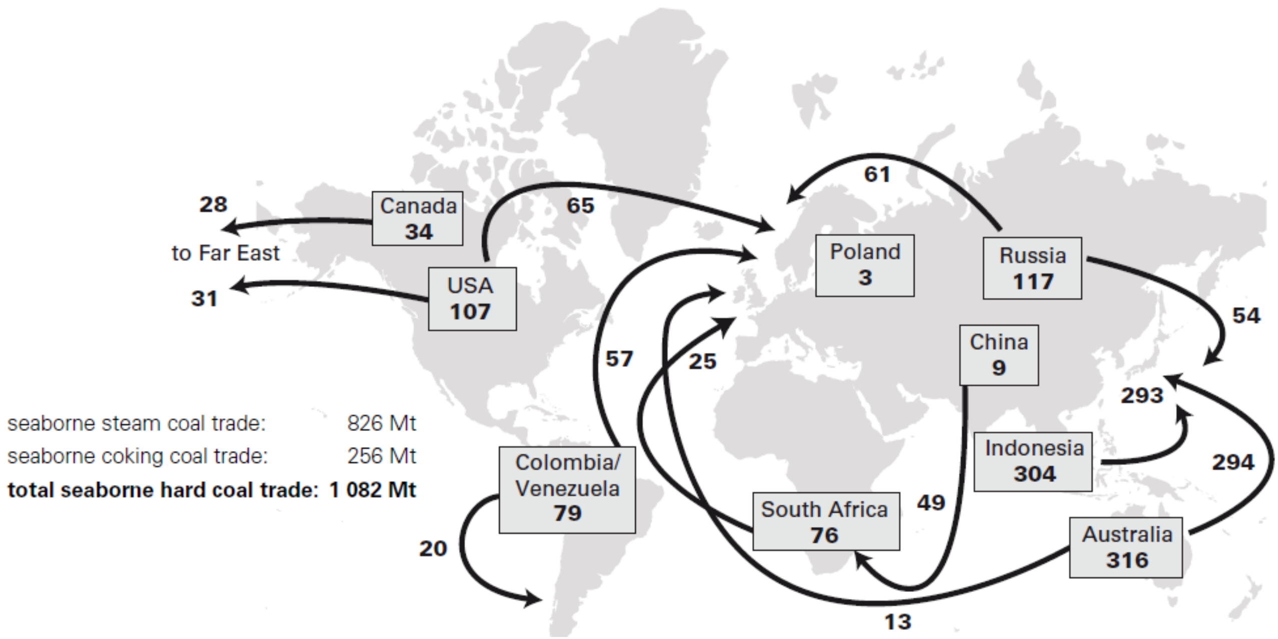
304 See Melanie Amann et. al., 'Die Kohle-Koalition', Der Spiegel 14/2015, p. 38-39; 'Länder wehren sich gegen Gabriels 'Strafabgabe für Kraftwerke', EurActiv, 30 March 2015; Alexander Fröhlich/Kevin P. Hoffmann, 'Die Lausitz fürchtet um ihre Kohle', Der Tagesspiegel, 25 March 2015; Arthur Neslen, 'German Backlash Grows Against Coal Power Clampdown', The Guardian, 14 April 2015.

305 See Daniel Wetzel, 'Treibt Gabriel Kohle-Branche mit falschen Zahlen ins Aus?', Die Welt, 16 April 2015, p. 11.

306 See 'Länder wehren sich gegen Gabriels 'Strafabgabe für Kraftwerke' and Daniel.

307 See Government of the Russian Federation, 'Energy Strategy of Russia fort he Period up to 2030', Moscow 2009. See also F.Umbach, 'Die neuen Herren der Welt. Öl gleicht Macht: Energie-Verbraucherländer müssen umdenken', Internationale Politik 9/2006, pp.6-14 and idem/A. Riley, 'Out of Gas. Looming Russian Gas Deficits Demand the Readjustment of European Energy Policy', Internationale Politik-Global Edition 2007, pp. 83-90.

Figure 70: Seaborne Trade Flows on the International Hard Coal Market in 2012



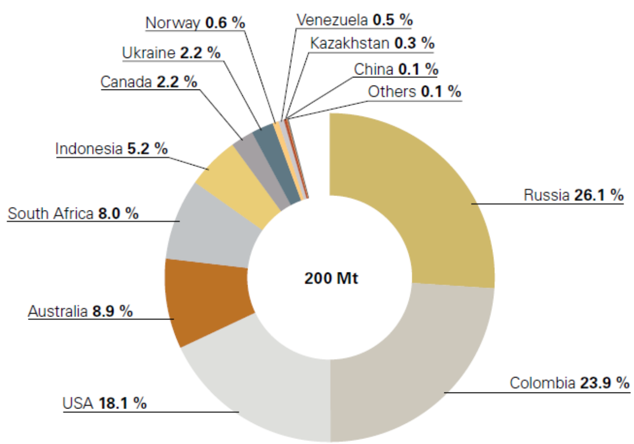
Source: Euracoal 2013.

security.[308] China, despite having the world's third-largest coal reserves, will also remain dependent on rising coal imports; meanwhile, India's coal imports by 2035 will be four times those of 2008 levels, and it will even surpass China in coal imports and coal consumption after 2030.

3. Europe's present coal imports accounted for around 29 per cent of all international coal trade in 2008; by decreasing this share to around 25 and 20 per cent in 2020, and 2035, respectively,[309] Europe will lose significant market share and competition power vis-à-vis its Asia-Pacific import rivals and Asian coal exporters.

4. Current high prices in Germany and other European countries' domestic hard coal production reflect the present situation of international coal markets. Thus, Germany and Europe are currently dependent on stable imports from countries, but rising coal demand from Asia will push up international coal prices.

Figure 71: Coal Imports into the EU by Source Country, 2011



Sources: DG Energy/European Commission, Euracoal 2013.

5. Remaining global coal reserves will last just 113 years of global production – down from 210 years back in 2000, and will continue to decline in the years and decades to come.[310]

6. The largest share of those coal reserves are concentrated in the United States, Russia, China, Australia, and India – 27.6, 18.2, 13.3, 8,9, and 7 per cent of global coal reserves, respectively. At 4.7 per cent, Germany has the sixth-largest reserves – Poland has only 0.7 per cent. Hard coal resources are even more concentrated, with about 83 per cent – and around 76 per cent of all reserves – located just in the United States, China and Russia.

308 See also F.Umbach, 'Globale Ressource Kohle und internationale Rohstoff- und Energiesicherheit. Die strategische Bedeutung der Braunkohle für die deutsche Versorgungssicherheit', in: Innovative Braunkohlen Integration in Mitteldeutschland (IBI, Ed.), 'Neue Strategien zur stofflichen Verwertung'. Fachsymposium. Tagungsband zur Abschlusstagung des Innovationsforums vom 26.-27.2.2009 in Freiberg mit Unterstützung des Bundesministeriums für Bildung und Forschung (BMBF), Halle 2009, pp. 49-58 and idem. 'Die Welt kommt an der Kohle nicht vorbei', in: Jürgen Petermann (Ed.), Sichere Energie im 21. Jahrhundert, 2. vollständig überarbeitete und aktualisierte Ausgabe, Hamburg 2008, pp. 151-155.

309 See also EIA, 'International Energy Outlook 2010', p. 67.

310 See BP, 'Statistical Review of World Energy 2014'.

7. Of the five largest coal reserves holders, neither the United States, China or India is among the top global exporters of coal – albeit the U.S. role is changing.[311]

8. While China, the United States and India are also leading coal consumers, coal is perceived as a kind of strategic fossil fuel reserve of fossil fuels in all three major global powers. Furthermore, it is expected in all three major powers that the increasing use of coal for electricity generation at existing, and especially in new, cleaner and more efficient power plants, will be combined with the expansion of CTL plants, at least in the medium term.[312] A global expansion of CTL may increase, rather than decrease, global coal consumption.

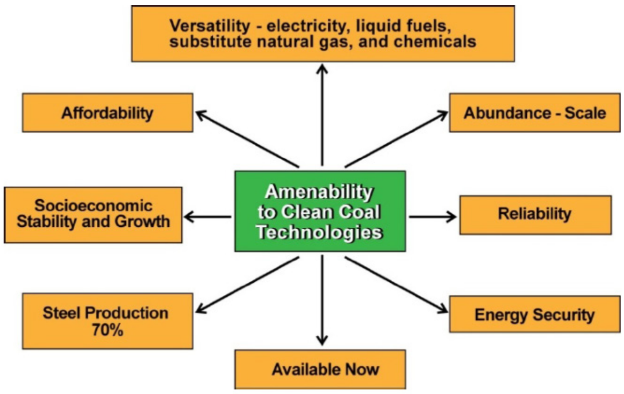
9. In the medium and long terms, Europe and Germany, currently dependent on coal imports from Australia, Indonesia and South Africa, will likely face supply competition given growing Asian demand, the rising global costs of coal production, and more expensive Asia-Pacific-to-Europe transportation routes.[313]

10. Moreover, the future supply coal and prices will also be dependent on future market concentration and cartelisation tendencies of international coal markets, For example, in 2009, the 25 leading coal companies accounted for about 35 per cent of global production and 50 per cent of global trade. Even more striking are the concentration processes used by the largest hard coal producing companies.[314] These market shares and concentration processes will further increase with China's present strategy of merging its own coal producing companies. In 2007, only 13 really large coal companies existed in China, yet four of them were already amongst the top 12 global coal producers.[315]

Do German and European Bans on Export Credit Finance for Coal Power Technologies Help Global Climate Protection?

The European public and political discussions need to recognize the fact that coal will remain one of the most important energy sources worldwide for the foreseeable future. As previously mentioned, it has a variety of industrial uses and is widely available, cost-competitive, and geographically widespread. Currently, 75 countries possess proven coal reserves of lignite, and in more than 50 countries coal can be mined. Hard coal, together with lignite, accounts for not less than about 55 per cent of all fossil energy resources. Moreover, it has a much longer availability than conventional oil and gas resources. All in all, European policy-making must strike an adequate and sustainable balance – the so-called energy triangle – when adopting climate protection measures.

Figure 72: The Attributes of Coal



Source: IEA, 'The Global Value of Coal' (Paris: IEA/OECD), p. 22.

A key decision of the 2010 Copenhagen accord is to provide energy to impoverished populations as a key condition for education, economic growth and social-political stability. This goal is all the more important given that around 1.2 billion people have no electricity supplies and another two billion people little or inadequate access to power. Despite the falling prices of solar and wind power, coal often remains often the only option that can sustainably meet the growing global demand at such a scale.[316] RES are still too expensive an option given the needed investments for transforming entire energy systems and building, ultimately, two parallel subsidised energy systems for a longer transition period. Even a more rapid expansion of RES in developing countries would require fossil-fuel power plants to ensure the base-load stability of electricity supply.[317]

In many regions outside Europe, coal remains essential for coping with lack of access to electricity, clean cooking, and other modern energy services. In fact, from 1990 to

311 The world's largest exporters of steam coal, dominating with about 70 per cent of the entire internationally traded coal in 2013, were Indonesia, South America (primarily Colombia), Russia, and Southern Africa (i.e. South Africa). For coking coal, Australia, the U.S. and Canada rank as the three largest exporters and are expected to remain so up to 2035. Together with Vietnam and China, Poland is expected to decrease its coking coal exports in the mid-term perspective, primarily because of geological difficulties. See EIA, 'International Energy Outlook 2010', p. 70.

312 See also EIA, 'International Energy Outlook 2010', p. 61 ff.

313 See European Commission, 'The Market for Solid Fuels in the Community in 2009 and Estimates for 2010', p. 36.

314 Around 30 per cent of the steam coal traded by sea and 47 per cent of the coking trade by sea are controlled by just four firms – see also Gesamtverband Steinkohle e.V., 'Steinkohle 2010. Unser Rohstoff-Unsere Sicherheit', Essen-Herne 2010, p. 55.

315 See BGR, 'Energy Resources 2009', p. 125

316 As the expert Richard O. Faulk has stated, "Without relatively inexpensive imported resources, developing nations cannot develop their economies – and insisting unaffordable alternatives denies them the opportunities that developed nations have exploited for centuries. The inevitable result will be continued poverty, depressed nutrition, increased disease and premature deaths in developing nations – a scenario that any reasonable climate advocate should find unacceptable" – Richard O. Faulk, 'Stop Demonizing Fossil Fuels', Forbes, 17 February 2015. See also James Wilson/Pilita Clark, 'BHP Chief: Stop Saying Gas Is Cleaner Than Coal', FT, 22 March 2015.

317 See also Patrice Hill, 'AS U.S. Scales Back, 'King Coal' Reigns as Global Powerhouse', Washington Times, 4 March 2013.

2010, some 832 million people gained access to electricity due to coal-fired generation in developing countries.[318] A continued sustainable supply of coal as a domestic resource and refurbished with clean coal technologies is a fundamental pre-condition to cope with global energy and economic development needs. Without affordable coal, the electrification – and, with it, modernisation and education – in countries like South Africa, India, and China, would have been impossible.

Tackling climate change not only requires new investments towards clean energy sources, but also addressing high emission assets that are already in place. For example, coal-fired power plants may be enjoying higher efficiency rates, but one-third of the worldwide, newly-built plants still have lower efficiency levels that are inadequate for reaching climate change mitigation goals. It is simply not realistic to replace these plants entirely with RES – not even in the long run. Instead, new coal power plants with higher efficiency rates could replace older ones, or these less efficient plants could be retrofitted and modernized with CCTs. Accordingly, OECD countries should proactively promote the deployment of CCTs instead of placing bans on export credit finance on these technologies.

Against this background, *energy efficiency* is a critical key factor to address both energy security and rising energy consumption. The need to replace no less than 40 per cent of the global fleet of the existing power plants offers huge export chances for German and European producers of highly efficient power plant technologies. Highly efficient coal-fired generation and CCS technologies can reconcile the increased use of coal with climate protection goals. In fact, if the world's power plants operated at ultra-supercritical efficiency levels of around 45 per cent by 2040, related emissions would be 17 per cent lower than in the IEA's New Policy Scenario. Further technological innovations for the next generation of fossil-fuel power plants are already underway to increase the efficiency of power plants beyond 50 and 60 per cent, and also to offer new technological solutions to reduce GHGE for new coal options such as UCG, CTL and CBM. This technology will also be critical for the worldwide application of CCS as the future key technology for reducing GHGE emissions in the entire energy intensive industry. Currently, there is no alternative technology available for reducing GHGE significantly in these industrial sectors.

Equally important, it is pivotal to consider the geopolitical consequences of international coal divestment efforts, which have only fuelled further Asian frustration with the West and its development institutions.[319] In this context, the newly launched Asian Infrastructure Investment Bank (AIIB) – to be established by the end of 2015 with China as its largest stakeholder – stands to offer a non-Western funding option for future energy infrastructure projects, including Pakistan's China-backed[320] Thar Coal and Energy Project.[321] Similarly, China has already announced financial support for other Pakistani priorities in energy and infrastructure as well as in other countries – i.e. coal power plants and coal mining projects.[322] Consequently, the United States and Europe do not only risk losing business and investment opportunities in the most economically dynamic region, but also undermining their own wider geo-economic influence, with potentially wide-ranging geopolitical implications.

Ultimately, there is no contradiction between supporting, on the one hand, clean coal technologies and, on the other, EU or German environmental ambitions. In the absence of European makers of these technologies, other foreign competitors would replace them – oftentimes with less effective tools and technologies to cut GHGE. Ultimately, this absence would merely lead to higher levels of pollution and the loss of huge export opportunities, to the detriment of European economic competitiveness and stability.[323]

In this context, export credit financing for coal-fired plants and CCTs should be granted as an active contribution to climate mitigation efforts. The European Commission itself appears to favour some level of financial support for European exports of coal-fired power plants and related technologies in an unpublished, informal document – despite its plans to phase out subsidies for domestic coal plants by 2018.[324] New conditions and criteria could be set in exchange for credit support. For instance, power plants beyond 500 MW could be required to guarantee an efficiency rate of 43 per cent for lignite power plants and 44 per cent for hard coal power plants, while the efficiency of the existing older power plants could be boosted by 75 per cent.

318 See Robert Price, 'Not Beyond Coal. How the Global Thirst for Low-Cost Electricity Continues Driving Coal Demand', Center for Energy Policy and the Environment (CEPE) at the Manhattan-Institute-Report, No. 14, October 2014, p. 2 and 9 f. See also IEA, 'Global Value of Coal'.

319 'US to World Bank: Don't Fund Coal-Fired Plants', The Times of India, 24 January 2015.

320 China has already announced to finance it via its own banks or by the support of the AIIB. See Manoj Kumar/Tony Munroe, 'For India, China-Backed Lender May be Answer to Coal Investment', Reuters, 5 November 2014; Peter Foster, 'Why Coal Looms Large in India's Future'. Financial Post, 16 April 2015and 'China's Cooperation Expedite Thar Coal Project', Samaa TV, 19 April 2015.

321 To the background of the project see Rafaqat Hussain, 'Thar Coal: From Dark to the Light', Pakobserver, 26 July 2014. See also Peter

322 These projects include the US$46 billion China-Pakistan Economic Corridor. See Jeremy Page, 'China's President to Cement Huge Coal Power Projects', Wall Street Journal, 19 April 2015; Naveed Butt/Ali Hussain, 'China to Invest $37 Billion in Energy Projects', Business Recorder, 18 April 2015

323 In the Asia-Pacific region alone, utilities are expected to order 275 GW of new coal power plants just in the next 5 years. See also European Power Plant Suppliers Association (EPPSA), 'Thermal Power in 2030. Added Value for EU Energy Policy', 2015, p. 37.

324 See Barbara Lewis, 'REFILE-EU Policy Paper backs Help to Export Coal-Fired Power Plants', Reuters, 3 June 2014 and 'EU Eyes Export Help for Coal-Fired Power Plants', EurActiv, 13 August 2014.

Conclusions and Perspectives

This study has strongly argued that coal-fired power generation has a future both internationally and in Europe – albeit under certain conditions and by balancing different energy policy objectives. In turn, these considerations would be conducive to an affordable, secure, and environment-friendly energy mix in place.

Balancing the Three Objectives of the 'Energy Triangle'

The expansion of RES has been celebrated as a huge success story of the Energiewende; however, many problems are ignored and – deliberately – overlooked. German authorities ought to pay more attention to energy supply security and economic competitiveness, especially if it wishes to keep the country's manufacturing industry as its strongest economic pillar.

Coal will remain, in all realistic scenarios, an important part of the global energy mix through 2040, and especially for electricity generation. It will also play an important role in overcoming the lack of access to electricity and modern energy services of almost one-fifth of humankind. In the EU-28, giving up coal will result in higher gas imports and supply risks that will merely undermine national and EU-wide energy security – particularly for Central and Eastern European countries, whose energy supply risks are already higher than those of Western Europe.

Against this background, Germany and the EU should maintain a broad and diversified energy mix. For the time being, intermittent RES are not able to replace nuclear power and, simultaneously, provide round-the-clock stable supply of electricity without a real technological and affordable solution for storing electricity. For the time being, only nuclear power and fossil-fuel power plants can guarantee national base-load and electricity supply security – in the form of an energy backbone combining de-centralized renewable energies with centralized thermal power plants.

Promoting Carbon Leakage?

The rules of the Kyoto-protocol oblige CO_2 reductions to be counted at the point of production and not of transport and use. Estimates suggest that seven per cent of the EU's CO_2 emissions between 1990 and 2008 were simply outsourced to the developing world in the form of manufacturing imports. This outsourcing also produces more GHGE – by using more energy – as a result of often long transport routes from other countries and regions.

Any unilateral and overly ambitious climate change policy framework will merely drive out German and European energy-intensive industries and have broader economic consequences. Less coal production in Europe will likely lead to more expensive, unstable gas imports with higher CO_2 emissions – as highlighted previously by Germany's experience with Russia after 2006. The EU should bear these facts into consideration as it proceeds with its climate protection targets. In fact, the EU's 40 per cent reduction target for 2030 means that the bloc is aiming to reduce emissions within just one decade – 2020 to 2030 – by the same amount that it has yet to achieve by 2020 in the span of three decades – 1990 to 2020.

Neither is fuel switching from coal to gas alone sufficient or realistic for achieving the 2°C target, as GHGE from natural gas are too high. Consequently, gas power plants, too, need CCS. At the same time, gas power plants with CCS are more expensive than those with coal-fired ones in the long run. Furthermore, by taking into consideration life-cycle analyses, including Europe's long transport routes for gas imports and end use, Russian pipeline gas produces nearly the same amount of GHGE as domestic European and German coal production. Moreover, in contrast to the United States with its indigenous shale gas reserves, a radical switch to – imported – gas would further increase European and Germany energy import dependencies and their potential vulnerabilities.

Reviewing the Changes in World Energy Markets and Assessing the Impact on Germany and the EU Energy Union

Any national and regional energy policy will only prove sustainable and successful as long as it reflects strategic developments and changes in world energy markets. The 2007-2008 European common energy policies were based on the following assumptions and core beliefs:

- Fossil fuel prices would rise continuously as global demand would exceed supply;
- Europe would gain industrial and economic advantages by being the first major region in the world to develop a low-carbon economy based on RES and other green technologies;
- A gradually rising carbon price would increase the cost of externalities, including air pollution and climate change, until RES became fully competitive;
- The negative effects of higher energy costs on competitiveness would be mitigated by a binding global agreement on climate change.

Today, those tenets no longer hold true:

- Fossil fuel prices have dramatically fallen by more than 40 per cent – oil even by more than 60 per cent –; likewise, new drilling technologies have made unconventional gas and oil resources available and cheaper;

- Geopolitics and international conflict have brought back energy supply security to the top of Europe's security agenda;
- The RES transition has given Europe no real sustainable economic advantages and instead proven to be costly, while real research and development progress has increasingly shifted to China and other countries;
- Efforts for setting higher carbon prices have failed, and coal is now even stronger than gas in EU energy markets;
- None of the other largest GHG emitters have followed the EU's ambitious climate mitigation footsteps, and, despite the recent joint U.S.-China declaration, the chances for a comprehensive and binding global climate change agreement at the 2015 UN Climate Change summit in Paris are still minimal.[325]

If these global energy developments are not sufficiently integrated into German and European policy-making, the chances to strike the right balance in the energy trilemma will remain minimal and inflict lasting economic pain.

Promoting Clean Coal Technologies

As long as the world relies on fossil fuels, CCTs will remain an essential climate change mitigation tool. CCTs not only pave the way for the environment-friendly use of coal, but also for the potential use of CO_2 as an industrial good. This last point, in turn, stands to decrease the costs of CCS projects and to develop new value chains.

As almost all growth in coal consumption is taking place in non-OECD countries, introducing CCTs at a global level is a crucial pre-condition for successful, ambitious climate mitigation efforts at the global level. The adoption of CCTs, highly efficient coal-based energy generation technologies, and CCS will be key factors for limiting a dramatic global rise of CO_2 emissions and for ensuring a reliable transition to a low-carbon economy. Hence, making coal use cleaner and more efficient in developing countries and emerging economies is environmentally significant and economically effective.

Currently, CCS is the only technology that can achieve large reductions in CO_2 emissions in power plants, fossil fuel extraction, and energy-intensive industries. Given the considerable economic and emission reduction potential of CCS, most major economies have announced ambitious plans for large-scale pilot projects. Overall, experiences and progress are still limited for commercialization purposes, but, in the meantime, even the IPCC has stressed the strategic importance of CCS as an important climate mitigation tool.

In the end, advanced economies need to make a frank assessment of their economic future against the necessary efforts to avoid dramatic climate change consequences. This needs not be an either-or proposition – on the contrary, acknowledging and accepting coal as a key element in their electricity mix should be part of a delicate balance that, in the words of the Japanese energy expert Shoichi Itoh, "tak[es] into account both economic viability and environmental burdens."[326]

325 See Nick Butler, 'European Energy Policy – Time to Start Again', FT, 27 October 2014 and Matt Ridley, 'Fossil Fuels Will Save the World (Really)', Global Warming Policy Forum (GWPF), CCNet 14/03/15.

326 Shoichi Itoh, 'A New Era of Coal: The 'Black Diamond' Revisited'.

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