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# The New German Energy Policy:

## What Role for Gas in a De-carbonization Policy?


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Ralf Dickel, February 2014

## Preface

In a cursory review of the European energy landscape an observer might reasonably ask how Germany, one of Europe's most successful economies, had arrived at a power generation aspiration dominated by the rather incongruous mix of solar, wind, coal and lignite?

German Energy policy – in its current form the Energiewende - is the product of a complex evolution of overt aspirations of many of the parties in and out of governing coalitions since the turn of the century, and a covert fear of import dependency on Russian gas combined with 'coal-mindedness' – an affinity for the use of coal and lignite, despite the country's net coal import position.

In this extensive and comprehensive paper, Ralf Dickel explains the political path by which Germany's current energy policy was derived and in particular the way in which the Fukushima disaster on March 2011 finally catalysed an embedded desire to exit nuclear energy in many political factions to fulfillment through consensual legislation. Phased nuclear closure and a desire to achieve decarbonisation targets drove the many scenarios underpinning energy policy, but the role of gas was never explicitly addressed within the governing political mainstream. The choice between gas and coal/lignite was comprehensively 'ducked' but as the abject failure of the ETS system unfolded it was convenient to ascribe such a choice as being 'for the market to decide'. At present a CO2 price of €50/tonne $CO_2$ would be required to burn gas in favour of coal in German power plant.

Looking ahead however, the paper anticipates potential developments for which the maintenance of the German gas sector and its transmission grid would be much more positive (preserving options) than allowing gas to wither and coal and lignite to maintain dominance. These include the continuation of biogas generation, gas with CCS (having superior investment economics than coal and lignite) and power to gas, via the Sabatier process, by which surplus renewable power generation could be stored as (zero carbon) gas and utilised by the existing transmission and storage system.

I thank Ralf for this timely and though provoking paper. On the OIES Natural Gas Research Programme we value leading edge research on developments in key gas markets. And on a wider, philosophical but very germane level, in his conclusion Ralf poses the question: 'If a country like Germany is not able or willing to phase out coal for de-carbonization, why should China or India do it'?

Howard Rogers
Oxford, March 2014

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## Summary

The new German energy policy was decided in its final form in 2011 following the Fukushima disaster and has since been called “Energiewende” (Energy Turn Around, herein called “New German Energy Policy”). It has two major objectives: phasing out nuclear by 2022 while maintaining a reliable power supply and de-carbonizing the German energy sector by more than 80% by 2050. As gas is the fossil fuel with lowest $CO_2$ emissions one would expect gas to play a major role in the Energiewende.

The contrary is the case. The role of gas in the Energiewende was hardly discussed and is not addressed in the official policy. Discussing the role of gas in de-carbonization and power generation would by implication have to address the role of coal and lignite, which would have to shrink, unless CCS became commercial and broadly applied. By tradition Germany has a strong affinity to coal and lignite as domestic energy sources and this is deeply entrenched in the political system. By contrast gas - while perceived as environmentally benign - creates security of supply concerns due to import dependence especially on Russia. The environmentalists see the advantages of gas, but have very ambitious targets for renewables to which they subordinate the role of gas.

Another obstacle for gas is that any de-carbonizing policy has to improve energy efficiency, energy saving and to introduce renewables, inevitably reducing gas sales in its traditional segments. A role for gas could be in power generation to reduce $CO_2$ emissions by replacing coal/lignite-based power production. There is a wide spread proposal that the role of gas for de-carbonization could be to complement intermittent renewables due to the flexibility of gas-fired power plants. However, CCGTs have no advantage in operating in load following mode over state of the art coal- or lignite-fired power plants. The issue of $CO_2$ emissions and gas demand depends on the volumes of gas used for power generation, which are decided by the merit order between gas and coal, which is determined by relative fuel costs inclusive of the costs imposed on $CO_2$ emissions. A larger role for gas in de-carbonization is impeded by the shortcomings of the present EU carbon emission trading regime. Its present carbon price of less than €10/t $CO_2$ is far below the trigger price of about €50/t $CO_2$ for fuel switching from coal to gas. In addition the construction of new gas-fired power capacity is hampered by the prevailing energy ‘market only’ design where fixed costs are remunerated only by scarcity rents or rents from operating cost differentials. This problem is exacerbated by the strong and increasing introduction of intermittent renewables fed in at almost zero marginal costs: PV is cutting the mid-day peak demand and wind power makes the use of dispatchable thermal power plants not only subject to the (known) variations of demand but also to erratic wind conditions. Peak plants, while necessary as back-up for reliability, may not be run for years: whether run on gas or fuel oil or coal matters only marginally for total $CO_2$ emissions and for gas demand.

Fuel switching to gas would be a major contribution to a transition to a de-carbonized energy sector. A long term role for gas in a strongly de-carbonized world requires de-carbonization either by CCS or by producing $CO_2$ neutral gas such as biogas or synthetic gas from renewable surplus power (Power to Gas). Successful development of CCS would benefit coal and lignite as well. The jury on the development (and acceptance) of CCS and Power to Gas is still out. Both developments could define a low carbon future: while CCS would be a strongly centralized, power dominated system with gas competing with lignite (and coal) for power generation with CCS, a successful development of Power to Gas allows for a more decentralized system maintaining large parts of today’s gas infrastructure.

After the Federal elections of September 22, 2013 the Energiewende continues to be supported by a large majority of the German population: post-election polls showed 80% to be in favour of its continuation. The new Government, a great coalition between CDU/ CSU and SPD was finally installed on December 17, 2013 after long negotiations of a detailed coalition agreement. The section on the Energiewende is a prominent part of the coalition agreement. It makes clear the political will of this coalition to continue the Energiewende with a phase-out of nuclear by 2022 and keeping the concrete decennial goals for de-carbonization. To keep control over the development of renewables and the implications for costs and reliability of power supply a binding corridor for the development of renewables is defined. The role of conventional power plants (lignite, hard coal and gas) for maintaining reliable power supply is emphasized, the advantages of gas as low $CO_2$ emitting fuel are addressed but left to the ETS. However, a public discussion on the role of lignite and hard coal has started in view of their continued if not increased $CO_2$ emissions. The closer we get to 2020 and its ambitious 40% $CO_2$ reduction target and to the phase-out of German hard coal production by 2018, the more the government will have to move away from the traditional German 'coal-mindedness' and open up to the role of gas to meet the ambitious targets of the Energiewende as the only available instrument which can compensate for shortfalls of other policies.

## Introduction

A strategy for strict de-carbonization (at least an 80% reduction of GHG emissions by 2050) will obviously have to reduce energy demand as much as possible by higher energy efficiency (inclusive of energy saving without loss of comfort levels) and a maximum use of renewables. In view of its chemical and technical superiority over other fossil fuels, gas could obviously make a major contribution to de-carbonization both in the transition period up to 2050 but also in the target period post 2050 by giving the highest energy yield for the restricted $CO_2$ emissions. The possibility to use the present gas infrastructure for carbon neutral methane from bio processes, or from power to gas, and to contribute to the use of CHP, plus the possibility to add CCS to gas-fired power plants makes gas a 'future proof' option in a largely de-carbonized environment. This is in contrast to coal which would have to rely solely on CCS and would restrict the energy distribution to the final energy user largely via the power grid.
German energy policy has since the 1990s been driven by an increasing consensus to de-carbonize the energy sector through efficiency and renewables and after the Fukushima disaster in 2011 also by a broad (and probably irreversible) consensus, to phase out nuclear within ten years.

However, the new German "Energy Concept" of 2010[1] revised in 2011 by the phase out of nuclear after Fukushima (thereafter called "Energiewende"[2] or New German Energy Policy) did not reverse nor even address the declining role of gas in Germany. It missed the opportunity for an assessment of the role of gas in the light of the ambitious de-carbonization policy of the German government, especially the potential of gas in power generation to achieve a swift and effective de-carbonization considering the much lower specific $CO_2$ emissions of gas compared with coal.
The first annual monitoring report by the government on the implementation of the Energiewende was delivered in December 2012[3], as well as the comments by four

[1] BMU (2011,October)
[2] BMU (2011, October)
[3] BMWi (2012a),

independent experts[4] attached to it, are silent on this topic, maybe due to the focus of the report on factual developments. A more analytical approach will be the subject of the first progress report due in December 2014 and thereafter to be delivered every three years. This will offer another opportunity for an assessment of the role of gas in the German de-carbonization policy. The discussion about how to make use of the benefits of gas for de-carbonization as early as possible has however to start now.

The debate (or rather the lack of a debate) on the role of gas for de-carbonization has suffered from two misunderstandings:

(i) A confusion between, on one hand, using gas-fired capacity for load balancing to ensure reliable power supply, and on the other hand producing electricity by the use of gas-fired capacity replacing coal or lignite to reduce $CO_2$ emissions. While there must be enough dispatchable power capacity to ensure reliability of power supply and grid operation (which can principally be provided by any fossil power plant) it is the level of usage (load factor) of such capacity which determines $CO_2$ emissions. Here gas is clearly superior to other fossil fuels. However, for a power plant which is only used as back up maybe only for a few days, maybe not at all during a given year, the $CO_2$ intensity of power production has only a marginal effect on the overall $CO_2$ balance and on fuel consumption. It makes little difference if the back-up capacity is a gas turbine run on gas or on gas oil or even an otherwise idle coal-fired power plant. This is different for middle or base load, where the difference in $CO_2$ emissions between gas-fired power and coal- or lignite-fired power becomes substantial. If Germany´s 25,000 MW of gas-fired capacity is run at 4,000 hrs/year instead of 2,000 hrs/year, replacing power from coal, the resulting difference of about 20 million $tCO_2$/year[5] really matters for the total of Germany´s $CO_2$ emissions of about 800 million $tCO_2$/year[6]. However this requires that marginal costs (inclusive of the costs of carbon) of gas-fired production are below those of coal-fired power production, reversing the present merit order.

(ii) Another misperception is about the role the market could play without a dedicated policy to phase out carbon and the use of effective instruments to implement this policy.

The belief that the role of gas, and by implication of coal for de-carbonization, should or could be solved by the market neglects the fact that while coal prices are world market prices and gas prices are formed on regional hubs or contract markets, there is no immediate tangible market for non-emitted carbon. Any valuation of carbon (non) emission is in the end heavily influenced by the structure and limits provided by policy and above all political decisions. Emission trading for $CO_2$ is in the EU ETS predominantly applied to the power sector, (bound to a location in EU and producing about 30% of all $CO_2$ emissions, while the other sectors of the ETS are not bound to EU and contribute only less than 15%[7]). It would need a price of presently about €50/$tCO_2$[8] (as a result of political action) to compensate for the cost differences between coal and gas in power generation to trigger a switch of the merit order between fuels, while switching to carbon-free electricity production is already induced by other politically given instruments. The effect of emission trading on efficiency is merely reinforcing economic effects already derived through fuel saving. This belief in the market takes as irrevocable past and present policy decisions defining the market, many of which

[4] BMWi (2012b)
[5] Based on emission factors of 0.4 kg $CO_2$/kWh for gas and 0.8 kg $CO_2$ / kWh for coal
[6] BMWi (2012a), p. 78
[7] Umweltbundesamt. (2013, February) Tabelle 2
[8] The calculations are in chapter 3.2

have favoured coal for political reasons. Referring to ‘the market’ is a convenient means to hide all the now invisible decisions taken in favour of coal in the past, to avoid a controversial political debate, but missing a de-carbonization opportunity.

This report describes and analyses the new/old German Energy Policy with a focus on the role gas plays or might play in de-carbonization in Germany and how it has been addressed in public discussion and in policy decisions and their implementation.

Chapter 1 reviews the de-carbonization policy and objectives of German governments since it, together with the phase- out of nuclear, first became a central topic of German politics with the election of a Red Green government in 1998.

It then describes the Energy Concept of 2010 which continued in a more structured and comprehensive way the previous de-carbonizing policy, derived from the international commitments based on the 4th assessment report of the IPCC. While the New Energy Concept stipulated a prolongation of nuclear to become the bridge fuel, the Fukushima disaster in March 2011 triggered a sudden return to the previous nuclear phase-out policy (Energiewende).

Details are then given on the instruments (institutions and legislation) established to implement this energy policy.

Chapter 2 reports on the technical, regulatory and political developments since the enacting of the Energiewende, especially on the power grid and the discussion on its implementation and on the first monitoring report presented by the government in December 2012. Section 2.5 presents details of the controversial costs and benefits of the Energiewende, especially of the support for renewables. Section 2.6 describes the policy on Energiewende as defined in the coalition agreement of the new government formed on December 17, 2013.

Chapter 3 looks at the role of gas in de-carbonization in Germany, at its potential medium term role and on ways in which this could be further enhanced. A crucial step would be to put a value on carbon emissions from power generation at a level which makes fuel switching between coal and gas economically attractive, which is not the case with the present ETS. When it comes to investment in new gas-fired power generation, which may become necessary when old coal-fired power plants have to be closed, a major challenge is how new plants can earn sufficient revenue to also cover fixed costs in the present market design, which values only energy but not capacity. This problem is exacerbated by increasing feed in of renewable power at almost zero marginal costs. Finally for the long run the future of gas and gas infrastructure depends on technical developments of a decarbonized use of gas via power plants with CCS or by transforming surplus renewable electricity to synthetic gas via electrolysis and the Sabatier process. Above all – in spite of much lip service paid to gas – in Germany the role of gas is not being at all seriously explored under present policy discussions.

Finally conclusions are drawn in chapter 4.

# 1. The Development of the Energiewende (New German Energy Policy)

The Energiewende (New German Energy Policy) now has two major targets, which are partly intertwined: the first was de-carbonization of the energy system by 80 – 95% by 2050 with milestones for every decade up until 2050 (New Energy Concept). This was followed in 2011 by the phase out of nuclear by 2022 (Energiewende) while maintaining a reliable power supply in Germany (and across the UCTE[9] grid of which the German grid is a crucial part). While German energy policy since the end of the last century has been increasingly driven by de-carbonization, the role of nuclear was controversial up until the dramatic policy change by the CDU/CSU/FDP government in the wake of Fukushima. The fostering of renewables was less controversial, as long as this could be regarded as creating additional (export) business for the German (export) industry and did not jeopardize the very high reliability of power supply in Germany. This paper discusses the development of political discussion and policy objectives on these two points as well as the almost complete failure to address the potential role of gas in the de-carbonization of Germany.

Politically, a failure to meet a milestone on the way to de-carbonization in 2050 by a few percentage points or a few years will not be considered too dramatic, but a large black out across Germany or even the EU, which could be attributed to the phase out of nuclear or the renewables policy risks becoming a political disaster and could, especially in winter, become a real disaster.

Therefore at present the focus is on the first objective.

## 1.1 Development of German De-Carbonization and Nuclear Power Policy (Policy Objectives, Political Development and Debate)

To avoid confusion in what has been a complex evolution, "Energiewende" refers to the German Energy Policy as a result of the parliament decision of June 30, 2011 to phase out nuclear by 2022 together with the elements of the Energy Concept of 2010, most of which were put into legislation on June 30/ July 1, 2011[10].

Outside of Germany the Energiewende of 2011 is sometimes considered as a complete new energy policy of which especially the nuclear phase-out came almost overnight after the Fukushima disaster. However, German energy policy has since the end of last century been substantially influenced by a policy to reduce GHG emissions with de-carbonization as its dominant component. De-carbonization of GDP is a general trend in OECD countries triggered initially by the oil price shock of 1973. From 1973 to 2010 major OECD countries such as the US, UK, France and Germany have at least halved their $CO_2$ emissions per unit of GDP. This included special aspects such as: the broad introduction of nuclear in France at the end of the 1970s, the restructuring of a largely inefficient economy in East Germany after unification and the dash for gas in UK. France by virtue of its large share of nuclear

[9] Union for the Coordination of the Transmission of Electricity which coordinates the operation and development of the electricity transmission grid across most of Continental Europe.
[10] Deutscher Bundestag (2011, July 1)

production has lower specific emissions than the UK which in turn has lower specific emissions than Germany. Germany´s rank among IEA members changed from tenth most carbon intensive in 1990 to nineteenth in 2011[11].

In addition to continuing de-carbonization, when the Red Green (SPD/Green Party) government took office in 1998 they followed up on a major election campaign promise to phase out nuclear. So, many if not most of the elements of the Energiewende go back to the time of the first Red Green Government. What was new about the Energiewende was that it was decided by de facto unanimity in the German parliament (ending the political divide on nuclear phase-out). De-carbonization policy was very much continuing the policy of previous governments, but was now derived from international targets stipulated by e.g. the G8[12] and UNFCCC/IPCC[13] in the second half of the first decade - to reduce GHG emissions globally by 2050 by 50%, but for industrial countries by 80% or more compared to 1990. Section 1.1 will describe the main developments leading to the Energiewende and then describe in detail the discussion leading first to the New Energy Concept in 2010 and the reaction to the Fukushima disaster which resulted in the Energiewende of 2011. The development of the instruments (focused on Federal legislation) to implement the energy policy and the institutions involved (mainly on the Federal level) will be described in more detail in section 1.2.

### 1.1.1 The Development of German Energy Policy under Governments before 2009:

#### *The Two Red Green Governments (1998 – 2002 and 2002 – 2005)*

At the elections of September 27, 1998 the SPD and the Green Party together won 345 of 669 seats in parliament[14] and the Red Green Government they formed ended 16 years of government under Chancellor Kohl. A major issue in the election campaigns of both the SPD and the Green Party was a promise to phase out nuclear and to foster renewables and energy efficiency instead.

The Coalition Agreement of October 20, 1998[15] contained an ecological tax reform imposing and increasing taxes on the consumption of mineral oil, natural gas and electricity, the income from which was used to reduce “Lohnnebenkosten” (costs in addition to wages, shared between employee and employer: health insurance, pensions and unemployment insurance) with a view to reduce the overall burden on labour beyond wages for employers.
Regarding energy policy the agreement stipulated the promotion of energy saving, fostering of renewables and CHP and the phase-out of nuclear as soon as possible in consensus with the industry, as well as non-discriminatory grid access.

A basic approach was to foster renewable power generation (together with reducing electricity consumption) to replace nuclear. To promote the use of renewables a law was enacted (EEG = Erneuerbares Energie Gesetz = Law on Renewable Energy[16]), which with several amendments is still in force today (see chapter 2 for details).

[11] IEA (2013), Germany 2013 review, Paris, 2013, p. 52
[12] G8. (2009) .Meeting at L’Aquila, Chairman´s summary, Responsible leadership for a sustainable future, item 65
[13] IPCC. (2007)
[14] Bundeswahleiter (1998)
[15] BÜNDNIS 90/DIE GRÜNEN. (1998, October 20)
[16] BLE. (2000, March 29)

Regarding energy saving, an agreement with the energy using industry was concluded on the voluntary reduction of energy, which included support for CHP and a reporting mechanism on the realization of the goals agreed[17] (see section 1.2 for details).

More controversial was the discussion with the nuclear power industry on phasing out nuclear. However on June 14, 2000 a compromise between the government represented by Chancellor Schröder and the ministers concerned on one side and the CEOs of the main power companies was found and initialled[18], as a basis for legislation which was then enacted in 2002[19]. The core provisions would allow each reactor to produce electricity volumes corresponding to 33 years of production at the best 5-year average over the 1990s with the possibility of transferring unused production volumes from older to newer plants. The nuclear industry accepted the compromise because it allowed a continuation of nuclear generation under acceptable conditions. They expressed their opposition but acknowledged the government´s objective of phasing out nuclear and its political power to substantially impact the operation of nuclear (e.g. by means of necessary permits)[20]. The Christian Democrats announced that they would reverse the decision as soon as they regained government[21]. Criticism came also from the environmental movement and from some parts of the Green Party who believed that a faster nuclear phase out could have been achieved. Their criticism was linked to the question of how and how fast nuclear energy could be replaced by low or zero carbon power generation.

This explains why the appetite of the industry to address in conceptual or practical terms the questions related to the phase out of nuclear and the phase in of renewables in the following years was limited. Questions of integrating growing capacity of (intermittent) renewables into power and grid management were not addressed; nor were a potential role of gas-fired power as back up for renewables or as bridge technology.

Gas had become an established and growing part of the German energy mix and everybody believed this trend would continue. With regard to the position of gas in power generation, it was probably not addressed for different reasons: the green movement feared that gas-fired power would undermine the drive for renewables; the Social Democrats always had a strong affinity to coal, with mining communities forming a strong part of their constituency, and on the side of the industry and the Christian Democrats there was the hope that a new government would reverse the decision of the Red Green Government. Also the gas import dependency argument will have played a role in the background.

### *Red Green Coalition from 2002 – 2005*

Contrary to expectations the Red Green Government was re-elected in 2002, however with a smaller majority in parliament.

In the new coalition agreement of October 16, 2002[22], energy policy was not as prominent a topic as it had been in 1998, merely a subtopic under the heading ecological modernization

[17] Bundesministerium der Justiz; juris GmbH. (2002, March 19)
[18] BMU. (2000, June 14)
[19] Deutscher Bundestag (2002, April 22)
[20] IZE. (2000, July). p 6
[21] Deutscher Bundestag (2002, April 22),p 1.
[22] SPD; Bündnis90/DIE GRÜNEN. (2002, October 16)

and consumer protection. It mainly provided for the continuation of the energy policy of the previous government: under the heading “Fortsetzung der Energiewende” (Continuation of New Energy Policy) [23]energy policy was framed by the international context (reference to commitments at the UNFCCC Conference of 2002 in Johannesburg 10 years after the Rio Conference) as well as promoting the idea of an international agency for renewables. In the national context major topics were the development and adjustment of the EEG, fostering of offshore wind, further promotion of CHP and energy efficiency and confirmation of the phase out of nuclear energy.

Regarding the upcoming emission trading system in the EU, a major concern was that the improvements in $CO_2$ emissions achieved by a voluntary commitment by German industry would not be adequately taken in to account and that the emission trading regime should be compatible with the flexible mechanism of the Kyoto Protocol[24].

Gas was not mentioned at all, not even in the context of market reform.

The focus of the government during this legislative period was very much on the reform of the labour market and social security systems, leading to heated discussions and finally to early elections in 2005.

When looking at the energy policy of the Red Green Government, it should be remembered that the Kyoto Protocol was concluded on December 11, 1997, just a year before the Red Green Government was elected. The issue of whether the Kyoto Protocol would come into force took priority for a time until Russia ratified it in November 2004[25] and it came into force in February 2005. At that time the reduction targets of the Kyoto Protocol were considered ambitious. Beyond improvement of energy efficiency (also by restructuring of the economy) it was clear that in the long run a solution to the need for carbon-free energy production would have to be found. Nuclear energy however was linked to severe problems of weapon proliferation, waste disposal and inherent safety which resulted in large resistance to nuclear in Germany. CCS was just entering the discussion and was very much uncharted territory while renewables, which promised least interference in the environment, looked like the best solution in principle, although costs had to come down substantially.

A major challenge at that time was to prove the feasibility of renewables and to show they could be made commercially viable. This would require an effective instrument to encourage renewables development and to drive up the number of units produced in order to bring unit costs down in line with the learning curve experienced with other new technologies.

The two Red Green Governments (1998-2002 and 2002-2005) addressed many energy policy issues driven by the target of de-carbonization and de-nuclearization and issued important legislation on phasing out nuclear and fostering renewables and energy saving. This policy was not explicitly based on scenarios and the instruments were not compiled in a comprehensive piece of legislation. Gas was not specifically addressed by that policy; except for a surprising decision to levy an ecological tax on gas, but not on coal or lignite[26]. During its time the Red Green coalition did not come up with a comprehensive piece of legislation combining the various elements of their energy policy. Also it was not guided by a concrete

[23]SPD; Bündnis90/DIE GRÜNEN. (2002, October 16), p. 37
[24] SPD; Bündnis90/DIE GRÜNEN. (2002, October 16), p. 37
[25] UNFCC (2004, November 18)
[26] Spiegel online. (1999, November 11)

overall target of GHG reduction or de-carbonization, which was only formulated later at an international level; nor were the effects of phasing out nuclear and introducing renewables for reliability of power supply analysed in detail to derive policy measures.

### *The Great Coalition (CDU/CSU and SPD) from 2005 – 2009*

The snap election on September 18, 2005 resulted in a distribution of seats in parliament where the only two party coalition with a majority was one between CDU/CSU and SPD which both won a similar number of seats: 226 for CDU/CSU vs. 222 for SPD[27]. Coalitions of three parties were not practicable because of the wide range of political directions.

In the Coalition Agreement between CDU/CSU and SPD signed on November 18, 2005[28] energy was a topic amongst several others; its focus was more on the economy and labour market. On energy the new coalition basically continued the policy of the previous government. Regarding the phase-out of nuclear energy the disagreement between the coalition partners was spelled out, with the consequence that the agreement of 2000 and the respective changes in the atomic law of 2002 were not up for amendment[29]. Otherwise emphasis was put on energy efficiency, ambitious goals for renewables and more competition for electricity and gas. It also supported the creation of an International Renewable Energy Agency. (IRENA [30] an intergovernmental organization was founded on January 26, 2009 in Bonn. At the time of writing it has 118 member countries with a Secretariat located in Doha.)
The role of gas for de-carbonization was not specifically mentioned and was at best only indirectly referred to by the target to modernize the fleet of power plants and support CHP[31]. Regarding climate there was agreement to push for Germany to take a leading role in climate discussions promoting a restriction of global temperature increase to 2°C compared to preindustrial levels, at international conferences[32].

This decision was taken not least with a view to the export potential of German industry. The promotion of the Joint Implementation (JI) and the Clean Development Mechanism (CDM), both instruments under the Kyoto Protocol to foster $CO_2$ reduction in countries in transition and in developing countries, was explicitly motivated by the wish to improve the market position of German industry abroad; so was the creation of IRENA with an increased support for an export initiative for renewables.

With regard to the global discussion of climate change the 4th IPCC assessment report of 2007 endorsed by the UNFCCC Conference in Bali in December 2007 proclaimed the need to reduce GHG emissions by 50% by 2050 in order to keep within the 2°C (as a median value) target[33].

While the G8 meeting in Toyako (Japan) in 2008 did not go much further than the G8 meeting at Heiligendamm in 2007 regarding commitments to abate climate change, the G8 meeting at L'Aquila in 2009 was more specific. In the G8 session, leaders recognized the scientific view on the need to keep global temperature rise below 2°C above pre-industrial levels, and

[27] Statistisches Bundesamt. (2005, September 18)
[28] CDU; CSU; SPD. (2005, November)
[29] CDU; CSU; SPD. (2005, November)., p. 50
[30] CDU; CSU; SPD. (2005, November)., p. 52
[31] CDU; CSU; SPD. (2005, November)., p. 52
[32] CDU; CSU; SPD. (2005, November). p. 65
[33] UNFCCC (2008, March 14)

agreed on a global long-term goal of reducing global emissions by at least 50% by 2050 and, as part of this, on an 80% or more reduction goal for developed countries by 2050:

"We reaffirm the importance of the work of the Intergovernmental Panel on Climate Change (IPCC) and notably of its Fourth Assessment Report, which constitutes the most comprehensive assessment of the science. We recognise the broad scientific view that the increase in global average temperature above pre-industrial levels ought not to exceed 2°C. Because this global challenge can only be met by a global response, we reiterate our willingness to share with all countries the goal of achieving at least a 50% reduction of global emissions by 2050, recognising that this implies that global emissions need to peak as soon as possible and decline thereafter. As part of this, we also support a goal of developed countries reducing emissions of greenhouse gases in aggregate by 80% or more by 2050 compared to 1990 or more recent years. Consistent with this ambitious long-term objective, we will undertake robust aggregate and individual mid-term reductions, taking into account that baselines may vary and that efforts need to be comparable"[34].

As of the August 9, 2007 interest rates of interbank loans soared[35], heralding the financial crisis which followed and increasingly dominated the political discussion.

The Great Coalition did not touch on the decision to phase out nuclear but continued an active policy of de-carbonization, including promotion of an ambitious de-carbonization policy at international conferences such as the G8 or UNFCCC COP/MOP. The German policy was coordinated on a government level by the Integrated Climate and Energy Program (IEKP: Integriertes Energie- und Klimaprogramm) agreed at a cabinet retreat in Meseberg in 2007 (Meseberger Conference)[36]. The role of gas for de-carbonization was not discussed.

### 1.1.2 Preparation of the New Energy Concept by the CDU/CSU/FDP Government (since 2009)

In the elections of 27 September 2009 a coalition of Christian Democrats (CDU/CSU) and Liberal Democrats (FDP) won a clear majority with 194/45 plus 93 = 332 seats out of 622 seats in parliament[37]. Their coalition agreement of 24 October 2009[38] stipulated the prolongation of the lifetime of existing nuclear plants while banning the construction of new nuclear plants[39]. Regarding de-carbonization it continued the policy of preceding governments to promote renewables and energy efficiency and to keep the internationally leading position of Germany on climate protection, renewables and to develop further the measures of the IEKP (Meseberger Conference) of 2007[40]. (The coalition agreement contained also an element which was to become controversial later: to have the nuclear industry participate in the costs of cleaning up the failed nuclear waste disposal site Asse II[41]). There was also an international driver, the international commitment by industrial states to reduce their GHG emissions by 2050 by at least 80%. The Coalition Agreement provided that

[34] G8. (2009, April 6) Chair's summary, The G8 Declaration at L'aquila (2009) "Responsible Leadership for a Sustainable Future"
[35] ECB. (2010, November 11)
[36] BMU. (2007, August), Eckpunkte für ein integriertes Energie-und Klimaprogramm
[37] Bundeswahlleiter (2009)
[38] CDU (2009,October 26)
[39] CDU (2009,October 26), p. 29
[40] CDU (2009,October 26), p. 26
[41] CDU (2009,October 26), p. 29

Germany would develop a concrete plan to de-carbonize by at least 80% by 2050 and hold paramount the objective to reduce emissions by 2020 by 40% (not linked to commitments of other countries)[42].

The energy mix the new government would aim at was an "ideology free, technology open and market-oriented energy policy" ("Wir wollen eine ideologiefreie, technologieoffene und marktorientierte Energiepolitik")[43]. But nevertheless an explicit enabling of new highly efficient coal-fired power plants (while confirming the phasing out of subsidies for German hard coal) and a pledge to implement without delay the EU directive on CCS[44] was included. The emission trading system of the EU was considered to be the priority instrument for climate protection. Gas was not mentioned except for the feed-in of bio gas[45].

The new government pledged to present during 2010 a new energy concept formulating scenario based guidelines for clean, reliable and affordable energy supply[46].

The contextual motivation might have been that time was running out for two of the nuclear reactors (Neckarwestheim and Biblis A)[47] which under the prevailing legislation were to be shut down and avoided closure only by reducing loads and conducting maintenance while awaiting a change in legislation to prolong their lifetime. While the tabling of the respective laws was originally planned before the summer parliament break in 2010 it was finally tabled after the summer break[48].

In the run up to the decision in parliament many elements beyond the prolongation of nuclear surfaced and are discussed in more detail below:

(i) **Scenarios:** There was intensive scenario work by green NGOs and by the Green Party in preparation for the discussion of the new energy concept, followed by scenarios commissioned by the government.

(ii) **Financing:** Apart from the scenario discussion on the costs involved, there was intensive discussion on how to finance further de-carbonization, and especially how to share the economic savings from a prolongation of nuclear power plants, and linked to that discussion – in the eyes of the power industry contrary to the view of government – on a tax on nuclear fuels.

(iii) **Grid:** There was also a discussion on the impacts of an increased share of renewables on grid design (especially for offshore wind) and stability and reliability of power supply and in that context also on the complementarity of renewables and nuclear plants as a backup to compensate for the intermittency of renewables.

[42] CDU (2009,October 26) p. 25/26
[43] CDU (2009,October 26), p. 26
[44] CDU (2009,October 26), p. 28/29
[45] CDU (2009,October 26)p. 27
[46] CDU (2009,October 26)p. 26/27
[47] Die Welt.(2010, January 24)
[48] n-tv.(2010, June 15)

### (i) Scenario Work for Energy Policy Decisions

#### *Purpose of Scenarios Produced*

Many scenarios have been created and investigated in the context of discussing German energy policy since 2000. Moving beyond mere forecasting, target scenarios were used to investigate what degree of de-carbonization was feasible, to understand the instruments needed to achieve it (also to understand how to overcome the impacts of phasing out nuclear) and to investigate the consumer costs and economic impacts of certain technologies, e.g. renewables.

Another objective of this work was to use scenarios as guidance ("Leitstudie 2010" by BMU for long term renewable policy[49] and later also by BNetzA, the Federal Network Agency, for the ten Year Network Development Plans[50]).

Some scenarios examined the technical feasibility of certain technologies in view of de-carbonization targets; others took economic impacts into account, or assumed certain prices as a basis for the use of different kinds of fossil fuels.

However, what was in a way new was that no scenario denied the feasibility of a de-carbonization target of 80% by 2050 and no scenario denied the feasibility of reaching that goal despite phasing out nuclear. During the 1990s such positions/estimates were still regarded as exclusively owned by the Greens and at best considered unrealistic by others.

The questions which the scenarios tried to answer were rather the economic effects of nuclear and renewable policy (GDP, cost of energy, trade balance, electricity balance etc.).

A different issue proved to be the more detailed scenarios/simulations of impacts of different phase-out scenarios on the reliability of power supply and of the power grid which, while not challenging nuclear phase-out per se, addressed the concrete problems which had to be addressed without delay.

#### *Evolving Time Horizon of Scenarios / Nexus to International Discussion*

At the beginning of the decade when the Kyoto Protocol was not yet in force (which only happened in 2005 after the ratification by Russia) the scenarios which were commissioned by the BMU and the UBA were focused on the time horizon to 2020 and were often driven by the specific issue of the introduction of renewables, such as their impact on de-carbonization and their impact on the power grid and power generation in general.

Looking at a time horizon to 2050 was probably driven by the context of the 4th IPCC Assessment report of 2007 which went beyond the 3rd IPCC Assessment report of 2001 by not only describing the anthropogenic impacts of GHG but, based on a better understanding, also tried "... to evaluate possible development pathways and global emission constraints that would reduce the risk of future impacts that society may wish to avoid."[51]

[49] BMU. (2010, December)
[50] FNB Gas (2013, March 10)
[51] IPCC ( 2007), p 26

In the context of the discussion leading to the 4th assessment report of the IPCC scenarios beyond 2020 up to 2030 and to 2050 were produced in Germany. Several of these scenarios were target scenarios oriented at quantitative goals for de-carbonization or achieving a certain share of renewables in the future by 2030 or 2050.

### *The Role of Gas and Other Fossil Fuels in Scenarios*

The role of gas in a successful de-carbonization strategy was in general not discussed in those studies, in the beginning because renewables had to be supported and their potential to solve climate issues to be demonstrated. The advantages of gas were taken as given in the CHP part of the de-carbonization strategy. Later, gas was not addressed specifically because the balance between coal/lignite and gas was left to market mechanisms, which meant in practice left to the relationship between the assumed development of gas and coal prices and the price of carbon. It was implicitly assumed that the ETS (as the dominant de-carbonization policy) would fairly and directly reflect the $CO_2$ emission advantages of gas over coal.

Exceptions were the study commissioned by Greenpeace - "Erdgas – Die Brücke ins regenerative Zeitalter" (natural gas – the bridge to a sustainable era)[52] with a time horizon to 2050.

In 2009 UBA produced a target scenario illustrating the possibility of an all renewable electricity sector by 2050 [53] based on storage by power to gas.

A scenario published by the BMU (Federal Ministry for Environment) in August 2009 – 'Lead Scenario 2009[54]' and updated in 2010 to include a nuclear prolongation scenario, also did not address the role of gas vs. coal except for an assumed increase of power generation from CHP plants.

### *Scenarios in the Run-up to the New Energy Concept*

The coalition agreement between the CDU/CSU and FDP claimed that its de-carbonization targets were "ideology free, market driven, technology neutral and scenario based pathways". The role of scenarios in earlier policy making might be best described as policy accompanying scenarios. Policy action was more derived from the political will of the Green Party and the Social Democratic Party in discussion with their constituency.

Also the green movement (Greenpeace and WWF)[55] [56]produced and updated their scenarios in the run up to the discussion of the Energy Concept, and so did the power industry[57]. A compilation and analysis of already existing scenarios was done by Germanwatch[58]. In view of the wish of the conservative coalition to prolong nuclear, the major focus of these studies published ahead of those commissioned by the government was the role of nuclear, the feasibility of de-carbonization targets and the overall costs.

[52] Greenpeace (2010, August)
[53] Umweltsbundesamt. (2010, July)
[54] BMU (2009, August)
[55] Greenpeace (2009)
[56] WWF (2009)
[57] Forschungsstelle für Energiewirtschaft (2009)
[58] Burck, J., von Blücher, F., & Fabian, T. (2010, August)

Not surprisingly the scenarios by the green movement, but also by the BMU came to the conclusion that the government goals of de-carbonization by 40% by 2020 and by 80% or more by 2050 could be reached without prolonging nuclear and without major economic losses.

In general these scenarios also came to the conclusion that the role of gas in its traditional non-power generation sectors would shrink due to increasing energy efficiency and improved insulation of buildings. The role of gas in power generation showed quite a range of possible outcomes.

Some of these studies emphasized the role of gas as a bridge fuel and all studies addressed the benefit of having highly flexible gas power plants. The conditions under which gas could take a specific role were not discussed. The role of gas was in most scenarios a function of exogenous or implicit $CO_2$ emission prices, partly with forecasts of $CO_2$ prices which from today's point of view look optimistically high. In several studies the argument was made that the ETS would automatically achieve emissions limits and being EU wide, changes in $CO_2$ emissions in Germany would merely influence the price of ETRs within the set limit of emissions.

An early study ordered by the new government was the Energy Forecast 2009 (Energieprognose 2009)[59] published on July 6, 2010. It compared a forecast under the existing environment with two scenarios; one with a prolongation of nuclear to 40 years of operation (compared with the 33 years implicit in the phase out legislation), and a scenario with prolongation to 60 years of operation. The conclusion was that Germany could abide by its Kyoto Commitments and reduce GHG by 34% by 2020 and by 44% by 2030. It would however fall short of its commitments on the renewables share of the energy mix. This would not change with a further prolongation of nuclear which nevertheless would have positive economic effects and result in less energy import dependence[60].

In the run up to the discussion in cabinet and the final decision in the parliament, scenarios commissioned by the government were investigated by the economic research institutes EWI, GWS and Prognos[61]. Contrary to the investigation in the Energy Forecast 2009 the scenarios commissioned were deemed target scenarios. These scenarios were compared with a base case (business as usual)[62].

While the role of CCS for coal-fired power was a subject of evaluation, with some rather optimistic assumptions of CCS being commercially established as early as 2025[63], CCS for gas was not discussed, maybe in the belief that CCS for gas would make power from gas too expensive, or based on the assumption that once CCS was available power generation from coal would anyhow out-compete power generation from gas with or without CCS.

The scenarios prepared for the Energie Konzept were published in August 2010 as a comparison of the base case scenario with four scenarios each with two cases for the refurbishment costs of nuclear.

[59] BMU (2010, July)
[60] BMU (2010, July), p. 21
[61] EWI, GWS, Prognos (2010, August 27)
[62] EWI, GWS, Prognos (2010, August 27), p. 1
[63] EWI, GWS, Prognos (2010, August 27)p. 3

Table 1 below compares the assumptions for the business as usual scenario with the assumptions of the target scenarios[64].

**Table 1: Changes in Sectoral Energy Consumption and Sectoral Energy Productivity in the Reference and Target Scenarios for the Energy Concept of the Federal Government for the Periods between 2008 - 2020 and 2008 - 2050**

| | Reference scenario | Target Scenario | Reference scenario | Target Scenario |
|---|---|---|---|---|
| | 2008 to 2020 | | 2008 to 2050 | |
| | Changes in the respective energy consumption in % | | | |
| Primary energy use | -14 | -16 | -34 | -51 |
| Final energy use | -8 | -12 | -24 | -43 |
| Industry | -12 | -13 | -18 | -38 |
| Business, trade, services | -11 | -19 | -35 | -47 |
| Transport | -3 | -6 | -25 | -41 |
| Households | -9 | -12 | -25 | -47 |
| Gross electricity consumption | -7 | -10 | -10 | -26 |
| | Changes in the respective energy productivity in % per year | | | |
| Primary energy use | 1.9 | 2 | 1.8 | 2.5 |
| Final energy use | 1.3 | 1.7 | 1.5 | 2.1 |
| Industry | 1.3 | 1.4 | 1.0 | 1.6 |
| Business, trade, services | 1.9 | 2.6 | 2.1 | 2.5 |
| Transport | 1.5 | 1.9 | 1.7 | 2.3 |
| Households | 1.4 | 1.7 | 0.9 | 1.8 |
| Gross electricity consumption | 1.2 | 1.5 | 1.0 | 1.5 |

Source: [Prognos et al., 2010] (own calculations)

The base case (business as usual) assumed the existing policy including the phase out of nuclear plants as foreseen under existing law (i.e. classical forecasting)[65]. By contrast all scenarios were assumed to meet the target for de-carbonization in 2050 (inclusive of a target for the share of renewables in 2050), i.e. target scenarios (also called a back-casting approach)[66]. There were four cases of prolongation of the operational lifetime of nuclear plants by 8, 12, 20 or 28 years with two variants for each case for the cost of refurbishment of such plants. New construction of nuclear plants was not considered (in line with the coalition agreement). The assumptions leading to the fulfilment of the government targets of de-carbonization and share of renewables were agreed between the government and the institutes[67], namely: CCS fully commercially available in 2025 and a high rate of electricity saving and efficiency improvements.

64 BMWi (2012 b), p. 22
65 Deutscher Bundestag. (2010, April 29)
66 EWI, GWS, Prognos (2010), p. 4
67 EWI, GWS, Prognos (2010),, p. 1

Such a "back-casting approach" is not unusual, in order to explore the implications of policy alternatives or policy action to meet a given target. What was unusual, (and was criticized in the public debate), was that the four scenarios, (with two cases each, all of which were by definition meeting the policy targets for 2050), were compared against the reference case (forecasting) which was the only scenario with no prolongation of nuclear, and that there was no alternative back-casting case without prolongation of nuclear as an equivalent vehicle for comparison. The comparison thus seemed to suggest that the de-carbonization targets could only be met by prolonging the lifetime of nuclear reactors.

The main parameters were set by the government, in discussion with the institutes, which led to the fulfilment of the government targets on de-carbonization and share of renewables[68]. The main questions to be answered by the scenarios were about the import/export balance of power exchange with other countries and the economic consequences depending on the length of prolongation of nuclear.

The mix of fossil fuels especially in power generation between coal/lignite and gas, was predetermined by the assumptions:

- CCS was assumed to be available at full commercial scale by 2025,
- power demand was assumed to be reduced through efficiency measures; and,
- of equal importance in an equilibrium model, the relation of coal to gas prices and the assumed price development of carbon emission rights were chosen by the institutes[69].

While for 2050 gas-fired and coal-fired capacity (50% with and 50% without CCS) are broadly the same in all scenarios, coal-fired power was running in middle–merit load, while gas had a purely back up function (i.e. a load factor close to zero)[70].

In this way 'the rabbit (of nuclear prolongation) was put into the hat' and the political debate on the merits of prolonging the lifetime of nuclear plants, but also about the role gas could play in de-carbonizing the energy and especially the power sector, was avoided and hidden by the setting of parameters, which per se might not be unreasonable, but the implications of which were not discussed.

While the institutes explicitly mentioned the assumptions provided by the government, such finessing was lost in the public debate. What one would have expected in such target scenarios was an explicit analysis of the effects of variations of the assumption made on reaching the given goal of de-carbonization, inclusive of actions to compensate for 'reality' diverging from initial assumptions as time progressed.

(These issues were raised later by the four experts and also by an EWI study, see sections 2.2 and 2.4)

This consequent setting of an 80-95% GHG reduction target for 2050 and breaking this down into decennial landmarks with a discussion of the instruments to achieve the objectives was certainly a positive step in defining a credible de-carbonization-based energy policy. This

[68] EWI, GWS, Prognos (2010),, p. 3 ff
[69] EWI, GWS, Prognos (2010),, p. 30
[70] EWI, GWS, Prognos (2010), table A 1-12

would have provided an excellent opportunity to discuss the role of gas (of course also of coal) in the transition to achieving these interim targets and for achieving the long term 2050 target. This could have included an analysis of how much faster (or more reliably) the target(s) could be achieved by fostering the use of gas for power generation instead of coal.

### *(ii) Financing the Energy Policy*

From 1999 the costs of fostering renewables were born by a special fee on electricity customers, however with some exemption for energy intensive industries, the scope of exemptions was substantially expanded under the conservative government.

The basic idea of the EEG was to share the costs of bringing renewables to a commercial stage amongst electricity consumers and not to fund it from the state budget. Through its design (feed in tariffs combined with an obligation on the grid operator to take all renewables unless grid stability was at risk) this would ensure effectiveness of fostering renewables by providing strong incentives and ensuring that all renewable generation available would be used. By placing the burden on electricity consumers the "Verursacherprinzip"[71] was to some extent implemented, with the exception being energy/electricity intense industries. (Here one could make the principal argument that such industry is better located in other countries where comparative advantages are more favourable, especially when their products – aluminium being the typical example - are relatively inexpensive to transport over long distances).

Subsidies from the budget were focused on supporting CHP[72], even though this only supplemented a voluntary agreement with the industry to increase efficiency. In addition some support programs for efficiency measures and building insulation were established[73].
As most nuclear plants were already essentially depreciated and being cheaper than electricity production from fossil fuels on a marginal cost basis (not accounting for the costs of waste disposal nor for the potential costs of dealing with nuclear disasters) a prolongation would create additional windfall profits for the nuclear industry, even taking into account additional costs for the refurbishment required for the prolongation of the permits for the nuclear plants.

Before entering the parliamentary procedure for the New Energy Concept, the issue of sharing costs and benefits of a prolongation of nuclear plants was discussed with the nuclear power industry.

### *Special Fund to Share the Benefits of Prolonging the Operating Time of Nuclear Plants*

The government raised two issues with the nuclear power industry: a new tax on nuclear fuel of about €2.3 billion/year and a 50/50 sharing of the extra profit from the nuclear prolongation between the state budget and the nuclear generating companies.

While the power industry accepted the concept of sharing the extra profit from prolongation of their nuclear plants it preferred the solution of a fund. The government made it clear that the

[71] Principle that those causing damage or costs must bear the costs
[72] KWK. (2001, May 14)
[73] BMWI (2012a)

tax on nuclear fuel was a stand-alone fiscal measure in view of the enormous costs linked to the cleaning of Asse II (explained in more detail under "Tax on nuclear fuel" below), a site for the disposal of nuclear waste. The government took up the idea of a fund and negotiated it behind closed doors with the four nuclear generation companies until some intelligence was inadvertently leaked, whereupon due to public pressure, the status of negotiation was released to the public and also made part of a briefing to parliament[74].

As a result a fund was created (Energie und Klimafonds - EKF) which would be financed by the nuclear power industry, but also by the income from the auctioning of emission trading rights out of which measures for renewables and research would be underwritten. With the cancellation in 2011 of the prolongation of nuclear and the failure of the ETS this fund is now at risk of depletion.

### *Tax on Nuclear Fuel*

An element of the discussion which created strong tensions in the run up to the new Energy Concept was the introduction of a tax or fee on used nuclear fuels.

The compromise between the Red Green government and the four large power companies in 2000 explicitly renounced any unilateral measures discriminating against nuclear energy including taxation, as part of a quid pro quo for achieving a compromise on the phasing out of nuclear energy[75].

Such a tax on nuclear fuel could be justified based on the fact that the final disposal of radioactive waste was organized by the government out of its budget. In 2010 the government, explicitly referring to its budget consolidation policy, introduced the idea of a tax on nuclear fuel aiming at an extra revenue of about €2.3 billion/year for the years 2011 to 2016 inclusive.

The government took issue with the costs of cleaning up the Asse II site for disposal of low and medium level radioactive waste as well as with the windfall profits realized by the power generators due to the free allocation of $CO_2$ emission rights, the price of which was effectively included in the wholesale price and passed to final consumers. Asse II is an old salt mine in Lower Saxony which was used between 1967 and 1978 as a large scale pilot project for the disposal of low and medium level radioactive waste. Some 120,000 barrels of radioactive waste were disposed of in the caverns created by the former mining of salt, to a large extent without any retrieval option. In time, concerns raised earlier in the permitting procedure were confirmed, that ground-water was entering the mine which was now also in danger of collapsing. The total income from charges for the disposal of nuclear waste in Asse II was only a few million Euros. The concept for the clean-up of Asse was to retrieve the waste for disposal at a more suitable facility. Costs are estimated at a minimum of €2 billion; some estimates are as high as €6 billion[76]. The Federal Ministry of Finance in September 2010 publicly committed to pay for the clean-up (in line with the coalition agreement) instead of the local state of Lower Saxony where Asse is located.

[74] Spiegel Online. (2010, September 9)
[75] BMU. (2000, June 14), p. 7
[76] Spiegel Online (2013, April 20)

In the final version of the Energy Concept the tax on spent fuel of €245/g of Uranium or Plutonium, which translates into about €20/MWh of electricity produced was enacted as a separate piece of legislation[77]. The tax is due when the nuclear fuel is loaded into the nuclear reactor. It was maintained also in 2011, when the prolongation of the operating life of nuclear plants was rescinded. As a consequence of the closure of 8 nuclear reactors the income from the tax was reduced from €2.3 billion to €1.3 billion/year.

While the prolongation of the lifetime of nuclear plants was regarded as a quid pro quo by the four large utilities, there was no formal link between the tax on spent nuclear fuel and the prolongation of the lifetime of nuclear plants in contrast to the energy and climate fund (EKF) which was clearly based on a prolongation of nuclear.

### *(iii) Stability of the Power Grid/Reliability of Power Supply*

In hindsight it is conspicuous that the grid and back up issues stemming from the replacement of nuclear by renewables were not addressed earlier. As late as 2009 the future operation of the high voltage grid was discussed and consideration was given to creating a national power grid organization [78]. At the end of the legislative period 2005 – 2009 a law on the expansion of the power grid was enacted (Netzausbaugesetz 2009[79]).

DENA commissioned two grid studies: DENA Netzstudie I which was published on February 23, 2005[80], and a follow up to look at the years 2015 – 2020 with perspectives to 2025 which was published 5 years later on November 23, 2010[81], indicating disagreements between the participating representatives of the large power companies and the renewable industry and arriving rather late in the day to contribute to a solution of the grid related issues. This somewhat lacklustre approach to an issue which is now very much in focus might be explained by the anticipation of a change in government which would reverse the phase-out legislation of 2002 and postpone the time when issues relating to replacement of nuclear power would need to be addressed, but also by a lack of anticipation of the effects of renewables on grid operation which, at the beginning of the decade, were within what the system could handle especially if also using nuclear plants for managing load variations.

Another possible explanation is the split of responsibility which came with unbundling. Managing power grid reliability is a combination of grid management and load management which, at the beginning of the decade in each of the areas of the four large power companies, was under a uniform control with some coordination across the areas. This arrangement was certainly able to cope with fluctuating feed-in of renewable energy in the early days of renewables roll-out.

As of 2005 BNetzA became responsible for regulation of grid-bound power and gas, triggered by the implementation of the EU internal market directives. The BNetzA then had to build up its expertise in grid issues which were in the hands of the four large companies until they were sold or had unbundled their grid activities. The unbundling by the 3rd Energy Package[82]

[77] BGBl. (2010, December 8)
[78] BMU. (2009, May)
[79] Bundesministeriums der Justiz. (2009, August 21)
[80] dena. (2005, February 23)
[81] DENA. (2010, November 11)
82 The 3rd package consists of: Regulation (EC) No /13/2009 (Creating ACER), Regulation (EC) No 714 and 715/2009 access conditions for electricity and gas and Directives 2009/72 and 73/ EC concerning common rules for

adopted by the EU Parliament on April 29, 2009 and published in the Official Journal of the European Union on August 14, 2009 seemed to rely on market forces to establish reliability of grid operation and the necessary power balance, especially as balancing markets were created suggesting that the short-term physical balance could be delivered by the market alone. A decisive element was probably the EU single market objective because the unbundling resulting from the 3rd package in 2009 placed the formerly integrated balancing responsibility beyond the remit of the four companies so that there was unclear accountability for the overall stability of the system. Instead of integrated responsibility for grid and back-up power, these issues had to be managed across an interface between market-driven power generators and regulated grid companies with an additional, new, split decision-making process between the TSO and the regulator BNetzA. It was also not clear where in the government administration the responsibility for reliability of grid operation and power balance was located.

Following a decision by the EU Commission of November 26, 2008[83] E.oN offered its power grid for sale, which was realized on November 10, 2010[84], following the sale of the grid of Vattenfall announced on November 3, 2009[85]. RWE followed later on July 14, 2011 with the sale of the majority shareholding in its grid while keeping a 25.1% minority share[86]. EnBW instead chose the ITO model and kept ownership of its unbundled grid, now under a separate entity called TransnetBW[87].

In any case the high voltage grid expansion was already lagging behind the needs of increasing onshore wind generation. By contrast PV which is fed in to the lower voltage grid is roughly in line with the demand curve over the day, even though it is subject to predictable variations in its size due to season but also to erratic reductions due to cloud cover. PV reduces the mid-day peak demand making peak load plants such as gas fired power plants uneconomic.

The linkage of offshore wind power is facing a chicken and egg situation: offshore wind parks need cables to tie in their power while offshore cables will only be built once it is clear they will be utilized and so get reimbursed, an issue addressed by government action[88].

### *Potential of Nuclear Power to Manage Load Variations (Lastfolgefähigkeit der KKW)*

During the run up to the Energy Concept, studies on prolonging the lifetime of the nuclear plants were published showing that nuclear plants could provide the flexibility to compensate for the intermittence of renewables necessary for the management of the frequency stability of the grid. This was not denied by the green movement regarding the mechanical and thermo-dynamic aspects but was put into question regarding impacts on the nuclear part of

the internal market in electricity and natural gas; published in the Official Journal of the European Union L211 Volume 52 14 August 2009; at: Official Journal of the European Union. (2009, August 14)

83 Phillippe Chauve and others, Competition policy newsletter 1/2009 (2010, November 11)

84 DENA. (2010, November 11)

85 Spiegel Online (2009, November 3)

86 Spiegel Online. (2011, July 14)

87 Transnet BW. (2012, March 2)

88 BMWi. (2012, August 29)

the plant and in view of the permissions based on a base load operation[89]. It was claimed that nuclear plants were a perfect match for renewables because of their large capacity to follow variations of electric load (Lastfolgefähigkeit) to balance the variation in power supply which resulted from introducing more renewables. The ability to change the power output of nuclear plants (when operating in the higher load range with a gradient of about 10% of peak capacity/minute for a reactor of between 1000 and 1400 MW, i.e. in absolute figures a load variation of between 100 and 140 MW/minute) is based on the possibility of rapid regulation of the nuclear energy produced transformed into steam and in view of the low temperature inlet to the nuclear steam turbine (at about 350°C) as compared to about 600°C of fossil fuel fired steam turbines. The high variability of steam production and the faster reaction of the saturated steam turbine could not be doubted – also in view of increasingly more frequent occasions when several nuclear plants were run in load following mode at the end of the 2000s. In mid-2013 many nuclear plants in Germany, e.g. the nuclear plants in Bavaria, continued to be operated in load following mode[90].

### 1.1.3 The New Energy Concept

On September 28, 2010 the cabinet decided on the “Energy Concept for an Economically Sound. Reliable and Affordable Energy Supply” and tabled it to the parliament (Bundestag)[91]. The same day the government´s coalition submitted the following drafts to the Bundestag:

- Draft 11th law to change the nuclear law[92]: prolonging the lifetime of nuclear plants by 12 years on average: 8 years for plants which started operation before 1980 and 14 years for the other plants;
- Draft 12th law to change the nuclear law[93]: implementing EURATOM directive 2009/71 regarding nuclear safety;
- Draft law to create a fund for climate and energy[94], to be financed from the profits of prolongation of nuclear and as of 2013 from the earnings from auctions of EUAs;
- Draft law to tax nuclear fuel[95]: levy of a tax on nuclear fuel resulting in €2.3 billion/year for the years 2011 to 2016;
- A request to acknowledge positively the Energy Concept presented by the government the same day and to request the federal government to implement the Energy Concept by submitting the legislation necessary for its implementation, give high priority to research and inform the parliament every three years about the results of the monitoring[96].

These drafts were all approved by the Bundestag on October 28, 2010 with the government majority outvoting the three opposition parties after heavy debate[97]. The opposition parties announced that they would take the law on prolongation of nuclear to the Constitutional Court (Bundesverfassungsgericht) because they claimed that the rights of the Länder (the states) were not respected by the law. The complaint of five SPD-governed states was then submitted to the Constitutional Court on February 28, 2011[98].

[89] Greenpeace (2011, January)
[90] Bayerischer Landtag. (2013, September 13).
[91] Deutscher Bundestag. (2010, September 28-1)
[92] Deutscher Bundestag. (2010, September 28-3)
[93] Deutscher Bundestag. (2010, September 28-4)
[94] Deutscher Bundestag. (2010, September 28-5)
[95] Deutscher Bundestag. (2010, September 28-6)
[96] Deutscher Bundestag. (2010, September 28-2)
[97] Deutscher Bundestag. (2010, October 28)
[98] Frankfurter Allgemeine. (2011, February 28)

In this way three elements were decided on October 28, 2010: the prolongation, a tax on nuclear fuel and the creation of a fund to be fed by extra profits from prolongation of nuclear and as of 2013 from auctioning of EUAs. The legal acts to implement the New Energy Concept were to come later (in fact most would be decided on June 30 and July 1, 2011 together with the Energiewende).

Prolonging the lifetime of nuclear plants by eight/fourteen years opened up (in line with the long-time declared policy of the conservative parties) the agreement reached with the industry by the Red Green Government in 2000. The resulting discussion of the energy concept in 2010 was therefore very much focused on the role of nuclear while de-carbonization targets and instruments were little discussed. De-carbonization targets, together with other targets in the Energy Concept were detailed by decade as were the means to reach them. Germany through the New Energy Concept became a frontrunner internationally in promoting an 80% plus GHG reduction target by translating it, and the instruments and procedures to implement it, into a government declaration supported by the government majority in parliament.

**Table 2: Status Quo and Quantitative Targets of the Energy Concept (2010)**

| | 2011 | 2020 | 2050 | | |
|---|---|---|---|---|---|
| **Greenhouse Gas Emissions** | | | | | |
| Greenhouse Gas Emissions (in contrast to 1990) | -26.4% | -40% | 2030 -55% | 2040 -70% | 2050 -80% to - 95% |
| **Efficiency** | | | | | |
| Primary energy use (in contrast to 2008) | -6.0% | -20% | -50% | | |
| Energy productivity (final energy use) | 2.0% per year (2008-2011) | 2.1% per year (2008-2050) | | | |
| Gross electricity consumption | -2.1% | -10% | -25% | | |
| Share of CHP-generated electricity | 15.4% (2010) | 25% | - | | |
| **Buildings** | | | | | |
| Heating demand | no data | -20% | - | | |
| Primary energy demand | no data | - | in the order of -80% | | |
| Refurbishment rate | about 1% per year | doubling 2% per year | | | |
| **Transport** | | | | | |
| Final energy use | around -0.5% | -10% | -40% | | |
| Number of electric vehicles | ca. 6600 | 1 millon | 2030 6 million | - | |
| **Renewable energy sources** | | | | | |
| Portion of gross electricity consumption | 20.3% | at least 35% | 2030 at least 35% | 2040 at least 50% | 2050 at least 80% |
| Portion of gross final energy consumption | 12.1% | 18% | 2030 30% | 2040 45% | 2050 60% |

Source: [99]

[99] BMWi (2012a). p. 16

In more detail the following issues were to be addressed by new or modified legislation: (See also chapter 1.2.2 on institutions and instruments)[100]:

A. Renewable energies as a cornerstone of future energy supply
B. Energy efficiency as a key factor
C. Nuclear power and fossil-fuel power plants
D. An efficient grid infrastructure for electricity and integration of renewables
E. Energy upgrades for buildings and energy-efficient new buildings
F. The mobility challenge
G. Energy research into innovation and new technologies
H. Energy supply in the European and international context
I. Transparency and acceptance

### *What Were the Differences of the New Energy Concept Compared to Previous Energy Policy?*

Above all was the controversial prolongation of nuclear plants. While the first decision in parliament in 2002 on the phase-out of nuclear was taken by the then Red Green majority against the minority of Christian Democrats and Liberals, this time it was the other way around: a decision which was based on continuing the divide – at least in parliament.

Sharing the extra profits was the price tag for the industry while the tax on nuclear fuel was regarded as adjusting or clawing back extra profits of the past from free EUAs and covering the costs of the careless disposal of nuclear waste in earlier years in Asse.

### *What was New in the New Energy Concept?*

On de-carbonization the New Energy Concept continued the policy of previous governments (as was mentioned in the coalition agreement) so it was rather more of an update of the previous de-carbonization policy, with the exception of nuclear policy. By prolonging nuclear it took some heat out of the issue of how to deal with an increasing share of renewables in the grid, which would become a more imminent problem if nuclear was to be closed down because (i) of a reduction of dispatchable power and (ii) regional disparities created by the closure of nuclear plants in the south of Germany.

A monitoring process (already conceived by the Meseberger Conference) was established to keep track of the project and to analyse the effectiveness and efficiency of the instrument mix applied and to modify it if needed. Every three years, starting in December 2014, a progress report is to be presented showing the status of implementation together with a detailed analysis for major elements giving recommendations where needed[101].

Later on, after the changes in 2011, the requirement for an annual monitoring report was added. Every year by December 15, starting in 2012, the government has to present a monitoring report (issued by BMU and BMWi) to parliament with the main facts and indicators relevant to the objectives of the project as well as a list of measures taken by the government

[100] Deutscher Bundestag. (2010, September 28-1).; p. 1
[101] Deutscher Bundestag. (2010, September 28-2). p. 2

and their status. (See section 2.4 for a description of the first report). The process also involves four Independent Energy Experts giving an independent comment on the government's report in the form of an annex. Every third year there will be a progress report with a deeper analysis.

The new Energy Concept of 2010 defined a comprehensive Energy Policy guided by the conclusions of international organizations following the fourth assessment report in 2007 of the Intergovernmental Panel on Climate Change (IPCC) to reduce GHG emissions by 50% and the burden sharing agreed e.g. at L'Aquila that industrialized countries should reduce their GHG emissions by at least 80%. In that context nuclear was chosen as a bridge fuel to a decarbonized economy while the role of gas was at best addressed implicitly (except for power to gas, a technology under development for storing surplus renewable electricity).

De-carbonization objectives and instruments were further developed without big differences from the policy of previous governments. As before the large potential benefit of fuel switching to gas from coal/lignite in power generation was not mentioned at all.

By translating the international target of minus 80% and more into a concept acknowledged and supported by the parliament Germany was going beyond previous governments which informed parliament about their concept but then involved the parliament only with concrete draft laws. Presenting a comprehensive energy concept probably also reflected the progress made in the international discussion, especially the progress from the 3rd to the 4th IPCC assessment report. By breaking the targets for 2050 down into decennial periods the new Energy Concept took very important steps for practical and verifying purposes.

Also the monitoring mechanism foreseen every three years was not completely new. Some single policy elements as well as the IEKP already provided for reporting and monitoring. It certainly made sense in the context of an integrated concept, offering the possibility to adjust the policy mix if needed or useful, and demonstrated the political will to reach the targets of de-carbonization.

### 1.1.4 Fukushima and Following Debate

Then came the disaster of Fukushima (on March 11, 2011) and with it a revival of the historically strong anti-nuclear movement in Germany, especially in Baden-Württemberg, which was facing local elections. Within days of the Fukushima disaster Chancellor Merkel decided, to impose a moratorium of three months on the prolongation of nuclear power [102] because (in her own words) Fukushima demonstrated that even a country like Japan was not able to master the challenges of nuclear power. (Some say the decision was taken in view of the risk of a political swing such as that shown in elections in the state of Baden Württemberg on March 27, 2011). The first step was a moratorium pronounced on March 15 for the 7 oldest nuclear plants[103] which under the old law were due for shutdown at the latest during 2012 but had been prolonged by 8 years in 2010. By decision of the federal government and the Prime Ministers of the states with nuclear plants (Bavaria, Baden Württemberg, Hesse, Lower Saxony, Schleswig Holstein) these nuclear plants were to be taken off grid for 3 months to undergo safety investigations. In addition the nuclear plant at Krümmel (operator: Vattenfall) which had been shut in for repair and maintenance since July 2007 and after

[102] Bundesregierung. (2011, March 11)
[103] Zeit Online. (2011, March 15)

coming back into operation in in June 2009 had to be shut in again after two weeks of operation, was included in the moratorium. On March 18, 2011 Philippsburg I and Neckarwestheim I (EnBW) went off-grid followed by Isar 1 and AKW Unterweser (both E.ON) as well as Biblis A (RWE), so that all together 5,000 MW were taken off grid in an unplanned manner. Brunsbüttel like Krümmel (both Vattenfall) were closed for maintenance and had already been off grid for more than two years. Biblis B had been closed for maintenance since end-February 2011, so that together 8,422 MW were off grid as a consequence of the moratorium. In addition Grafenrheinfeld with 1,275 MW was also taken off grid for planned maintenance on March 26, 2011.

Nevertheless the local election held a week later on March 27, 2011 in Baden Württemberg, a traditional stronghold of both the CDU and FDP was lost for both parties (each losing about 5% of the vote and as a consequence the majority to form a government[104]) also for local reasons beyond the nuclear question. For the first time in the history of Germany, Baden Württemberg did not have a conservative government, but a Green Red Coalition with the Green Party coming in with a higher vote than the Social Democrats.

On April 11, 2011 BNetzA published a first assessment of the moratorium (in collaboration with the four System Operators)[105], indicating that taking 5,000 MW off the grid almost overnight created an unprecedented challenge, but was still within the limits for managing grid reliability.

In an update of May 26, 2011[106] it was confirmed that keeping the plants off grid would create a difficult situation for winter 2011/12 but subject to further analysis (and possible actions like mobilizing cold reserve) a reliable power supply could still be maintained.

### *The Ethics Commission*

Bypassing existing parliamentary institutions (committee on sustainable development, also the ethics committee of the parliament, focused more on biology and medical issues) the government installed an ad hoc Ethics Commission with members chosen by the government to look into the issue of termination of the use of nuclear[107]. The Ethics Commission was chaired by Klaus Töpfer (former Minister of Environment under the Kohl government and later head of UNEP) and by Professor Matthias Kleiner, President of Deutsche Forschungsgesellschaft (German Association for Research) with a relatively broad representation of society (churches, workers' unions, researchers etc.). The Commission worked from April 4, 2011 until May 28, 2011 and then gave its report on May 30, 2011[108] with the following results:

- The main merit of the report of the Ethics Commission was to lay the ground for a broad consensus in the upcoming vote in the parliament on the phase out of nuclear and especially to attract the vote of the conservative parties of the Chancellor’s CDU/CSU and FDP coalition, in contrast to the votes in 2002 and 2010 which were split along party lines.
- The main argument on ethics was a distinction between a rejection of nuclear energy based on categorical grounds and a weighted judgment in view of the alternatives available.

[104] Statistisches Landesamt Baden-Württemberg.( 2013)
[105] BNetzA (2011, April 11)
[106] BNetzA (2011, May 26)
[107]Bundesregierung. (2011, March 22)
[108] Bundesregierung. ( 2011, May30)

In practical terms both positions would lead to the same conclusion to replace as soon as possible the use of nuclear energy by less risky energies having due regard to ecological, economic and social aspects. This created a bridge for many conservatives in parliament to vote for a phase-out and to end the split in parliament (and society) on the nuclear issue. On the basis of the Ethics Commission one does not have to reject nuclear energy in principle, it was sufficient to share the unanimous judgment of the Ethics Commission that nuclear energy could be replaced in Germany in an ecologically, economically and socially acceptable manner.

- Beyond the 10 pages on ethical issues (categorical vs. relative rejection of nuclear) the Ethics Commission came up with about 50 pages of additional analysis and recommendations.
- For the new energy policy of withdrawing from nuclear and replacing it by renewables, while strictly de-carbonizing the economy would become a major challenge affecting all aspects of society, they proposed the creation of a special parliamentary institution (Parlamentarischer Beautragter für die Energiewende: Parliamentary Representative for the Energiewende) and a more public institution (Nationales Forum Energiewende) as a focus for a broad public discussion (also in view of the federal structure of Germany). While the second chamber (Bundesrat) was supportive of such institutions, the government reduced the idea to an annual monitoring report with comments from four independent experts.
- In its discussion the Ethics Commission also tried to take a more holistic view and to address the changes needed in the context of broader social issues such as housing, urban development and traffic. (This issue was also taken up later by the expert commission of the monitoring process which discussed, for instance, collateral effects of biomass or the use of land).

Interestingly the Ethics Commission devoted two pages to the role of gas, under the title: “Erdgas hilft, um Versorgungslücken klimafreundlich zu schließen” (Natural gas helps to close [energy] supply gaps in a climate friendly way)[109]. It explicitly mentioned that this subject was missing in the Energy Concept of 2010 and that it should be addressed now. It pledged that natural gas would have a crucial role in bridging the gap especially in power generation. It saw the possibility for diversification of supplies and in view of the possibility of writing off the gas-fired power plants before 2050, no economic risk of lost investment. It also mentioned bio gas (provided it was not in competition with food production) and the prospects for power to gas. For coal-fired power the focus was to replace old plants with efficiencies as low as 30% by the modern ones already under construction.

### *Discussion on Final Closing Dates*

During the months following Fukushima, parallel to the discussion of the Ethics Commission, controversial debate was stirred about whether to promote a final date for closing all reactors and in that context by some political movements, what should be the role of gas.

The original law of 2002 foresaw a limit on the total volumes to be produced by any single nuclear reactor (and in total) with a possibility to transfer volumes from older reactors to newer reactors. This was under normal operating conditions tantamount to a final closing date. However, this proved not to be necessarily the case. Several reactors which would reach their total allowable remaining volumes before the decision by the coalition in 2010 to

[109] Bundesregierung. ( 2011, May30) . p. 82 ff

further prolong their lifetime, such as Biblis A. were taken off grid for maintenance shortly before the exhaustion of their remaining operating volumes, thus avoiding a final cessation which would otherwise have been triggered.

On March 22, 2011 the SPD submitted a draft law to parliament, stipulating the closure of all reactors which were subject to the moratorium on account of safety deficits[110]. The main argument was that they were not designed to withstand the crash impact of a large plane. This was put forward with a view to cut off any claims for expropriation as well as to stop the transfer of remaining production volumes from one reactor to another – except for the agreed transfer of originally 107 TWh from Mülheim-Kärlich to six specified other nuclear plants. By this draft law the overall amount of nuclear electricity generated would have been possibly less than the total volume previously intended because of the non-transferability of volumes and the possibility that the supervising ministry could close nuclear plants on the grounds of safety concerns.

Shortly after the Fukushima accident requests arose for a finite date of closure of the remaining nuclear plants. The SPD committee (Präsidium) named 2020 as the date for final closure on March 14, 2011[111]. The issue was then raised by the "Länderrat" (small party convention) of the Green Party in Mainz on March 19, 2011 which claimed a final closure by 2017[112], while Die Linke (The Left Party) came up with a request to close all nuclear plants by 2014 in a petition to the Bundestag on June 8, 2011[113]. On the side of the parties forming the government it was the Bavarian CSU which first raised the issue (final closure by 2020 at the latest by 2022) in early May 2011[114]. Others also participated in the debate: The President of UBA considered that a closure by 2017 was possible without problems for electricity supply[115].

Participants at the Deutscher Kirchentag (Annual meeting of the Protestant Church) suggested closing by 2020 if not 2015[116].

Other analysis such as that of the WWF Germany at the end of March 2011[117] came to the conclusion that a complete phase out by between 2015 and 2020 was feasible and referred to the speedy expansion of gas-fired power in Spain in the first decade of this century as an example of a quick build-up of gas-fired capacity. Consideration of the $CO_2$ effects would be left to the ETS market.

BDI published a study[118] which compared a phase out by 2017 (apparently as a response to the proposal by the Green Party) with the phase out according to the New Energy Concept and found that it resulted in much higher prices and costs, but did not question the feasibility of a phase-out by 2017. The Green Party on May 25 2011 tabled a draft law for closing reactors [119] at the latest after 28 years of operation, under which the last reactor (Neckarwestheim 2) would go off grid on April 15, 2017.

[110] Deutscher Bundestag. (2011, March 22)
[111] SPD. (2011, March 14)
[112] BÜNDNIS 90/DIE GRÜNEN. (2011, March 19)
[113] Deutscher Bundestag. (2011, June 8)
[114] Merkur Online. (2011, May 2)
[115] Frankfurter Rundschau. (2011, March 11)
[116] Kirche in Hamburg. ( 2011, June 3)
[117] Öko-Institut e.V. (2011, March)
[118] R2B ENERGY CONSULTING GMBH. (2011, April 20)
[119] Deutscher Bundestag. (2011, May 25)

In the discussion on fixing a final date for all nuclear power production and individual closing dates for each individual reactor there were two fears:

- A fear that by not fixing a final date the end of any nuclear power generation would be stretched by the four nuclear companies by expanding maintenance or by running the reactors in partial load; and
- A fear that all remaining reactors would remain in operation until the end of 2022 creating a situation where the simultaneous closure of 9 plants with a total of 12,500 MW would create a situation which could not reliably be managed (too much to be closed over a short period) and might be an invitation for another policy turn around (Energiewende).

In a meeting on June 3, 2011 with the prime ministers of all Länder (Federal States) Chancellor Merkel accepted a staggered plan under which in the years 2015, 2017 and 2019 one reactor each should be closed and the remaining six reactors would be closed in 2021 and 2022 (each year three reactors)[120]. Coincidentally (or not) this scheme would still allow the production of all the remaining planned/allowable electricity volumes, assuming normal operation. Still the federal government insisted on keeping open the possibility of having one nuclear plant in cold reserve for winter 2011/12 and later for 2022/2023. Having power capacity in cold reserve means that a mothballed power plant can be mobilized usually within some weeks maybe months. While this is a known concept for fossil fuel-fired plants, and is used just in case some operating plants are not available for the winter peak, for example because of prolonged maintenance, the concept had so far never been applied to nuclear plants. Later on August 31, 2011 the BNetzA communicated[121] that no nuclear cold reserve was needed, and that no closed down nuclear plant should serve as cold reserve, but other fossil fuel cold reserve was available in southern Germany and Austria, which the grid operators took under contract.

Apart from maybe some clandestine hope of keeping the largest and newest nuclear plants in operation beyond 2021/22 the discussion was driven by concerns over reliability of power supply in the aftermath of the now unexpected and sudden final closure of 8 nuclear plants. With a reduction of overall electricity consumption the additional renewable capacity foreseen for 2020 would produce enough electricity to replace production from nuclear power without additional $CO_2$ production. It was clear that the integration of more and more renewables would result in a completely different load management challenge, which would not only have to balance variations of demand but also variations of supply from renewables. An almost one to one capacity back up would be needed at least for wind power, as there could be periods of several days in a row with low wind. The role of gas was regarded as compensating for missing power or managing load variation, due to the phase-out, but not on its $CO_2$ saving potential vis-a-vis coal. Typically the paper by the government of Baden Württemberg sought some form of capacity market to make the investment in gas-fired power economically feasible[122]. However, in 2012 and 2013 some brand new gas-fired power plants were shut down, as the low price of coal relative to gas did not allow gas-fired plants to cover their costs and keep the plants operational[123].

[120] Süddeutsche Zeitung. (2011, June 3)
[121] BNetzA (2011, August 31)
[122] Baden Württemberg, Ministerium für Umwelt, Klima und Energiewirtschaft; Mai 2011; Positionspapier der Landesregierung zur Energiewende at: http://www.um.baden-wuerttemberg.de/servlet/is/82460/Anlage.pdf?command=downloadContent&filename=Anlage.pdf
[123] Reuters Deutschland .( 2011, March 6)

Perhaps due to the rather sudden closure of substantial generation capacity the focus of the discussion of the Energiewende was not on de-carbonization but rather on maintaining a reliable power supply after the decision to phase out nuclear and eventually integrate renewables. Maybe also because the political issue of nuclear was more a ‘yes or no’ question, whereas de-carbonization, on which there was no dissent in principle, involved dozens of legislative measures (see later).

### *Addressing the Role of Gas*

Some political groups were explicitly addressing the role of gas.

At the end of April 2011 the Bavarian sister party of the CDU, the CSU announced a road map on how to replace nuclear electricity by gas-fired electricity by 2021[124]. The Bavarian Government on May 24, 2011 then presented a “Bavarian Energy Concept; Innovative Energy” which named the expansion of existing infrastructure as a major challenge and pleaded for the building of additional gas-fired power plants and a corresponding expansion of the gas grid[125]. It also indicated 5 sites for new 800 MW CCGTs to compensate for the closure of the nuclear plants in Bavaria by 2022.

After the decision on the Energiewende the Bavarian parliament on July 13, 2013 installed a commission to follow up on the implementation of the Energiewende in Bavaria[126].

NGOs mainly Greenpeace on May 29, 2011 presented a concept for phasing out coal and lignite by 2030/2040[127].

### 1.1.5 The Energiewende

The net result of all this discussion was to return to the compromise of 2000/02 (now with fixed final closing dates for each reactor) and to establish an annual monitoring report jointly by BMU and BMWi with comments by four independent experts.

The cabinet on June 6, 2011 approved a legislative package for a phase-out reversing the prolongation of 2010 and confirming that the 8 reactors affected by the moratorium would definitely go off grid, while fixing closing dates for the rest of the nuclear plants[128]. In addition various draft bills were approved to implement the components of the de-carbonization part of the New Energy Concept[129].

A very short piece of legislation – given the weight of the issue – just one page (“Entwurf eines Dreizehnten Gesetzes zur Änderung des Atomgesetzes”) tabled on June 6, 2011 saw the reversion to the original consensus of 2000/02 now with the confirmation that the 8 reactors (Biblis A, Neckarwestheim 1, Biblis B, Brunsbüttel, Isar 1, Unterweser, Phillipsburg 1 and Krümmel) under the moratorium would be definitely closed and defining a concrete

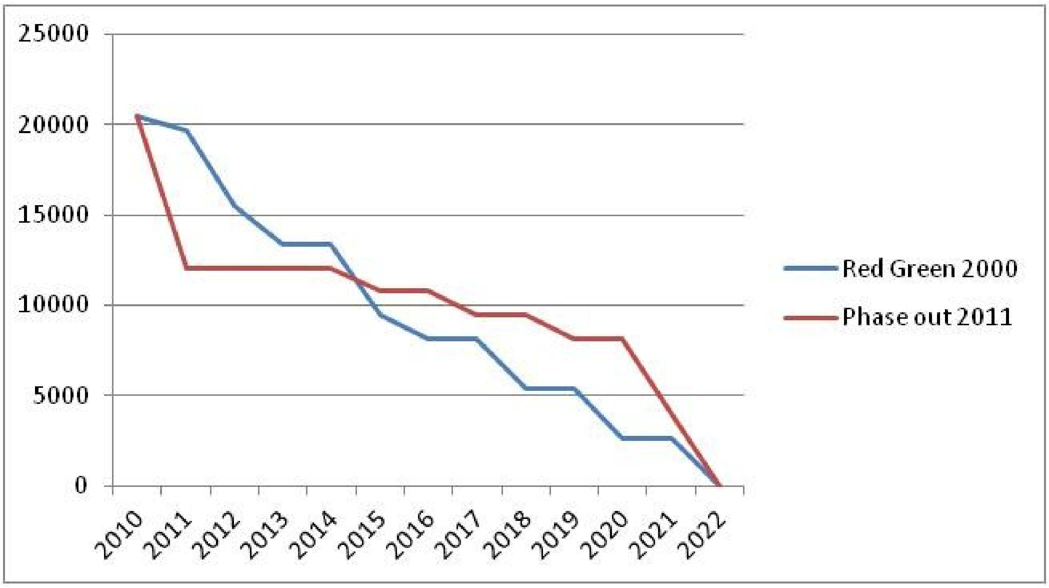
[124] n-tv. (2011, April 29)
[125] Bayerische Staatsregierung. (2011, May 24)
[126] Bayerischer Landtag. (2012, Septemebr 27)
[127] Greenpeace. (2012, May)
[128] Deutscher Bundestag. (2011, June 22)
[129] BMU. (2011, June 6)

schedule for the closing of the remaining 9 reactors (although they would still be allowed to use all the remaining production volumes, including the volumes left by the 8 reactors closed in and the volumes conceded in 2000/02 to compensate for the disputed closure of the nuclear plant Mülheim Kärlich):

- Closing each by December 31
- 2015: Grafenrheinfeld
- 2017: Gundremmingen B
- 2019: Philippsburg 2
- 2021: Grohnde, Gundremmingen C and Brokdorf
- 2022: Isar 2, Emsland and Neckarwestheim 2
- The possibility was considered of keeping one reactor in cold reserve, but this was later rejected by the BNetzA as neither necessary nor useful.

While this looked radical, it did not differ much from the original decision to phase out nuclear in 2000/2002, except that it gave final closing dates where the previous scheme gave total volumes of nuclear electricity which could still be produced, transferred and eventually accumulated on single nuclear plants, with an implicit rule that remaining volumes should only be transferred from older to newer reactors. The overall difference in remaining volumes compared with the law of 2002 was not that large, See Figure 1 below.

**Figure 1: Remaining Nuclear Power Capacity (In MW) Under the Phase-out of 2000 and 2011**




Source: own calculations

The new scheme with fixed closing dates made the production of the remaining full power volumes vulnerable to any interruption of the operation be it through technical problems or administrative/permitting problems.

The scheme implied that one reactor would close during the legislative period (assuming no snap elections) of 2013 – 2017 and two during 2017 – 2021 and then in the legislative period

2021 -2025 three reactors at the end of 2021 and three the following year, each time taking off about 4,000 MW in the midst of the winter.

The Bundesrat (2nd chamber) in its comments[130] took up the idea of a parliamentary institution to follow the Energiewende which was then transformed by the government into an annual monitoring mechanism.

There were then two pieces of legislation[131]: one taking back the prolongation of nuclear, with fixed closure dates defined and the other a package filling in the framework for the de-carbonization policy. The decision to phase out nuclear was taken almost by unanimous vote in the parliament (only the Left Party – Die Linke - did not agree because it thought that a quicker phase out of nuclear was possible and it wanted the phase-out to become part of the constitution)[132]. Similarly the phase-out was supported by a large majority of the population (a poll commissioned by the chemical industry showed 80% in favour of closing nuclear and only 10% rejected paying for it[133]).

The package consisted of:

- Renewable Energy Act Amendment
- German Energy Act Amendment (unbundling)
- Acceleration of Expansion of Electricity Grid Act
- Energy Efficient Renovations of Residential Buildings Act
- Energy and Climate Fund Act Amendment
- Strengthening Climate Friendly Measures in Towns and Municipalities Act
- Offshore Wind Farm Revision

The package was accepted with voting largely along party lines (on 1 July 1, 2011)[134].

So except for the prolongation of nuclear all other elements of the Energy Concept remained, especially all de-carbonization targets. See Table 2.

Also the decision to tax nuclear fuel (originally ca €2.3 billion/year, now for the reduced number of reactors only €1.3 billion/year) was not touched.

### *Scenarios to Assess the Effects of Energiewende*

The scenarios developed for the new Energy Concept showed a successful route to de-carbonization only in the cases of nuclear prolongation while the non-prolongation case was only represented by the 'Business as Usual' (BAU) projection which did not meet the de-carbonization targets. The missing target scenario was delivered after the decision of parliament to go back to the phase-out of nuclear, by comparing the old scenario II b of 2010 (prolongation by 12 years and individual costs for refurbishment of reactors, which was closest to the decision in 2010) with the now decided non-prolongation case, adapting it also to some recent de facto developments[135]. The result was that economic losses by not

[130] Deutscher Bundestag. (2011, June 22)
[131] Deutscher Bundestag, (2011, July 1)
[132] Deutscher Bundestag, (2011, July 1), p.1
[133] Rp-online ( 2011, September 16)
[134] Deutscher Bundestag. ( 2011, July 1): p. 2, 3
[135] EWI; GWS; Prognos. (2011, July)

prolonging the lifetime of reactors were deemed manageable (between 0.1% and 0.3% of GDP)[136]. The overall additional costs of power generation or import until 2030 would in sum be €16.4 billion in nominal terms or an NPV of €10.5 billion using an interest rate of 3%.

It would have been another good occasion – as also suggested by the parts of the report of the Ethics Commission – to raise the issue of the role of gas and eventually ask about the contribution of gas to de-carbonization and also under what economic or policy-driven conditions it could be realized.

### *Reliability of Power Supply/Grid*

For de-carbonization and reliable power production in the period to 2022 the closing of nuclear under the law of 2011 did not change too much compared to the original law in 2002; some deferral but only a short term effect with regard to capacity questions and resulting grid issues.

The new schedule was supported by a detailed analysis by the German regulator (Bundesnetzagentur = BNetzA) which concluded that the closing scheme for the nuclear plants was challenging but feasible without jeopardizing the n-1 criterion for reliable power supply. In hindsight it is a bit of a surprise that such analysis was not done while the old law of 2002 was still in force. Initially there was a proposal to keep one nuclear plant in cold reserve, however investigations by the BNetzA came to the conclusion that that would not be necessary to maintain the n-1 criterion during the winter 2011/12[137].

In addition the BNetzA carried out a detailed examination of the grid and imposed some concrete measures for the reinforcement of the north-south grid link.

If Fukushima had not happened, tackling the issues stemming from the integration of renewables could have been postponed for many more years, as the prolongation of nuclear would have postponed the $CO_2$ issue for some time to come and maybe also because of the availability of more dispatchable power (and overcapacity for a much longer time). With 8 reactors closed it is expected that maintaining grid stability prior to the closures of the last six reactors in 2021 and 2022 will be manageable.

It is fair to say that some of the problems of a large scale introduction of renewables are becoming clearly visible only now, even though maybe one could have foreseen them earlier. While the intermittency problem was known, it has only recently become apparent what it means to have a capacity of about 30,000 MW each of wind and PV on the grid.

## 1.2 Institutions and Instruments

In sections 1.2.1 and 1.2.2 the institutions and instruments are described as they were before the elections on September 22, 2013 and the formation of a new government on December 17, 2013. This means that although the sections are written in the present tense, and much of

[136] EWI; GWS; Prognos. (2011, July)., p. 33
[137] BNetzA (2011, August 31)

what follows is unchanged, some of the details are now different. An update on the changes implemented or intended by the new government is given in section 2.6.

### 1.2.1 Institutions

*On Federal Level*

**The Parliament**

The parliament consists of two chambers (Bundestag with the delegates from Federal elections) and Bundesrat, the representation of the Federal States' (Länder) governments. The split of responsibility is defined in the Constitution (Grundgesetz) and there are parliamentary institutions to settle conflicts between both chambers and in any case conflicts (usually over the competence of the respective institution) may be referred to the Constitutional Court (Bundesverfassungsgericht).

In general the structure of standing committees of the Bundestag corresponds to the split of tasks between ministries. There is a committee for environment, protection of nature and reactor safety as well as one on economy and technology, but so far none of them has played a prominent role in the Energiewende perceived by the public.

**Government**

Before the elections on September 22, 2013, Germany never had an energy ministry. Responsibility for energy matters is mainly split between the Ministry of Economy and Technology (Bundesministerium für Wirtschaft und Technologie, BMWi) and the Ministry of Environment, Protection of Nature and Reactor Safety (Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, BMU) while the Ministry of Traffic, Construction and Housing (Bundesministerium für Verkehr, Bau- und Wohnungswesen, BMVBW) has de facto a substantial influence on the implementation of the Energiewende.

**BMWi**

Responsibility for the regulation of the power and gas grid lies mainly with the Ministry of Economic Affairs. The Ministry for Economic Affairs has a broad portfolio, where energy is one out of eight directorates dealing with substance (Abteilungen). At the beginning of the century the previous separate section for gas issues under the directorate for energy was merged into the section dealing with liquid energies. BMWi supervises two agencies relevant for energy: the Cartel Office (Bundeskartellamt) and the Bundesnetzagentur (BNetzA), regulator for grids.

**BMU**

All environmental impact issues including nuclear permitting issues are with the Minister of Environment. In the BMU "Energy, climate and international environmental policy" is one out of four substantive directorates. The Ministry of Environment as a relatively new ministry tends to have younger people dedicated to environmental issues and maybe a bit more budget headroom. The BMU was created in 1986 under the Kohl government and except for its first office holder Walter Wallmann (1986-87) all its successors still play a prominent role in German politics:, Klaus Töpfer (1987-1994) (heading the Ethics Commission) and Angela Merkel (1994-1998) (Chancellor since 2005) - all CDU - followed by Jürgen Trittin from the Green Party (party leader of the Green Party until 2013) from 1998 to 2005 then four years until 2009 by Sigmar Gabriel now party leader of the SPD before the office went back to the CDU (first Norbert Röttgen, then Peter Altmeier).

The BMU supervises one agency relevant for energy, the UBA (Umweltbundesamt: Federal Office for Environment). The expert council for environmental issues (Sachverständigenrat für Umweltfragen) founded in 1972 is an independent expert commission under the administrative supervision of but not reporting to the Ministry of Environment.

**Dichotomy between BMWi and BMU**

Since its creation the Ministry of Environment (BMU) has been in the hands of a party different from the Ministry of Economic Affairs (BMWi): CDU/FDP then Green Party/SPD, then SPD/CSU and finally CDU/FDP. This dichotomy is also reflected in different approaches: while the Ministry of Environment tends to emphasize the public good aspects of de-carbonization and environmental protection as a starting point for defining policies, the Ministry of Economic Affairs by tradition emphasizes competition and markets as the applicable instruments. Beyond these fundamental questions, the split of responsibility for energy issues between two ministries tends to create frictions, because relatively simple administrative issues which could be handled under the authority of one minister easily become subject of coalition disputes and profiling efforts. The third ministry involved in de-carbonization politics the Ministry for Traffic, Construction and Urban Development (Bundesministerium für Verkehr, Bau und Stadtentwicklung, BMVBS), where the bulk of $CO_2$ reduction can be achieved by improved energy efficiency is in the hands of still another party, the Bavarian CSU.

No new institutions at the governmental level were created in the follow up to the Energiekonzept or Energiewende, i.e. responsibilities remain split between several ministries. However, in view of the importance of the Energiewende (publically perceived as second only to the Euro Crisis), the Chancellor tends to involve herself regularly.

### *Local State (Länder) Governments*

In Germany as a federal country the local governments have partial responsibilities of their own affecting the Energiewende. In addition they have to implement certain tasks on behalf of the federal government (Auftragsverwaltung), e.g. supervising nuclear plants.

In general the dichotomy between the responsibilities of a ministry for economy and a ministry for environment on the federal level is also reflected in local governments where the responsibility is partially with the ministry of economy or the ministry of environment while some Länder have ministries where the responsibility for energy is shown in their title as part of their responsibility, either integrated into the ministry of economic affairs or into the ministry of environment.

Coordination of the Energiewende between the federal level and the local level is a major challenge; for instance many states have aspirations for the construction of renewables which in sum exceed by far the plans on the federal level. One reason may be because it is regarded as an easy way to create jobs without burdening the local budget.

Another influence of the local states is via spatial planning, e.g. by reserving certain areas for wind power. Especially in the South of Germany the areas opened so far for wind power are relatively small while the southern states have a high capacity of PV. In view of the phasing out of nuclear in the South large volumes of offshore wind power may have to be transmitted from North to South, while the wind potential in South Germany is underutilized. A change of mind is underway and Baden-Württemberg is going through a procedure to declare more areas suited for building wind power plants[138].

Grid planning issues have until recently been under the authority of local governments, which resulted often in slowing down of permitting procedures if a line crosses more than one state. Local governments have involved themselves in the energy politics of the federal government. A major disputed issue is the search for the final disposal site for high radioactive waste.

Some Länder have issued their own policy on Energiewende for their state, a prominent example is Bavaria, which always wanted to ensure reliable and affordable energy being short of local energy resources[139].

### *Municipal Level*

Also at the municipal level the implications of Energiewende are addressed in the frame work of the local responsibility mainly for traffic and housing but also for local energy distribution and last but not least as owners or shareholders in the local or regional utilities. Many municipalities explicitly address the issue of Energiewende.

### *Special Institutions*

**BNetzA (Federal Network Agency: Regulator for Grid Bound Energy)**

The Bundesnetzagentur (BNetzA) is the recently created regulator, first for telecommunications, but since 2005 it was mandated also to regulate gas and electricity grids. It covers all tasks stemming from the EU directives on gas and electricity. Increasingly it plays a crucial role in the practical implementation of the Energiewende, due to its responsibility for grid issues, for instance handling the ten year network development plan for gas and electricity (in the context of the 3rd package) which defines the frame for the asset basis for the system operators. It also has special tasks given to it for supervising the EEG financial streams and for ensuring the reliability of power supply in cooperation with the four grid operators as well as special investigations, for example on the issue of keeping one nuclear plant in cold reserve for the winter 2011/12. In view of the need to catch up with delayed grid reinforcement becoming pertinent with the closure of eight nuclear plants, reliability of supply issues tend to trigger a more interventionist approach compared to the market-driven approaches BNetzA fosters under the 3rd package. More recently BNetzA was given the task of implementing power line projects which cross state borders within Germany[140].

**Cartel Office (Bundeskartellamt)**

The Cartel Office plays a role in supervising anti-competitive behaviour. This could be linked to grid-bound energies, but also to the production of wind turbines or PV panels and so on. It

[138] BWE Landesverband Baden-Württemberg. (2013, February)
[139] Bayerische Staatsregierung. (2011, May 24)
[140] BDEW. (2013, May 29)

publishes regular assessment reports on the status of competition in grid bound energies. However it has no direct role in the implementation of the Energiewende.

**Federal Environmental Agency (Bundesumweltamt, BMU)**
Apart from operative tasks such as dealing with chemicals, and air quality, it is also responsible for emission trading and for planning of the environment and on a conceptual basis for strategies for sustainable development which include climate protection. While reporting to the BMU the UBA demonstrated the ability to produce independent analysis. It regularly publishes scenarios to guide the process of reducing GHGs, as well as models for largely fossil fuel free power generation in 2050.

**dena (Deutsche Energie Agentur)**
dena was created in 2000 as a centre of competence to promote energy efficiency, renewables and intelligent energy systems[141]. It is organized as a plc (the owners are 50% federal government, 26% KfW, and 8% each: Allianz, Deutsche Bank, DZ Bank). It supports pioneer projects, analyses energy technologies and markets and gives advice at the interface of politics and economy.

### *The EU Context*

The German Energiewende (whether as of 2000/02 or as of 2010/2011) has also to be seen against the background of the creation of the EU internal market (second gas directive in 2003 and 3rd package in 2009[142]). There is obviously an overlap with regard to the effects of the 3rd package and the internal energy market reform on one side and the Energiewende on the other hand. An example is the design and use of electric grids which are on one side affected by a substantial increase of electricity trade for which the grids were not designed but on the other hand also have to accommodate changes due to the Energiewende, in particular the feeding in of more renewable electricity and the effects of switching off eight nuclear plants on reliability.

There are some similar effects for the gas grid stemming from the prescribed entry-exit system. The German gas grid was developed as a gas importing grid and is now used as a trading hub. However because of its relatively large storage capacity, inertia of gas flow due to some buffer capacity in large pipelines and also some flexibility in the pressure management of the pipelines, gas transport systems have not experienced “blackouts” so far; at most a reduction of the pressure in the system, which may however be critical for the supply of gas-fired power plants.

The 2010 Energy Concept was an important input into the discussion at EU level on the 2050 road map towards a goal of 80 – 95% de-carbonization by 2050[143].

While energy mix is the responsibility of member countries under the Treaty of Lisbon, environmental and GHG issues are the responsibility of the EU. Thus Germany was free to step out of nuclear and to go for renewables. Other energy-related topics are part of the EU framework, such as regulation for grid bound energies (electricity and gas), minimum goals

[141]dena. (2013, November 9)
[142] Official Journal of the European Union. (2009, August 14)
[143] European Commission. (2011, March 8)

for renewables and also some guidance on energy efficiency by the new Energy Efficiency Directive.

The role of gas and coal seems legally in the hands of the national governments. However, their relationship is or at least could be very much influenced by the GHG emission trading regime. This has proven to be ineffective; however a change of the ETS can only be accomplished through EU procedures. While Germany could for example decide to phase out of coal as it decided (twice) to step out of nuclear, this might interfere with the EU instruments on de-carbonization. Like the renewable policy, a coal phase-out would be a direct instrument of de-carbonization which might render the ETS ineffective.

On the other hand, it is clear that the electricity systems in the EU are more closely intertwined than they were when the national power systems were originally designed due to increased trade and an increased number and capacity of interconnections.

In this situation, while going for an ambitious renewable policy (which countries like UK, Spain and Denmark are also pursuing) and phasing out nuclear power is within Germany's competence according to the Lisbon Treaty, the concerns of its neighbouring countries are understandable as changes in the operation of the German electricity system will affect them as well. Obviously the closure at short notice of eight nuclear plants (which nevertheless was foreseeable under the previous law of 2002) changes the capacity balance and the power flows not only in Germany but also in the EU grid; so does new feed-in wind capacity.

This argument can however also be made for all larger EU countries and their power capacity policies. Countries having a low degree of diversification of their operational power generation capacity can especially face risks of systemic short or longer term outage of capacity, such as the unforeseen switching off of nuclear plants in Belgium during winter 2012/13[144], or more generally the risk of systemic failure of pivotal nuclear components in ageing nuclear fleets, not to speak of the consequences of a severe nuclear incident. The need to phase out a large capacity of coal-fired power generation according to the EU large combustion plant directive will also have important implications on the overall power balance in EU.

### 1.2.2 Instruments for De-carbonization

Major instruments to de-carbonize the economy go back to the Red Green Government and to the Great Coalition following it or stem from an EU context. The Energy Concept could build on these instruments and on the framework designed by the Meseberger Conference and could further develop these approaches. These elements were: For renewable policy the EEG (law on renewables energy) for energy efficiency, NEEAP, following EU directives, standards for new buildings and also a first initiative to accelerate the permitting procedures for new power lines (EnLAG, law to accelerate the construction of power lines) while emission trading and its transposition into German legislation followed the EU legislation.

The result of the Meseberger Conference of 2007 (basically a cabinet meeting dedicated to energy and de-carbonization) was a comprehensive list of measures which were communicated to parliament. However, they were not embedded into an overall strategy at that time.

[144] Deutscher Bundestag, (2013, May 15)

The Energy Concept of 2010 was the first policy document presented to parliament to give a comprehensive compilation of energy targets (derived from an 80% plus reduction target for GHG) as well as a comprehensive list of instruments and measures to achieve the targets based on scenario evaluation. To make the 80% target more manageable and avoid postponing decisions into the future it is broken down into decennial steps. At the same time a review every three years is introduced to oversee the effectiveness of the measures taken and if necessary correct them. This was later complemented by an annual monitoring report with comments by four independent experts. The monitoring report contains a list of all pertinent measures and instruments showing the status of their implementation. About 160 measures and instruments are listed in the 2012 monitoring report (see section 2.4).

The energy concept had the following components each with several instruments of implementation:

A Renewables as a cornerstone of de-carbonization
B. Energy Efficiency as the key factor
C. Nuclear power and fossil fuel power plants
D. An efficient grid infrastructure for electricity and integration of renewables
E. Energy upgrades for buildings and energy – efficient buildings
F. The mobility challenge
G. Energy research towards innovation and new technologies
H. Energy supply in the European and international context
I. Transparency and acceptance

In the following the topics relevant for the role of gas (A to E) are introduced with their relevant instruments:

### *A. Renewables as a Cornerstone of De-carbonization*

- The main instrument is the EEG (Erneuerbares Energie Gesetz, law on renewable energy) which goes back to the Red Green government, although it was amended several times to follow the development of costs and taking experience into account. Its first version was enacted in 2000[145], with amendments in 2004, 2009 and 2012. It provides a system of feed in tariffs paid for by an extra levy on the power price by all (non-exempted) customers plus an off-take obligation for grid operators for power from renewable energy.
- The EEG has been the cornerstone of long term German de-carbonization policy since the Red Green Government was elected in 1998. From a more abstract view it served to promote the development of renewable technologies, which at that time were far away from being commercially or at least economically viable. By fostering the installation of renewable energy by a guaranteed feed-in tariff for twenty years and by an obligation to take renewable energy as a priority the income from it was reasonably predictable (just depending on the wind or the sunshine statistics). This system also created a strong incentive to keep installations in good order to produce as much renewable energy as possible. The demand triggered by that scheme increased the number of installations rapidly so that the new technology could benefit from the usual (double logarithmic) learning curve bringing costs down, indeed for PV in an impressive way. (See chapter 2.5.2 for a more detailed discussion)

[145] BGBl I 2000, 305; Gesetz für den Vorrang Erneuerbarer Energien vom 29. März 2000; at: http://www.gesetze-im-internet.de/bundesrecht/eeg/gesamt.pdf

- The EEG is still the corner stone of the renewable instruments, but the total support especially for PV is now considered to be too high and a consensus seems to exist that the EEG has to be reformed, although with widely differing opinions as to how. (see chapter 2.5.2)

Many other measures are in place to promote or support renewables, such as various programs for offshore wind or dealing with details of reserving areas for onshore wind as well as various measures to foster bio energy.In total the Monitoring Report of December 2012 [146] lists 25 concrete measures at the Federal level.

### *B. Energy Efficiency as the Key Factor*

The Second German NEEAP (National Energy Efficiency Action Plan) [147] was submitted to the EU on August 31, 2011 in line with the EU Directive 2006/32/EG. According to this report Germany will fulfil the target of increasing energy efficiency by 9% in 2016 compared to the average of the years 2001 – 2005. Some 90 measures have been evaluated, including energy savings in residential and public buildings, support for measures of energy savings in small and medium industry, fuel efficiency of cars and promoting public awareness.

Other measures (20 are listed in the Monitoring Report of 2012) include the development of a contracting market, product standards and labels, public awareness and financing support for small CHP.

### *C. Nuclear Power and Fossil Fuel Power Plants*

A major task is now the closing of all nuclear plants by 2022, dismantling them and disposing of the radioactive waste. Of course the disposal of used nuclear fuel remains of highest importance.

On non-nuclear plants measures include the expediting of construction of new power plants, the support for high efficiency power plants and two pilot projects for CCS - however on hold because of public resistance[148].

The KWK Gesetz (law on CHP) was first issued on January 25, 2002[149], and amended several times since and prolonged. The core part of it is the support of CHP by priority feed-in and a support of the resulting power production by up to 2.56 €cts/kWh above price for base load electricity, and especially for mini CHP with an electric capacity of up to 50 kW by 5.11 €cts/kWh above price of base load electricity for 10 years. The aim of the latest amendment of July 12 , 2012[150] is to reach a share of 25% of electricity produced from CHPs by 2020. It is financed by a fee on the electricity bill staggered by the total offtake of electricity under which larger customers pay a lower fee.

### *D. An Efficient Grid Infrastructure for Electricity and Integration of Renewables*

It is conspicuous how much effort is dedicated to grid issues: 28 specific measures relating to grid infrastructure are listed in the Monitoring Report of 2012, more than for any other component of the Energiewende

[146] BMWi. (2012a, December) .p. 108f
[147] BMWi. (2011, July)
[148] DIW Berlin. (2012, February 8)
[149] Bundesministerium der Justiz; juris GmbH. (2002, March 19)
[150] BGBl. (2012, July 18)

Under the great coalition a law on enlargement of the power grid (EnLAG)[151] was enacted, which referred in its background not only to the consequences for the grid of feeding in renewables but also to the need stemming from the introduction of EU-wide electricity trading. Based on the EnLAG from 2009 the planning process for the national power grid has been further strengthened, by further development of a power grid forum, by defining a target grid for 2050 and coordinating the planning procedure on a federal level by transferring planning authority for lines crossing state (Länder) borders and for offshore lines to the BNetzA[152]. It also includes several measures supporting the connection of offshore wind[153].

Also the building of a large HVDC overlay power transport system [154]for electricity markets and/or for securing power across Germany by the transport of large volumes and capacities of wind power from the North Sea is a key requirement.

### *E. Energy upgrades for buildings and energy – efficient buildings*

For new buildings mandatory standards are given by the Energy Saving Law (Energie EinsparGesetz, EnEG) of September 7, 2005 [155]implementing the respective EU regulation on efficiency in buildings of 2002 which is setting standards for new buildings. By a new amendment of the EEWG of July 4, 2013 [156] new public buildings have to comply as of 2019; other new buildings as of 2021 with the zero energy house standard.

For existing buildings various programs are offered by KfW (Kreditanstalt für Wiederaufbau) for refurbishment of private buildings as well as for measures taken by municipalities.

The Energie- und Klimafonds provides support under a $CO_2$ refurbishment program for 2013 and 2014, which is supposed to change to a budget neutral program by 2015.

Another element is the labelling of energy performance of buildings vis-a-vis tenants or buyers.

### *Prioritizing Needed!*

In view of the plethora of measures of different reach and detail it is very important to prioritize the objectives and instruments to achieve them as suggested by the comments of the four independent experts to the monitoring report 2012 (see chapter 2.4).

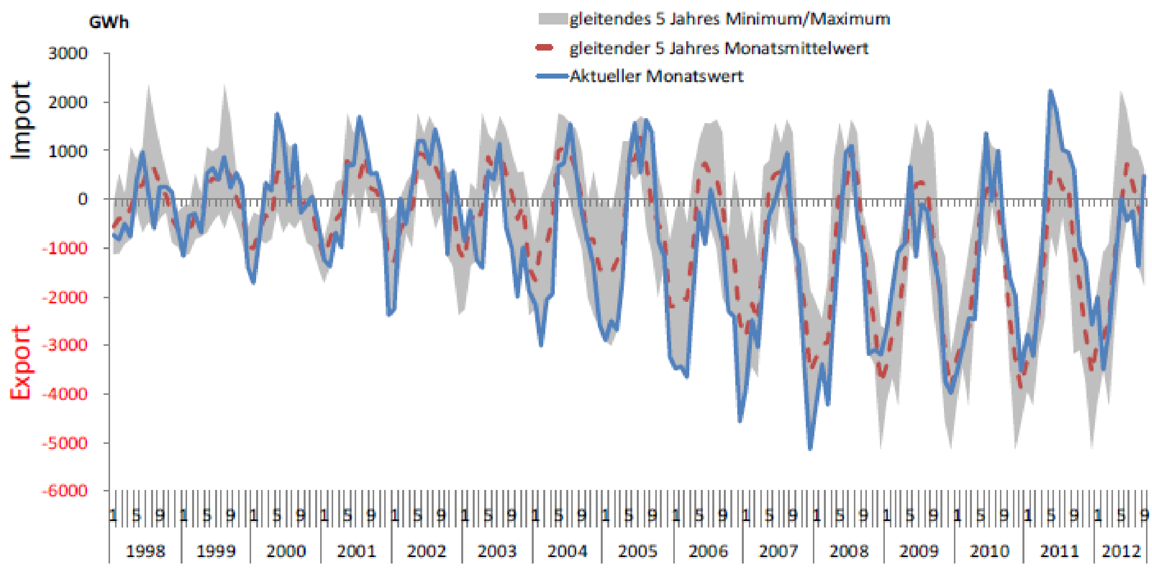
[151] Bundesministeriums der Justiz. (2009, August 21)
[152] BDEW. (2013, May 29)
[153] Netzentwicklungsplan Strom. (2013, April 14)
[154] TU Graz. (2012, December 12)
[155] BGBl. (2008, August 7)
[156]BGBl. (2013, July 4)

## 2. What Has Happened since the Energiewende was Decided?

When the decision to phase out nuclear was taken anew in 2011 (which surprisingly came as a surprise) the issues of intermittency of renewables and adequacy of power supply suddenly became imminent practical issues to be tackled with priority, as a failure of reliable power supply could lead to political disaster as well as an actual disaster.

But it is worth noting what did not happen: since the decision on the Energiewende on June 30, 2011 there have been no large scale black-outs, the SAIDI (System Average Interruption Duration Index) has been on the low level of previous years[157], the power export balance has not decreased in total or in winter (see Figure 2 below), there has been no recourse to French nuclear power except due to price differentials on the EU power market. On the contrary during the cold snap in February / March 2012 Germany exported several 1,000 MW during the peak hours in the evening and in the first quarter 2013 Germany driven by price relations exported coal based power to the Netherlands shutting in gas fired power generation in the Netherlands[158].

**Figure 2: Monthly Power Imports and Exports 1998 to September 2012**




Quelle: [ENTSOE, 2012] (Eigene Darstellung)

Notes: Vertical Axis label: Export / Import
Horizontal Axis label: Year
Key Legend: Grey: Moving 5 year minimum/ maximum range, Red: Moving 5 year monthly average, Blue: Actual monthly average
Source: ENTSOE, 2012, (own presentation), [159]

[157] BNetzA (Bundesnetzagentur). (2013, February 1)
[158] Frankfurter Rundschau. (2013, April 2)
[159] BMWi. (2012b, December) p. 86

Nevertheless the situation especially in winter 2011/12 was at times tight as detailed in section 2.1. The phase-out within ten years of nuclear power required grid and capacity planning on the electricity side and has implications for the gas grid as well. The need for planning of the 10 years to 2022 coincided with the first Ten Years Network Development Plan (TYNDP) for Electricity and for Gas to be developed under the 3rd package, discussed in section 2.2. In view of the priority given to avoiding black-outs, and probably because of the delay for various reasons in dealing with power grid questions in the past decade, there is now a strong focus on expediting the grid expansion but also on addressing capacity development, see section 2.3. Section 2.4 presents the key results of the first monitoring report with comments by the four independent experts published in December 2012, while section 2.5 discusses the costs of the Energiewende, with a focus on the impacts of the EEG, especially of the support for Photo Voltaic as the financially largest and most disputed element. Section 2.6 gives an update of the developments since the elections of September 2013 and of the energy policy of the new government as defined by their Coalition Agreement.

## 2.1 The Situation in Winter 2011–12 and 2012–13

### *Assessment of Winter 2011/2012 by BNetzA*

During the cold snap in most parts of Europe, including Germany, at the end of February 2012 and the beginning of March 2012 the press reported on tight power supply situations in Germany coinciding also with shortfalls of gas supplies in the south of Germany. On May 3, 2012 the BNetzA published a comprehensive report and analysis on the winter 2011/12[160] with the following points:

- The situation in the power grid was very tight. The gas supply shortage in February 2012 was an unexpected additional burden.
- The situation in winter led to an increase to 197 interventions by the TSOs in power plant schedules and in renewables feed-in to maintain the integrity of the grid and also to a strong increase in (commercially motivated) re-dispatch measures on the most severely affected power line between Remptendorf (Thuringia) and Redwitz (Bavaria) totalling 2,140,997 MWh, compared to 100,150 MWh, in winter 2010/11.
- In February 2012, the unexpected gas shortage and several natural gas–fired power plants not producing to full capacity required mobilizing cold back-up power from plants in Germany and Austria (360 MW/935 MW).

### *Implications of Winter 2011/2012*

The BNetzA came to the following conclusions for the following winter 2012/13:

- The system of balancing energy pricing as well as forecasting must be revised.
- BNetzA expected that the situation in the electricity supply grid in the winter of 2012/2013 would be similar to the winter 2011/12.
- But there was no reason to expect new shortages in gas supply for winter 2012/13.
- BNetzA recommended to the TSOs to contract reserve capacities amounting to around 2,150 MW for the winter of 2012/13, an increase of 505 MW over the 2011/2012 winter.

[160] BNetzA (2012, May 3)

- BNetzA was concerned about the announcement that several power plants in South Germany would be taken out of operation.

The situation in winter 2011/12 led to a discussion on capacity mechanism to promote the construction of new power capacity, as well as to an ordinance issued in 2013 to prevent the taking out of operation of power plants against reimbursement of the costs needed to keep the plant operational.(see section 2.3).

### *Situation in Winter 2012/13*

On June 20, 2013 BNetzA published the follow up report on the situation in the electricity and gas grids in winter 2012/13[161]. Due to more moderate temperatures the situation was less tense for power supply than in the previous winter, also due to some consequences from the 2011/12 situation. Partly the situation was more critical on the side of short term oversupply of the grid on December 24, 2012 and on February 10, 2013, leading to negative prices on the electricity exchange. Beyond a request to improve forecasting, especially for PV, the BNetzA suggested installing remote control for feed-in for renewables. A critical situation lasting several hours happened at the end of March in the grids of Tennet and 50 Hz due to short term non-availability of the power plants Irsching 5 and Staudinger (both E.ON) in combination with some grid problems in east Bavaria.

The BNetzA emphasized the importance of the finalization of the critical power line between Thuringia and Franconia reinforcing the links between the East German grid and the nuclear plant at Grafenrheinfeld, which is crucial for the successful taking out of operation of the Grafenrheinfeld nuclear plant at the end of 2015. The TSOs 50 Hz and Tennet are confident that the power line will be operational in 2015.

## 2.2 TYNDP 2013 /2022 and 2014/2023 and Related Scenarios

A new element in handling this new situation has been the introduction of an annual process of ten year network development plans in line with EU requirement for a non-binding bi-annual TYNDP for electricity and for gas compiled by ENTSO-E and ENTSO-G. The national TYNDPs are produced annually and are binding for the TSOs. The first German TYNDP was produced for the period from 2013 to 2022, coinciding with the ten year period for the phase out of nuclear power.

The procedure is that reference scenarios are suggested by the TSOs to BNetzA which, after public hearings, are made the binding basis for the development of the TYNDP by BNetzA. The TYNDP is then proposed by the TSOs and after hearing and modification made binding by BNetzA, with the possibility of challenge in the court system. BNetzA promotes coordination between the gas and power grid operators in view of the interface of the gas grid supplying gas-fired power plants, which proved to be a problem in winter 2011/12.

[161] BNetzA (2013, June 20)

### *TYNDP 2013 – 2022 and Related Scenarios*

In the first exercise both the power grid operators and the gas grid operators developed three scenarios each reflecting different degrees of development of renewables to gauge the range of possible grid measures. Power Scenarios labelled A, B and C and Gas Scenarios labelled I, II and III differ according to the role of renewables:
Scenario A: modest penetration of renewables (almost done)
Scenario B: realistic penetration, also a longer term scenario to 2032
Scenario C: ambitious targets for renewables
Power Scenarios B, C = Scenarios II, III of gas industry
Power Scenario A and Gas Scenario I did not correspond to each other. They were worst case scenarios with highest utilization of the power and gas grid respectively.
Regarding the link to neighbouring countries the scenarios are consistent with ENTSO- E / -G 10 year network development plans.
The first scenario framework for electricity was sanctioned by BNetzA on 20/12/ 2011[162]. The scenario framework for gas was decided on 2/2/2012[163] in line with the proposal by gas grid operators.

### *Conclusions from Gas Scenarios*

Looking at the scenarios (see Table 3 below): Gas Scenario I is rather unlikely and is mainly used as a worst case for grid design. The likely outcome will be between Scenario B/II and C/III: Gas to power will develop between 2009 and 2022 by an increase of gas-fired capacity of between 15% and 43%, however resulting in a decrease of gas consumption for power generation between 15% and 3% due to increased power generation by renewables. Total gas consumption would decrease between 11% and 19%, while gas imports would only decrease by between 4% and 14% due to the decrease of domestic gas production. This decrease corresponds roughly to the expected decrease of Dutch gas imports.

The Phase out of nuclear in Germany is not necessarily translated into extra gas demand for power; the extra power sector gas demand, if any, is possibly just compensating for loss of demand in other segments.

**Table 3: Gas Usage in Scenario I, II, III of the Framework Scenarios for Gas (in TWh/a)**

| | | **Scenario I** | **(modest)** | **Scenario II** | **(realistic)** | **Scenario III** | **(ambitious)** |
|---|---|---|---|---|---|---|---|
| | 2009 | 2022 | % change | 2022 | %change | 2022 | % change |
| | | | | | | | |
| **PEC** | 826 | 802 | -3 | 737 | -11 | 665 | -19 |
| **Final EC** | 583 | 532 | -9 | 492 | -15 | 448 | -23 |
| **Gas to power/DH** | 213 | 237 | 11 | 206 | -4 | 178 | -16 |
| **Imports** | 696 | 737 | 6 | 672 | -4 | 600 | -14 |

*Source:* [164] PEC: Primary Energy Consumption, EC: Energy Consumption; DH: District Heating

162 BNetzA (2011, December 20)
163 BNetzA (2012, February 2)
164 FNB Gas (2012, April 1), p. 10 - 12

The grid development plan gas was published on April 1, 2012 based on the scenarios of February 2, 2012 In its decision of December 10 , 2012 BNetzA requested changes which then were accepted by the TSOs[165]. Major points of discussion under the TYNDP Gas were the list of all power projects as a basis for both the power grid development and in the case of gas power plants also as a basis for the development of the gas grid. What is disputed is if in a pure entry/exit model power plants (and even more so gas stores) can be served on the basis of firmly attributable capacity in view of the flexible entry points from where the gas for the power plant may enter.

Another point of discussion was about power to gas, where surplus power is transformed into hydrogen by electrolysis, possibly followed by a Sabatier process reducing hydrogen to methane. While feeding methane into the gas grid would cause no problems and could be done anywhere within the capacity of the system, feeding in hydrogen was considered unproblematic by the TSOs only if hydrogen concentration is kept below 2%. At higher concentrations there is a risk that the hydrogen could spread to other pipeline systems in an uncontrollable way and might also damage some of the gas storage in aquifers. This would limit the hydrogen feed-in to points with high and relatively constant gas flows, mainly the import points.

### *TYNDP 2014 – 2023 and Related Scenarios*

The next (annual) exercise for the TYNDP for gas for 2014–2023 was started by the submission of a new scenario framework on October 1, 2012 which was confirmed by BNetzA on October 18, 2012. Compared to the previous scenario framework it was mainly an update. Based on the agreed scenario framework the draft for a new TYNDP by the 17 gas TSOs was published on the website of the TSOs on April 2, 2013[166] for consultation by June 21, 2013. New in the TYNDP are seven variants to assess the implications of various transportation products – especially for storage and power plants - for the costs of grid expansion in the framework of a cost benefit analysis by the TSOs.

## 2.3 Discussion on Capacity Needed and Grid Expansion

While the increase in renewable power installed capacity (by the end of 2012 about 30,000 MW onshore wind and about 35,000 MW PV) is impressive, PV capacity is not considered to be reliably available and a maximum of 5% of installed wind energy is usually counted as reliably available. While the maximum yield of PV depends on predictable phases of the day and the year reduced by unpredictable weather conditions, wind is completely unpredictable in the longer run even though wind predictions have become more reliable over a period of a day or two ahead.

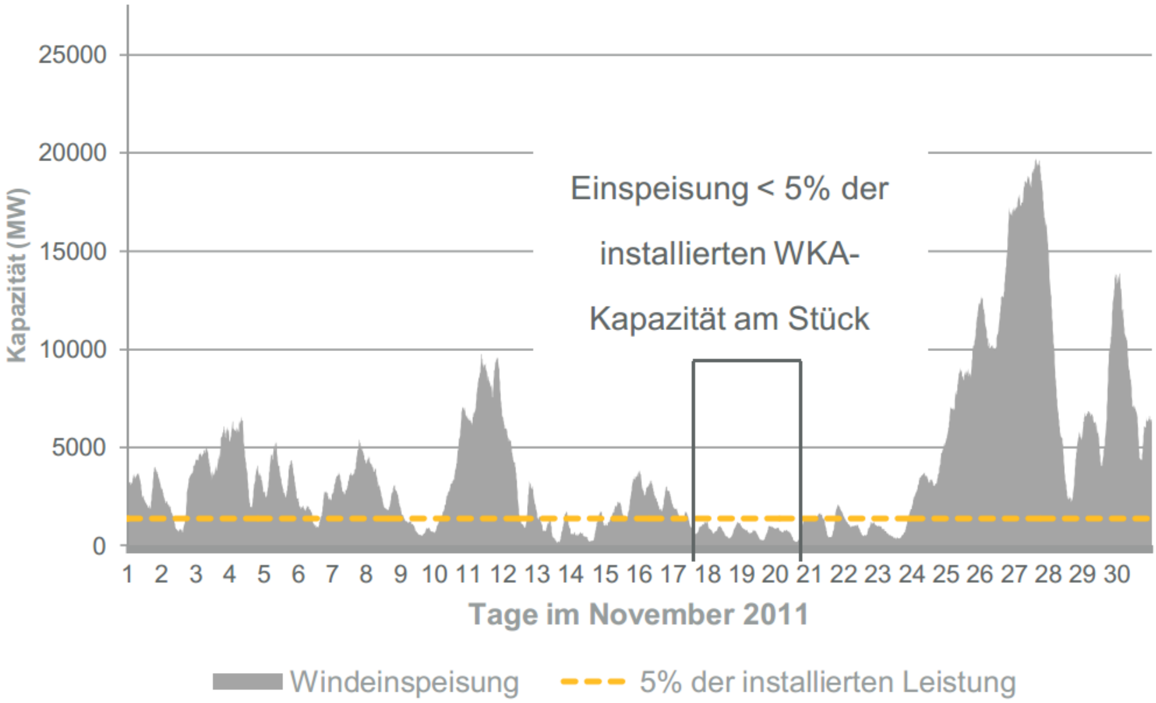
The requirement for balancing variations of wind power is illustrated by Figure 3 below which shows the situation in November 2011 with a period of ten days when not much more than 1,000 MW of wind power was fed into the grid, preceded by a feed-in of 10,000 MW and followed by a feed in of 20,000 MW.

[165] FNB Gas. (2013, March 10)
[166] FNB Gas. (2013, April 2)

### *Demand Side Measures*

As shown in a study published in December 2011 tasked by BMWi to EWI, Demand Side Measures (DSM) have a limited potential as they would defer demand just by a few hours[167], which is not relevant in the context of variation of wind power as shown in Figure 3 [168].

**Figure 3: Wind Energy Output in November 2011**




Notes: Vertical Axis label: Capacity (MW)
Horizontal Axis label: Days in November 2011
Key Legend: Grey: Wind energy input, Yellow: 5% of the installed capacity, Legend in the center: Energy input < 5% of the installed wind turbine capacity
Source: ENTSOE, 2012, (own presentation) [169]

### *Back up for Renewables / Load Following Mode*

This raises new flexibility requirements, as thermal power plants do not only have to cover the variations in demand but also in addition variations of intermittent renewables, wind power and PV (load-following mode). In principle this load following task can be covered by all thermal power plants (nuclear with the caveat of safely excluding any problems with the nuclear part of the reactor). All fossil fuel fired power plants are in principle suited to run in load following mode. Capacity gradients of state of the art power plants are reported as 4%/2.5%/ 4% of installed capacity per minute for coal/lignite/CCGT plants with further optimization potential and minimum load factors of 25%/50%/40% respectively. Only open cycle gas turbines are more flexible especially for both hot and cold starts where plants with a

[167] EWI. (March, 2012).p. 31ff
[168] EWI. (March, 2012), p. 22
[169] EWI. (March, 2012), p. 22

steam turbine need up to 4 hours for a hot start and up to 8 hours for a cold start, while a gas turbine need less than 6 minutes (at the cost of shortening substantially the maintenance intervals)[170]. However with improved wind forecasting such short quick start capacity will not be needed on a large scale. (For a more detailed discussion, see section 3.4).

### *Capacity Balance / New Power Plants, Closing Old Plants*

Beyond back up for renewables, especially wind power, there is an issue of overall capacity in the German grid after the phase-out of nuclear capacity. This is partly linked to some power plants under construction being delayed, but also to taking off grid old power plants and recently even brand new CCGTs because of the negative spark spread and because of the disappearance of the midday price peak with more PV feeding in at midday. (See also discussion under 3.2 about the energy-only market). While BNetzA as an intermediate measure obliged the TSOs to contract cold reserve capacity for winter 2011/12 and 2012/13 the discussion at government level was on a long term solution through some kind of capacity mechanism (also under discussion in other EU countries) and in the shorter term on measures to ensure reliability of power supply and prevent the closing of capacity needed for reliable power supply.

A new ordinance was issued by the German government on June 12, 2013 to keep enough power generation reserve capacity (Reservekraftwerksverordnung) [171] based on the amendment of December 20, 2012 of the Energy Law (Energiewirtschaftsgesetz)[172] which in §13 empowers the government to issue an ordinance to govern the acquiring of necessary power generation reserve capacity to ensure reliability of power supply. The ordinance is so far valid until end-2017. The main focus is on power plants which are about to be temporarily or finally taken out of operation. Exceptionally even the construction of new capacity may be considered, for instance in the context of the closing of the nuclear power plants. The main purpose of the ordinance is to create a clear and transparent procedure with as little as possible interference in the power market.

While the list of power plant projects under the TYNDP is long, only one project passed an FID recently, the Lausward power plant of Stadtwerke Düsseldorf which replaces an old coal-fired power plant serving an existing district heating system. The new CCGT plant will have about 500 MW and Stadtwerke Düsseldorf and Statoil in June 2013 concluded a gas supply contract for that plant[173].

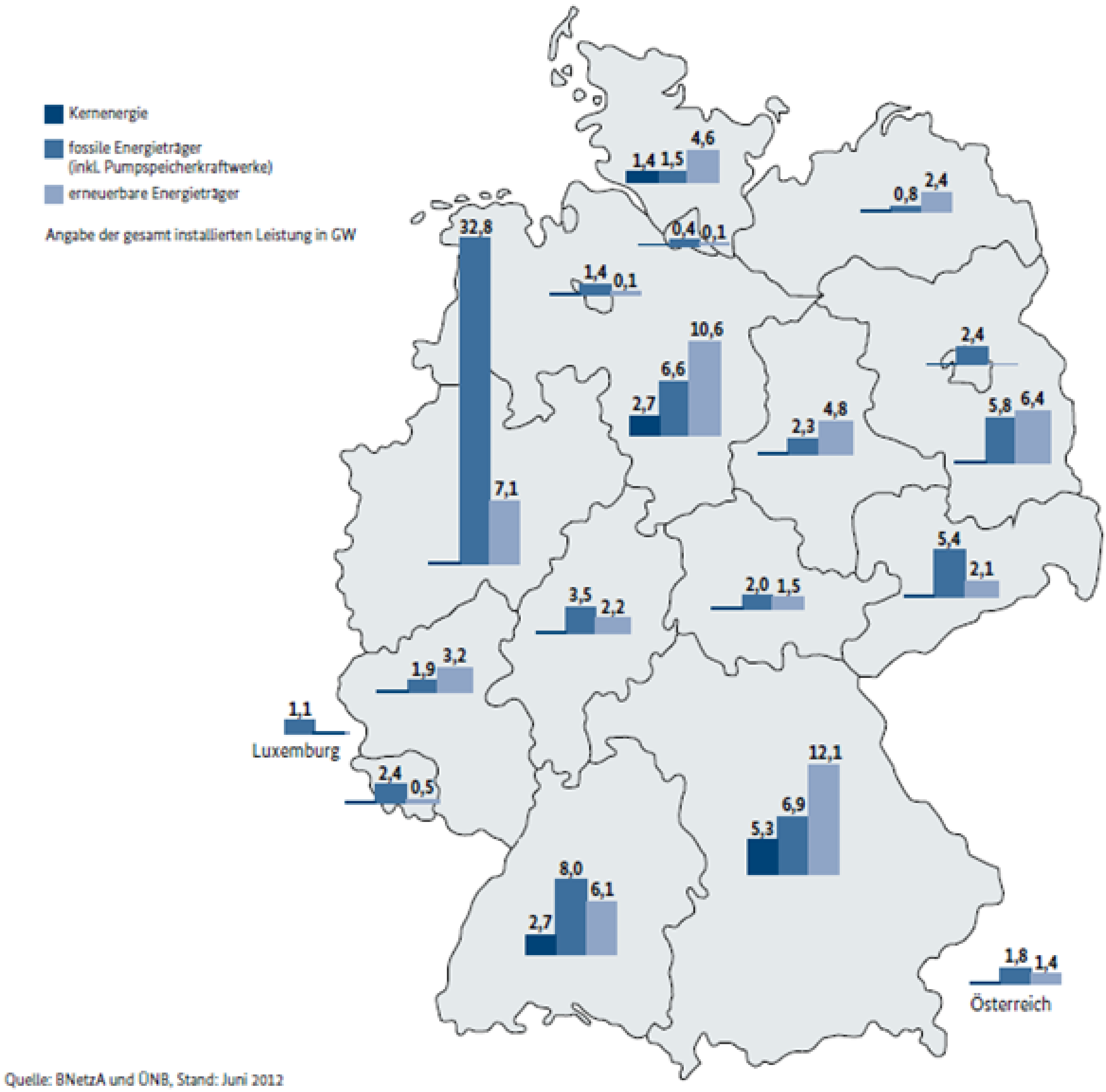
### *Power Grid Discussion*

The changing requirements for grid design and operation stem from two parallel developments for which the German (and EU) power grids were not designed: the increase of EU-wide electricity trade now in combination with the increase of power fed in by renewables. Both developments require a much more flexible power grid and larger capacities to transport power.

[170] Magin, Wendelin. (2012,October 10)
[171] BGBl. (2013, June 27)
[172] BGBl. (2012, December 20)
[173] Stadtwerke Düsseldorf. (2013, June 13)

The map below shows the present distribution of power capacity in the states of Germany. Only four states are left with nuclear power, which is concentrated in the South in Baden Württemberg (BW) and Bavaria and around Hamburg but outside in the neighbouring states of Lower Saxony and Schleswig Holstein. Fossil power capacity is highly concentrated in North Rhine Westphalia, while renewable power capacity is more evenly spread. However in the North and the East it is dominated by wind power whereas in BW and Bavaria renewables so far are predominantly PV.

**Figure 4: Distribution of Power Station Capacity across German States (in GW)**




Key Legend: Dark blue: Nuclear energy, Blue: Fossil energy sources (including pump-storage hydroelectricity), Light blue: Renewable energy sources,
Bottom Right: Austria
Source: BNetzA and UNB, 2012, [174]

[174] BMWi (2012a), p. 47

In order to expedite the planning and permitting procedures which were under the competence of the Länder the Great Coalition of 2005-2009 already issued a law on the expansion of power grids (Energieleitungsausbaugesetz EnLAG) which listed 24 projects as projects necessary for the power supply of Germany, with binding character for any permitting procedure (Planfeststellungsverfahren). By a new law (Netzausbaubeschleunigungsgesetz Übertragungsnetz, NABEG)[175] on expediting grid enlargement for power lines crossing the borders of German states or the external border or for offshore infrastructure an ordinance by the government approved by the Bundesrat can give the authority for planning and permitting procedures for such lines to the BNetzA. Further to that the Energiewende proposed a large number of further measures to expedite the planning and construction of high voltage power lines onshore inclusive of the construction of an overlay HVDC grid, but also the tie in of offshore wind power, illustrating the focus on grid measures. On the operational level a detailed discussion is held every year by the four TSOs with BNetzA about worst case scenarios for the coming winter[176].

## 2.4 Monitoring Report

On December 19, 2012 the government published its first monitoring report[177] with the comments/statements by the four independent experts attached to it[178]. This first report only covered the short reporting period of about a year since the enactment of the Energiewende. Therefore it was more laying the ground for the structure and methodology of future monitoring reports. Basically the report, which is focused on the period to 2020 and the targets defined for 2020 by the Energiewende, confirms that while complying with the nuclear phase out scheme decided on June 30, 2011 by the parliament, development so far is on track to meet the 2020 targets. In addition it contains a list of some 160 measures decided by parliament and government to implement the Energiewende with a short report on the status of their implementation[179]. Also compatibility with the triangle of economic efficiency, reliability/security of energy supply and environmental protection is discussed.

The independent experts suggest establishing a set of indicators to monitor the progress of the project[180], and to identify important deficiencies in reaching the goals of the Energiewende, as well as shortcomings in reaching particular targets. This will require several improvements of the existing statistical basis as well as a discussion of several methodological issues (handling of data on nuclear power, renewables, private stocks of fuel oils, temperature-adjusted values and so on). While indicators reflect the past, which is important for analytical purposes, some should also be directed towards the future especially regarding reliability of power supply.

Given the plethora of instruments and measures it is indispensable to have a hierarchy of targets and sub-targets and to attribute measures to various targets and sub-targets. The highest priority of targets would be the phasing out of nuclear (without jeopardizing the reliability of power supply) and meeting the de-carbonization target (or reduction of GHG

[175] BGBl. (2011, July 28)
[176] BNetzA. ( 2013, September 16)
[177] BMWi (2012a)
[178] BMWi (2012b)
[179] BMWi (2012a) p. 108 ff
[180] BMWi (2012b) p. 11 ff

emissions) for 2020[181]. Such a hierarchy would also help to understand coherence, overlapping or eventually contradictions between various measures and instruments.

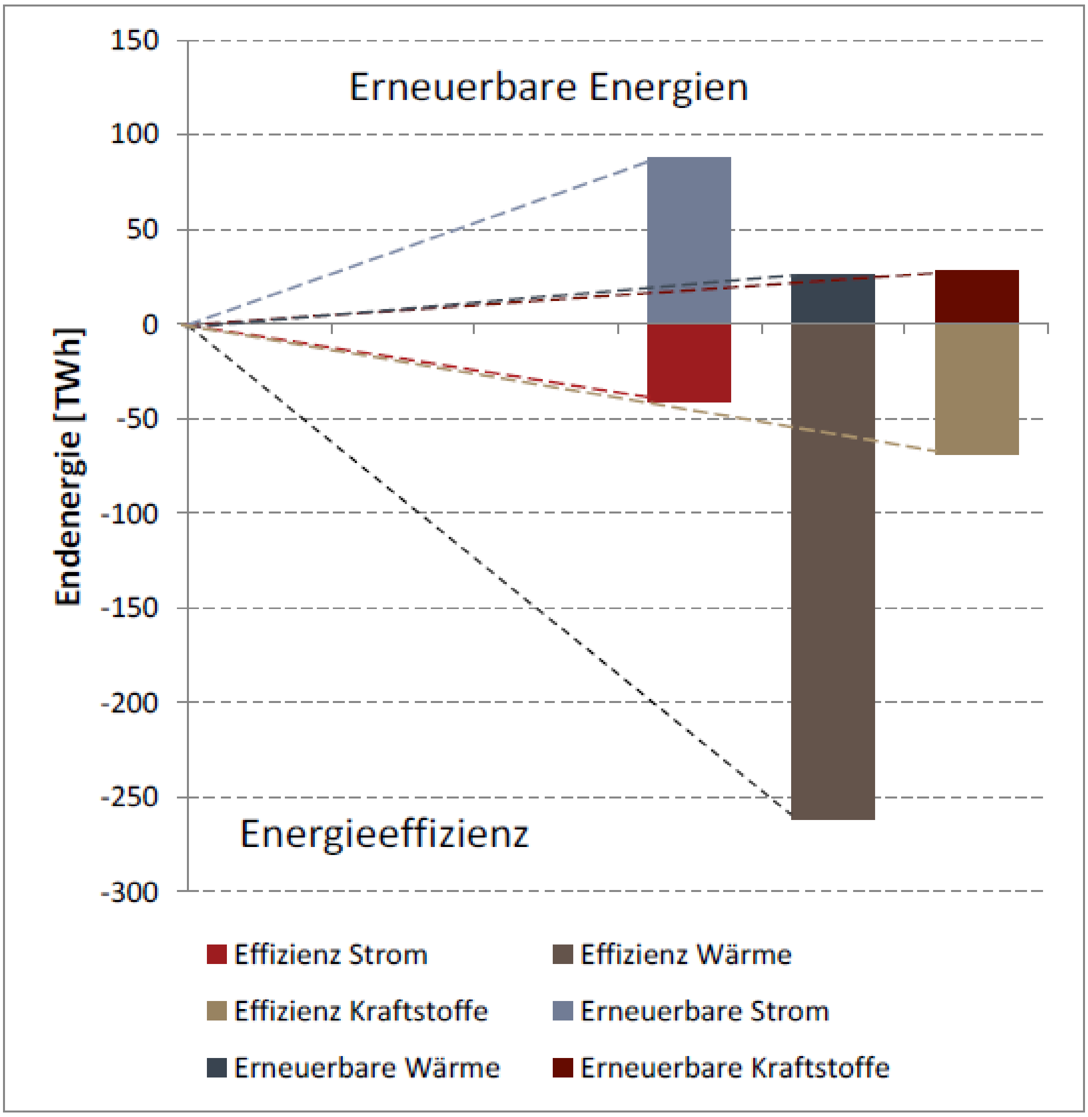
Another important request made by the experts is for an impact assessment of the (positive and negative) mainly environmental implications of the Energiewende but also the implications for the economy. This applies especially to the role of bio fuels and their competition with food production directly or indirectly by the use of land[182].

On economic impacts, it seems to be too early to assess the overall or individual economic implications of the Energiewende (cost and benefits). However, in the context of the campaign for the Federal Elections on September 22, 2013 a broad and controversial debate on the costs of the Energiewende began (see section 2.5).

The independent experts emphasized the importance of understanding the relative impacts of various measures to improve energy efficiency for heating, traffic and power on one side and the effects of the promotion of renewables for power generation, automotive fuels and heating on the other hand. A crucial question is about the possibility to compensate a shortfall on reaching one target by over-achievement on other targets. This also illustrates which components are absolutely critical (see Figure 5 below)[183]. Obviously – regarding reduction of final energy consumption – missing the target on heating efficiency would be crucial and could hardly be compensated by any other measure shown. This is discussed in more detail in chapter 3.4 together with the role fuel switching to gas in power generation could play to compensate for shortfalls.

[181] BMWi (2012b)., p. 6
[182] BMWi (2012b)., p. 63 ff
[183] BMWi (2012b)., p. 125

**Figure 5: Change in Energy Consumption between 2010 and 2020**




Quelle: Eigene Berechnungen

Notes: Vertical Axis label: Final energy (TWh)
Text in upper part: Renewable energy; text in lower part: Energy efficiency
Key Legend: Light Red: Electricity efficiency, Beige: Fuel efficiency, Dark grey: Renewable heat, Light grey: Heat efficiency, Blue: Renewable energy, Dark red: Renewable fuels
Source: Source: Monitoring Report 2012, Comments by independent experts, [184]

[184] BMWi (2012b)., p. 125

## 2.5 Costs and Benefits of Energiewende

From outside Germany the Energiewende is often perceived as a luxury that maybe Germany can afford but that could not be transposed to other countries. Eventually neighbouring countries even argue that they are negatively affected by the Energiewende, for instance by exposure to intermittence of renewables or by shouldering the burden of the phase-out of nuclear.

If the German Energiewende is to become a reference case for other countries aiming at de-carbonization, these points have to be addressed: It should be ensured that the Energiewende can be introduced on a stand-alone basis and especially without negatively affecting neighbouring countries. In addition, focus must be on reducing the costs of the pioneer Energiewende project, to make it more affordable for other countries and to avoid jeopardizing the broad national consensus by too high a burden on some social groups.

That raises the question about the costs (and benefits) of the Energiewende. A plethora of studies has been produced on the costs of nuclear, renewables, the externalities, and open and hidden subsidies, so that almost every figure can find some justification. It is important to understand what question exactly is asked, for instance to distinguish between the costs for the economy of Germany and the costs for an industry or a single entity or social group.

In times of election campaigns such topics frequently become the subject of political and lobby rhetoric. In Germany the costs attributed to the Energiewende are often portrayed as excessive and an undue burden for private households and industry jeopardizing the competitiveness of Germany. (This sounds a bit like “crying wolf” as Germany in 2012 exported goods worth €1,100 billion with a €188 billion surplus of its trade balance[185]). A first question concerns the impacts of the promotion of the Energiewende on the budget. Contrary to traditional energies like coal and nuclear, renewables have only a small impact on the public budget. Support for domestic coal continues to be paid from the public budget, at present about €2 billion/year[186]. There is a long debate on hidden costs of nuclear with regard to externalities but also budgetary implications[187], via tax benefits and direct payments from the budget. Most of these costs and payments are linked to periods outside the operating phase, such as substantial upfront costs linked to research and failed pilot projects and to the post operating phase; mainly the safe disposal of nuclear waste and closing reactors. By the introduction of the tax on nuclear fuel in 2010 the nuclear power industry started to directly contribute to costs paid out of the public budget for radioactive waste disposal. Limiting the remaining operating time of nuclear plants saves some costs to the extent that less radioactive waste is produced.

By contrast the budgetary impacts of promoting renewables are rather small. The main payment from the budget for the Energiewende is via the Energy and Climate Fund (Energie und Klimafonds, EKF) created in 2010 to share the windfall profits from prolongation of nuclear plants between the nuclear power industry and the Federal budget. After the withdrawal from the prolongation of nuclear the fund is fed so far predominantly from the

[185] Spiegel online.(2013, February 8)
[186] Spiegel Online. (2012, December 8)
[187] FÖS; Greenpeace. (2012, September)

German income from the ETS. Under the budget plan for 2013 the EKF will dispose of about €1.1 billion[188]. A variety of measures are financed from the EKF, such as energy efficiency, renewables, energy storage and grids, improvement of buildings. In 2012 a total of €452 million was spent. The program for electro-mobility is mainly focused on support for R&D and soft measures, but promises also some tax advantages and includes budgetary measures from the past program to overcome the economic crisis.

Most elements of the Energiewende are promoted by instruments outside of the budget: via voluntary agreements with industry for instance to improve GHG emissions or energy efficiency standards, by the ETS or via standards imposed (regarding minimum efficiencies, automotive fuels with a minimum share of biofuel or phase-out of nuclear) while the major support for renewables comes from a surcharge on electricity bills (with exemptions) according to the EEG.

The focus here is on the costs of the two components of the Energiewende, both related to the power sector:
(i) Phasing out nuclear and
(ii) The introduction of intermittent renewables,

### 2.5.1 Costs of Phasing Out Nuclear

When looking at the phase-out of nuclear the first question is about the yardstick for comparison. To the extent that the Energiewende is merely implementing the decision already taken in 2000/02 it is not adding any costs above those relating to that decision, because the phase-out schemes are very similar. The 2011 study commissioned by the government compared the costs of closing the reactors in line with the 2011 phase-out decision with the prolongation decided in 2010[189]. The benefits of saving fossil fuel are compared with costs of nuclear fuel (and waste disposal) and of refurbishing the reactors to allow for the prolonged operating time plus macroeconomic differences, resulting in a difference in projected GDP of a maximum of 0.3% /a[190]. In the long run not prolonging nuclear will save the costs of disposing of the corresponding additional radioactive waste.

Phasing out nuclear capacity raises the question how to replace that dispatchable capacity. After the first eight plants closed in 2011 Germany was still in a comfortable capacity situation[191]. However, for 2022 the assessment of the IEA shows a tight situation[192]. Depending on sufficient savings in peak usage of electricity the 12 GW of dispatchable power capacity of the nuclear plants would not have to be replaced, because of sufficient reduction of peak demand.

While the overall economic costs of not prolonging nuclear look manageable in the context of the German economy, the effects of the new policy for the four operators of nuclear plants are more severe. This includes first of all lost windfall profits (even if they would have been shared with the national budget) from written-off nuclear plants for the 8/14 years of prolongation. The missing windfall profit for the first 8 reactors will be for the 8 years up to

[188] Bundesministerium der Finanzen (BMF). (2013, April). p. 34
[189] EWI, GWS, Prognos. (2011)
[190] EWI, GWS, Prognos. (2011) p. 33
[191] IEA (2013), p. 148
[192] IEA (2013). p. 149

2020 and for the remaining 9 reactors with a total of 12 GW it will be for 14 years from the middle of this decennium to the mid-2030s when the last reactor would be closed. With an annual power production of about 6 TWh for older reactors and about 10 TWh for new reactors lost income at a base year price of €40/MWh is between €240 million/year/reactor for the older reactors and €/400 million/year/reactor for the new reactors. In addition is the tax on nuclear fuel decided in 2010 (for the years 2011 – 2016) of about €1.6 billion/year or about €20/MWh. Even if the windfall profit is split between the nuclear power companies and the budget this amounts to a drop of annual income in total for the four nuclear power companies of about €3 billion/year until 2016 and a similar amount thereafter - a substantial loss of income.

### 2.5.2 Costs of Fostering Renewables

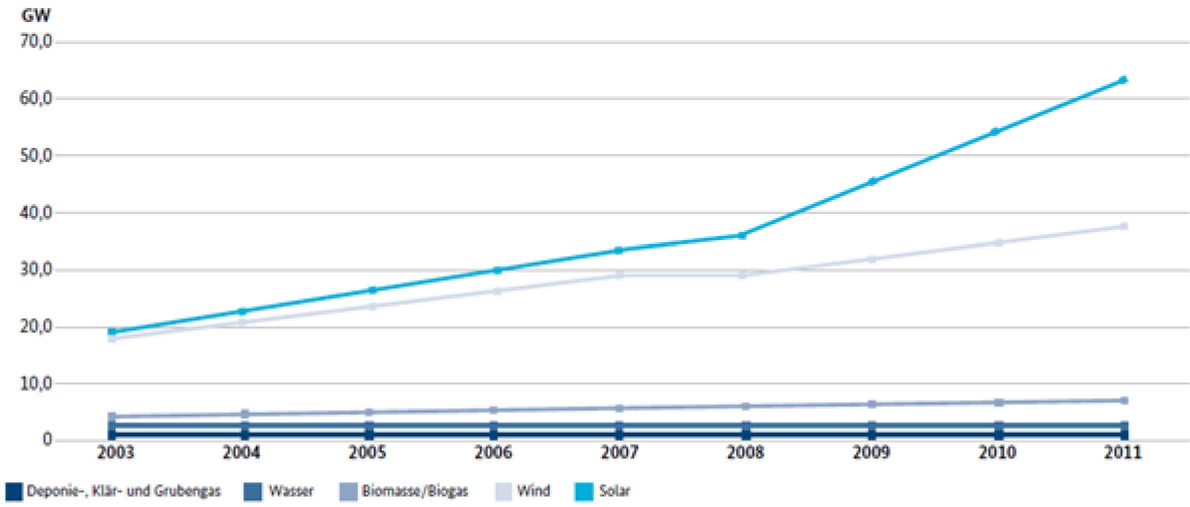
The main idea behind supporting renewables is to foster a technology breakout from fossil fuel energy which is obviously needed for a substantially reduced carbon future. It is the normal approach to support new technology until it is competitive in the market.

Support of renewables in Germany is via the EEG, by which renewables producing electricity are supported by a feed-in tariff, paid by a general fee levied from all electricity customers (with exceptions). Fostering renewables started in the late 1990s. A major idea was to support new non-carbon renewable technology making use of the learning curve: with increasing numbers of units installed of a new technology unit costs will decrease. That relationship often follows a double logarithmic curve, for instance for PV doubling the installed capacity will decrease specific costs for PV cells by a factor of about 0.8[193].

The EEG provided a strong incentive to install new PV by guaranteed revenue for twenty years amortizing the invested capital within 10 years which corresponds to an interest rate of about 7%. When interest rates in the capital market dropped in the financial crisis a guaranteed return of 7% plus hedging of the future electricity bill was a strong incentive, providing an attractive ‘pension scheme’ for house owners and farmers. This is reflected in the sharp increase in installed PV capacity as of 2008, as shown in Figure 6.

[193] Fraunhofer ISE. (2013, October 21), p. 8

**Figure 6: Renewable Energy Power Plants Eligible to Be Funded through the EEG**




Notes: Key Legend (from left): Landfill-, bio- and mine gas, Water, Biomass/biogas, Wind, Solar
Source: [194]

Not only the direct costs of fostering renewables should be looked at but also the follow up costs especially the effects on grid reinforcement and enlargement to create a large enough demand range for renewables and some additional costs of running thermal power plants in load following mode at a lower fuel efficiency and higher maintenance costs. Not earning money from written-off investment which are still operational (golden end), however would – not cause extra costs to the companies, but would be opportunity costs to the economy. The golden end may (in a regulated system) accrue to the customers who have already paid for it or in a non-regulated system result in extra profit for the companies. When the operation of the written-off investment comes with large externalities, like for nuclear, this may compensate for not realizing the golden end. This looks different for fossil fuel-powered plants, which still can be used as cold reserve.

There are not only costs but also benefits linked to closing nuclear and expanding renewables, such as avoided costs for fuel supply and waste disposal or avoided externalities on the environment, GHG emissions and improving security of supply by using domestically produced energy.

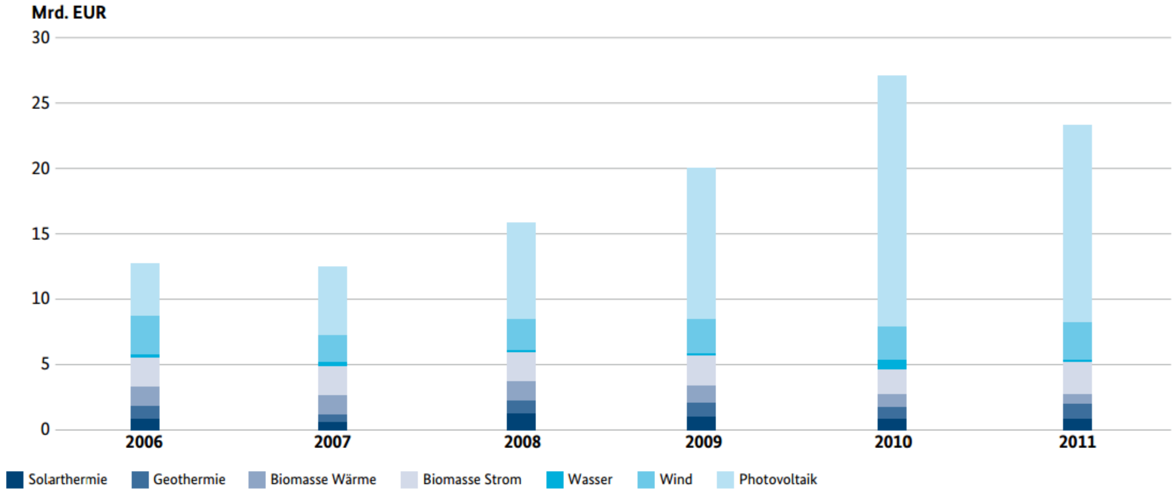
Any value put on $CO_2$ emissions, such as the costs of $CO_2$ emissions trading rights or as a tax or as a shadow price (by restrictions imposed on power plants to reduce $CO_2$ emissions) will increase the variable operating costs in line with $CO_2$ emissions and result in higher prices charged on the wholesale market, to the detriment of the consumer and to the benefit of the institution which cashes in the earnings for the EUAs or for the tax. Like a shadow price it may result in fuel switching which results in an extra rent for the $CO_2$-low fuel (i.e. gas) or in investment in higher efficiency plants creating some extra cash costs which are fictitiously counterbalanced by externalities not produced.

The main costs of renewables are investment and financing costs as most renewables have no or small operating costs (mainly maintenance). Substantial investment was made in

[194] BMWi (2012a), p. 46

renewable energy in recent years (see Figure 7 below). Since 2008 the largest portion was for PV. This is mainly private investment by households and farmers (and only a minor part of it by power companies). Overall investment in 2012 decreased to €19.5 billion (of which €11.2 billion was for PV), while the renewable capacity added increased compared to 2011, due to cost reduction for renewable installations[195].

**Figure 7: Investments in Renewable Energy**




Notes: Vertical Axis label: Billion EUR
Key Legend (from left): Solar thermal, Geothermal, Biomass (heating), Biomass (electricity), Water, Wind, Photovoltaic
Source: [196]

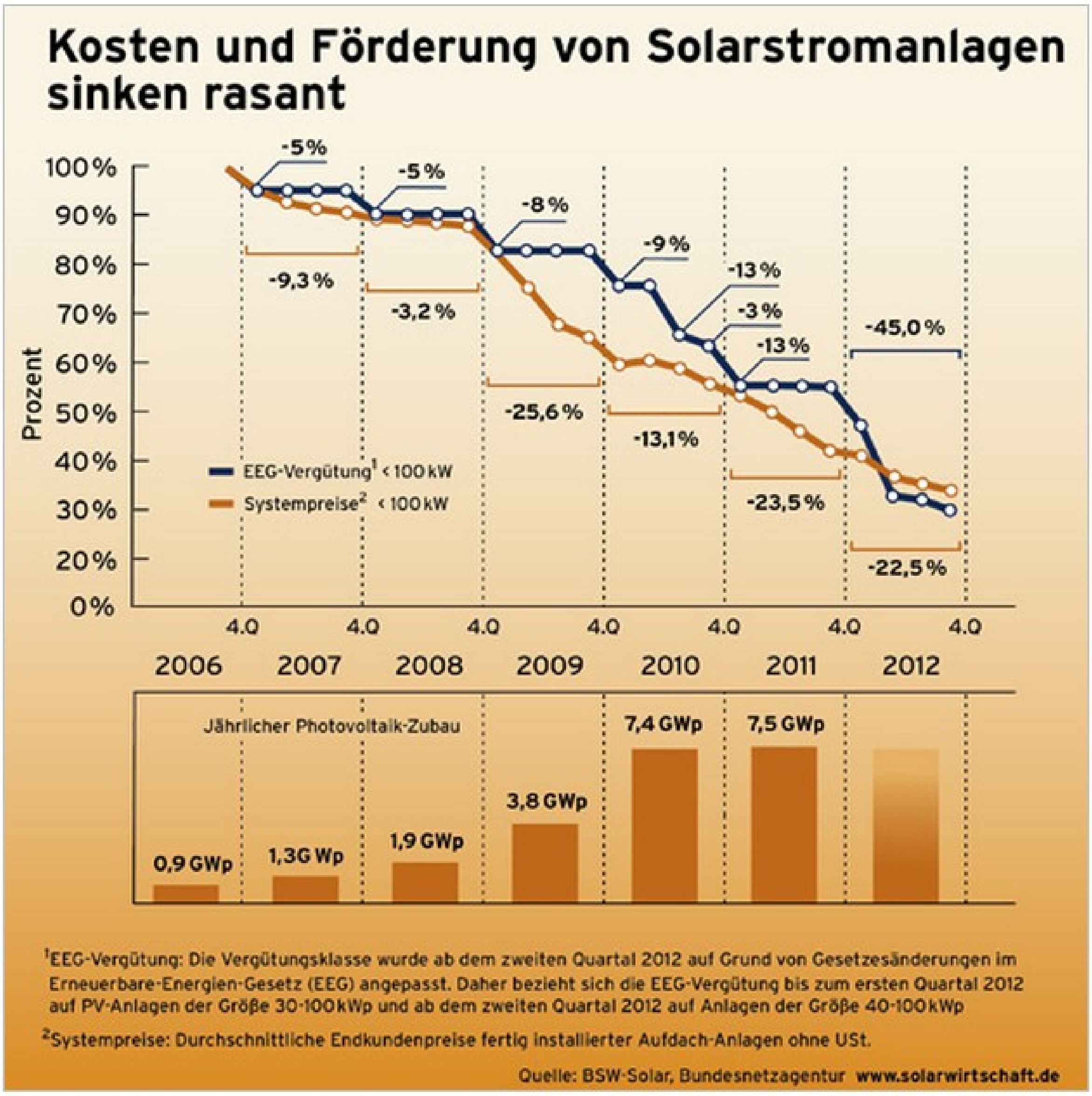
From an overall economic point of view the invested money is saving cash costs for fuel and fictitious (internalized) costs of $CO_2$ emissions.

From an overall economic point of view reduced earnings by the existing thermal plants is not an economic loss but rather a redistribution of costs and earnings. Total earnings for the thermal power plants are reduced by the volumes now produced by renewables. For the remaining volumes of thermal power the wholesale market price is lower as the marginal plants determining the wholesale market price are those having lower variable operating costs. This loss of income for the power plant operators is to the benefit of the buyers on the wholesale market. At the same time the capacity of the thermal power plants is needed to guarantee reliable power supply but in an energy-only market they are increasingly not paid for keeping capacity available. Or: wholesale buyers are paid less for amortizing the fixed costs of the necessary power plant capacity, while the full costs of renewables are paid by all non-exempted power customers.

The feed-in tariffs for installations have been following the decreasing costs especially of PV cells maybe with some delay, see Figure 8 below.

[195] BMU. (2013, February 28). p. 11
[196] BMWi (2012a) p. 105

Figure 8: Costs and Funding for PV Systems Sink Rapidly




Notes: Key Legend: Blue: EEG funding <100 kW*, Brown: System prices <100 kW**, Lower graph: Yearly PV increase

*The EEG (Renewable Energy Law) funding category was amended in Q2 2012. Until Q1 2012, EEG funded PV systems of 30-100 KWp. Effective from Q2 2012, EEG funded PV systems of 40-100 kWp.

**Average end customer prices for installed roof solar panels (without VAT).

Source: BSW-Solar, Bundesnetzagentur www.solarwirtschaft.de, [197]

## *Flaws in the EEG for PV*

The main flaw in the scheme for PV is that the feed-in tariff was not adjusted when the costs of capital fell as a result of the financial crisis, creating a large incentive to invest into PV. As

[197] Solar Contact. (2013, September 29)

an illustration: An investment of €100 in PV creates a cash flow of €10 over 20 years, corresponding to an interest rate of about 7%. Discounting the cash flow of €10 over 20 years with a typical interest rate for long term financing of about 3% creates an NPV of about €150. The commitment resulting from the EEG scheme to remunerate PV is at the present price of capital about 50% above the value of the investment.

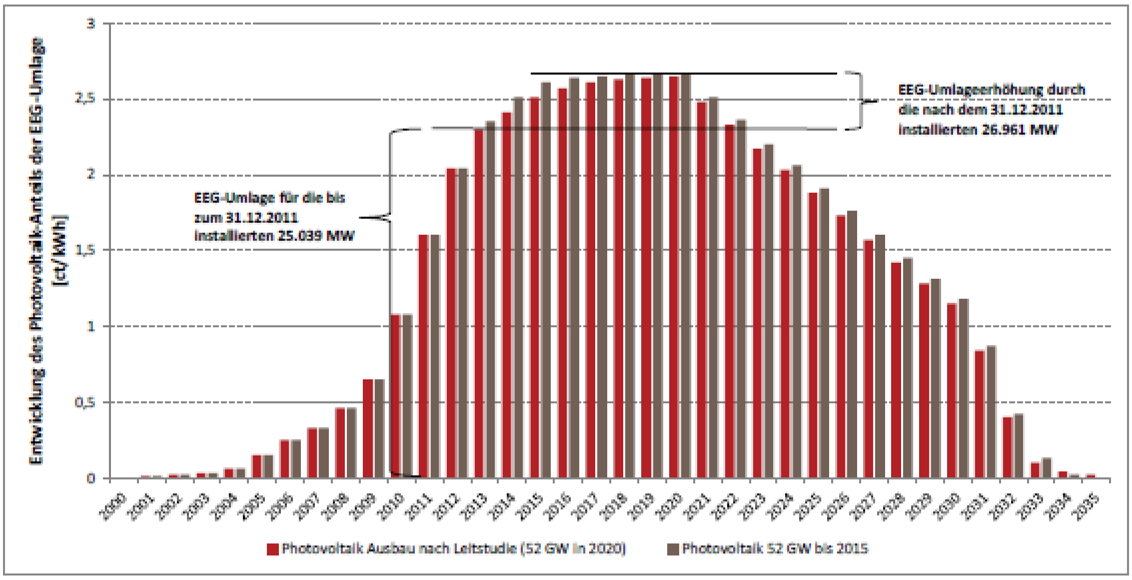
This generous incentive then resulted in a very high number of units installed after the financial crisis as of 2009, a consequential flaw in retrospect as the units could have been installed a few years later when costs had come down the learning curve. In 2009 out of 7.4 GW worldwide 3.8 GW were newly installed in Germany and the following years saw a tremendous increase of newly installed annual capacity worldwide: 2010: 7.4 GW were installed in Germany out of 17.1 GW worldwide. 2011: 7.5 GW installed in Germany out of 30.4 GW worldwide and 2012: 7.6 GW installed in Germany out of 31.1 GW worldwide[198]. From 2005 to 2010 worldwide total installed capacity developed from 5.4 GW to 40.7 GW and further to 102.0 GW in 2012. Prices for installed PV (in Germany) dropped from €5,000/kW in 2006 to €3,000/kW in 2010 and further to €2,000/kW in 2012 and €1,660/kW in mid-2013[199]. The increase in German PV installation by about 7.5 GW in each of the years 2010, 2011 and 2012 was not any more an essential contribution to the increase in installations worldwide (and thereby to cost decrease) but would have been available for about half the price if installed 3 to 4 years later. This steep capacity increase was also not necessary to reach the overall German renewable target of 35% of power production in year 2020 and the steep development of PV rather created difficulties in integrating the new PV capacity into grid operation. Following that logic if about half of the capacity of 18.6 GW installed during 2009 – 2011 or about 10 GW were installed at a price which was about €1,000 - €1,500/kW higher than 3 or 4 years later: a total difference in investment costs of about €10 - €15 billion could have been saved.

### *Past Mistakes*

As the feed-in tariffs are guaranteed for 20 years, it will take time until the support (to be paid by electricity customers via the EEG fee) for the large PV capacity additions of the years 2009 – 2012 to come to an end. Figure 9 below reflects the impact of the steep building up of PV capacity in the years 2009 to 2012 as a component of the EEG fee and the moderating effects of the ceiling for new PV capacity and the cost reductions in the time after 2012. Even under the restrictive policy (and cost reductions) for new PV the impact of existing commitments on the EEG fee are only slowly reduced over the next almost 20 years.

[198] BSW Solar, (Juni 2013), p. 2; EPIA. (2013, May)., p. 13
[199] BSW Solar, (Juni 2013) p. 4

**Figure 9: Share of PV in the EEG Fee while Reaching the 52 GW Threshold in 2015, compared with 2020**




Quelle: [DLR et al., 2012] (Eigene Berechnungen)

Notes: Vertical Axis label: Development of the PV share of the EEG subsidy [cts/kWh]
Key Legend: Red: PV development based on pilot study (52 GW in 2020), Grey: 52 GW of PV by 2015
Comment in the left portion of the graph: EEG subsidy for the 25,039 MW installed by 31 December 2011
Comment in the right portion of the graph: EEG subsidy increase for the 26,961 MW installed after 31 December 2011
Source: DLR et al., 2012 (own calculations), [200]

These are mistakes of the past which should be addressed when designing the support frameworks for future investments. It seems to be the consensus in Germany that the tariffs of the EEG should not be corrected retroactively. This would violate the Energy Charter Treaty to which Germany is a Contracting Party, which in article 10 (1) stipulates[201] "Each Party shall observe any obligations it has entered into with an Investor or an Investment of an Investor of any other Contracting Party." While this would not directly apply to German investors, any investor from any ECT Contracting Party could go to arbitration against Germany with a reasonable expectation of winning. And as important: Germany would jeopardize its triple A rating as retroactive changes of investment promises would not go unpunished by the rating agencies and by investors.

Investing too early in PV before costs had come down was spending too much money which could have been spent otherwise for Germany. By contrast the high interest rate is an issue of welfare distribution benefitting the wealthy. This could be readjusted on a broad basis by social policy instruments completely outside of the energy sector.

[200] BMWi. (2012b, December). P.51
[201] Energy Charter Secretariat. (2004). Energy Charter Treaty Art 10.1

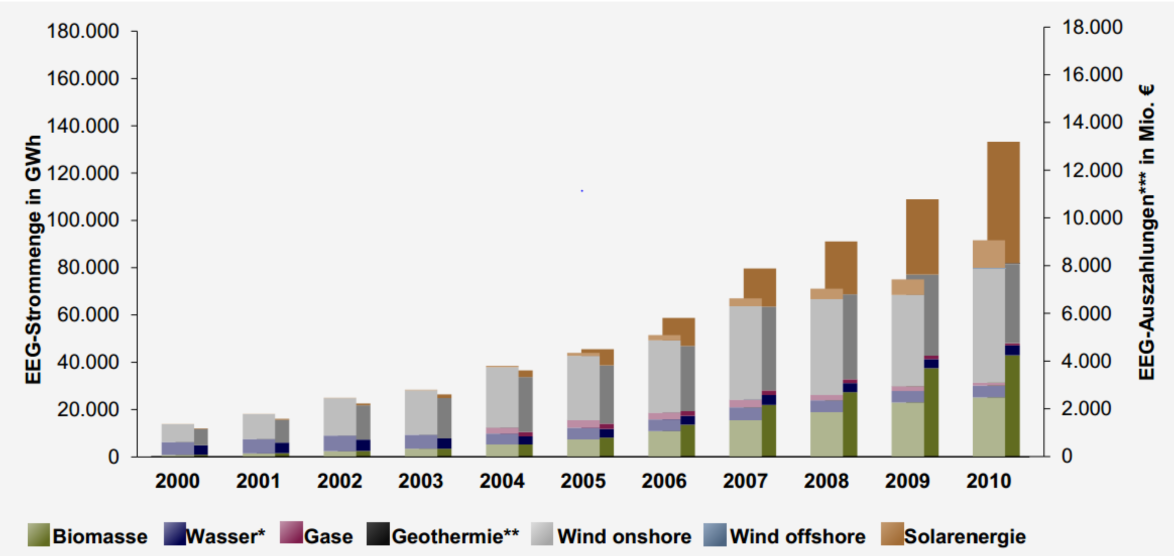
### *Supporting the Right Renewable?*

Another issue is the disproportionate support of PV compared to other renewables when comparing the results.

Since 2008 more than half of the investment in renewables has been in PV, while in 2012, out of total earnings of €14.4 billion from renewables only €1.22 billion was from PV. By contrast, earnings from biomass as automotive fuel were €3.53 billion and earnings from biomass for power and heat were €6.77 billion, together about 70% of total earnings [202].

Payments for PV are now markedly disproportionate to the volumes of electricity generated by PV, see Figure 10 below.

**Figure 10: EEG-Subsidised Electricity Volumes and Volumes of Subsidies**




Notes: Left Vertical Axis label, columns in the foreground: EEG-subsidised electricity quantity in GWh
Right Vertical Axis, columns in the background: EEG payments in Millions of EUR***
Key Legend: Green: Biomass, Blue: Water*, Purple: Gasses, Black: Geothermal**, Grey: Onshore Wind, Light blue: Offshore Wind, Brown: Solar Energy
* Until end 2003, water also included the gas category
** Geothermal not visible in graph; 2010: electricity quantity 28 GWh, EEG subsidy 5.7 m EUR)
*** 2010: EEG subsidy excl. payments for private consumption of PV, EEG paragraph 33 (2)
BDEW Bundesverband der Energie- und Wasserwirtschaft e.V. (Association for Energy and Water Management [a registered society])
Source: EEG-Jahresabrechnungen, [203]

A recent study by EWI compares the overall costs of different renewables inclusive of the resulting grid enlargement costs. Wind power in the South of Germany comes out as most economic. See chapter 3.2.

[202] BMU. (2013, July)
[203] BDEW. (2012, January)

### *Other Countries' Corrections of PV Feed-in Schemes*

Apparently in some countries the stress on the budget, the economy or the consumers' bill from PV feed-in schemes was building up to a point that the government implemented retroactive corrections to the schemes. In an open letter to EU Commissioner Oettinger EPIA[204], the European Photovoltaic Industry Association, lists 5 cases in Belgium (Flanders), Bulgaria, the Czech Republic, Greece and Spain, claiming that retroactive measures affecting PV investments had been enacted while more measures were being considered in the Czech Republic, France and Spain.

In spite of these concerns, the Spanish government on July 16, 2013 announced more retroactive changes by replacing the feed-in-tariff system for renewable energy, by a guaranteed return on renewable investment of 3% above treasury bonds. There are some parallels between the Spanish and the German promotion of PV by a feed-in tariff, the steep increase of PV installed capacity and support to PV in the order of 0.5% of GDP[205]. There are however some important differences: the Spanish system involved the state budget in the payment of the PV feed-in tariffs instead of passing its costs directly to electricity customers as in Germany. By not passing the costs of the feed-in tariffs to the customers a substantial deficit was accumulated in the Spanish budget and tax payers instead of power consumers paid for the scheme. In addition, the Spanish adaptation to the development repeatedly included retroactive changes to the detriment of PV investors, which has not happened in Germany.

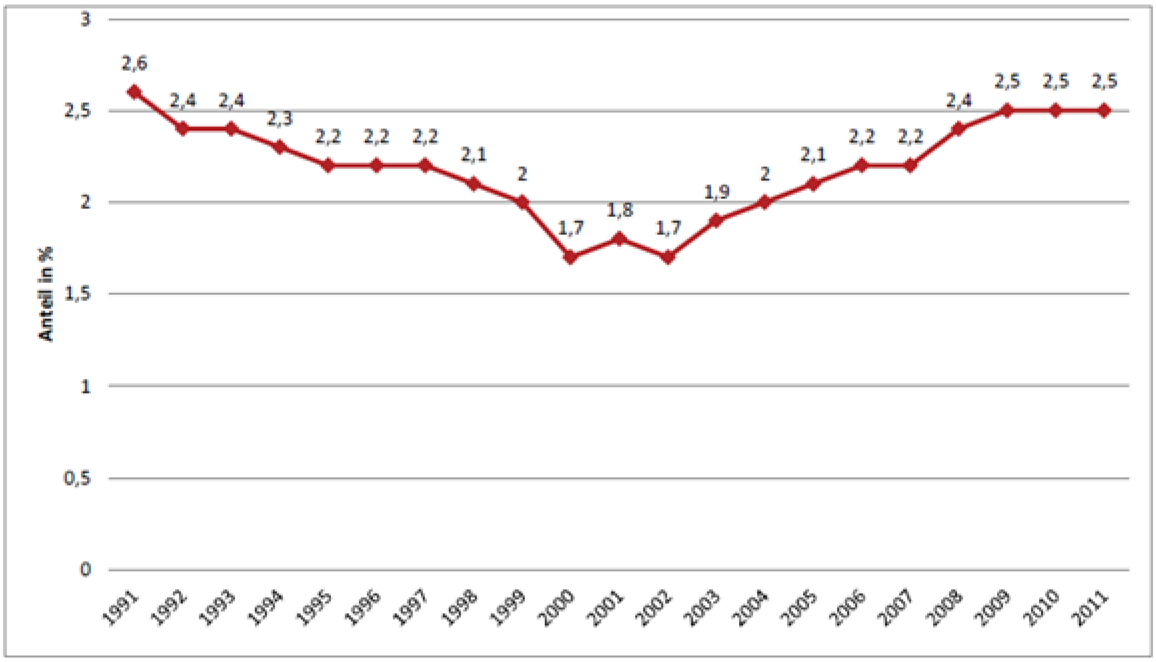
### *Energy Prices and EEG Fees: Too Much of a Burden?*

During the German election campaign in 2013 it has been repeatedly claimed that high energy costs – often referring to the fees under the EEG – would jeopardize the competitiveness of German industry and be too high a burden on households. Looking at the development of the last 20 years it seems that the level of burden of energy costs and EEG costs in particular are still within the level experienced in the past.

The share of spending on electricity (which includes the costs of electricity, the fees for the grid and the EEG fee as well as concession fees and energy taxes), fell from 2.6% of GDP to 1.7% in 2002 and then rose steadily back to 2.5% in 2011. See Figure 11[206] below.

[204] EPIA. (2012, December 17)
[205] The Economist. (2013, July 20)
[206] BMWi. (2012b, December). p. 101

**Figure 11: Share of the Aggregate End User Spending on Electricity in GDP (1991-2011)**



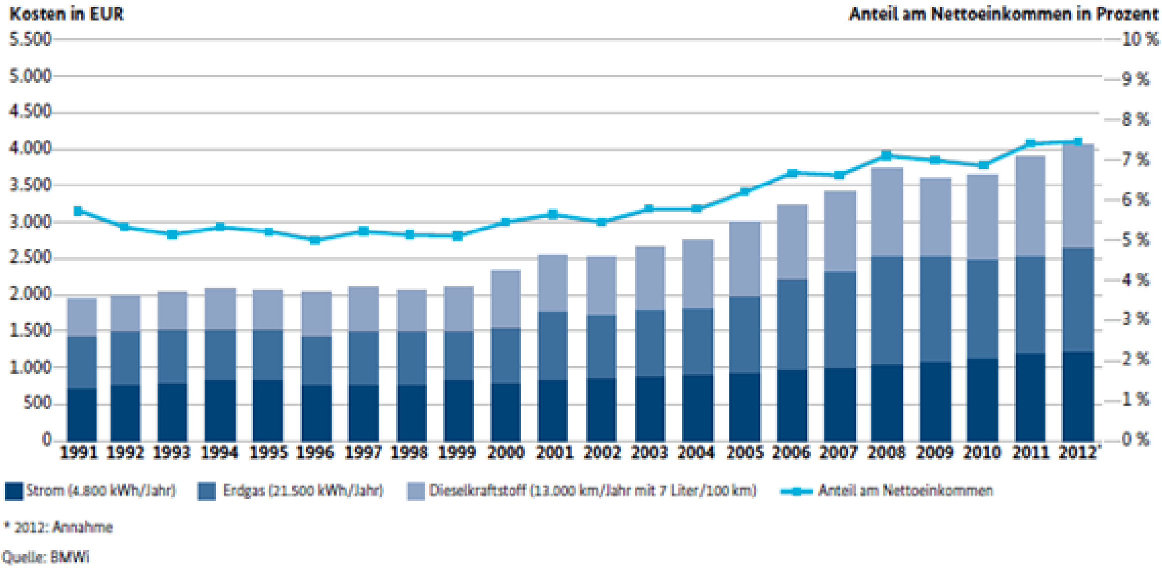

Quellen: [Destatis, 2012g], [Destatis, 2012h] (Eigene Darstellung)

Notes: Left Vertical Axis label: Share in %
Sources: [Destatis, 2012g], [Destatis, 2012h] (own presentation), [207]

Figure 12 below [208] shows the burden of energy bills for a typical 4 person household in absolute terms and as a percentage of the household net income. Since 1991 the total expenditures on energy increased from slightly below 6% to slightly above 7%, while expenditures on electricity in the same period were rather constant at about 2% of their net income. The development shown does obviously not reveal the distributional effects especially due to the PV scheme. For the poorer parts of the German population the share of their electricity bill in total income is probably higher and its increase more difficult to absorb. These are problems which should rather be addressed by social policy instruments.

[207] BMWi. (2012b, December). p. 101
[208] BMWi (2012a). p. 95

**Figure 12: Annual Energy Costs and Share in Net Income for a Typical Four-person Household**



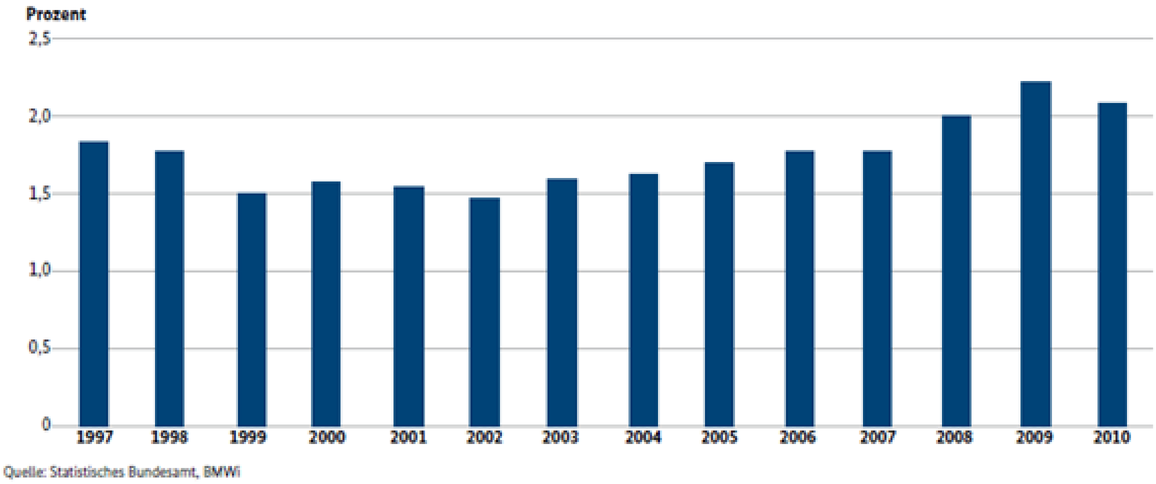

Notes: Left Vertical Axis label: Costs in EUR
Right Vertical Axis: Share of net income in %
Key Legend: Dark blue: electricity (4,800 kWh/year), Blue: natural gas (21,500 kWh/year), Light blue: diesel fuel (13,000 km/year at 7 litres/100 km), Blue line: Share of net income
* 2012: prediction
Source: BMWi, [209]

Traditional wisdom has it that the share of energy costs of manufacturing industry (on which German exports are based) is about 2% of their gross value of production. While at the beginning of the first decennium this was only 1.5% (mainly due to low oil and gas prices) the gradual rise to 2% in 2010 did not harm German competitiveness when measured by the export position of Germany. See Figure 13 below[210].

There is even less reason for most industry to complain as the number of exemptions from paying the EEG fee has increased substantially since 2010, not only exempting large electricity consuming industries like aluminium but also industries with much smaller electricity consumption. The EU Commission has raised concerns over the expansion in the number of customers being exempted from paying the EEG surcharge[211].

[209] BMWi (2012a) p. 95
[210] BMWi (2012 a) p. 97
[211] Spiegel Online. (2013, May 29)

**Figure 13: Share of Energy Costs in Gross Value of Production in the Manufacturing Industry**




Notes: Left Vertical Axis label: Costs in EUR

Source: Statistisches Bundesamt (Federal Statistical Office), BMWi, [212]

There is no doubt that mistakes were made by over-generous support of PV after the financial crisis. But apart from having invested too early in PV when it was still on the steep part of the learning curve, the generous support of PV via implicitly too high interest rates built into the feed-in tariffs is mainly a distributional effect which can be corrected by instruments of social policy. Most of the fee to be paid for the next 10 – 15 years stems from past investment promises which should not be changed retroactively. In that regard the room for adjustment is only for future support. Here however, it would be useful to readjust the support scheme to look for more electricity produced and more income as a result of the support, mainly by fostering more biomass in Germany and more onshore wind power in the South of Germany.
And when it comes to achieving the de-carbonization targets it is absolutely crucial (see chapter 2.4) to ensure the targets for energy savings in buildings are met.

## 2.6 Results of the Election of September 22, 2013

The elections held on September 22, 2013 were a large success for the Chancellor's Christian Democrats: The CDU and its Bavarian Sister Party CSU together won 42.5% of the vote resulting in 311 out of 631 seats in Parliament 5 seats short of an absolute majority of 316 mandates [213]. As the previous coalition partner FDP only got 4.8%, missing the 5% threshold for entering the Parliament,  a continuation of the previous coalition conservative coalition was not possible. The SPD improved only slightly, by 2.7%, reaching 25.7 % of the vote. The Green Party came in with a rather disappointing 8.4 % even narrowly surpassed by the left party (Die Linke) with 8.6%. While a red-red-green coalition would have a narrow majority in parliament, the parties for such coalition were at this time not politically prepared for it.

[212] BMWi (2012a), p. 97
[213] Bundeswahleiter (2013, October)

### *Negotiation of a Coalition Agreement between CDU/CSU and SPD*

Consequently coalition talks were held between the CDU/CSU and SPD until November 27, 2013 when the 185 page coalition agreement[214] was finalized and presented to the public. As a novelty the leadership of the SPD put the result to a vote of their 475,000 members of which 78% participated. The result was released on December 14, 2013: a clear majority of 76% voted in favor of accepting the coalition agreement[215]. The coalition agreement was then signed on December 16, 2013 [216]and the next day Angela Merkel was for the third time elected as Chancellor by the parliament and sworn in together with her new cabinet[217].

One out of twelve committees in the coalition negotiations dealt with energy and was co-chaired for the Christian Union by Peter Altmeyer (CDU), the minister of environment in the CDU/CSU/FDP government. The co-chair on the side of the SPD was Hannelore Kraft, prime minister of North Rhine Westphalia, the Land with the strongest activities in traditional energies like lignite and coal and the headquarters of RWE and E.ON. The coalition agreement “Deutschlands Zukunft gestalten” (Shaping Germany´s Future) deals under section 1.4 [218] with the Energiewende under the title: "Die Energiewende zum Erfolg führen" (Making the Energiewende a success).

### *The Coalition Agreement on the Energiewende*

***Generic approach***

The text is obviously the result of negotiations and compromises between many different positions, not only between the three political parties involved, but also between different states (Länder) with representatives in the negotiating team. Not surprisingly it is not inspiring, nor stringently structured but rather reflects the various conflicts of interest which came up since the Energiewende was decided. However, it makes clear that this coalition has the political will to continue the Energiewende with the phase out of nuclear by 2022 and keeping the concrete decennial goals for GHG and $CO_2$ reduction based on sustainable development, as engine for progress and competitiveness, derived from international climate policy goals while modifying its implementation where deemed necessary by proposing concrete measures.

Interestingly the notion of affordability is introduced as the third pillar of the classic triangle of energy policy (together with environmental protection and security of energy supply) reflecting the dispute over the rising EEG fee, which was a major subject during the election campaign. This notion of affordability clearly differs from the elements of economic efficiency and competitiveness usually referred to as the third pillar for instance by the IEA, but also by previous German policy documents.

This notion of affordability is reflected in caveats such as that achieving ambitious European de-carbonization goals must not be to the detriment of energy intensive industry in

[214] CDU (2013, November)
[215]SPD (2013, December 13 )
[216] Spiegel Online. (2013, December 16)
[217] Deutscher Bundestag (2013, December)
[218] CDU (2013, November) p. 49 - 61

international competition and also by hinting at possible dichotomies between the Energiewende and keeping jobs and value chains. This is obviously addressing the discussion of the EEG fee which is perceived as too high, but also the vested interest to keep the exemptions which have been broadened under the previous CDU/CSU/FDP government in favour of a larger number of smaller industries. It is recognized that this issue will be influenced by the position of DG Competition in the context of state aid.

Below the main elements are presented in more detail:

***Phase out of Nuclear while Maintaining Reliable Power Supply***

The chapter on nuclear energy starts with a clear statement confirming that nuclear will be phased out by 2022 with an emphasis on safety for all nuclear plants to their last day. The nuclear industry is expected to responsibly cooperate on the phase out and to carry the costs of the dismantling of nuclear plants and of the safe disposal of radioactive waste. This will become subject of talks with the industry. The challenge for reliability of power supply of phasing out nuclear is dealt with in detail in the context of renewables.

***Climate Policy / GHG and $CO_2$ Reduction***

The coalition agreement reconfirms the GHG and $CO_2$ reduction targets of the Energiewende, and even aims at making the most important of them binding legislation. Especially the target for Germany of a 40% reduction by 2020 is reconfirmed.

How to reach the GHG targets is mainly referred to the instrument of the ETS, which should only be corrected if targets are missed.

Conspicuously the issue of CCS is not mentioned.

*Energy efficiency*

The importance of energy efficiency as a crucial element of the Energiewende is emphasised and the need to deal with it as policy to be coordinated across several sectors. However, many proposals are not very concrete nor supported by financing. The target of a 2% refurbishment rate of old buildings, crucial for meeting the de-carbonization targets is not mentioned.

Two elements are presented in detail:

(i) The establishment of a National Action Plan for energy efficiency with a monitoring mechanism, the first to be decided in 2014. The first measures listed are mainly a continuation and further development of existing policy and instruments including proper implementation of the EU energy efficiency directive; and
(ii) The creation of a climate friendly heat market based on an analysis of the potential development of markets for energy efficiency. The target of an almost climate neutral building stock by 2050 is reconfirmed. Beyond continuation and further development of existing instruments the usage for heat production of excess power from renewables which otherwise would have to be regulated down is introduced as a new element.

Under another section dealing with "good and affordable housing" the measures of the Energiewende regarding energy efficient building construction and refurbishment are confirmed, also the policy to support research for new construction approaches[219].

The target of 1 million electric cars by 2020 is confirmed in the section on traffic [220]. Regarding the role of gas in transportation, tax breaks for gas fuelled cars should be prolonged beyond 2018 and the use of LNG in shipping should be promoted.

*Renewables*

Half of the section on the Energiewende (6 out of 12 pages) is devoted to renewables, their support and consequences of renewables for the power balance and the grid and to the development of power storage. This seems to be driven by three issues:

(i) How to avoid excessive costs and negative implications on competitiveness of industry:

There is a clear and unambiguous guarantee that past investment under the EEG will not be affected, i.e. that there will be no retroactive changes in the EEG scheme.

The main driver seems to be protection against excessive and uncontrolled development of renewables by defining a legally binding development corridor (also serving as a basis for grid development, further development of the conventional part of the power system and changes in the method of supporting renewables). The overall corridor for renewables is defined as a share of renewables in power production of 40 – 45% in 2025 and 55 – 60% in 2035, close to the minimum of the earlier decided framework. The corridor will then be broken down for the individual renewable energies.

For offshore wind the targets will be adapted to existing development foreseeing 6.5 GW by 2020 and 15 GW by 2030.

For PV no change is foreseen to the present system of a flexible cap. For biomass the focus will be on waste and an overall concept will be developed to avoid competition with food production.

For onshore wind the focus will be on sites with strong winds. However, the proposed option for Länder to individually define the minimum distance between wind power installations and settlements may impede further installations especially in the South.

(ii) Increasing market integration of renewables: For new installations above 5 MW a changed model of support is foreseen, a premium on top of the market price instead of a feed in tariff. Generally more market elements should be introduced and instruments to reduce feed in of renewable power if required for safe grid operation by regulating down a certain percentage of new installed capacity. By 2018 a pilot model of how to support renewables via tender should be developed.

The exemptions from the EEG should be checked to ensure conformity with EU rules and self-consumed electricity from at least new installations should in principle participate in the financing of the EEG.

[219] CDU (2013, November), P 116
[220] CDU (2013, November), P 44

(iii) Maintaining reliability of the power system: This includes sufficient dispatchable power capacity and the necessary development of grids on all voltage levels (power market design) and the development of power storage.

The need for highly efficient and flexible conventional power plants is emphasized and a need for mechanisms to keep dispatchable capacity in the market. Existing fossil fuel plants may serve as part of the existing grid reserve (“Netzreserve”) and BNetzA will in this context check the need for new capacity and ensure its construction if proven necessary. Also flexibility options on the demand side have to be considered. Medium term an EU-consistent capacity mechanism should be developed which is technology neutral, cost-efficient and market-based.

The existing target to increase the share of CHP to 25% by 2020 was reiterated; an in-depth-analysis of its potential is to be carried out as soon as possible.

The development of the high voltage grid will be based on the corridor for development of renewables. Acceptance is still a major problem for grid enlargement. New DC technologies will be tested and the integration of the EU power grid supported.

Investment conditions for distribution grids will be improved by further development of the incentive regulation and of intelligent grids.

The financing of grid infrastructure will be checked, an introduction of a capacity charge for grid use also for feeding into the grid considered.

Framework conditions for power storage should be technology neutral, especially pump storage should remain commercially viable. The technology of power to gas should be brought to the commercial stage by more pilot projects.

### *Participation, Institutions*

The coalition agreement suggests creating two new institutions: An Energiewende Forum (Energierat) for a permanent dialogue between representatives of the economy, trade unions, science and relevant social groups, and a centre of competence - “Naturschutz und Enegiewende” - to foster a more qualified discussion.

### *New Shape of Ministries*

The new government has changed the shape of the ministries relevant for the Energiewende: responsibility for the Energiewende is concentrated at the ministry for economy, which changed its name from “Ministry for Economy and Technology” to “Ministry for Economy and Energy”. The respective additional responsibilities for renewables and climate policy issues in the context of the Energiewende were taken out of the Ministry for Environment which instead took over responsibility for housing and urban planning from the Ministry of Traffic.

The politically important issues of energy policy on one side and on the other hand of climate policy, for which refurbishment of buildings is most important, each are now in a single ministry allowing a more stringent policy implementation at the ministry level. It also helps that for the first time both ministries are in the hands of the same party (SPD) so that unnecessary party politically motivated disputes, as experienced for instance over Germany´s position in the discussion of the EU energy efficiency policy, should be avoided. The importance given to the Energiewende is supported by the fact that Sigmar Gabriel, the new

Minister of Economy and Energy is at the same time Vice Chancellor and party leader of the SPD, having sound political experience with environmental issues as former minister of environment during the 2005 – 2009 great coalition. Also the nomination of Rainer Baake as administrative deputy minister (beamteter Staatssekretär)[221] is considered by many as a token of engagement by Sigmar Gabriel for the success of the Energiewende. Baake played a crucial role in the negotiation to phase out nuclear in 2000 and for the design of the renewables policy during the 1998 – 2005 Red Green Government.

### *The Role of Gas*

The role of gas is again not addressed in any explicit way, except for power to gas and fracking, which strangely is dealt with under the sub-section on phasing out nuclear just after the topics of disposal of nuclear waste and protection against nuclear radiation.

Otherwise the role of fossil fuels (lignite, hard coal and gas) in power generation is seen as necessary to ensure reliability of power supply and in particular to cover the residual resulting from the corridor for renewables. While the compensation of intermittence by all fossil and dispatchable power plants is acknowledged no consideration is given to the different $CO_2$ impacts of the fossil fuels. This is again implicitly left to the (energy only) electricity market and the ETS, which are not discussed in a critical way, in spite of their questionable rationale and their proven problems / ineffectiveness.

Not addressing the role of gas stems also from the lack of a holistic view and from reducing the discussion on the economic optimization and consequences of the Energiewende to the impacts of the EEG.

The further development of fossil fuel power generation is left on one side to the strongly regulated development of renewables and on the other hand to a politically unguided “free market” reaction by the players in the classic means of power production. This creates uncertainty for the investors and employees in that sector and gives little guidance to the large power companies and the municipal utilities (Stadtwerke), foreseeably creating tension for the implementation of the Energiewende.

In a comment published on January 2, 2014[222] Klaus Töpfer, former head of UNEP and head of the ethics commission in 2011, has already criticized that the role of lignite for security of supply and the role of gas for climate protection is not addressed in the coalition agreement .

221 BMWi (2014, January 9)
222 Süddeutsche Zeitung. (2014, January 2)

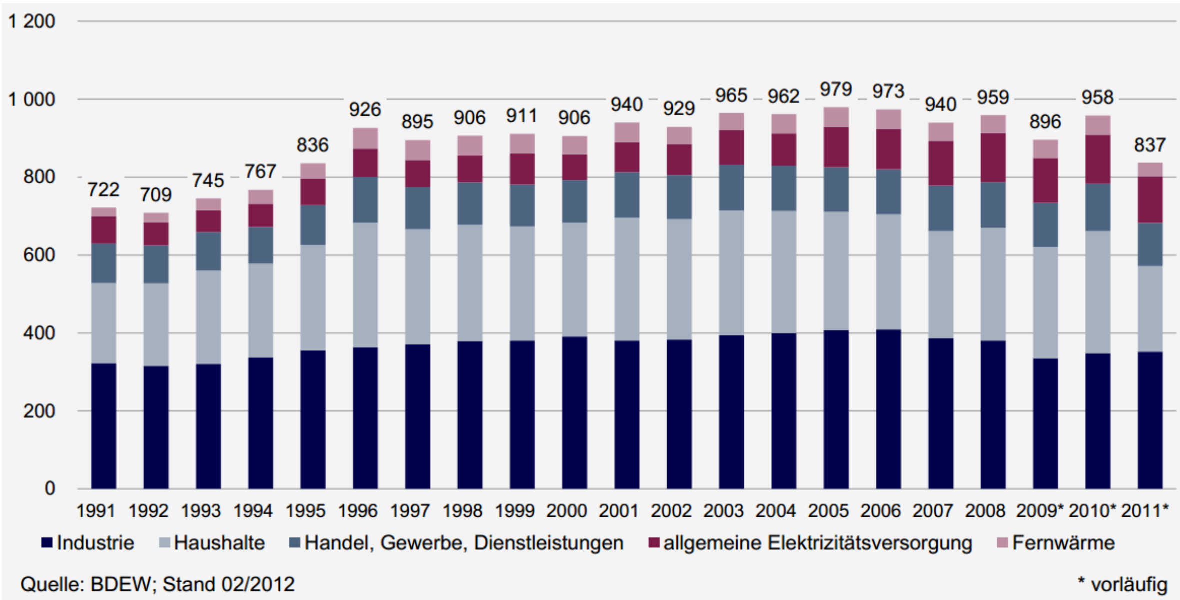
## 3. Role for Gas

While the two preceding chapters dealt with the various elements of the German Energiewende the following chapter will address specifically the role of gas in German energy policy and in the EU and in more generic terms its role in de-carbonization. The first section will address the recent development of the role of gas in its traditional segments as well as in power generation especially also touching on the role of fuel prices and of carbon pricing in the context of the merit order and the role of the ETS. The second section will elaborate on the role of gas in scenarios and the policy discussion supported by it. Section 3 will address the long term role of gas from which its potential role for a transition period is derived in Section 4. Section 5 then tries to outline ways to improve the role of gas for de-carbonization (in German energy policy).

### 3.1 Recent Developments

After an impressive development prior to the turn of the century, gas consumption increased only moderately until 2005 and thereafter was stagnant and even decreased (see Figure 14).

**Figure 14: Industry is the Biggest Natural Gas Consumer**




Notes: Vertical Axis: Natural gas usage in Germany in billion kWh

Key Legend: Dark blue: industry, Light blue: households, Grey: business, trade and services, Purple: public electricity supply, Pink: district heating

*preliminary

Source: BDEW; as at 02/2012, [223]

[223] BDEW. (2012, February)

From 2011 to 2012 gas consumption increased to 909 billion kWh while on a temperature adjusted basis it decreased by 2% (2011 was a rather warm year, while 2012 was colder than average).

Industry and households are the largest sectors of gas consumption. While industry consumption is relatively stable but depends on economic activity (as in the decline in demand post 2008) gas consumption in households but also in the commercial sector shows a strong dependence on temperature. The use of gas for power increased during the last decade with new power plants coming on line as the effective ban on gas use in the power sector in Germany was withdrawn from the mid-1990s. By international comparison the use of gas for power generation in Germany is small in absolute and in relative terms, as is its use in district heating and refrigeration/air conditioning.

What is undisputed is that gas fits very well with CHP of all sizes, even though the share of gas-fired district heating is below 50%.

So far gas consumption in transport is marginal. However there are initiatives by the gas industry to promote natural gas as LNG or CNG for trucks and ships. In the US, with relatively cheap gas prices, gas is winning demand in the transportation sector mainly for trucks but also for locomotives. Some pictures show long coal trains in the US pulled by gas (LNG) driven locomotives.

### *Recent Developments in Traditional Sectors*

While the number of households has only slightly increased, the share of gas in domestic heating has reached 49.2%, more than 10 percentage points more than 15 years ago.

Gas has won market share in households mainly at the expense of coal (in recent years mainly in East Germany) and also at the expense of gas oil, which is still used in a remarkable 29% of existing dwellings. District heating and electricity have been constant at about 13% and 6 % respectively and electric heating by night storage and direct electric heating is gradually being replaced by electric driven heat pumps. See Table 4.

**Table 4: Heating Structure of Housing Stock**

| Year | Number of households in million | Share in % | | | | |
|---|---|---|---|---|---|---|
| | | Gas | District Heating | Electricity (1) | Heating Oil | Other Solid Fuels (2) |
| 1996 | 35.7 | 39.0 | 12.0 | 6.2 | 33.7 | 9.1 |
| 2000 | 36.9 | 44.5 | 12.3 | 5.9 | 32.6 | 4.7 |
| 2004 | 37.7 | 47.2 | 12.4 | 5.8 | 31.3 | 3.3 |
| 2005 | 37.8 | 47.6 | 12.5 | 5.8 | 31.0 | 3.1 |
| 2006 | 37.9 | 48.0 | 12.5 | 5.8 | 30.6 | 3.1 |
| 2007 | 38.0 | 48.3 | 12.5 | 5.9 | 30.3 | 3.0 |
| 2008 | 38.1 | 48.5 | 12.5 | 6.0 | 30.0 | 3.0 |
| 2009 | 38.1 | 48.9 | 12.5 | 6.0 | 29.8 | 2.8 |
| 2010 | 38.2 | 49.0 | 12.6 | 6.1 | 29.6 | 2.7 |
| 2011 | 38.3 | 49.1 | 12.7 | 6.1 | 29.3 | 2.8 |
| 2012 | 38.4 | 49.2 | 12.8 | 6.1 | 29.0 | 2.9 |

(1): Includes households heated with electricity-consuming heat pumps
(2): Among others wood, coke/coal
Source: [224]

The number of new dwellings has fallen from some 500,000 per year in the mid-1990s to some 200,000 new dwellings per year now (and below during the financial crisis). In parallel the share of new dwellings heated by gas fell from 70% in the 1990s to 50% now while the share of heating oil has practically disappeared. The winners were heat pumps which grew from a negligible share in the 1990s to almost a quarter of all new dwellings in 2012, and biomass which grew from zero to now 6%. Also the share of district heating grew during this time from 10% to more than 16%. See Table 5.

[224] BDEW. ( 2013, March 11) Anhang Tabelle 2

**Table 5: Heating Systems in New Housing Units**

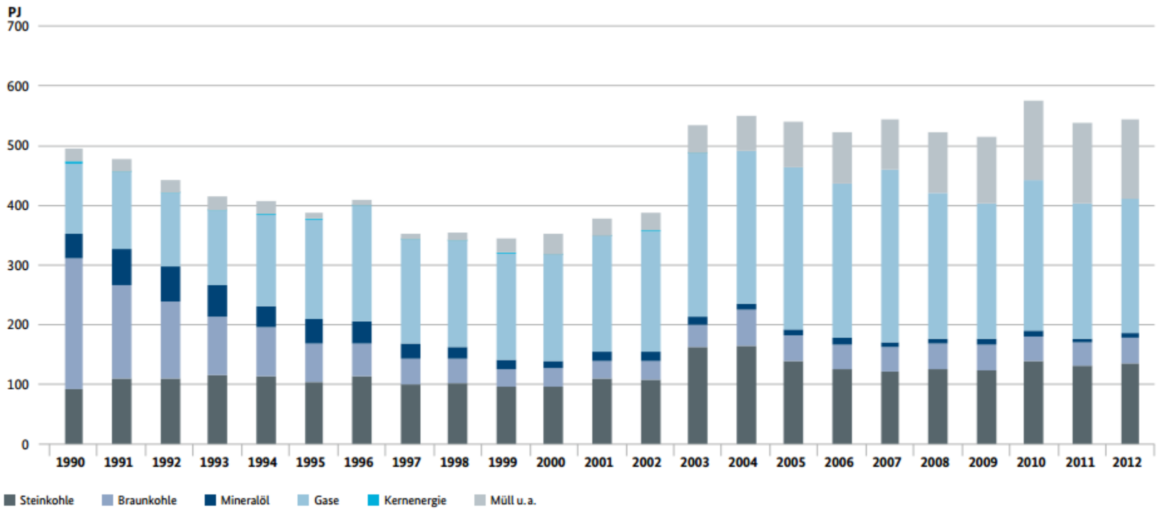
| Year | Number of housing units (1) | Share in % | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Gas | Heat Pumps | District Heating | Electricity | Heating Oil | Wood, wood pellets | Coke / Coal | Other (2) |
| 1996 | 500,554 | 72.1 | • | 9.9 | 1.1 | 16.5 | • | 0.1 | 0.3 |
| 2000 | 304,248 | 76.7 | • | 7.0 | 1.4 | 13.4 | • | 0.2 | 1.3 |
| 2004 | 236,352 | 74.9 | 3.1 | 7.3 | 1.2 | 10.7 | 1.2 | 0.2 | 1.4 |
| 2005 | 211,659 | 74.0 | 5.4 | 8.6 | 1.2 | 6.4 | 3.0 | 0.2 | 1.2 |
| 2006 | 216,519 | 66.9 | 11.2 | 9.0 | 1.0 | 4.3 | 6.0 | 0.1 | 1.5 |
| 2007 | 157,148 | 65.6 | 14.3 | 10.2 | 1.3 | 3.2 | 3.0 | 0.1 | 2.3 |
| 2008 | 148,300 | 58.4 | 19.8 | 11.9 | 1.0 | 2.3 | 4.0 | 0.1 | 2.5 |
| 2009 | 153,701 | 50.9 | 23.9 | 13.1 | 0.8 | 1.9 | 5.0 | 0.1 | 4.3 |
| 2010 | 164,540 | 50.4 | 23.1 | 14.6 | 1.0 | 1.8 | 5.0 | 0.0 | 4.1 |
| 2011 | 200,061 | 50.1 | 22.6 | 16.3 | 0.9 | 1.5 | 5.6 | • | 3.0 |
| 2012* | 211,000 | 49.8 | 24.5 | 16.6 | 0.6 | 0.9 | 6.0 | • | 1.6 |

* Provisional estimate
(1): New housing units approved for construction
(2): Included heat pumps and wood until 2000 incl.
Rounded figures
Source: Statistisches Bundesamt (Federal Statistical Office) [225]

Part of the district heating load is based on gas so that indirectly dwellings heated by district heating consume gas. However, so far the share of gas in district heating is below 50% in spite of gas being very well suited for CHP and district heating.

[225] BDEW. ( 2013, March 11) Anhang Tabelle 1

**Figure 15: Fuel Use in Thermal Power Stations and District Heating Plants**




Quelle: Arbeitsgemeinschaft Fernwärme (AGFW), Arbeitsgemeinschaft Energiebilanzen (AGEB), Bundesministerium für Wirtschaft und Technologie (BMWi)

Notes: Vertical Axis: PJ

Key Legend: Dark grey: hard coal, Blue: brown coal, Dark blue: mineral oil, Light blue: gasses, Turquoise: nuclear energy, Light grey: waste and others

Source: Arbeitsgemeinschaft Fernwärme (AGFW), Arbeitsgemeinschaft Energiebilanzen (AGEB), Bundesministerium für Wirtschaft und Technologie (BMWi), [226]

Gas sold in its traditional segments (residential and commercial, small industry) is subject to the implications of policy instruments reducing the use of gas in heating by fostering better insulation and by imposing a 15% share of renewables for new houses[227], but no incentives exist to promote gas for instance in apartment blocks. A policy reducing gas demand is accepted based on energy saving in the household which mainly affects gas. It is left to the decisions of gas customers how to optimize their energy bill but is also a result of subsidies and support and regulation by government.

### *The Role of Gas in Power Generation*

The share of gas in power generation is lower in Germany compared to countries with their own gas resources such as the UK, NL or US. In fact Germany has a long-standing, coal-friendly tradition especially for power generation, both by lignite (domestically available in West and East and cheap) and hard coal (domestically available but since the 1960s not cheap compared to fuel oil; later imported coal was substantially cheaper).

### *Recent Price Relationships of Coal, Gas, and Carbon*

In the US low gas prices since 2011 have resulted in the displacement of coal in the US power market. The growth in US coal exports and other competing suppliers such as Columbia or South Africa and Indonesia has resulted in low priced European coal imports.

[226] BMWi. (2012)
[227] BGBl. (2008, August 7)

The present price level is below $100/t (7,000 Mcal) [228] free ARA (Amsterdam, Rotterdam, Antwerp) with no obvious drivers likely to increase this level over the next years.

Gas prices at the NBP (the UK National Balancing Point) which are developing in line with prices in Northwest Europe were around $10/MMBTU[229] in 2013, while some gas import prices were above that level and consequently some contracts have been subject to arbitration proceedings. Recently the arbitration between RWE and Gazprom for gas supply to the Czech Republic was concluded and, reportedly includes a gas hub pricing element in the pricing formula[230]. It is questionable whether the much lower US gas prices will have a lowering effect on EU prices, even when a large number of planned LNG export terminals may come on-stream. Assuming a Henry Hub price of $4/MMBTU plus 15% for liquefaction losses plus $3/MMBTU for liquefaction plus shipping costs of $1/MMBTU from US to EU compared with $2/MMBT/U for East Asia, plus $0.50/MMBTU for regas the delivered price to the EU is about $9/MMBTU. Reportedly the fob price for Centrica of exports via Cheniere's Sabine Pass LNG export terminal is HH +15% plus a tolling fee of $3/MMBTU[231]. The Sabine Pass project (trains 1 – 4) has non-FTA approval by the DOE and approval by FERC. Three more projects (Freeport LNG, Lake Charles and Cove Point) received non-FTA approval by the DOE during 2013 but still have to go through the FERC approval procedure[232], which is technical in nature. All projects basically have tolling agreements with the gas sourced from the US gas grid and the LNG delivered fob at the liquefaction plant. The fob delivery implies that the gas can be sold anywhere and after the opening of the extension of the Panama Canal planned for 2014, which makes it fit for standard LNG tankers, Asia might become an even more attractive market for LNG.

At present price relations with an EUA price around €5/ton $CO_2$, (even after the limited back loading was agreed in a second round by the EU parliament on July 3, 2013[233]), gas is hardly commercial in power generation except for cases where exhaust heat or steam is used as an additional source of income or on days when the capacity is needed.

### *Merit Order*

In principle – apart from technical restrictions such as minimum load or restrictions during ramp up or down - power plants in a connected grid will be employed in the order of their variable marginal costs (merit order). This applied earlier for the power plant portfolio of regional monopolies and now also applies under the conditions of an open electricity market, only that in an open market all power plants participate in bidding into the market according to the overall merit order – except for gaming or speculation.

By far the largest part of the operating costs of a power plant is fuel costs. Other variable costs are: cost of water lost in the steam turbine process, costs to dispose of ash etc. (only for coal and lignite), mechanical wearing of the coal mills, disposal of the products of desulfurization and in future disposal of $CO_2$ and other variable costs of the carbon capture process.

[228] EURACOAL. (2013, September)Table 1
[229] Gas Matters. (2013, October) p. 36
[230] Ria Novosti. (2013, July 9)
[231] US Department of Energy. (2013, September 19) FE Docket 13-42-LNG April2, 2013
[232] US Department of Energy. (2013, September 19)
[233] European Parliament. (2013, July 3)

The merit order is independent of the size of the marginal cost difference between two plants: small differentials result in the same merit order as large differentials between two plants.

Before the widespread introduction of renewables the use of plants along the merit order was usually that nuclear plants and lignite plants with the lowest marginal operating costs would run in base load, as long as they were available with a load of 6,000 h/a and more. The middle load would be covered by hard coal (earlier also fuel oil), typically during working days from 6:00 to 22:00, which would be idle at night and during the weekend. Gas- and gasoil-fired plants would run to cover peak demands and some unexpected variations of the supply demand balance (for instance to compensate for unexpected outage of plants). With the introduction of intermittent renewable power generation, typically wind and PV which feed into the grid with priority, the pattern changed. The more or less predictable pattern of demand is now modified by an erratic pattern of PV and wind power supply. The resulting balance between power demand and supply by renewable power has to be accommodated by so far limited demand side measures, and dispatchable power supply from other generating sources. Wind and PV cannot be considered as reliably dispatchable power capacity and have to be backed up almost 'one to one' by dispatchable thermal power or hydro. Within the start-up time for thermal units there must be enough power plants on the grid with spare capacity to be able to compensate for relatively quick and large changes in the power balance.

For these reasons the traditional distinction between base, middle and peak load becomes less and less applicable and on windy days with low demand even lignite plants (or nuclear plants still in operation) may have to reduce load to make room for renewables or market their surplus production outside of Germany.

Apart from plants already on the grid in partial load which may be given priority when a quick ramp up is needed, for any time span, day or hour, the merit order tends to be applied.

Within power plants operated by the same fuel which is priced by the market, with equal access to fuel at market prices, the electric (conversion) efficiency decides upon the merit order which is inverse to the electric efficiency of the plants (other operating costs also tend to move inversely with the electric efficiency). While the absolute differential in operating costs between two given power plants using the same fuel would depend on the price of fuel, the merit order will not. That applies also if a cost of carbon is added which has the same effect as increasing the price of the respective fuel.

Between different fuels the merit order depends mainly on the relative prices of the fuels. The merit order of plants using different fuels can overlap, e.g. at certain price relationships the highest efficiency CCGTs can compete with the lowest efficiency coal plants.

### *The Role of Carbon Pricing for Merit Order and $CO_2$ Emissions*

The pricing of carbon can change the merit order between fuels due to the different specific carbon content (and corresponding different specific $CO_2$ emissions) per unit of energy contained in the fuel plus eventually a higher electric conversion efficiency which comes with the combination of a gas turbine whose exhaust heat is fed into a steam process (CCGT) - possible for gas oil and gas, but not possible for coal and lignite with pure steam turbines.

This way a cost of carbon either for a specific fuel, such as coal or lignite or on all fuels can change the merit order between the fuels in power generation.

This can of course also happen due to a large enough shift in fuel prices, as we saw in UK in the 1990s with the (associated, must sell) gas from the UKCS coming on stream expelling coal from base load into middle load which resulted in substantial reductions of UK $CO_2$ emissions.

The more recent example is the US where shale gas (increasingly associated with shale oil or from wet shale gas with liquids) is sold at Henry Hub at below $4/MMBTU[234] and in the 2nd quarter of 2012 was even slightly below $2/MMBTU for a short time, which makes gas competitive with coal in power generation[235].

### *Effect of Fuel Switching on $CO_2$ Emissions*

To the extent that the merit order between gas and coal is reversed, the volumes which are then produced by gas instead of coal emit only half of the $CO_2$ per kWh produced[236].

As a simple order of magnitude calculation: 10 billion kWh produced in a state of the art CCGT emits around 4 million tonnes of $CO_2$, while the same amount of electricity produced by a state of the art coal-fired power plant emits twice as much and more for lignite-fired power plants. So shifting 10 billion kWh of power generation from coal to gas saves about 4 million tonnes of $CO_2$.

Contrary to much of the discussion about highly flexible gas-fired power capacity (and eventually the discussion of a capacity mechanism) the role of gas for de-carbonization is about the load factor of gas-fired power vs. the load factor for coal- and lignite-fired power, that is about the respective volumes of fuel used.

While coal prices are world market prices the price of coal for use in power plants could be influenced by a levy on the use of coal or by an import and domestic tax on coal. The price of gas is also determined by a market or contract price, but in the future the price of gas for power generation might receive a rebate by forfeiting some of the resource rent of gas production. The incentive for a gas exporting country could be to sell more gas by granting a rebate for gas used for power generation. This gas could even be sold on an interruptible basis as the driver is saving $CO_2$ emissions which depends on volumes of electricity produced by lower carbon fuels but not necessarily on reliable power capacity.

The relationship between gas and coal could of course be adjusted by placing a price on $CO_2$ by emission trading or by some other means (such as a $CO_2$ tax, or a shadow price of $CO_2$). A shadow price could be the result of direct restrictions of $CO_2$ emissions in the power sector, similar to a sectoral $CO_2$ goal or eventually from the phasing out of electricity volumes produced by coal or the amount of $CO_2$ emissions from coal-fired power generation over time. The switching point between gas and coal is a defined point when comparing state of the art coal with gas power which at the present price relationship between coal and gas is about

[234] EIA. (2013, June 11)
[235] : EIA. (2013, May 23)
[236] Specific $CO_2$ emissions: from CCGT: 0.4 kg $CO_2$ / kWh ; for coal fired power. 0.8 kg$CO_2$ / kWh

€50/t $CO_2$[237]. When considering the range of different electric efficiencies of existing coal-fired power plants and CCGTs there is not a clearly defined switching point but a certain narrow range when with increasing prices for carbon increasingly new CCGTs replace coal-fired power plants until carbon prices are so high that either all CCGTs are in operation or no coal-fired power plants are left to be replaced by a CCGT. When carbon prices increase further the merit order is not changed until gas is replaced by the next carbon-avoiding technology.

Claiming that only gas-fired power would be able to follow the now stronger variation of residual power demand is not valid for Germany since many coal and lignite plant have the necessary output flexibility and at fuel and carbon prices prevalent in mid-2013 are clearly more economically attractive than CCGTs and therefore occupy a lower place in the merit order. Otherwise said: The role of gas in power generation and its de-carbonization is decided by the merit order, which is a function of the relative fuel prices of gas and coal and the price on carbon emissions.

### *The ETS*

By Directive 2003/87/EC which entered into force on October 25, 2003 the EU introduced the Emission Trading System (ETS).[238] This directive was limited to $CO_2$ emissions and to the following processes:

- Energy activities from combustion, refineries and coke ovens
- Production and processing of ferrous metals: Metal ore roasting or sintering installations, or pig iron or steel
- Mineral industry: production of cement clinkers or lime
- Glass industry
- Ceramic products: roofing tiles, bricks, tiles, stoneware and porcelain
- Other industries: Pulp and paper and board

The so-called linking directive [239] of 2004 provided for the recognition of emission credits under the JI and CDM of the Kyoto Protocol by the EU ETS.

In 2009 the application of the ETS was extended to include also nitrous oxide from 2013[240]. It was also extended to include more processes, namely: aluminium production, non-ferrous metal, carbon black, carbonization of organic substances, nitric acid, adipic acid, glyoxal, ammonia, bulk organic chemicals, hydrogen and synthesis gas, soda ash and sodium bicarbonate, capture and pipeline transport of Green House Gases for geological storage and aviation.

If the ETS were only applied to the power sector any $CO_2$ price below the first switching point where the highest efficient gas plant replaces the lowest efficient coal plant would have no effect on the merit order and thereby on $CO_2$ emissions. Any $CO_2$ price beyond the price where the most efficient coal plant is replaced by the least efficient gas plant would have no further effect. In between these two points the physical volume of switching depends on the total amount of thermal power capacity needed at a given time and the exact split resulting

[237] Assumptions for gas: price 10 $/MMBTU, electric efficiency: 0.57 , for coal: price: $ 100/ t (7000Mcal), electric efficiency: 0.43; additional operation costs : 0.15 cts/kWh; €/$ exchange rate: 1.3
[238] Official Journal of the European Union. (2003, October 13)
[239] Official Journal of the European Union. (2004, October 27)
[240] Official Journal of the European Union. (2009, April 23)

from the plants with different efficiency at that time. The impact of carbon pricing on the efficiency of power plants used is negligible in the short run as the carbon price does not change the merit order within a fuel. The effect on investing in more efficient power generation within a fuel appears to be also very limited certainly at present carbon prices, as they would only marginally modify the profitability of efficiency investment already given by improved fuel efficiency.

For the other sectors covered by the ETS accounting in total for less than 15% of $CO_2$ emissions in the EU the impact of the ETS is a question of improving efficiency. Improving efficiency is a question of the investment cycle already promoted by the costs of the carbon containing material used or eventually by the cost advantage of another production method (such as for steel production oxygen furnace instead of coke furnace). In addition there is always a question of the overall activity in the EU in the respective sector and to which extent reinvestment will happen in the EU. Contrary to power production, which is locally based, the products of all other industries can be produced and imported from outside the EU.

The price of the carbon contained in the raw material used is much higher than the price of carbon currently imposed via the ETS mechanism, so that not much of an additional incentive is offered for higher efficiency or for process switching. Higher carbon prices from the ETS would justify the transportation costs of imports from outside the EU and finally lead to a shift of the respective industrial production to places outside EU.

The dilemma for a uniform carbon pricing regime beyond the power sector is: low carbon prices will hardly incentivize increased efficiency for the power industry and the other industries beyond the efficiency improvements following from the investment cycle and no fuel switching in power generation, resulting in minor effects on $CO_2$ emissions. High carbon prices in the order of €50/t $CO_2$, which would trigger fuel switching from coal to gas with substantial effects on $CO_2$ emissions, risk driving out of the EU traditional industries subject to a carbon regime, like the steel and chemical industry considered to be clusters of core competency in Germany.

The way to an almost carbon emission-free world would need carbon-free energy production such as renewables or a technology capturing and storing $CO_2$ (CCS) and energy saving by zero energy buildings. The first is still facing technical and economic challenges which can be solved but need time, the second is at best at a pilot project stage with serious cost challenges and above all acceptance problems. Zero energy houses are state of the art but the turn-over of existing building stock takes a long time.

So in the meantime energy efficiency is a possible element to drive $CO_2$ emissions down with lasting effect but fuel switching also has a role to play.

### *Looking at the Supply Curve within the Emission Trading Framework*

The first category is so called “hot air” (i.e. emission reduction by the contraction of energy intensive economic activity in newly restructured economies and from JI or CDM projects at very low costs but with physical effects, if any, only outside the EU). The next category comprises the efficiency gains driven by the costs of the carbon needed in the processes covered by the ETS outside the power sector. At a share of less than 15% of total EU $CO_2$ emissions efficiency improvements by new investment would hardly exceed 10%; this would account potentially for hardly more than 1% $CO_2$ reduction). The last category – $CO_2$ emission from power production - accounts currently for about 30% of emissions. Fuel switching from coal and lignite to gas could make a significant impact. For every 10% increase in the share of gas in power generation displacing coal would amount to halving the $CO_2$ emissions of the coal displaced, 1.5%. and more when lignite is replaced. A potential increase by 30 percentage points in the share of gas in fossil fuel power generation in Germany would decrease $CO_2$ emissions by up to 5%.

In principle emission reduction schemes including cap and trade schemes follow an externally set (top-down) target for de-carbonization which is not addressed per se by the market. Also the emission trading framework is dependent in several respects on government: setting the rules, importantly setting the limits and de facto undermining it by trading 'hot air' and allowing the use of EUAs from JI and CDM, which do not reflect any reduction in EU $CO_2$ emissions.

The failure of the ETS and the consequent low carbon price currently results in a bias in favour of coal and traditional industries and penalising gas. Correcting the ETS because it has not achieved the original intention cannot be claimed to be 'interfering in the market' (other polices did that anyhow). It is just that currently such 'interference' would not favour the traditional beneficiaries.

## *Recent Policy*

### The Role of Coal

When trying to understand the respective role of coal and gas in German Energy politics it is useful to examine the deeply entrenched role that coal has acquired in Germany over the last several decades.

As a reaction to the oil crisis in 1973/74 for energy security reasons Germany strongly supported the use of (uncompetitive) domestic hard coal by compensating power plant operators for its use by carrying the cost difference from imported oil while restricting the use of oil in power generation[241]. Later in 1978 this approach was extended to also compensate the cost difference between using coal and gas in large power plants and the use of gas was restricted[242]. Another year later in 1979 power plant operators were incentivized to predominantly use domestic coal and consequently reduce the level of much cheaper imported coal[243]. The restrictions on the use of gas in large scale power generation were only abolished in the mid 1990s.

The compensation payments for the use of domestic coal were sourced by a levy on the electricity price (so called Kohlepfennig) from 1975 until declared unconstitutional by the Bundesverfassungsgericht (Constitutional Court) in December 1994[244]. The court decision was about the levy (the method of sourcing the revenue) - not the fact, that coal was supported. At that time a total of about DM75 billion (almost €40 billion) had already been collected from electricity customers and passed to operators of domestic coal power plant. After the court decision, the system was changed by a new law (Steinkohlebeihilfegesetz) to direct subsidies from the federal and regional budgets, but with a programmed decrease from

[241] BGBl. (1974, December 17)
[242] Deutscher Bundestag. (1976, February 13)
[243] Deutscher Bundestag. (1977, November 4)
[244] Bundesverfassungsgericht. (1991)

DM10 billion in 1997 to DM5.5 billion in 2005. Payments from the federal budget of a total of DM46 billion plus about an additional half of that sum paid from the budget of the Länder concerned (mainly NRW and Saarland). After intervention by the EU Commission the support for use of German hard coal will be phased out by 2018 (support from 2009 to 2018 in total: €13 billion)[245].

The use of coal is now dominated by the use of imported coal (only three active pits are left in Germany which will be phased out by 2019). Domestic lignite is commercially attractive: in the West (between Cologne and Aachen) three large lignite open pits are operated by RWE (about 100 million tonnes/a of lignite) for use in its mouth of mine power plants. Five lignite pits are operated in Lausitz in the East by Vattenfall with about 60 million tonnes/a of lignite used in their power plants. Three pits are operated in Central Germany with a total production of about 20 million tonnes/a. Total installed lignite power plant capacity in Germany is about 20,000 MW operated with a load factor above 6,000 hours/a. Plants in the East were refurbished in the 1990s to the state of the art, while in the West very modern power plants stand side by side with plants of the 150 MW class built in the1960s.

Both (subsidized) domestic hard coal and profitable lignite are exempted from the 10% royalties to be paid under the German mining law.

Apart from the direct restriction on the use of gas in large power plants until the mid-1990s, the support for domestic hard coal (and to a lesser extent lignite) exhibits the traditional strong links in German politics with coal on the local and federal level. Exceptions to this are the Green party and green NGOs. Also the Bavarian government and the local conservative party CSU, hesitant about dependence on mining in North Rhine Westphalia, preferred to promote local energy supplies considered to be more modern: nuclear in the 1970s as well as natural gas with the supply of Russian gas to Waidhaus in Bavaria and the MEGAL system crossing Bavaria. Concerns over dependence on Russia were apparently less than concerns about dependence on North Rhine Westphalia. The rather unpretentious approach to Russian gas is also demonstrated by an initiative of the Bavarian government following the Energiewende to explore the feasibility of constructing 5 large gas-fired power plants (800 MW each) in Bavaria together with Gazprom (the outcome is open, but difficult in view of the present price relationships).

The open or clandestine support for hard coal over gas was also reflected by the free allocation of EUAs in the first two trading periods in line with the historic specific emissions of coal-fired power plants (based on 750 g $CO_2$/ kWh, twice as high as for gas with 375 g $CO_2$/ kWh) including grandfathering for new coal fired power plants.

The gas industry had not addressed the role of gas in large power generation by itself. Ruhrgas as a major player in the German gas industry had its roots in the mining sector which held a large part of Ruhrgas shares until the merger with E.ON in 2003. And equally important: the gas producers / exporters did not traditionally sell gas at price conditions which would allow selling gas for power generation outside smaller installations. Until the second half of the 1990s use of gas in large power was against EU rules and against the German Kohleverstromungsgesetz.

[245] BGBl. (2007, December 20)

Since the mid-1990s several larger sized gas-fired power plants were built or refurbished, often by municipalities or in connection with chemical companies such as BASF Ludwigshafen (440 MW), Heizkraftwerk Berlin Mitte (440 MW), Heizkraftwerk Berlin Lichterfelde (300 MW by 2016), Kraftwerk Knappsack (800 MW), Trianel Hamm Üntrop (850 MW), Irsching Block 4 and 5 (569 MW/860 MW), Heizkraftwerk Potsdam Süd (84 MW) or Heizkraftwerk Würzburg (125 MW  switched to gas in 2003).

RWE and Gazprom discussed sharing the coal- and gas-fired plants of RWE plus at some point investing in new projects, but talks stalled and were called off at the end of 2011.

Several new power plant projects are included in the recent TYNDP[246] for electricity and gas, but very few are close to FID. A recent new project by Stadtwerke Düsseldorf (Kraftwerk Lausward feeding into an existing district heating grid) was able to conclude a long term supply contract with Statoil announced in June 2013. This seems to be rather an exception: in view of the present price levels (of gas and coal/electricity and a very low price for ETRs) it is difficult to justify a new CCGT, unless it has additional revenues from making use of steam for chemical processes or for district heating.

**Gas and Renewables**

A major argument of the gas industry for the complementarity of gas and renewables is the high flexibility of gas-fired power. While this is true for gas turbines it comes at the price of shortened maintenance intervals at least when dealing with high efficiency turbines. For any power plant, such as CCGT, using a steam turbine, the gradient of power capacity change is similar for coal, lignite and CCGT state of the art plants: 3% to 4% of peak capacity/ minute[247]. In the past coal-fired plants were not designed for frequent load changes, but can be retrofitted for it.

To ensure reliability of power supply peak demand capacity must be covered by dispatchable power at all times, by the sum of gas, coal and lignite (and nuclear) capacity, independent of availability of renewables. Renewables will increasingly push out power generation from thermal plants, which are now run in load following mode. In between the thermal plants the merit order will define their dispatch for the remaining load and thereby the $CO_2$ emissions related to that dispatch. Unless a substantial value is put on $CO_2$ emissions leading to a fuel switch in the merit order gas will be at the end of the merit order, and some thermal plants will only be dispatched sporadically every few years, depending on wind conditions in winter. This way the increasing use of renewables pushes thermal plants out and because of the present fuel price relationships in the EU, at very low prices for carbon gas is pushed out first and its $CO_2$ benefits are not realized.

In Germany gas-fired power is only used as a backup for the wind not blowing at times of high capacity demand in winter because of a large coal and lignite-fired power capacity, as opposed to being a dynamic buffer in the case in Spain and increasingly in the UK. This use has only marginal effects on $CO_2$ emissions as well as for gas demand. From a $CO_2$ emissions point of view such back-up power (only used sporadically every few years for a few days) could be just as well provided based on gas oil (which can be run in gas turbines and CCGTs) with slightly higher $CO_2$ emissions, but not needing the associated gas grid and storage system. Such back up could also be provided by old mothballed coal-fired power

[246] BNetzA (2013, October 16)
[247] VDE. (2012, April 18)

plants given enough lead time to mobilize them and in view of there being no substantial impact on the $CO_2$ balance from the short time of their operation, as happened during the last two winters.

The combination of gas and renewables makes more sense in view of the limited expansion speed of renewables and the necessity to reduce $CO_2$ emissions beyond the result of limited contribution by renewables for a transition time. This implies increasingly replacing volumes of coal-fired power generation by gas-fired power generation and requires a change in the merit order between gas and coal.

**Demand and Supply Capacity in Germany**

In Germany the winter peak in 2013 is about 83 GW [248]usually occurring in the evening of a winter working day, obviously without PV feed in. Demand can be as low as 40 GW and about half of the time it is lower than 60 GW.

As a consequence reliable power supply for Germany (without import or exports) for 2013 needs available dispatchable power of 83 GW plus a certain reserve capacity for unforeseen deviation in plant availability or in demand.

Non-renewable dispatchable power capacity is about 100 GW including 9 GW of pumped storage with a total volume of only about 40 GWh[249], leaving 91 GW dispatchable without restrictions on duration of their operation.

Dispatchable renewable power adds 11 GW (5 GW run of river hydro and 6 GW based on biomass), resulting in 102 GW of sustainable dispatchable capacity plus 9 GW of hydro storage (with 40 GWh).

This compares with a total of 63 GW of intermittent renewable power (33 GW PV plus 30 GW onshore wind (offshore wind so far is below 1 GW) with priority feed in. Feed in by wind is erratic. Recorded feed in by wind power plants over the year but also over the winter was as high as 25 GW and as low as 1 GW over several days out of 30 GW installed capacity.

Dispatchable power has to cover demand and its predictable variations of up to several 10s of GW between night and day minus feed in of PV and wind and their variations, subject to a large erratic element: while the 33 GW PV are subject to regularities of daylight reduced by erratic cloud cover the 30 GW of wind power are completely erratic apart from within the short timescale of reasonable wind forecasting. That implies that in addition to following the predictable changes in demand up to 30 GW of wind power on the grid may have to be replaced by dispatchable power within the time span given by wind forecasts about 24 to 48 hours ahead as well as the feed in of about 33 GW changing with the phases of daylight and cloud cover. Hydro storage provides only 9 GW and not for long. In principle it means that the sum of dispatchable power must be able to cover the demand peak with or without renewable feed. And with a ramp up given by the 24 to 48 hour lead time of weather forecasts for wind and a ramp up speed covering the (predictable) increase in demand and the (somewhat predictable) change in PV feed-in and the stochastic feed-in of wind. This may add up to a change of 40 to 50 GW or half of the thermal capacity of Germany within 12 hours.

[248] IEA (2013) p. 148

[249] Hartmann, Niklas et al.; ZfES. (2012, July)

While before the introduction of renewables unforeseeable variations of supply load were in the order of a few GW it can now be in the range of several tens of GW. What is new is the complete stochastic element depending on wind. The dispatch of about 30,000 MW dispatchable capacity backing up wind depends fully on the stochastic function of the wind not blowing[250]. While the system has been able to meet such challenges so far, in reality part of the variations are covered by variations of the import/export balance. For instance lignite plants – while technically able to follow such variations – in reality would rather run in steady mode and sell the resulting surplus power produced at low marginal costs on the EU power market as long as the market price is above their marginal costs, pushing out gas-fired power generation in neighbouring countries.

## 3.2 Role of Gas in Recent Scenarios / Policy Discussion

### *Scenarios*

Table 6 below shows the development of gas consumption as addressed in the forecasts preparing the discussion of the new Energy Concept in 2010[251]:

**Table 6: Development of Natural Gas Usage - Reference Scenario**

| Natural Gas Usage (PJ/a) | 2008 | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|---|
| Private Households | 893.8 | 743.4 | 618.3 | 515.9 | 427.1 |
| Business. Trade. Services | 386.1 | 323.6 | 267.6 | 204.2 | 154.1 |
| Industry | 888.9 | 783.1 | 685.2 | 635.5 | 627.0 |
| Electricity Generated from Natural Gas | 563.0 | 233.0 | 458.0 | 539.0 | 405.0 |

Source: EWI, GWS, Prognos 2010; own calculations

According to this forecast the consumption of gas will shrink in all segments of demand, in households and in business, trade and services by more than 50% by 2050 and in industry by some 30% by 2050. While gas consumption in power generation is projected to shrink by 30% by 2050 its development is very uneven from decade to decade.

By contrast in the target scenarios of 2010, for instance in scenario IIb (which was also used in 2011 to gauge the effects of an early phase out of nuclear) the demand for gas in the power sector goes down to close to zero. Scenario II b shows 0 hours of full load for gas-fired power plants in 2050[252] (see Table 7 below) in spite of a gas-fired capacity of 22 GW[253](see Table 8 below). This means that gas in power generation in 2050 has a purely backup function.

This is due to the assumed commercial roll out of CCS for coal based power generation as of 2025 and the resulting merit order where the use of coal is not burdened much by carbon pricing.

[250] Lambertz et. al. (2012, July)
[251] EWI; GWS; Prognos. (2010, August 27)., compiled from tables A 1-8, A 1- 14, A 1-15, A 1- 16
[252] EWI; GWS; Prognos. (2010, August 27).. Table A 1-22
[253] EWI; GWS; Prognos. (2010, August 27)., table A1-21

**Table 7: Load Factor (hrs/year) for Scenario II A (12 Years Prolongation / Standard Refurbishment Costs)**

| | 2008 | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|---|
| Nuclear | 7359 | 7279 | 6936 | 0 | 0 |
| Hard coal, without CCS | 4547 | 3386 | 3419 | 3744 | 4801 |
| Hard coal with CCS | n/a | n/a | 6779 | 6372 | 6259 |
| Lignite without CCS | 6814 | 5849 | 4072 | 2964 | 5289 |
| Lignite with CCS | n/a | n/a | n/a | 7032 | 6035 |
| Natural gas | 3183 | 901 | 1111 | 643 | 0 |

Source: EWI, GWS, Prognos 2010; own calculations

**Table 8: Installed Capacity (in GW Installed, Gross) under Scenario II A (12 Years Prolongation / Individual Refurbishment Costs)**

| | 2008 | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|---|
| Renewables | 39.1 | 90.0 | 101.6 | 110.9 | 117.6 |
| Nuclear | 20.4 | 20.4 | 12.1 | 0.0 | 0.0 |
| Hard coal, without CCS | 30.7 | 21.3 | 18.2 | 18.9 | 14.8 |
| Hard coal with CCS | 0.0 | 0.0 | 1.8 | 5.1 | 10.4 |
| Lignite without CCS | 22.4 | 21.2 | 11.7 | 6.6 | 0.7 |
| Lignite with CCS | 0.0 | 0.0 | 0.0 | 0.5 | 0.6 |
| Natural gas | 25.7 | 16.3 | 26.5 | 27.4 | 22.0 |

Source: EWI, GWS, Prognos 2010; own calculations

Table 9 shows the price assumptions on which the study was based and the resulting switching price of $CO_2$ at which the merit order would shift from a modern coal-fired power plant to a modern gas-fired CCGT (without CCS):

**Table 9: Price Assumptions in Scenarios of 2010 (in 2008 EUR)254**

| | 2008 | 2020 | 2030 | 2040 | 2050 |
|---|---|---|---|---|---|
| $CO_2$ Certificates BAU (€/t$CO_2$) | n/a | 20 | 30 | 40 | 50 |
| $CO_2$ Certificates Target (€/t$CO_2$) | n/a | 20 | 38 | 57 | 75 |
| Natural Gas (cts/kWh) | 2.7 | 2.3 | 2.6 | 2.9 | 3.2 |
| Steam coal (/t SKE) | 112 | 77 | 83 | 91 | 110 |
| => Switching from coal to gas | | | | | |
| At certificate prices of (€/t$CO_2$) | 34 | 41 | 49 | 56 | 56 |

Source: EWI, GWS, Prognos 2010; own calculations

The target scenarios include some remarkable assumptions:

The price of carbon is 50% higher in 2050 in the target scenarios compared to the reference case. Achievement of de-carbonization in power is based on a substantial reduction of power

[254] EWI; GWS; Prognos. (2010, August 27)., p. 30

consumption (depending on the assumption, consumption is up to 20% less than in the forecast used as reference)[255].

This leads to prolongation of nuclear and what look like successful de-carbonization cases (by assumption) while non-prolongation does not achieve the de-carbonization targets as it is only considered under a business as usual (BAU) forecast without dedicated policy measures and assumptions.

The role of gas is not discussed in the scenarios of 2010, but its role in power generation is left to implicit assumptions in the target scenario work. This is surprising as the full cost of decarbonized power generation (with CCS) would be lower for gas than for coal because of the lower investment and operating costs for power generation with CCS based on gas compared to coal. This follows from the assumptions made for investment in the energy scenarios[256] (see also Table 11) but also from independent studies[257].

The target scenario which was missing in 2010 with phasing out nuclear by 2022 was delivered after the decision to phase out nuclear was taken on June 30, 2011[258]. It was based on target scenario IIb (prolongation of nuclear by 12 years with individual assessment of the nuclear refurbishment costs) which was closest to the decision taken in 2010. It was updated in light of the decisions taken in 2010 and compared with Scenario IIb modified by the assumption that nuclear would be phased out by 2022. This way the economic impact linked to withdrawing the prolongation could be gauged: a loss in GDP between 0.1% in 2015 increasing to 0.3% in 2030[259]. The role of gas was again not touched on in these scenario considerations, but left to implicit assumptions.

Instead, one could have asked the question, under what circumstances could gas replace coal in base load/upper middle load, with or without CCS, and what would be the benefits for de-carbonization and what would be the costs of such a policy?

In the run up to the debate on the new Energiekonzept Greenpeace came up with a study supporting gas as the bridging fuel to an overall renewable future and discussing the dependence on Russian gas. This seems to be the only study at that time which came close to addressing the potential role of gas for a transition period looking both at the power sector and at the transport sector[260].

A March 2013 study by EWI[261] raises this question together with the question of optimization of the overall costs of reenwables.

This question is about comparing the costs (up to 2022) of different options for de-carbonization by adding electricity generation from different renewables including the costs of grid expansion (see Figure 16 below[262]). Implicitly this asks the obvious question, how to achieve the de-carbonization targets for 2022 at least economic costs, instead of promoting specific targets for different renewable energies. The result is that in this timeframe onshore

[255] See chapter 3.2
[256] EWI; GWS; Prognos. (2010, August 27)., p. 43, 44
[257] Rogers, H. (2012, September 13)
[258] EWI; GWS; Prognos. (2011, July)
[259] EWI; GWS; Prognos. (2011, July). p. 33
[260] Greenpeace. (2010, August)
[261] EWI. (2013,March)
[262] EWI (2013,March) p. 86

wind is the most economical way to increase the production of renewable electricity. Offshore wind is more expensive because of much higher specific investment combined with the extra costs of reinforcing the grid between the North and South in Germany to transport the wind power. Within the time frame to 2022 the limited rate of de-bottlenecking the power grid leads to a steep cost increase above adding an annual capacity of 3 GW/a of offshore wind. PV while having the advantages to feed in electricity into the low voltage grid close to consumption, and therefore not being subject to the restriction of the high voltage grid has much higher specific investment costs and lower load factors than onshore or offshore wind.

**Figure 16: Difference of Total System Costs vs. $CO_2$ Emissions in 2022 Compared to Target Scenario**

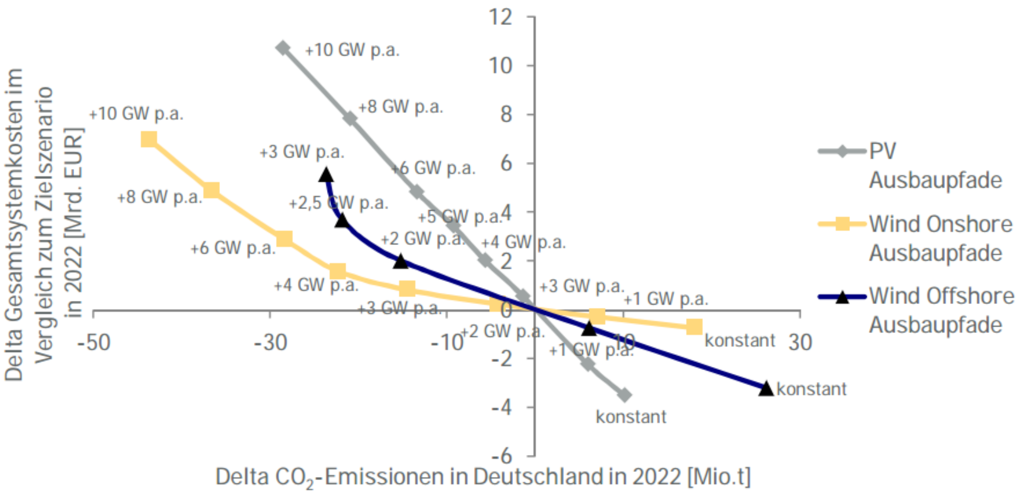



ABBILDUNG 73: DELTA GESAMTSYSTEMKOSTEN UND $CO_2$-EMISSIONEN IN 2022 IM VERGLEICH ZUM ZIELSZENARIO

*Quelle: EWI.*

Notes: Vertical Axis: Difference of total system costs vs. $CO_2$ emissions in 2022 compared to target scenario in 2022 [billion EUR]

Horizontal Axis: Change in $CO_2$ emissions in Germany in 2022 [million t]

Key Legend: Grey: PV development, Yellow: Onshore wind development, Blue: Offshore wind development

Source: EWI, [263]

The report puts the emissions from the German power sector in the context of the EU ETS as well as the EU wide electricity grid and trade. In general all considerations of the development of the German power sector have to be seen in the EU context because of grid interconnections and the possibility and at times necessity to trade cross-border. By 2022 a relatively large part of renewable electricity will be exported to neighbouring countries but not attributed to the GHG balance of Germany (see Figure 17 below).

[263] EWI. (2013, March) ; p. 86

**Figure 17: Impacts on Power Trading of Adding Renewables**

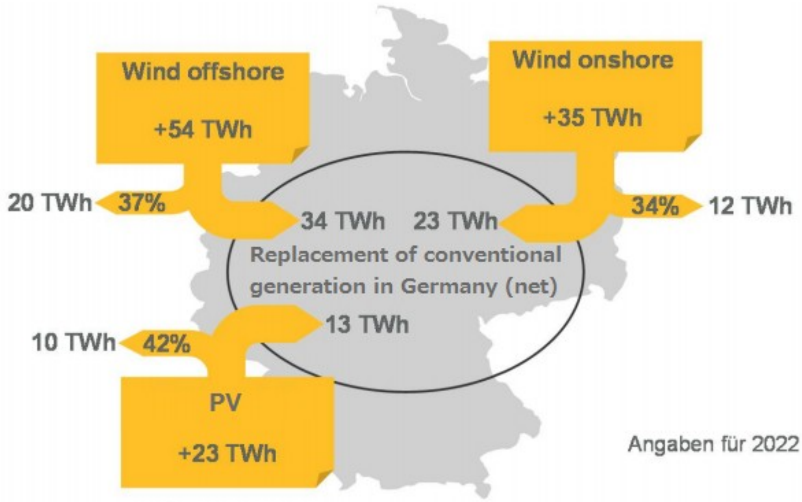



ABBILDUNG 11: WIRKUNGEN DES ERNEUERBAREN-ZUBAUS AUF DEN HANDELSSALDO

*Quelle: EWI.*

Source: EWI, [264]

Regarding the contribution of gas to de-carbonization the report discusses the relationship of fuel prices for coal and gas and the prices for EUAs. It shows that while on days with strong wind the contribution of coal and gas-fired power plants is marginal anyhow, the contribution by fossil fuels on days with weak wind is substantial. The relationship between coal and gas-fired power produced on such days (obviously) depends on marginal cost (merit order). A change of the merit order would (given that coal prices look to be stable for the next years) depend either on lower gas prices and or higher carbon prices.

With the prices assumed for the target scenario of the EWI study the change from hard coal to gas starts at €40/t $CO_2$ (when the oldest low efficiency coal-fired power plants are replaced by modern CCGTs) and ends at €70/t $CO_2$. The switch triggered by carbon prices is confined to that price range. See Figure 18.

[264] EWI. (2013, March), p. 9

**Figure 18: Difference of volumes produced in 2022 at different $CO_2$ prices compared to target scenario**

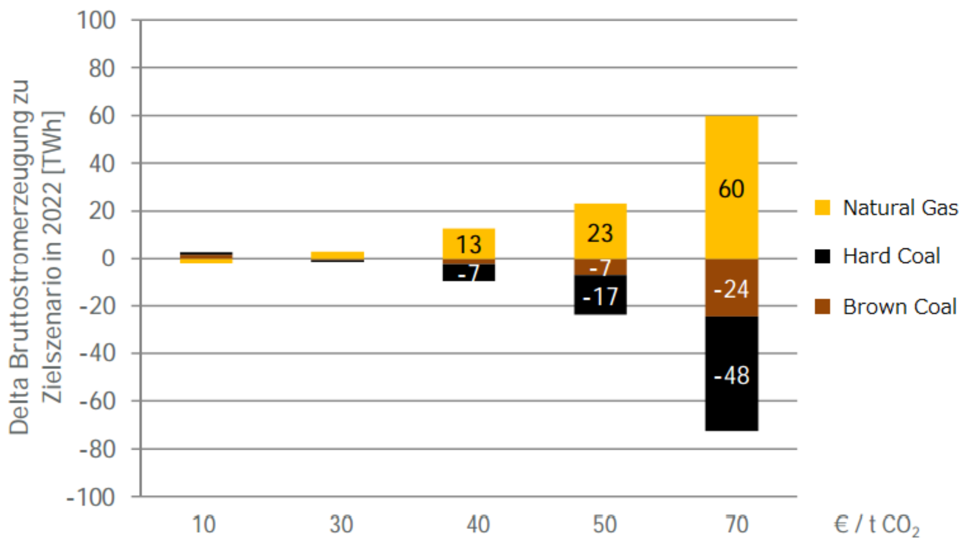



ABBILDUNG 13: DELTA ERZEUGUNGSMENGEN IN 2022 BEI UNTERSCHIEDLICHEN $CO_2$-PREISEN IM VERGLEICH ZUM ZIELSZENARIO

*Quelle: EWI.*

Notes: Vertical Axis: Change in Gross production compared to target scenario in 2022 [TWh]
Source: EWI, [265]

Looking at it the other way around, i.e. assuming a (relatively high) carbon price of €24.5/t $CO_2$ the switching from coal to gas can also be shown as a function of the gas price (see Figure 19[266]:

[265] EWI. (2013, March). p. 11
[266] EWI. (2013, March). p. 10

**Figure 19: Differences of Volumes Produced by German Power Plants in 2022 at Different Gas Prices Compared to Target Scenario**

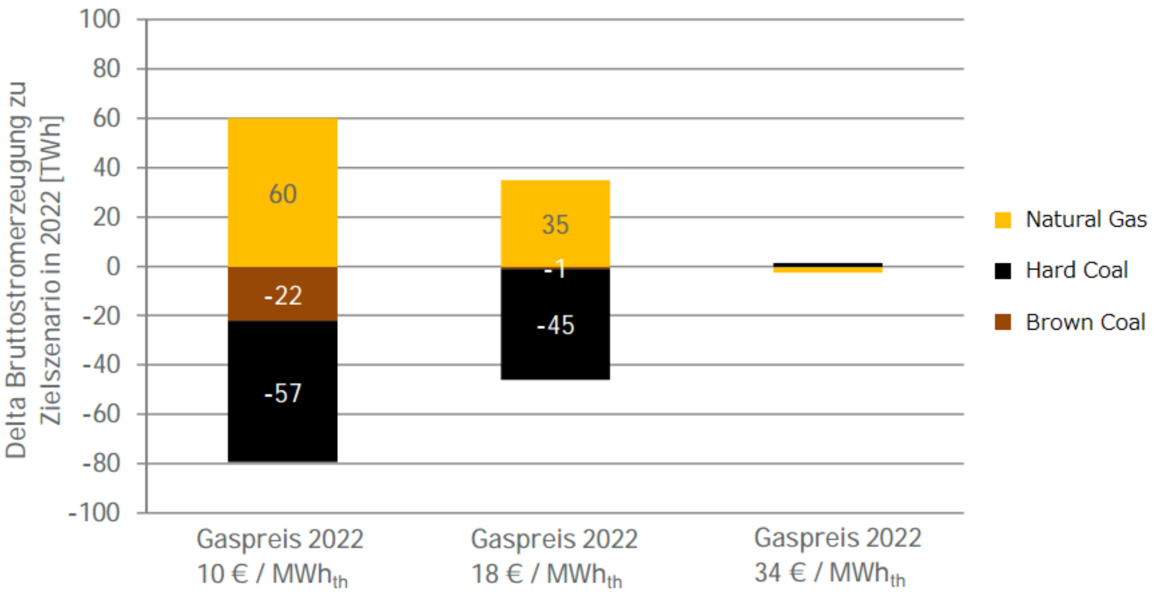



ABBILDUNG 12: DELTA ERZEUGUNGSMENGEN DEUTSCHER KRAFTWERKE IN 2022 BEI UNTERSCHIEDLICHEN GASPREISEN IM VERGLEICH ZUM ZIELSZENARIO

*Quelle: EWI.*

Notes: Vertical Axis: Change in gross production compared to target scenario in 2022 [TWh]
Source: EWI, [267]

The study concludes on the role of gas in power: “as power from natural gas results in clearly less $CO_2$ emissions than from coal, the price relationship of these fuels in connection with the price of $CO_2$ is a decisive factor for the carbon emission balance of Germany.“ (“Da Erdgas deutlich $CO_2$ ärmer verstromt werden kann als Steinkohle, ist das Preisverhältnis dieser Brennstoffe im Zusammenspiel mit dem $CO_2$-Preis ein entscheidender Faktor für die Emissionsbilanz Deutschlands.”[268])

### *Policy Discussion of the Role of Gas*

With the decision to phase out nuclear the overarching target of German energy policy became to avoid any black-outs which could be attributed to the phase out of nuclear and the increase of renewables. Such black outs would not only be a political disaster but if it happened on a cold winter day could be a real (human) disaster. This way the public good of reliability of supply has become an overriding element, while the public good of de-carbonization is put more on the backburner in the political discussion, because missing the ambitious de-carbonization target for 2020 by some percentage or by some years might be regarded as a normal slippage.

[267] EWI. (2013, March) p. 10
[268] EWI. (2013, March) p. 102

At the same time markets are considered the major instruments for delivering energy policy if not a TINA instrument (TINA= there is no alternative).

The following Table 10 tries to illustrate the trade-offs between gas and coal and lignite on the fields of environment / GHG emission vs. costs vs. import dependence.

Table 10: Trade-offs between Gas, Coal and Lignite

| Trade offs | | gas | coal | lignite |
|---|---|---|---|---|
| | | | | |
| environment impact | | no pollutant | particulate matters | particulate matters |
| | | | | |
| GHG Impact transition | coal=100% | 50% | 100% | 120% |
| (with CCS) | coal =100% | (5%.) | (10%.) | (12%.) |
| options for 2050 | | CCS ,P2G, CHP,biogas, biofuel | only CCS, only power grid | only CCS, only power grid |
| | | power plus gas grid, more KWh/CO2 | all elctric plus bio fuel | all elctric plus bio fuel |
| | | | | |
| invest new power plant | €((2008)/kW | 950 | 1300 | 1850 |
| invest new plant with CCS | €((2008)/kW | 1173 | 1848 | 2498 |
| | | | | |
| fuel cost without carbon | €(2008)/GJ | 7.2 | 3 | 0.4 |
| full costs 5000h/a | €(2008)/MWh | 76 | 69 | 69 |
| full costs 2500h/a | €(2008)/MWh | 108 | 113 | 132 |
| (full costs 5000h/a with CCS) | €(2008)/MWh | (98.) | (112.) | (115.) |
| | | | | |
| resource rent | | relative high | relative low | no rsource rent taken directly |
| dependence from | | gas exporting country, RUSSIA | world market , US Columbia | domestic |

The GHG disadvantages of coal and lignite might be overcome, if CCS could be successfully developed, which right now seems remote for Germany due to lack of acceptance. Acceptance of CCS might even be more difficult for lignite with CCS compared to coal with CCS as lignite is bound to the site of the lignite mine and therefore requires a long CCS pipeline to transport $CO_2$ from the site for storing it, for instance in the depleted fields of and the aquifers beneath the North Sea using the existing oil and gas infrastructure. On a full cost basis the costs for gas with CCS would be lower compared to coal and lignite up to about 5,000 h/a, which would be a high load factor in a renewable driven power system. Given the fuel cost advantages and the domestic character of lignite it might nevertheless be worthwhile to keep the option of lignite with CCS until it is clear that CCS will not work or that the Power to Gas option is available on a large scale.

Gas has environmental advantages (no pollutants, much lower $CO_2$ emissions and more options for a decarbonized world) as well as low investment costs which result in lower full costs at low load factors (which increasingly apply with a higher renewable share) against its higher fuel costs which include a resource rent passed to gas exporting countries, mainly Russia. Import dependence on gas for use in power generation is not really an argument as long as enough back up coal capacity remains operational, which should happen anyhow in view of low wind periods.

By contrast lignite has the advantage of a domestic fuel set against the disadvantages of its low environmental and GHG performance. The latter could be overcome in the event of the successful development of CCS. However with CCS the fuel cost advantage disappears when looking at full costs when lignite would be more costly than coal or gas even at an unrealistic 5,000 h/a.

With coal taking a middle position between gas and lignite the major trade off is between domestic lignite with low environmental performance and high fixed costs against gas with good environmental/GHG performance, much lower fixed costs, but import dependence on Russia (and passing a resource rent to Russia instead of additional employment of domestic investment industry).

Hard coal, contrary to lignite and gas has the lowest transportation costs and therefore practically no elements of specific investment. By contrast lignite is bound to the mine location and gas is bound to the fixed pipeline infrastructure, eventually even cross border infrastructure. International coal is traded on a functioning world market and within Germany transported by low cost barges on the main rivers linked to the North Sea, mainly the Rhine with its tributaries, which do not however reach Bavaria. By contrast the gas sector needs some regulation of the fixed infrastructure and lignite is not suited for trade on a market at all.

### *Dealing with the Trade-Off - Political Parties and Currents in Germany*

Apart from the different perception of these trade-offs the political parties/interest groups will also give different weights to different instruments. For liberals and part of the conservatives the focus will be to emphasize the importance of markets (eventually as a TINA instrument) and low energy costs which would favour coal, while coal has no other specific advantage. Many might be wary of the gas import dependence on Russia (even though mitigated by the need for enough back up capacity for renewables) and the transfer of resource rent to Russia.

This might not be the case for the Bavarian conservatives who consider Russian gas as a diversification from domestic energy supply from other local states while Bavaria would not be supplied by coal using river transport. The more green elements in German politics would favour gas as long as it does not harm the development of renewables. Social Democrats were tied in the past to the milieu of miners in the Ruhr area, which however disappeared as domestic hard coal production closed down.

These positions were reflected in the programs of the parties for the Federal elections on September 22, 2013. While most parties would plead for affordable electricity prices and would therefore support reforming the EEG and emphasize the flexibility of gas-fired power they differ along the lines drawn below:

**CDU/CSU** (**The conservatives)** basically repeat the main elements of the Energiewende[269]. Gas is not specifically mentioned except for the potential of power to gas, otherwise the "Technologieoffenheit" (openness regarding technology) is emphasized and the need to compensate for variations of renewable power production by modern coal- and gas-fired power plants from which the need is derived to accelerate the building of efficient power plants. The different impact of coal- and gas-fired power is not mentioned.

**FDP (The Liberals)** frame their program more in ideological terms - "Wir wollen mehr Marktwirtschaft und raus aus der Planwirtschaft"[270] ("we want more market economy and leaving the planned economy"). Consequently gas is not addressed in the GHG context but in the context of improving competition in Germany and independence from gas imports from only one country[271] (apparently Russia is meant even though recently gas imports from Norway were slightly ahead of Russia).

**SPD (The Social Democrats)** consider both gas *and* coal to be bridge technologies[272] towards de-centralized power generation. Their program supports the redesign of the ETS [273] to become the central market-oriented instrument to foster investment into energy efficiency.

**Bündnis 90/ die Grünen** (**The Green Party)** have a very explicit program with about 20 pages on energy.[274] They want to accelerate the phase-out of nuclear beyond the present scheme by imposing strict yardsticks on operating permits for nuclear plants (such as effective protection against plane crashes) and aim at 100% renewable electricity production by 2030. At another place a phase out law for coal by 2030 is stipulated in the program. Gas having the lowest GHG emissions is mentioned as a bridge technology especially when used in CHP. High efficiency gas-fired power plants are regarded as the best instruments to bridge the variation of renewables. Fracking and CCS are rejected in the same sentence.

**Die Linke (The Left Party)** frames its program for energy by a context of public ownership. It aims at an ambitious 50% reduction of GHG by 2020 [275] and claims an energy policy without

269 CDU/CSU. (2013, September 11). p. 44

270 FDP. (2013, May) p. 17

271 FDP (2013, May) p. 19

272 SPD (2013) p. 35

273 SPD (2013) p. 41

274 BÜNDNIS 90 / DIE GRÜNEN. (2013, April 26) p. 27 ff

275 Die Linke. (2013, June 14)., p. 60

nuclear, oil and coal (not mentioning gas in this context). The ETS is considered as failed and a law to phase out coal by 2040[276] is suggested instead.

The two large parties do not take a position on the role of coal versus gas for de-carbonization, while the liberals would emphasize the role of the market to sort things out.

The role of coal and the phasing out of coal is addressed explicitly by the green and the left parties, but the role of gas is only mentioned explicitly by the green party as a bridge function in power generation until in 2030 a 100% renewable power system is in place.

The role of gas for de-carbonization thus is lost somewhere between the two large parties not willing to address coal, the market ideology of the liberals, the public service paradigm of the left addressing a phase-out of coal but with a rather cautious time frame and the very ambitious targets of the green on renewables.

### *Development of Gas Industry Position on Gas*

Coal is deeply entrenched in German energy policy, starting with the support of domestic coal which features in the budget to deal with “Altlasten”, costs stemming from the past such as water management in former pits or damage from ground subsidence in areas of former mining. While domestic hard coal production is proposed to be phased out, and replaced by imported coal, the technology of mining and coal-fired power plants is still considered to be an industrial stronghold of Germany.

The gas industry had its origin in the coal mining industry: Ruhrgas was founded in 1926 to market coke oven gas from the Ruhr area. With the imports of Dutch gas in the 1960s natural gas replaced fuel oil, which had started to replace coal in the 1960s. Under the pricing philosophy of replacement/net back value the gas industry always emphasized its competitiveness and the free competition of fuels. When gas sales in the traditional sector stalled at the beginning of this century and regulation of the gas sector began, Ruhrgas was merged with E.ON under a special permit of the Ministry of Economic Affairs overriding the objection of the Cartel Office. Ten years later on May 2, 2013 E.ON Ruhrgas AG was dissolved and became part of E.ON Global Commodities SE. Gas for large power plants was not in focus for a long time: until the mid-1990s gas in power plants was limited by the German laws on coal and the exporters did not foster the sale of gas in large power plants by not including coal-related elements in the pricing formulas. This changed when gas to gas competition mainly between WINGAS and Ruhrgas emerged in the 90s, when WINGAS as a newcomer was selling to larger power plants (e.g. to BASF Ludwigshafen) and Ruhrgas had to compete (e.g. for Kraftwerke Mainz Wiesbaden). However with the steep increase of oil prices in the first decade of this century the oil price linkage made such deals unattractive compared to coal-fired power.

Since the turn of the century the gas industry has lost focal points to voice their interest: with the merger of Ruhrgas and E.ON gas interests became subordinated to electricity interests[277]. In addition the former section in the BMWi dealing with gas was merged with the section dealing with liquid fuels. In an era of transition for the gas industry forced by the 2nd gas

[276] Die Linke. (2013, June 14), p. 65
[277] Stern, Jonathan et al.(2012)

directive[278] of 2003 and the 3rd package[279] on the EU level the German gas industry lost much of the possibility to voice their gas specific interest as well as a dedicated interlocutor in the government, and most difficult a clear attribution of responsibility for the gas industry as a whole.

This is partly a result of the gas industry claiming that the role of gas should only be determined by competition with other fuels, with as little political influence as possible. This is in contrast to the position of the coal industry in the past and more recently of the renewable industry. This gas industry attitude was also eroded by the restrictions imposed on domestic Long Term Contracts (LTCs) by the Cartel Office decision in April 2005[280], the unbundling under the 3rd package and by the creation of import capacity, both by pipeline and by LNG, much beyond likely demand requirements. These developments enabled the traditional customers of gas importing companies to bypass the import level (e.g. Ruhrgas) because they were freed of former LTC commitments and now had access to the pipeline infrastructure and to import capacity and could buy at the emerging wholesale market. The final stroke came in 2009 with oversupply of LNG based on must sell gas from gas-liquid production from Qatar sold in the EU instead of in the US in view of the shale gas development in US and due to low gas demand in the EU and word-wide because of recession.

The philosophy that the inter-fuel market can solve everything without intervention by politics is now replaced by a philosophy that gas to gas competition based on an EU-wide regulated infrastructure will deliver low prices, security of supply and environmental protection as well as GHG reduction by the additional instrument of the regulated ETS.

### *Government Policy Regarding Gas*

The role of coal vs. gas is under the Lisbon Treaty a subject for member states. As with nuclear power production Germany could define a phase-out process for coal basically driven by $CO_2$ emission considerations, similar to a sectoral $CO_2$ limit over time.

While past and present German governments made a choice in favour of renewables and against nuclear power production, they were silent on the main remaining choice in power generation - between coal/lignite and natural gas. While it seems clear that neither of them will play a role in a strongly de-carbonized world after 2050 (except when fitted with CCS or carbon-neutral gas such as bio gas or gas from power to gas), the choice between coal and gas in power generation is referred to the market, the price relationships (for fuels and for carbon) for the already existing capacity and for capacity additions, if any, triggered by the market.

In the Red Green coalition there was a dichotomy between the SPD, partly still based on traditional workers' milieu inclusive of domestic mining, and the Green Party which was trying to foster renewables and was afraid of anything which risked undermining the role of renewables.

[278] Official Journal of the European Union. (2003, June 26)
[279] Official Journal of the European Union. (2009, August 14)
[280] Böge, U. (2006, January 17).; Bundeskartellamt. (2006, June 20)

The Great Coalition would focus on de-carbonization as a joint denominator while nuclear was controversial and not touched. The role of gas would not be touched in view of the coal affinity of the SPD and the promise to prolong nuclear to become the bridge energy technology of the Christian Union.

The CDU/CSU/FDP government, while explicitly addressing nuclear forwards and backwards would not address the role of gas in view of the paradigm that this should be sorted out by the market, after all a common denominator between the CDU and the FDP.

The new Energiekonzept could have raised the issue of the role of gas – because of the effects of much lower $CO_2$ emissions from gas-fired power as compared to coal-fired or lignite-fired power. Gas in the new Energy Concept gas was not mentioned at all, except for the new concept of power to gas.

Also in previous concepts fossil power generation was usually not mentioned. Instead the topic was referred to the mechanism of emission trading on the EU level, while at the beginning of the ETS the issue of how to incorporate EUAs from JI and CDM was raised to the benefit of coal and lignite.

Apart for Bavaria and the green spectrum, gas is not addressed as a contribution to de-carbonization (in spite of the blatant examples of the UK and US). Part is the coal mindedness of many CDU and SPD politicians mixed with the paradigm that the role of the fuels should be left to competition/the market, which was also emphasized by gas as long as it was about substitution/competition with oil products.

Policy in the context of de-carbonization is addressing gas predominantly from the point of view of the perceived advantage as flexible power plant to compensate for more frequent and larger variations due to the intermittence of wind and PV. This looks more like an alibi, keeping gas in the discussion, but for reasons of secondary importance and not really unique to gas and without any real impact.

The claim that the relationship between gas and coal should be left to the market mechanism of the ETS after gas was disadvantaged vis-a-vis coal, for instance by denying the benefits of gas vs. coal in the EUA allocation, sounds disingenuous.

An argument is now made to link employment and competitiveness in the EU and Germany to cheap power with the shale gas development in North America. Imported shale gas from the US, which looks possible after the recent granting of non-FTA approval to several LNG export projects (Sabine Pass, Freeport LNG, Lake Charles and Cove Point so far) would be almost twice the US Henry Hub gas price when arriving in the EU in view of liquefaction, shipping and regas costs, if not more expensive due to competition with Asian buyers. The discussion therefore seems to be aimed at relaxed regulation of shale gas in the EU, where it is not even clear how the resource base would compare with US costs of production[281]. Otherwise it would mean a preference for using cheap coal and neglecting environmental protection and GHG effects of coal use or asking gas exporting countries to forego parts of their resource rent.

[281] Gény, F. (2010, December)

## 3.3 Role of Gas and Gas Infrastructure in the Long Run

### *Possible Pathways / Final Stages*

When looking at 2050 as a target date and at possible target structures for the energy sector, it is clear that substantial change will have to happen to reach the de-carbonization target of 80% and more.

Regarding the role of gas: in 2011 natural gas consumption was responsible for about 163 Mt $CO_2$ or 21.8% of energy related emissions[282]. Natural gas adds to GHG less than other fuels, but too much for a world with 80 % and more reduction of GHG emissions proclaimed by G8 for industrial countries.

The target of 80% plus reduction of GHG may be achieved by several models or variations and combinations thereof. Certainly, the overall economic and living structures will change: urbanization and the turnover and refurbishment of the building stock will play a large role, how we work and how GDP is produced and also transport (as a function of urbanization but also of collective vs. individual transport).

In 2050 the issue of phasing out nuclear power now imminent in Germany will be 30 years in the past. On the way to 2050, 30 – 40 years in the future, today's existing (and even new) investment will be written off and may not matter anymore, except for infrastructure whose duration is beyond that time horizon (building stock, transport infrastructure and energy networks).

On the other hand the structure of the energy sector in 2050 will depend on technology developments especially of CCS, power to gas and batteries which are uncertain to predict even if supported by government action fostering research.

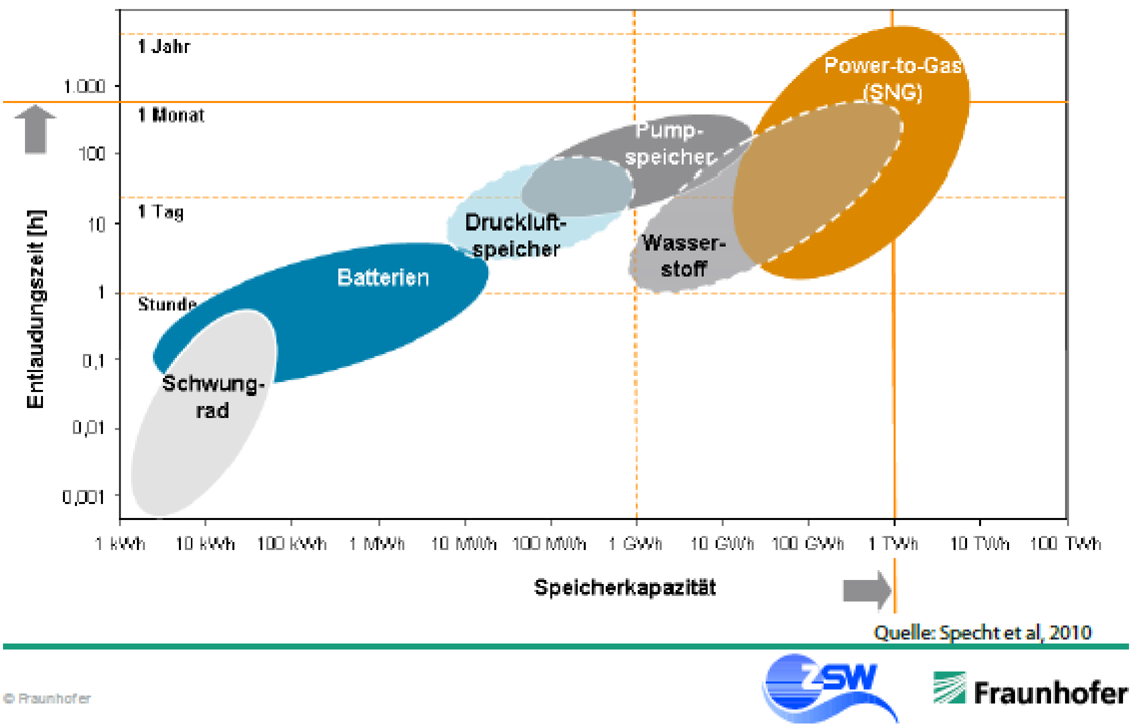
A crucial question is if storage for surplus renewable power can be developed beyond the rather limited volumes represented by hydropower in Germany, eventually using the much larger hydro power potential of Scandinavia, although with limited capacity and the high costs of connecting subsea cables.

Chemical storage as hydrogen or methane looks like the obvious way to store large volumes of electricity. Compared to the electro-magnetic forces, underlying chemical energy gravity is a rather weak force: For the generation of one kWh from hydroelectricity one cubic metre of water has to fall 400m whereas one cubic metre of gas at atmospheric conditions has an energy content of about 12 kWh at one bar and a corresponding multiple under a higher pressure (600 kWh at 50 bars). Figure 20 [283]illustrates the strong variations in storage volume and reach of different storage technologies. The present working gas volume of gas storage in Germany of about 20 bcm corresponds to more than 200 TWh yielding an electric power production of more than 100 TWh compared with only 40 GWh of the present hydro storage volume in Germany (which for geographical reasons cannot be enlarged much more). Models

[282] IEA (2013). p. 51
[283] Specht et. Al. (2009), p. 70

of an all-renewable power system for Germany show as much as 180 TWh surplus electricity with a deficit of 45 TWh needing large volumes of seasonal storage, which could only be provided by using hydrogen or SNG as storage [284] .

**Figure 20: Alternative / Supplementary Storage Technologies: Capacity and Reach**




Notes: Vertical Axis label: Depletion time (h), logarithmic scale: scales indicated from bottom: hour, day, month, year
Horizontal Axis: storage capacity , logarithmic scale
Areas from left to right; flywheel, batteries, pressurized air storage, pump storage, hydrogen, power-to-gas (SNG)

Several models of the energy sector could fulfil the 80% plus target in 2050. What seems clear is that final energy consumption has to be carbon free because it is difficult to think of any de-carbonization process in the domain of the small consumer. Such carbon free energy could be delivered as carbon free electricity or as carbon free methane or as carbon free liquid bio fuels.

Part of it will be delivered by local production of renewable energy (solar heat, PV, some wind) which will be used on site or fed into the low voltage grid and does not need long haul transportation nor large scale storage. This will not be enough to satisfy the needs of residential and commercial customers nor of industry and not of transport in every location. In addition seasonality has to be met, but local renewable production like PV would typically have an anti-seasonal pattern.

Therefore, beyond the supply chain needed for fossil fuels corresponding to 5% to 20% emissions remaining, transportation/distribution and storage of GHG neutral energy will be

[284] Sterner et al., P.-I. (2013, September 9)

needed. Both for the transport as for the storage of energy, density is a key aspect. Electricity can only to a rather limited extent be stored directly in batteries and energy transport capacity even of HVDC lines is much less (by a factor 5 and more) than the energy transport capacity of a large 48” or 56” gas pipeline and gas storage can store substantial amounts of energy. Energy density of liquid fuels is even higher than that of gas, even at 100 bar by a factor of 10. A question is whether the necessary storage can be arranged without using (GHG neutral) carbon (gaseous or liquid) as a means. Hydrogen might be produced in a GHG neutral way, however its energy density compared to methane is lower by a factor of about three and the safety of $H_2$ is so far not proven for volumes in the order of GWh, therefore methane looks like the better option. Alternatively all GHG neutral energy would have to be transported by wire.

GHG neutrality can be achieved (i) by a tail end process such as CCS producing $CO_2$-low electricity or (ii) upfront like power to gas, producing GHG-neutral hydrogen or better methane and biogas, which then can be used in a de-centralized way as it is easier to transport because of the much higher specific transport capacity compared to electricity.

### *All Electric System with CCS*

One could think of an all-electric system using large scale batteries or large numbers of batteries for instance in cars and GHG neutral carbon only as bio gas or bio fuel. That would require substantial progress in batteries and result in large scale electricity transmission and distribution.

Renewable electricity could be complemented by gas- or coal-based CCS power production to the extent that surplus renewable electricity cannot be stored or transported, eventually with some regulating down of peak renewable surplus production. Power plants with CCS could also solve the issue of seasonality (renewables would be built only to the point when practically all intermittent renewable production can be consumed in a large enough power grid with extra upwards flexible demand reacting to low prices of renewables and the rest is produced by CCS power plants plus some GT as reserve for extreme cases of lack of renewable power production.

The potential of demand side reaction may still develop in light of the increasing share of renewables. In general the possibility to reduce demand both in industry and in the residential and commercial sectors, seems to be restricted to postponing demand peaks by several hours until the demand is made up. A new development is starting new approaches to more flexible power off-takes, also on the upward side. Large power consumers are looking for ways to make use of cheap unforeseeable supply peaks and even night storage or other direct electric heating (power to heat) is back in the discussion to take intermittent cheap electricity peaks.

Electricity-only solutions imply more electricity transmission because of large spatial discrepancies between production and consumption of electricity which comes with the centralized approach to power production (large offshore wind plus power plants with CCS).

### *Gas Based vs. Coal Based CCS*

CCS could be based on domestic lignite or imported coal (globally widely spread) instead of gas from few sources (for pipeline gas with a physical link to a handful of producers and for LNG in competition with Asia).

Table 11 in section 3.4 gives the cost comparisons between lignite, hard coal and gas with and without CCS based on the figures used in the scenarios of EWI, GWS and Prognos produced in 2010 for the government. The investment for the CCS process per se is assessed to be cheaper on the basis of a CCGT as are the full costs of power production with CCS based on gas under present price assumptions and a load factor of up to 5,000 h/a.

On a marginal cost basis without pricing $CO_2$ emissions the merit order is very clear: first lignite, then coal, then gas. On a full cost basis (which is the consideration for the overall economy) at present price relationships gas is likely to be the cheaper overall option for de-carbonized power generation up to 5,000 h/a. It is unlikely that any base load power generation above 5,000 h/a will be left in a renewable dominated electricity sector.

The coal / lignite CCS option would not save money compared to gas. Gas CCS would be less sensitive to load because of lesser investment for capacity. It would also need a smaller infrastructure for disposal of $CO_2$ because of its higher efficiency. Coal or lignite-based CCS however, would possibly be less dependent on energy imports from specific countries, namely Russia. In view of the abundance of hard coal worldwide and even more so for the use of domestic lignite coal and lignite would offer price hedging.

### *The Power to Gas (p2g) Approach*

The power to gas approach mentioned in the Energy Concept refers to a process of producing hydrogen by electrolysis from surplus renewable power and then producing methane by reducing GHG neutral $CO_2$ with hydrogen by a Sabatier process. Both processes are well known, but electrolysis has not so far been established using intermittent electricity, and neither process has been applied on a large industrial scale, and for the Sabatier process not with GHG neutral $CO_2$.

In this way surplus power could be transformed into either hydrogen or methane, which could be transported and stored in the existing gas system. While methane causes no compatibility problem as natural gas mainly consists of methane, there would be limitations to the addition of hydrogen into the present gas grid. The German grid operators feel uncomfortable if hydrogen exceeds a 2% limit with the argument that in the open grids in Germany, the dissemination of hydrogen cannot be controlled and that it may damage some storage sites. Mixing substantial volumes of hydrogen in the gas flow would need high volume and rather constant flows of natural gas which is only present at major import points, whereas methane could be added at any point in the grid.

About a dozen pilot projects on power to gas are underway in Germany, the latest and largest being Falkenhagen with 2 MW inlet capacity of E.ON inaugurated on August 28, 2013[285] and the project of Audi at Werlte with 5 MW inlet capacity inaugurated on June 28, 2013[286].

The development of the first projects was as follows[287]:
- 25 kW ($H_2$/$CH_4$) as of 11/2009
- Mobile unit 2 kW ($H_2$/$CH_4$) as of 2012
- Further 4 projects of about 25 kW (mainly $H_2$): 2012 / 2013
- 3 Small pilots 2 $H_2$, 1 $H_2$/$CH_4$ (about 100 - 250 kW): mid 2012 – 2013
- 2 Pilots: Audi ($H_2$ / $CH_4$) 5 MW and E.ON 2 MW only $H_2$: both mid-2013

Scaling up by a factor of 10 may take some 3 to 5 years. The vision of an all-electric system would need to have about 60,000 MW inlet capacity, translating e.g. into 600 units of 100 MW inlet capacity, so that one or two more steps of up scaling would be needed. In addition, substantial cost reductions by going along the learning curve are needed to make the application of the power to gas technology economically viable. Acceptance for as many as 600 units might also become an issue.

Surplus electricity of 188 TWh/year would translate into about 16 bcm of gas which could be handled by the existing gas system in Germany (with a current storage volume of 20.4 bcm working gas).

### *Comparing CCS and p2g*

Which system or what combination will prevail depends on the success of testing CCS and power to gas, but above all on acceptance of either approach.

CCS runs into acceptance problems as it is a large scale technology and carbon storage is (wrongly) associated with nuclear waste disposal. In addition it would require a new infrastructure to transport $CO_2$, which would eventually not be distinguished from carbon monoxide pipelines, such as Bayer AG's CO pipeline built between Uerdingen and Dormagen but not yet operational, which faces very strong opposition.

In fact the German CCS law that entered into force in 2012 allows CCS on a test basis only and restricts the $CO_2$ to be stored to 1.3 million t $CO_2$ per year per site (4 million t $CO_2$ per year overall)[288]. So far, CCS projects are only at the pilot scale. "The Jänschwalde CCS project was cancelled despite receiving EUR 180 million funding from the European Economic Recovery Package, because of legal uncertainty and public opposition to onshore storage. On the other hand CCS related R&D supported by the BMWi is continuing and German government institutions as well as companies are active in international CCS technology co-operation."[289]

By contrast p2g can be built in a more decentralized fashion and can use existing infrastructure. Handling of hydrogen in industrial volumes is well known from coking plants,

[285] BMWi. (2013, August 28)
[286] Audi Media Services. (2013, June 25)
[287] dena. (2013)
[288] Bundesrat. (2012, June 27)
[289] IEA (2013), p. 110

refineries and the chemical industry. When spread across more locations it might also provoke some resistance. Although p2g projects are probably more flexible regarding location they must be close to the power grid and the gas grid and a source of GHG-neutral $CO_2$. This could be ambient air, adding to the costs of the process.

From an industrial policy point of view both technologies would have a promising export market potential. Any decision point about technology development is probably at least a decade into the future. It would be wise to keep both options open as long as possible.

## *How Today's Existing Infrastructure Might Evolve to Deliver Final Energy*

### Automotive Fuels

Because of their energy density liquid fuels are used for automotion and for heating in remote places or for other purposes beyond the reach of gas infrastructure. For automotion this can be replaced by biofuels (2nd generation), by methane as CNG or LNG for trucks and ships and also for individual vehicles (mainly for fleets).

The electric car or fuel cell car is still an uncertain option and depends on the further development of batteries. In 2013, the target of 1 million electric vehicles stipulated in the Energy Concept for 2020 looks remote. If such a development happens, the energy efficiency of cars would be substantially improved, and could be based on $CO_2$-free power production and may to some extent also be used to store surplus renewable electricity.

Although less energy efficient, it might be useful to use the existing infrastructure with biofuels (if problems with food production can be excluded) and gas-powered vehicles for some time.

### Gas

The existing gas infrastructure could be used in a de-carbonized economy when fed by biogas and gas from power to gas. However the sum of both would probably be a fraction of today's natural gas flow, and it is most likely not enough for the distribution of gas to residential and commercial beyond exceptional cases. Also from the demand side due to higher insulation standards not much gas will be needed in heating in view of the 2050 target of an almost $CO_2$ neutral building stock. Gas for hot water and cooking would not be enough to justify keeping a gas distribution grid.

When power to gas fails or is not produced in substantial volumes, biogas alone might not even be enough to justify maintaining all of the high pressure transportation grid and the gas storage sites. In that case the use of gas in small CHP would also be jeopardized.

### Electricity

It seems likely that the use of the electricity transmission and distribution grid will increase or at least not decrease due to improved electricity efficiency, as a large part of final energy will be delivered as electricity. With much better building insulation the heat developed by lighting and other electrical driven devices might be enough for heating in low energy houses.

$CO_2$ free or low $CO_2$ electricity could come from a combination of renewables and CCS-fitted power plants based on lignite, hard coal or gas and eventually some fossil fuel-driven power plant without CCS in a pure back up function. This could be gas turbines run by gas oil to avoid maintaining a gas grid as a backup just for a few hours use per year. The $CO_2$

difference between gas oil and gas would not justify keeping the gas infrastructure operational.

Alternatively renewable power from wind and PV might be used by a combination of EU wide transmission which would even out some variations of renewable power generation across the EU and more (upward) demand side measures to increase demand closer to intermittent supply by renewables. The rest could then be supplied by low $CO_2$ power production from CCS based on coal/lignite or natural gas.

**Implications for Infrastructure:**
Power to gas would allow the gas transmission and storage infrastructure to be retained, as well as CHP, as there would be enough gas to be used in CHP and decentralized gas-fired power plus some distribution. Power to gas would reduce the need for long haul transportation of surplus power which could be transformed into methane and transported via the gas grid. P2g would be a large absorber of surplus power which otherwise would have to be transported long distance by wire, or alternatively some renewable capacity would have to be shut. In general power based on centralized CCS power production would require more electricity transport by wire compared to a decentralized system of power to gas, which would also transfer the transportation tasks of renewables produced far from power consumption demand to the gas grid system which otherwise would increasingly become idle. Short of a breakthrough in battery technology, methane from power to gas will have a much higher specific storage capacity than batteries.

No new infrastructure for storage and transport is needed by p2g, nor a large upgrading of the power grid, but an open issue is the source of GHG-neutral $CO_2$ which could come from power plant processes, from ambient air or from bio processes.

If the gas system is retained, based predominantly on GHG-neutral methane (and natural gas used in power with CCS), also CHP and DH and some existing gas consumption could be maintained. Based on estimates of p2g plus bio gas, the overall average volume of GHG-neutral gas to be handled by the gas system would be in the order of 20 – 30 billion $m^3$/year. This should be enough to justify keeping the gas transport and storage system.

Basically the following three extreme scenarios might be thought of for a largely de-carbonized energy sector:

- *Pure renewable system with electricity storage as hydro power plus batteries in cars*
  This requires a substantial upscale of the power grid (depending on the offshore vs. onshore wind balance). Little use of the gas grid is left, eventually with some parts left to transport biogas. Gas-based CHP might not be supplied any more. Such a system would require a substantial improvement of the battery process, and the integration of batteries into the (low voltage) electric grid would be needed.
- *Renewables plus power with CCS*
  Substantial upscale of the power grid would be needed plus the creation of a new $CO_2$ transport infrastructure. Little use would be made of the gas grid unless CCS would be used for CCGTs instead of coal-fired plants.
  This scenario depends on the proof of feasibility and acceptance of CCS on a large scale. If the gas grid is maintained CHP plants could also continue to be used based on the remaining possible $CO_2$ emission after fulfilling the 80% plus reduction target.
  Electric cars would help to have low $CO_2$ mobility in addition to biofuels but would not be needed for grid balancing purposes.

- *Renewables with surplus electricity transformed via p2g*

  In this case the existing gas transmission and storage system could be maintained, while only a limited upscale of the power transmission grid would be needed, but in any case a modification of the power grid in view of predominant low voltage feed in (intelligent grids). CHP might be driven by $CO_2$-neutral methane or by natural gas using the remaining allowance for $CO_2$ emissions. If used in CCGT with CCS fossil natural gas could be used in the system. Gas distribution grids would however become the exception.

Assuming timely future technical and economic feasibility of both CCS and p2g, centralized CCS based on coal would not necessarily be cheaper but might be considered as a more secure supply option (i.e. less dependence on Russia). It would however risk ending the options linked to the gas infrastructure and gas (CHP, gas for cars, use of biogas via the gas grid, some remainders of gas distribution, p2g). Gas-fired CCS would at least contribute to the option of keeping the gas grid.

If p2g is more successfully developed than CCS, gas infrastructure and gas applications would in principle be future proof against structural changes from de-carbonization.

The long term role for gas in a de-carbonized world comes with carbon neutral synthetic natural gas from power to gas (electrolysis and the Sabatier process) plus biogas. Gas appliances and infrastructure would be long term strategy compatible, and therefore no regrets investment in contrast to coal.

## 3.4 Gas as a Transition Fuel

The Energy Concept provides clearly defined ambitious targets for reduction of GHG emissions for the decades to come: compared to 1990 a reduction of 40% by 2020, of 55% by 2030, of 70% by 2040 and by 2050 a reduction of 80% and more.

Looking at the scenarios produced for the discussion of the Energy Concept and also at the critical comments to the Monitoring Report 2012 by the four independent experts, reaching these target depends on meeting several demanding assumptions, in particular: optimistic assumptions on energy saving in buildings, especially on the refurbishment rate of the existing building stock, on savings in power consumption and a seemingly remote looking target of 1 million electric cars by 2020 as well as the commercial roll-out of CCS by 2025.

### *Potential Contribution of Gas to Reach the 2020 De-Carbonization Target*

While waiting on the outcome of technology development one should look for steps which can be taken which are compatible with any development and which are economically reasonable for the next one or two decades. A major approach is using the better GHG characteristics of gas to meet carbon reduction earlier and more reliably, also by compensating for the potential shortfall of other approaches. This applies mainly because of the better specific $CO_2$ emissions compared to coal combined with higher efficiency of the CCGT process compared to a steam process only. In addition gas-fired power has no large economies of scale for specific investment so that smaller plants are as economic as larger plants. Most heat sinks using exhaust steam or heat use much less than a thermal capacity of

100 MW. As the exhaust heat (measured in thermal MW) of power plants is at least of the order of the electric capacity (measured in electric MW) large plants like coal or lignite plants can only use a small portion of their exhaust heat or steam (except for use in refineries or chemical plants or parks). Gas-fired power plants by contrast can be built tailor-made to the size and the location of the heat sink achieving a high degree of energy use without increasing substantially the specific investment.

### *The Potential of Fuel Switching*

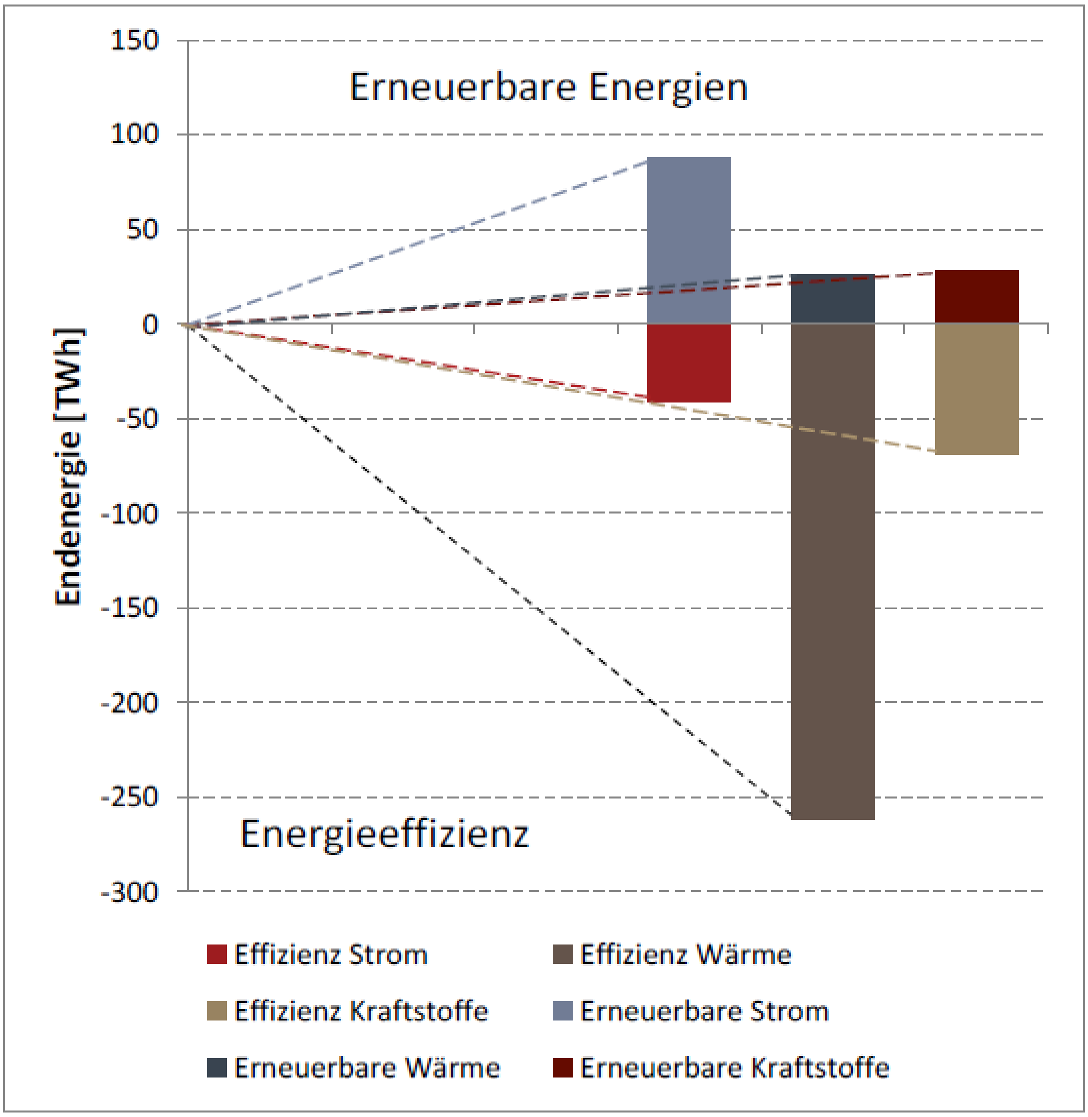
Fuel switching from coal to gas in power generation offers a substantial potential to compensate for any shortfalls in reaching these targets.

Figure 21 below shows the contribution of energy saving measures and of more renewable energy to reduction of final energy consumption in 2020. This figure raises the important question of the relative weight of various instruments and the potential to compensate shortfalls of meeting one target by over fulfilling another target. However, when looking at the $CO_2$ reduction targets the contribution of renewables energies would be larger as renewables would replace ceteris paribus a higher amount of primary energy (by a factor in the order of two and more) linked to corresponding $CO_2$ emission, while the final energy saved in heating translates by a factor of close to one to primary energy saved and corresponding $CO_2$ emissions saved.

From a total contribution of ca. 360 TWh contributed by energy saving the bulk (260 TWh) comes from higher energy efficiency in heating, while energy efficiency in electricity contributes 40 TWh to final energy saving and more efficiency in using automotive fuels contributes about 70 TWh. The final energy production of renewables amounts in total to ca 130 TWh of which 80 TWh are from renewable power generation, and about 25 TWh each come from use of renewables for heating and as automotive fuels.

Obviously meeting the 2020 targets depends critically on the performance of heating in the building sector. While missing some other targets could be compensated by a faster development of renewable power, which seems not impossible today, it will be extremely difficult to compensate for missing the energy efficiency target for heating.

**Figure 21: Change in Energy Consumption from 2010 to 2020**




Quelle: Eigene Berechnungen

Notes: Vertical Axis label: Final energy (TWh)
Key Legend: Light Red: Electricity efficiency, Beige: Fuel efficiency, Dark grey: Renewable heat, Light grey: Heat efficiency, Blue: Renewable energy, Dark red: Renewable fuels
Source: Monitoring Report 2012, Comments by independent experts[290]

To illustrate the potential of fuel switching in power generation: Saving of 100 TWh in the building sector (if based on gas) corresponds to saving the $CO_2$ emissions of about 10 bcm of gas. A similar amount of $CO_2$ emissions could also be saved when using 10 bcm of gas producing about 50 TWh of electric power in a CCGT instead of coal-fired power (as specific $CO_2$ emissions from coal are twice those of gas fired generation). At a capacity of 25,000 MW

[290] BMWi. (2012b, December). p. 125

of gas-fired power this would increase the load factor for gas by 2,000 h/a leading to a correspondingly lower load factor for coal-fired power.

These effects of fuel switching do not need new investment but policy action resulting in a change of the merit order between gas and coal.

### *Potential of Other Sectors*

Apart from the large $CO_2$ reduction potential by fuel switching, there is a remaining potential for fuel switching in heating which is still 30% covered by gas oil. Although in view of the long term perspective it would seem risky to expand the gas grid (beyond using and connecting to already existing infrastructure), the share of gas in district heating can certainly be improved, and the potential for gas in new CHP remains significant.

Other means of reducing $CO_2$ emissions would be new burners in existing apartment buildings, which would contribute to de-carbonization at limited cost short of the ambitious refurbishment targets. When looking at the building stock from the 1960s and early 1970s, some of it may better be torn down in future in view of its poor condition and in view of the trend towards shrinking cities in some parts of Germany.

### *The Impact of a Commodity-Only Market on Overall Costs of De-Carbonization and the Role of Gas*

Table 11 below (based on cost estimates used for the 2010 scenarios[291]) illustrates that – apart from not reflecting the externalities of carbon – another hurdle for the use of gas is the energy-only market. In energy-only markets investment costs and fixed operating costs are not necessarily part of price formation. A contribution to these fixed costs happens only for the time when power plants with higher variable, mainly fuel, costs define the market price by the differential to such market price.

[291] EWI; GWS; Prognos. (2010, August 27)., p. 42, 43; own calculations

**Table 11: Comparison of Full Costs of Lignite, Hard Coal and Gas Fired Power Plants**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | gas price in $/ MMBTU | | 10 | | |
| | | | | | | | coal price in $/ t (7000 Mcal) | | 100 | | |
| | | | | | | | exchange rate in$/€ | | 1.3 | | |
| **Cost comparison without CCS** | | | | | | | | | | | |
| | Specific | annuity of | | at load (h/a) | at load (h/a) | | | | | at load (h/a) | at load (h/a) |
| | investment | 0.15 | fixed OPEX | 5000 | 2500 | el efficiency | fuel costs | other costs | var. opex | 5000 | 2500 |
| | €/kW | €/kW*a | €/kW*a | €/MWh el | €/MWh el | kWhel/kWhth | €/MWh el | €/MWh el | €/MWh el | €/MWh el | €/MWh el |
| lignite | 1850 | 277.5 | 37 | 62.9 | 125.8 | 0.44 | 3.3 | 3.0 | 6.3 | 69.2 | 132.1 |
| hard coal | 1300 | 195.0 | 24 | 43.8 | 87.6 | 0.46 | 20.5 | 2.0 | 22.5 | 66.3 | 110.1 |
| gas | 950 | 142.5 | 20 | 32.5 | 65.0 | 0.60 | 43.8 | 0.0 | 43.8 | 76.3 | 108.8 |
| **Cost Comparison with CCS** | | | | | | | | | | | |
| | Specific | annuity of | | at load (h/a) | at load (h/a) | | | other costs | | at load (h/a) | at load (h/a) |
| | investment | 0.15 | fixed OPEX | 5000 | 2500 | el efficiency | fuel costs | (incl. CCS pipe) | var. opex | 5000 | 2500 |
| | €/kW | €/kW*a | €/kW*a | €/MWh el | €/MWh el | kWhel/kWhth | €/MWh el | €/MWh el | €/MWh el | €/MWh el | €/MWh el |
| lignite | 2500 | 375.0 | 90 | 93.0 | 186.0 | 0.38 | 3.8 | 18.0 | 21.8 | 114.8 | 207.8 |
| hard coal | 1850 | 277.5 | 59 | 67.3 | 134.6 | 0.37 | 25.5 | 15.0 | 40.5 | 107.8 | 175.1 |
| gas | 1175 | 176.3 | 33 | 41.9 | 83.7 | 0.51 | 51.5 | 6.0 | 57.5 | 99.3 | 141.2 |

Source: [292]

[292] EWI; GWS; Prognos. (2010, August 27). p. 42, 43, own calculations

As shown by Table 11 a coal-fired power plant would have to earn €44/MWh during 5,000 hours (at an assumed low annuity of 15%) to fully cover its fixed costs for the year. However the differential to marginal costs of a CCGT is only €21.3/MWh and gas-fired power would certainly not run for 5,000 h/a. Higher differentials caused by peaking plants like gas turbines setting the price would be rare, even more so now that mid-day peaks are cut by PV input.

The energy-only market model is fine when dealing largely with written off investment, which, in a regulated market, in principle would not be part of the asset base – the main exception being refurbishment costs. So getting a contribution for written off nuclear plants and written off coal-fired plants may be attractive in an energy-only market but it is difficult to justify investing in new power capacity on the basis of an energy-only market. In an energy-only market covering full fixed costs is coincidental at best but likely to fall short of covering 100% of the fixed costs. And it looks impossible for plants providing peak capacity as long as there is reserve power capacity under a philosophy of n-1 reliability. Peaking units could only earn money by gaming i.e. withholding capacity from the market. The model may make sense in countries which have their own resources which can be (or have to be) sold at any price, such as associated gas. Lowering the price for such resources below the market price can make the power plants commercially viable on a full cost basis. It may also make sense if reliability of power supply is not an absolute must (under an n-1 philosophy) but black outs or brown outs are accepted and the value of lost load (VOLL) is a realistic yardstick for providing back up power.

The issue is how to pass on the full costs of the power plant portfolio to the final customer. This worked during the time of regional (possibly private, and efficient) monopolies: the tariffs for the captive customers included the full costs of the power plant portfolio of the regional monopolies which were obliged to provide always enough capacity under the surveillance of the regulatory authority. Larger customers not subject to regulation could contest their delivery arrangements by threatening to build their own power plant.

Under these circumstances utilities could optimize long term their power plant portfolio knowing that they would recoup their investment from their captive customers and from their contract customers, which would also have to calculate the full costs of a contestable investment. This would not work in an energy-only market.

With renewables being fed into the grid by priority on account of zero marginal costs, or even because of off-take obligations, the average load factor of all fossil and nuclear plants shrinks and because PV is cutting the midday peak, also peak hours are reduced. This is exacerbating the problem created by the energy-only market.

### *Gas Most Flexible to Adapt to the Outcome of Technology Development*

Gas as a transition fuel would be future proof for a model in 2050 using methane from bio mass and from p2g and in general trying to maintain the gas infrastructure.

Technology development of CCS, car batteries and p2g is uncertain: its success, the timing, the economics and above all acceptance. A clear picture on the deployment of these technologies is unlikely to emerge before the mid-2020s.

If none of the technical developments (CCS, p2g, car batteries) are realized, or not realized in time or not to the extent necessary, using gas (instead of coal) is the least damaging option from a de-carbonization point of view (but also for environmental aspects such as emissions of particulate matter).

AND

Using gas as a transition fuel is an option which does not foreclose any further technical development as it is compatible with CCS, p2g and batteries: for CCS it has the lowest investment and fixed operating cost, p2g makes sense only with a gas grid for transportation and for load balancing, for car batteries gas is neutral compared to coal.

Betting on coal forecloses the p2g option and if technological development fails or is delayed the result will be use of coal with the higher $CO_2$ emissions. It would also jeopardize the economics of keeping a gas grid and therefore put at risk the investment in CHP plants. It would come at lower operating costs in existing power plants and would be looked at as a secure source given the spread of coal resources world-wide, whereas gas would under present circumstances come with higher operating costs and raise the issue of dependence. Apart from the positive record of Russia in fulfilling its contractual delivery obligations, the concern of dependence using more gas in the power sector is mitigated by (i) the large EU LNG regasification capacity (competing with Asia on price) and (ii) the possibility to switch back to coal in case of any interruption of gas deliveries.

Lignite may be different as it has cost advantages for base load (although small when retrofitted with CCS) and from a security of supply view because it is a domestic energy source.

Assuming eventual technical and economic feasibility of both CCS and p2g, centralized CCS especially based on coal would not necessarily be cheaper (at present full cost prices CCGT CCS would be cheaper) but might be considered as a more secure supply (i.e. less dependence from Russia). But it risks ending the options linked to gas infrastructure and gas (CHP, gas for cars, use of biogas by gas grid, some remainders of gas distribution, p2g). Gas-fired CCS would at least contribute to the option to keep the gas grid.

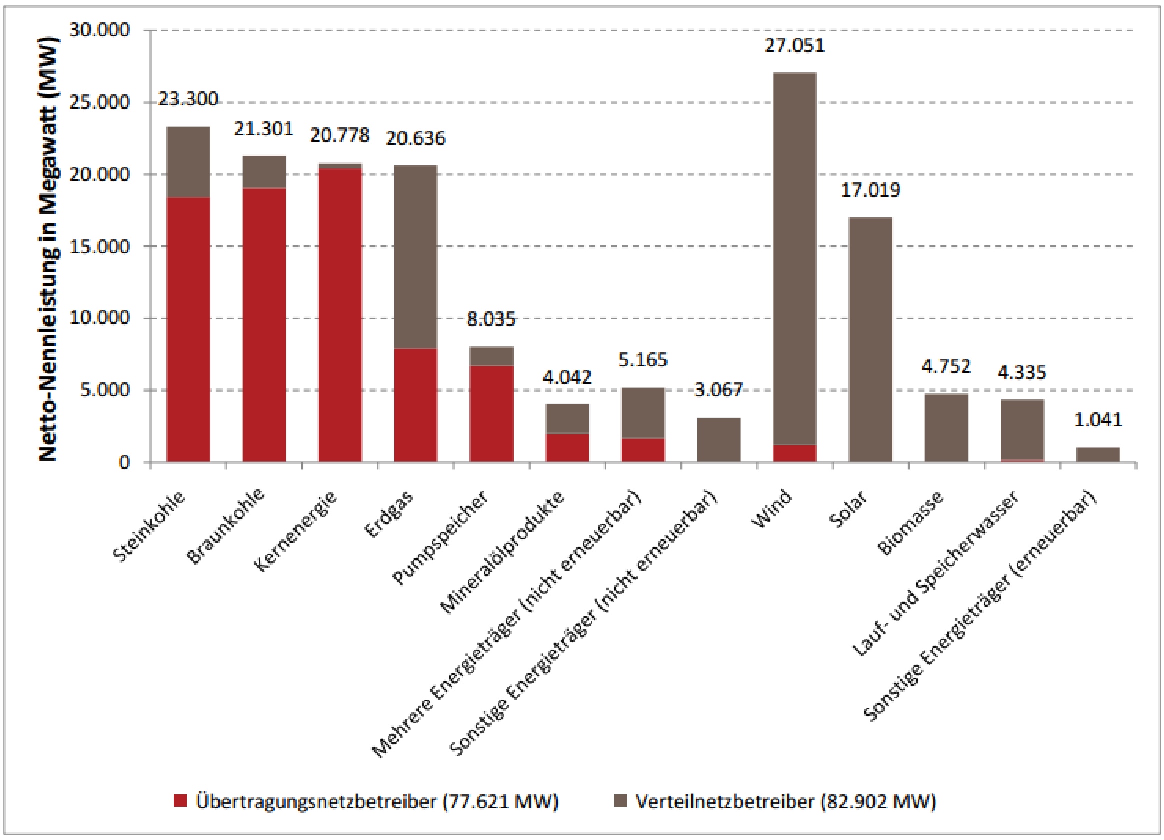
Whatever target model for an economy/energy sector will eventually be realized with 80% and more carbon reduction, gas should play a role in the transition in order to fulfil the ambitious interim targets for de-carbonization up to and after 2020.

If p2g is more successfully developed than CCS, gas infrastructure and gas applications are in principle proof against structure changes from de-carbonization. Also p2g could be considered as a domestic resource.

The core resistance against gas stems from dependence on Russian deliveries, which could be physically reduced by enlarging LNG import deliveries (but at a price competing with Asia). In addition, using gas instead of coal in power generation does not block the possibility at any time to go back to a higher use of coal should gas not be delivered as reliably as in the past. The dependence on Russia does not increase by using more gas in the power sector as long as the existing coal-fired capacity remains and could any time be used at a higher load factor. Gas is therefore the right choice over hard coal for the transition period

Today the majority of renewable electricity is fed into the low voltage system and so is the larger part of gas-fired capacity, while only a small part of coal and lignite-fired capacity is fed in to the low voltage grid. See Figure 22 below.

**Figure 22: Generation Capacities by Energy Sources on 31 December 2010 Differentiated by Transmission System Operator and Distribution System Operator**




Quelle: [BNetzA, 2011] (Eigene Darstellung)

Notes: Vertical Axis: Net Power capacity (in MW)

Horizontal Axis:Hard coal, lignite, Nuclear energy, natural gas, pump storage, oil products, multiple non renewable energies, other non renewable energies, wind, solar, biomass, run of river and storagewater, other renewable energies

Key Legend:brown: operators of high voltage grid Grey:operators of distribution grids

Source: EWI, [293]

Betting on CCS with coal and large amounts of offshore wind looks most inflexible and centralized and leaves less power production at a decentralized level by local renewables and CHP.

- CCS with gas would keep parts of the gas transmission grid and offers some room for decentralized CHP (on balance based on biogas and the remaining $CO_2$ emission allowance).

[293] EWI; GWS; Prognos. (2010, August 27).p. 88

- Power to gas would offer most opportunities for decentralized CHP and could transform offshore wind into decentralized CHP and other power generation (eventually still keeping some parts of gas distribution grids).

For implementing the delivery of final energy as power, utilities are the best actors because of their link with municipalities (and their role in defining the settlement and building structure). Many utilities own both the power distribution and gas distribution grids. So they may be best placed to optimize the further development of both grids: especially deciding how over time the electricity distribution grid will replace gas, and how to phase out the gas distribution grid to the extent necessary would best be managed by them.

Municipalities have district heating customers as captive customers and their domestic electricity customers do not tend to change supplier very often (although this is increasing even in Germany). Therefore they may have better chances to recover the full costs of a power plant or CHP investment. In addition the expectations for rate of return of their usually local municipal shareholders are lower than those of international shareholders.

With the closing of nuclear and the uncertain future for coal, the large power companies have lost an important part of their business model. A long term future of coal and lignite in a de-carbonized world needs CCS as a necessary condition, which in turn needs public acceptance as a necessary condition. As a result, the future of lignite and coal in Germany is rather uncertain. Also the business case for centralized offshore wind in which some of the large power companies are engaging, is not yet clear in view of the enlargement of the power grid needed to transport the power from the north of Germany to the South, but also in view of onshore wind as a less expensive overall option which still has a large potential, especially in the South of Germany which did not look at its systematic development in the past.

In general the large power companies, which were taken by surprise by the Energiewende of 2011, have to think about new business models. In Germany centralized power generation from lignite and coal with CCS and larger scale offshore wind does not look too promising. Models of cooperation with the municipalities living with the more modest rate of return of municipal business might be more reliable. (RWE has a long tradition of cooperation with the municipalities in the Rhine Ruhr area). Large power companies could also focus more on international business outside of Germany in the hope of earning the higher returns expected from companies which are quoted on international stock exchanges.

## 3.5 Elements to Improve the Role of Gas for De-Carbonization

Natural gas could make a major contribution during the transition period to reaching GHG reduction targets earlier or, more realistically, to having more options to compensate for shortfalls in achieving the efficiency targets mainly for heating. In addition p2g is an attractive vision for the future which would allow using existing power and gas grids for transmission, storage and distribution of renewable energy with the smallest upgrading need for the power grid and not requiring the creation of an additional grid for the disposal of $CO_2$. Even when CCS becomes economically viable – an option which should not be discarded – gas would be the overall cheaper and more flexible version of CCS power generation.

Several actors are involved which can influence the role that gas will play for de-carbonization: the gas industry, policy makers and politicians in Germany and the EU, and gas exporters.

### *Role of Industry*

While the use of gas could be fostered by industry, for instance by replacing old burners, an initiative to win more of the remaining share of gas oil in the heating sector, and the use of gas for transport, the major point for de-carbonization is about the role of gas in power generation, which depends on policy decisions by Germany/the EU and gas exporters. Contrary to the past, improving the role of gas is not only subject to its competitive advantages but also to political decisions.

### *Role of Policy Makers*

The main task is to create an explicit policy for the role of gas and gas infrastructure for the transition, and for the long term future based on an analysis of the potential contribution of gas to the Energiewende. By implication that would address the role of coal and lignite which by their nature are restricted to power generation against the background of the Energiewende.

A first step must be to deliver a comprehensive analysis of the role that gas (and by implication coal and lignite) should play for de-carbonization and the policy instruments suitable to enable that role.

Addressing these issues is not only needed in view of the Energiewende, but also to give a reliable perspective to the players in the energy sector. Especially coal and lignite have a limited future even if CCS is successfully developed, so it is necessary to create a reliable scheme for the remaining role to prevent waste of investment and allow for a smooth transition for employment.

A major issue is about competence at the EU level vs. the national/German level. While issues of energy mix are under national competence, issues of de-carbonization and energy efficiency are under the competence of the EU. So are access to infrastructure for gas and electricity leading to market design. In addition there is a de facto interdependence of the gas, and more so the power grids in the EU. Any approaches to the role of gas for de-carbonization would need careful coordination between Germany, its neighbours, suppliers and the EU. However, there is no reason why Germany should not look at the role of gas and coal/lignite in the context of its de-carbonization policy and do the analytical work as well as discussing adequate instruments and applying them where appropriate.

The long run issue is about fostering research and development. Here Germany could probably do more for the p2g research, but also to improve cooperation with EU research on p2g. Acceptance issues of p2g should also be addressed early on.

For the transition period, the relationships between gas and coal/lignite should be investigated in relation to their potential contribution to the Energiewende. Policy makers should not hide behind an argument that this should be sorted out by markets. Energy markets are always heavily influenced by policy and politics; definitely the design of de-carbonization instruments is politically biased in favour of coal and not working properly so far. Confronting gas with the result of the bias towards coal under the title “the market decides” cannot be the starting point of a serious analysis. Also the design of power and gas markets was guided by political paradigms.

There is no disagreement about fostering more gas-fired small and medium size CHPs: it has long been in line with the EU Energy Efficiency Directive and with the German policy supporting CHP. Still the result is falling short of expectation and of necessity. Screening the potential for CHP is certainly useful. CHP depends on gas and power prices but also on earnings from district heating. To implement CHP projects there must be clarity on the earnings from district heating as a contribution to cost recovery.

### *Gas for Large Scale Power Generation*

The relationship between coal, gas and carbon pricing is key for the use of gas in power generation. Analysis shows that at present price levels a substantial value has to be put on carbon dioxide, in the order of €50/t $CO_2$ to make gas competitive in power generation (see Chapter 3.2). To have any effect this threshold level must be reached, otherwise there will be no reversal of the merit order between coal and gas and the price for carbon might at best accelerate long term investment into higher efficiency of power plants but not lead to fuel switching with large reduction of $CO_2$. Alternatively a levy could be raised on the use of coal only. Such a result could also be achieved by a shadow price reflecting the costs of more direct measures, which could work like a phase out for coal-fired power generation (volumes, not necessarily capacity) or sectoral emission goals. This would make the use of imported but also EU coal more expensive. To mitigate the effects on coal mining in EU one could think of phasing out subsidies for coal mining in EU countries as were granted in Germany in the past.

However such measures are not in the hands of a single player. For coal it is left to a world market except for any fees levied on the use of coal for power. Direct or indirect carbon pricing is left to EU policy makers or for indirect pricing via volume restrictions on the use of coal eventually to Germany. For gas in power generation it is subject to gas pricing mechanisms. Gas prices are determined in the US by a market based on domestic production but the EU is import-dependent and beyond that facing an oligopoly of gas suppliers and strong demand from Asia. Therefore the marketing approach of gas producing countries to the power sector is important.

Using more gas in power generation needs a common understanding between Germany/the EU and gas exporters. Germany/the EU can address the following elements:
(i) carbon pricing for the power sector to improve the prices that can be earned by gas in power generation;
(ii) endorse different pricing schemes for gas in power by rebates for gas used for power, possibly on an interruptible basis;
(iii) amending the energy-only market scheme so that the investment in power generation capacity can be recouped and also the investment premium of gas- fired over coal-fired power can be realized.

(iv) Gas exporters (governments and companies) would have to make up their mind to which extent and under what conditions they are prepared to sell gas to the power sector at a rebate which would most likely give them a lower resource rent for these extra volumes.

***(i) Carbon pricing***

While some say that new investment in coal-fired power generation will stop, and the use of gas increase because of permitting and acceptance difficulties and old coal-fired power plants will be decommissioned due to the EU Large Combustion Plant Directive, that does not mean that new investment in gas-fired power will happen nor that gas-fired power would replace coal in base or middle load. The outcome could also be undersupply and black outs and pressure to continue using the coal fired power plants. It could also result in an increase of power imports from countries where coal-fired power plants comply with the EU Large Combustion Plant Directive, shifting the emission of $CO_2$ to these power plants. De-carbonization is not about the capacity installed based on gas or coal, but about the use (or load factor) of such capacity.

It would be wise to delink the carbon scheme for the power sector from the carbon scheme for the other industries, because of the risk that other industry becomes hostage to the scheme applied for the power industry, which is of a different character.

While the power industry is a locally bound service industry with an almost inelastic demand for its product, both aspects do not apply for most other industries under the ETS. While carbon is the core part in the process of thermal fossil power production it is a more or less necessary ingredient in the other processes having an important share, but not the crucial part, in the costs of the product. For these industries the main effect of a carbon price is to trigger higher efficiency, which is subject to investment cycle. On the other hand such other industries are under competitive pressure on a global market and cost increases or regulatory uncertainty may result in their divesting and migrating to other regions. For Germany this would be a severe issue certainly for all steel-related industry and the chemical industry which are considered to be core competence clusters.

The power industry offers much more potential for de-carbonization because of the much higher volumes of $CO_2$ emissions but also because with renewables carbon-free processes are technically proven but maybe not yet available at a commercial level. Pipe end decarbonization looks possible, though not yet tested and running into acceptance problems and for the medium term fuel switching to gas offers a large potential. While carbon pricing can influence the carbon streams through the power production process immediately, for other industry it would be only – if at all – via the investment cycle.

***(ii) Special pricing schemes for gas in power***

If coal equivalence determined the market price for gas, this would heavily reduce the earnings of marketing to traditional sectors. Potential ways to establish a system under which prices for gas in the power sector could deviate from prices in the other gas market segment could open a way to sell gas at competitive prices in the power sector without jeopardizing the other sales positions. Such an approach might be to grant rebates on the general gas price level for all gas volumes used for power generation. This would be similar to the solution found between Gazprom, the EU Commission and SNAM in 2003 to end the destination clause by delivering freely tradable gas in Baumgarten granting special rebates on the price at Baumgarten for all volumes sold in Italy. It could also be based on interruptible supplies, not needing dedicated infrastructure capacity, as the effect of gas in power generation on $CO_2$ emissions depends on volumes and not capacity secured at all times. Without such price differentiation gas sales to the power sector will not be attractive for producers, unless a carbon price is imposed which raises the costs of coal in power generation to the costs of gas, i.e. at present at a level of €50/t $CO_2$.

***(iii) Recouping costs of power capacity***

A generic issue also affecting the role of gas in power generation is the effects of an energy-only market on recouping investment in power plants. With the present system, most power plants, especially peaking plants such as gas fired plants, recoup only part of their fixed costs. This problem stems from the design of energy-only markets but is exacerbated by the large capacity of PV cutting midday peaks and priority feed-in of increasing volumes of renewable power in general. CCGTs have an investment premium compared to coal or lignite due to substantially lower fixed costs. Projections for power plants fitted with CCS increase that advantage to a point where CCGTs with CCS would have lower full costs than coal if run at less than 5,000 h/a which is less and less likely due to increased renewable feed-in. The discussion how that issue can be addressed has just started. A part of that discussion should be how the investment premium that gas has over coal might be realized by a gas seller.

### *The Role of the Gas Exporters*

***(iv) Resource rent***

An EU policy which puts a higher value on $CO_2$ emissions directly or indirectly, so that the savings from the lower specific $CO_2$ emissions of gas vs. coal together with the difference in electric efficiency between a coal fired power plant and a CCGT (plus eventually parts of the investment premium) could result in a gas price attractive for sellers to consider selling extra volumes of gas.

However, such EU policy might not always result in the same resource rent to the gas producing countries as sales to the general gas market. Gas producers have to decide to what extent they are interested in selling extra volumes of gas at conditions deviating from the general gas price in the market (when used for power generation). In this way they could sell larger volumes, however with a deviating (i.e. lower) specific rent for these volumes due to the rebate granted for such volumes. As the main purpose is to increase the gas volumes reducing $CO_2$ emissions by replacing coal volumes in power generation, not about power capacity, such gas deliveries could be sold under interruptible conditions, therefore not requiring investment in or booking of firm transmission system capacity which would ceteris paribus increase the net back price at the wellhead and the resource rent.

A special challenge would be developing a more differentiated rent-taking regime for exported gas. The present system in gas exporting countries tends to raise taxes for exported gas based on a norm price applicable regardless of de facto earnings to ensure taxation based on arms' length prices. When applying prices with special rebates to promote gas in specific sectors or to reflect deviations from standard delivery conditions, such a system would have to be adopted.

The EU´s answer to the threat to its climate policy and to its road map 2050 by the import of cheap coal triggered by shale gas in US but not necessarily caused by it, cannot come from a hope for cheap shale gas: Not from the US, because if any LNG is available for the EU, it will be more expensive than US coal or other coal, due to the costs of LNG transportation which adds some $5/MMBTU to the Henry Hub price (and competition from Asia resulting in even higher prices). Nor from EU shale gas, because no substantial volumes can be expected in this decade due to uncertain geology, acceptance problems and the lack of a sizeable drilling industry.

Sending substantial gas volumes to the power sector in the EU depends on a volume decision by main gas producing countries (Russia, Norway, Algeria) selling pipeline gas to the EU. (LNG exporters would rather look to sell more gas to the prosperous Asian market.) They would need a vision shared with the EU on the role of gas in power generation making the price for gas in power attractive enough for the gas exporters but would also need to send a signal that they are interested to sell to the power sector and at what conditions. Contrary to earlier times where such discussions were between commercial entities, this is a new situation, which needs the involvement of the politicians in view of their influence on carbon pricing and other pricing schemes in the EU, and on resource rent in gas producing countries.

## 4. Conclusions

1. An assessment of the role gas can play in the Energiewende (New German Energy Policy) is overdue. Due to its specific low carbon emissions and high efficiency in power generation gas could substantially contribute to meet the two targets of the Energiewende: (i) phasing out of nuclear while maintaining reliable power and (ii) ambitious de-carbonization of the energy sector. While the role of gas as a bridge fuel was explicitly advocated by the ad hoc ethics commission installed by the government after Fukushima this recommendation was ignored in the further debate. The new government formed after the elections of September 2013 in its coalition agreement does not address the role of gas for the Energiewende. It should do so at the latest by the progress report due at the end of 2014.

2. The role of gas in the transition to de-carbonization stems (predominantly) from its potential to replace coal-fired power generation at half the $CO_2$ emissions per kWh. This was demonstrated by the recent reduction of $CO_2$ emission in the US due to large scale switching from coal to gas in power generation. The stereotype of highly flexible gas plants as a good match for intermittent renewables is misleading. All fossil fuel power plants offer the flexibility needed for load following mode stemming from increasing intermittence. It is therefore necessary to find a capacity mechanism which pays for keeping enough thermal plants on the grid to back up renewables, avoiding stranded investment as well as windfall profits for written off plants. However, it is the rank of gas vs. coal in the merit order which is decisive for de-carbonization and the volumes of gas used in power generation.

3. At present price relationships for coal and gas the switching point in the merit order between gas and coal is at a carbon price of about €50/t $CO_2$, far above EUA prices. Coal prices are world market prices likely to stay at the present level of $100/t and below. Gas import prices in the EU are subject to trade with countries exporting gas to the EU, while the price put on carbon emissions in the EU is a function of political decisions by the EU. The dilemma of a uniform carbon price (the present EU paradigm) is: low carbon prices will not achieve much (being below the switching point from coal to gas) and high carbon prices risk driving carbon-intense industry other than power out of the EU. Promoting gas in power generation could result from an extra price put on carbon or specifically on coal used in power generation, combined with special rebates by producers for the the use of (interruptible) gas in power generation. This however needs a policy shared between the EU and its gas suppliers.

4. Promoting gas instead of coal keeps more technology options open for a decarbonized, renewables-based future. Such technologies are still under development with an open outcome, such as CCS for continued use of fossil fuels, power to gas and batteries to store surplus renewable energy and second generation biofuels. Power from coal would only have a future if equipped with (disputed) CCS leading to a centralized system dominated by electricity. CCS for gas would be even less costly on a full cost basis. In any case, gas offers more options. Promoting gas for the transition would also allow

maintaining the present gas system and be compatible with biogas and power to gas as well as with decentralized applications such as CHP.

5. The role of gas vs. coal is rather a political than a competition issue: the role of gas was earlier decided by competition with replacement fuels with little political influence, then increasingly by gas to gas competition framed by infrastructure regulation. Gas in power generation strongly depends on de-carbonization policy and its implementation and the resulting carbon price level and merit order. Effective de-carbonization for the next decades is first of all a political decision about a positive role for gas and a declining role for coal. The design of carbon pricing and the mechanics of emissions trading must follow from that decision. Germany has first of all to overcome her coal mindedness, often hidden behind market rhetoric and exaggerated security of supply concerns about imported gas, escaping the political issue. If a country like Germany is not able or willing to phase out coal for de-carbonization, why should China or India do it?

## List of Acronyms

| Acronym | German | English |
|---|---|---|
| AKW | Atomkraftwerk | Atomic Power Plant |
| ARA | | Amsterdam Rotterdam Antwerp |
| BAU | | Business as usual |
| BCM | | Billion cubic metres |
| BDEW | Bundesverband der Energie- und Wasserversorgung e.V. | Federal Association for Energy and Watermanagement (a registered society) |
| BDI | Bundesverband der Deutschen Industrie e.V. | FederalAssociation of German Industry (a registered society) |
| BMU | Bundesministeriums für Umwelt, Naturschutz und Reaktorsicherheit | Federal Ministry for Environment, Protection of Nature and Reactor Safety |
| BMVBS | Bundesministerium für Verkehr, Bauwesen, Städtebau und Raumordnung | Federal Ministry for Traffic, Construction, Urban and Spatial Development |
| BMWi | Bundesministerium für Wirtschaft und Technologie | Federal Ministry for Economy and Technology |
| BNetzA | Bundesnetzagentur | Federal Network Agency (regulatory agency for grid related activities) |
| B-W | Baden-Württemberg | Baden-Württemberg |
| CCGT | | Combined Cycle Gas Turbine |
| CCS | | Carbon Capture and Storage |
| CDM | | Clean Development Mechanism (Kyoto Protocol) |
| CDU | Christlich Demokratische Union Deutschlands | Christian Democratic Union of Germany |
| CH4 | | Methane |
| CHP | | Combined Heat and Power |
| CNG | | Compressed Natural Gas |
| CO2 | | Carbon dioxide |
| COP | | Conference of the Parties (of the UNFCCC) |
| CSU | Christlich Soziale Union in Bayern | Christian Social Union in Bavaria |
| Dena | Deutsche Energie-Agentur (dena) | German Energy Agency |
| DH | | District Heating |
| DM | Deutsche Mark | German Mark |
| DOE | | Department of Energy (USA) |
| DSM | | Demand Side Management |
| EC | | |
| ECT | | Energy Charter Treaty |
| EEG | Erneuerbare Energien Gesetz | Law on Renewable Energies |
| EKF | Energie- und Klimafonds | Energy and Climate Fund |
| EEWG | Erneuerbare-Energien-Wärme Gesetz | Law on Renewable Heating Energies |

| | | |
|---|---|---|
| EnBW | EnBW Energie Baden-Württemberg AG | Electric Utilitiy mainly active in Baden-Württemberg |
| EnEG | Energieeinsparungsgesetz | Law on Energy Saving |
| EnLAG | Energieleitungsausbaugesetz | Law on Expansion of Energy Grids |
| E.ON | | Energy Company with headquarters in Düsseldorf |
| EPIA | | European Photovoltaic Industry Association |
| ENTSO -E | | European Network of Transmission System Operators for Electricity |
| ENTSO-G | | European Network of Transmission System Operators for Gas |
| ETS | | (EU) Emissions Trading System |
| EU | | European Union |
| EUA | | European Emission Allowances |
| EUR | | Euro |
| FDP | Freie Demokratische Partei - Die Liberalen | Free Democratic Parrty - the liberals |
| FERC | | Federal Energy Regulatory Commission (USA) |
| FOB | | Free on Board |
| FTA | | Foreign Trade Agreement |
| G8 | | Group of Eight (USA, Canada, Japan, Russia, France, Germany, Italy and UK |
| GDP | | Gross Domestic Product |
| GJ | | Giga Joule = $10^9$ Joule |
| GHG | | Greenhouse Gas |
| GW | | GigaWatt = $10^6$ kiloWatt |
| GWh | | GigaWatt hour = $10^6$ kilowatt hours |
| GWS | Gesellschaft fuer Wirtschaftliche Strukturforschung mbH | Institute of Economic Structures Research |
| H | | hour |
| h/a | | hours per year |
| H2 | | Hydrogen |
| HVDC | | High-voltage Direct Current |
| IEA | | International Energy Agency |
| IEKP | Integriertes Energie- und Klimaprogramm | Intergrated Climate and Energy Program |
| IPCC | | Intergovernmental Panel on Climate Change |
| ITO | | Independent Transmission Operator |
| JI | | Joint Implementation (Kyoto Protocol) |
| KfW | Kreditanstalt für Wiederaufbau | Bank for reconstruction |
| KKW | Kernkraftwerk | Nuclear power plant |
| kW | | kilowatt |
| kWh | | kilowatt hour |
| LNG | | Liquefied Natural Gas |
| LTC | | Long term contract |

| | | |
|---|---|---|
| MEGAL | Mittel-Europäische Gasleitung | Pipeline for Russian gas imports crossing Germany in East-West direction |
| MJ | | Mega Joule = $10^6$ Joule |
| MMBTU | | Million BTU (British Thermal Unit) |
| MOP | | Meeting of the Parties (to the Kyoto Protocol) |
| MW | | MegaWatt = $10^6$ Watt |
| MWh | | MegaWatt hour = 1000 kWh |
| NABEG | Netzausbaubeschleunigungsgesetz | Grid Expansion Acceleration Act |
| NBP | | (UK) National Balancing Ploint |
| NEEAP | Nationaler Energieeffizienz Aktionsplan | National Energy Efficiency Action Plan |
| NGO | | Non-governmental Organization |
| OECD | | Organisation for Economic Co-operation and Development |
| P2G | | Power to Gas |
| PEC | | Primary Energy Consumption |
| PJ | | PetaJoule = $10^{15}$ Joule |
| PV | | Photovoltaic |
| R&D | | Research and Development |
| RWE AG | bis 1990: Rheinisch-Westfälisches Elektrizitätswerk AG | Utility originally serving the regions along the Rhine and Westphalia |
| SAIDI | | System Average Interruption Duration Index |
| SKE | Steinkohleeinheit | unit of coal eqivalent |
| SNG | | Synthetic Natural Gas |
| SPD | Sozialdemokratische Partei Deutschlands | Socialdemocratic Party of Germany |
| T | | metric tonne |
| TINA | | There Is No Alternative |
| TSO | | Transmission System Operator |
| TWh | | TeraWatt hour =$10^9$ kWh |
| TYNDP | | Ten-Year Network Development PLan |
| UBA | Umweltbundesamt | Federal Office for Environment |
| UCTE | | Union for the Co-ordination of Transmission of Electricity |
| UK | | United Kingdom |
| UKCS | | United Kingdom Continental Shelf |
| ÜNB | Übertragungsnetzbetreiber | Transmission System Operator |
| UNEP | | United Nations Environment Program |
| UNFCCC | | United Nations Framework Convention on Climate Change |
| VNB | Verteilungsnetzbetreiber | Distribution System Operator |
| VOLL | | Value of Lost Load |
| WTO | | World Trade Organization |
| WWF | | World Wide Fund for nature |

## Glossary of German Terms

| German | English |
|---|---|
| Abteilung | Department of a ministry |
| Altlast | Historic burden |
| Auftragsverwaltung | Administration on behalt of the Federal Government |
| Bundeskartellamt | Federal Cartel Office |
| Bundesrat | German federal Council (of the states) |
| Bundestag | Parliament (lower house) |
| Bundesverfassungsgericht | Federal Constitutional Court |
| Deutsche Energie Agentur (dena) | German Energy Agency |
| Deutsche Forschungsgesellschaft | German Association for Research |
| Deutscher Kirchentag | Annual meeting of the Protestant Church |
| Deutschlands Zukunft gestalten | Shaping Germany´s Future |
| Die Energiewende zum Erfolg führen | Making the Energiewende a success |
| Die Grünen | The Green (Party) |
| Die Linke | The Left (Party) |
| Energie Konzept | Energy Concept |
| Energie- und Klimafonds | Energy and Climate Fund |
| Energieleitungsausbaugesetz (EnLAG) | Law on the expansion of power grids |
| Energieprognose | Energy forecast |
| Energiewende | New German Energy Policy |
| Energiewirtschaftsgesetz | Energy Law |
| Entwurf eines Dreizehnten Gesetzes zur Änderung des Atomgesetzes | Draft of the 13th bill to change the Atomic Energy Act |
| Erdgas - eine Brücke, die trägt | Natural gas - a bridge which holds |
| Erdgas hilft, um Versorgungslücken klimafreundlich zu schließen | natural gas helps to close (energy) supply gaps in a climate friendly way |
| Erneuerbare Energien Gesetz /EEG) | Law on Renewable Energy |
| Fortsetzung der Energiewende | Continuation of the New Energy Policy |
| Forum Energiewende (Energierat) | Forum on Energiewende (Energy Council) |
| Gesetz | Law / act |
| Heizkraftwerk | Combined Heat and Power Plant |
| Integriertes Energie- und Klimaprogramm(IEKP) | Integrated Energy and Climate Program |
| Kohlepfennig | A levy on the electricity bill (1975-1994) |
| Kohleverstromungsgesetz | Law on the use of hard coal in power plants |
| Kraftwerk | Power plant |
| Länder (Bundesländer) | (Federal) states |
| Lastfolgefähigkeit | Load following capability |
| Lohnnebenkosten | Cost in addition to wages |
| Nationales Forum Energiewende | National Forum for Energiewende |

| | |
|---|---|
| Naturschutz und Enegiewende | Protection of Nature and Energiewende (centre of competence) |
| Netzausbaubeschleunigungsgesetz (NABEG) | Grid Expansion Acceleration Act |
| Netzausbaugesetz | Law on the expansion of power grids |
| Netzstudie | Power grid study |
| Parlamentarischer Beauftragter für die Energiewende | Parlamentarian Representative for the Energiewende |
| Planfeststellungsverfahren | Procedure of spatial planning |
| Reservekraftwerksverordnung | Ordinance on power plants providiing reserve power |
| Statistisches Bundesamt | Federal Statistical Office |
| Steinkohlebeihilfegesetz | Coal aid law |
| Technologieoffenheit | Neutrality regarding technologies |
| Übertragungsnetz | Transmission network |
| Umweltbundesamt (UBA) | Federal Office for Environment |
| Verursacherprinzip | Polluter pays principle |
| Wir wollen eine ideologiefreie, technologieoffene und marktorientierte Energiepolitik | We want an ideology free, technology open and market oriented energy policy |
| Wir wollen mehr Marktwirtschaft und raus aus der Planwirtschaft | We want more market economy and getting off the the planned economy |

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