Hamburgisches WeltWirtschafts Institut

FRACKING

Strategy 2030

— Wealth and life in the next Generation. — An initiative of the Hamburg Institute of International Economics and Berenberg —

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PARTNERSHIP SINCE 1590

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**»Shale gas could become the energy topic of 2013.
Would it bring to an end our dependence on gas imports?
Or does its extraction destroy the environment?«***

Ralf Nestler, Journalist ZEIT ONLINE

Strategy 2030 is the title of a research series that our Bank has been publishing since 2005, together with the Hamburg Institute of International Economics (HWWI). Our aim with these studies is to highlight trends that we are engaged with today which will also have an impact on tomorrow. After all, our behaviour today will definitively determine and influence the lives of the next generation.

The world is changing at an increasing pace. This pace is being driven by the increasing frequency of new technological innovations, a rapidly expanding body of knowledge, and a globalised economy. Political, social, technological and economic catalysts have become fully integrated in this process of transformation, sometimes magnifying each other's effects, sometimes hampering further progress. As a result, these changes are perceived as becoming ever more complex and increasingly less tangible. This point is gaining increasing relevance, as the developments that are taking place now will inevitably affect matters far into the future, resonating across generations.

In light of this, we are dedicating the »Strategy 2030 – Wealth and life in the next generation« series to long-term, macroeconomic questions which go beyond traditional themes related to financial markets, focusing on social processes of transformation. The studies combine the expertise of economic researchers who are renowned beyond our nation's borders with the comprehensive experiences of a leading private bank that is steeped in tradition.

* ZEIT ONLINE 31 December 2012.
[http://www.zeit.de/politik/2012-12/deutschland-streitet-ueber-ga] (14 June 2013).

Contents

Summary

In the last few decades, global energy consumption has increased rapidly, and we can assume that this process will continue to accelerate in the near future. The strong growth in demand comes particularly from emerging markets, which require large quantities of energy for their rapidly expanding economies. In 2000, Chinese energy consumption was just half that of the US; in 2010, China moved ahead of the US as the world's largest consumer of energy. This prompts the question – how can future energy supply meet this growing demand? Shale gas could play a particularly important role here, given the considerable shale gas deposits which have been discovered around the world in recent years. If shale gas extraction were to happen globally to the same extent as it is currently in the US, there would be far-reaching consequences for energy markets; it would have a considerable impact on price trends in fossil fuels, on changes in the static-lifetimes of resources, and potentially on the environment.

Several years ago, the so-called »shale gas revolution« took place in the US, leading to significant changes in the domestic energy market. As production has increased, American gas prices have seen sharp falls over and above the global average. Gas is increasingly used for electricity generation in the US, while the proportion of coal used is falling. As a result, the US was also able to improve its carbon footprint through increased shale gas extraction in addition to reducing dependence on natural gas imports. Shale gas can be extracted with the aid of »hydraulic fracturing« (fracking). In this process, a mixture of water, quartz sand and chemicals is pumped into the ground, forcing open rock strata in order to make the gas easier to extract. In Europe, there are still significant concerns surrounding this process. The fear is that the use of chemicals during fracking could pollute groundwater and also increase the risk of earthquakes.

The significant increase in natural gas extraction in the US not only impacts the domestic energy market and the position of the US as a centre for commerce, but has also influenced international markets. The decline in gas prices in the US and the associated fall in demand for coal has also led to a drop in the global price of coal. As a result, there is a greater incentive in Europe to increase the use of coal in industry and electricity generation, with negative consequences for Europe's carbon footprint. Due to the low cost of coal and the collapse in prices for carbon certificates, any motivation in Europe to invest in innovative and environmentally friendly technologies is being ignored. At the same time, energy-intensive companies in the US are profiting from low gas prices and therefore have a competitive advantage over their competitors in Europe and Asia. However, Germany should avoid taking hasty action over potential shale gas extraction, particularly in high-population German federal states, where any negative environmental impacts would have significant consequences for a large share of the population.

As a major gas exporter, Russia could be put under increasing pressure from low priced American natural gas. This would be particularly true if the US government gives permission for the construction of liquefied gas terminals and, above all, if it exports gas to Asia. In China's case, we can assume that the expansion of the gas sector will soon be accelerated due to the discovery of

shale gas deposits locally. Investments in the development of infrastructure in the form of pipelines as well as LNG (liquefied natural gas) terminals should be expected worldwide.

From an investor's point of view, it is important that we take into account uncertainties arising from unreliable estimates over of the size of extractable reserves and the considerable regional differences in the underlying conditions for shale gas extraction. Nonetheless, sector-specific performance of companies with involvement in shale-gas and its extraction in the US may provide important clues as to the future investment potential in other countries. Further, long-term effects on key currency exchange rates should also be expected.

Part A:
The global potential of fracking

HWWI

1 Introduction

In view of the growing world population, meeting energy demands in the coming years will be of global importance. We can assume that the demand for energy will keep increasing worldwide, and larger quantities of energy will be required, particularly in emerging markets to service their rapidly expanding economies. This therefore prompts the question – how can future energy supply meet this growing demand? Despite the increasing share of alternative sources of energy such as wind power, hydropower and biomass, it is primarily fossil fuels that will be consumed in the future in order to meet global energy demand. Shale gas, in particular, could take on a vital role here, as considerable shale gas deposits have already been discovered around the world in recent years. Several years ago, the so-called »shale gas revolution« took place in the US, leading to significant changes in the international energy market. While shale gas deposits are already being exploited in the US, there are still major concerns in Europe.

Shale gas can only be extracted with the aid of »hydraulic fracturing« (fracking). In this process, a mixture of water, quartz sand and chemicals is pumped into the ground, forcing open the rock strata under which the gas is located. The use of fracking is currently a controversial issue due to fears over any potential negative impact on the environment. This controversy means that it is difficult at present to establish a legal framework for fracking in Germany. Although the coalition government was able to agree on draft legislation in May, it is more than doubtful as to whether this will be accepted by the upper house of the German parliament, the *Bundesrat.* Opposition is expected in particular from federal states where there are shale gas deposits to be found as politicians from Lower Saxony, North Rhine-Westphalia and Baden-Württemberg are afraid of losing support among voters if they approve fracking. Fracking is also an issue at EU level in 2013.

For example, the European Commissioner for Energy, Günther Oettinger, has stressed that no technology should be ruled out in advance, particularly if it would change the attractiveness of areas as centres of commerce. Furthermore, replacing coal with shale gas for the generation of electricity can improve a country's carbon footprint, which has already occurred in the US. In addition to assessing global deposits and their impact on national markets, part of this study will therefore concern itself with the environmental aspects of shale gas extraction. The strong expansion in natural gas extraction in the US has not only had an impact on the domestic market, but has also influenced international markets. The lower demand for coal in the US and the associated fall in international coal prices have increased the incentive in Europe to use coal-fired power stations for electricity generation, with correspondingly negative consequences for the carbon footprint.

At the same time, energy-intensive companies (such as chemical companies) based in the US are profiting from low gas prices and therefore have a competitive advantage over their competitors in Europe and Asia. The impact of shale gas extraction on national energy markets is analysed in this study, as is the question of who the potential winners and losers of a global shale gas revolution would be.

2 Primary energy consumption

2.1 Total energy consumption

Worldwide energy consumption has more than tripled since 1965, increasing by over 225%. The 2.5% growth seen in 2011 is equal to the average annual growth of the last decade. However, there have been considerable shifts in particular countries. In 2000, Chinese energy consumption was just half that of the US; in 2010, China moved ahead of the US as the world's largest energy consumer. In general, a shift in demand away from developed nations and towards emerging markets is clear, especially in Asia.[1]

2.2 Shares of energy sources in primary energy consumption

Despite the development of renewable energies, the majority of primary energy consumption is still drawn from fossil fuels (gas, oil, coal). Fossil fuels make up 87% of global energy consumption. Today, crude oil has the largest share of energy consumption (see Fig. 1). During the 1960s, oil overtook coal as the maint source of energy. In the mid 1970s, oil reached its highest share, accounting for almost half of global energy consumption. Since then, its share has fallen to 33.1%. The share of coal in global energy consumption, which was barely 25% at the turn of the millennium, is now at 30.3%, the second largest behind crude oil. Over time, natural gas has increased its share of energy consumption to almost 25% in 2011. Global gas consumption grew to 23.7% in 2011, with the increase in China, Saudi Arabia and Japan again being in part offset by a sharp decline in demand

1 See BP (2012).

Global energy mix, 1965–2010

Figures in million tonnes of oil equivalent

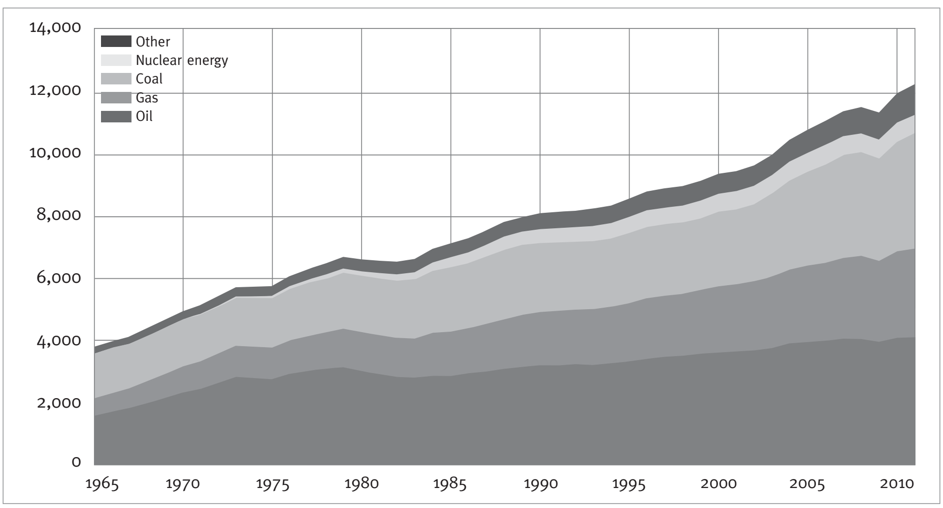

Fig. 1

Sources: BP (2012); HWWI.

Share of different fuels in primary energy consumption
Figures in %

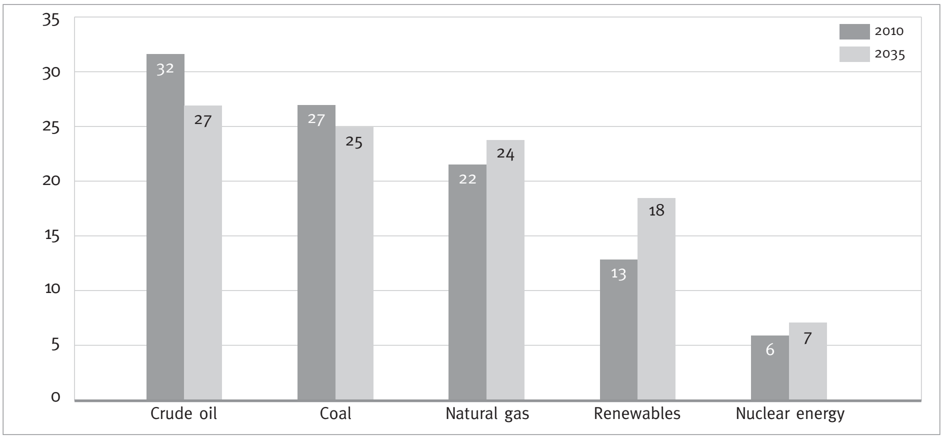

Fig. 2

Sources: IEA (2012b); HWWI.

in Europe (-9.9%). In 2011, nuclear power contributed approximately 5% to the global primary energy mix.[2] Use of renewable energies, in particular, has increased noticeably in recent years and achieved a share of roughly 2.1% of global primary energy consumption.

We can reasonably assume that, in the future, demand for energy will increase significantly due to continued strong economic growth in emerging markets and an exponentially increasing world population. For example, the Energy Information Administration (EIA) assumes in its reference scenario that from 2011 to 2030, global energy requirements will increase by at least 35%, and potentially by almost 45% by 2035.[3] The International Energy Agency (IEA) estimates that from 2010 to 2035, global energy demand will increase by 60%, with China, India and the Middle East primarily responsible for this. By 2035, the IEA expects the share of crude oil in the energy mix to see a slight fall to 27%, a decline in coal by three percentage points to 25% and an increase in the proportion of gas by two percentage points to 24% (see Fig. 2). Further, the IEA is forecasting an increase in global gas demand of nearly 50%, from 3.3 trillion m^3 to approx. 5 trillion m^3 in 2035. This means that gas will be the primary energy source worlwide, seeing the strongest growth in its share of the global energy mix over this period.

2 See ibid.
3 See EIA (2011).

3 Worldwide distribution of conventional natural gas deposits

An essential factor for meeting the energy demands of the world's population is having sufficient reserves of fossil fuels. Normally, an analysis of raw materials deposits focuses on reserves (proven quantities of energy feedstocks that can be extracted in a cost-effective way at today's prices and using today's technology) and not resources (proven quantities of energy feedstocks that cannot, however, currently be extracted in terms of technology and/or cost-effectiveness). The German Federal Institute for Geosciences and Natural Resources (BGR) assigns shale gas deposits to resources (instead of reserves), despite the possibility of mining them today in an economically viable way.

This can be explained by the fact that, other than in the US, there is no political consensus at national level in most countries with shale gas deposits regarding shale gas extraction. This is why, for now, this study deals with shale gas resources. The so-called »static lifetime« of fossil fuels is the relationship between current reserves and current consumption (see Fig. 3). If average global consumption remains constant, crude oil will last for another 51.5 years (if the ratio of reserve-to-production is examined, this rises to 54 years). This means that crude oil is the scarcest fossil fuel. Natural gas is in second place with 64 years, with the largest natural gas reserves are to be found in Russia. With a lifetime of approximately 112 years, coal is the fossil fuel with the largest reserves worldwide.

It is worth noting that over the last 30 years, static lifetimes have been constantly increasing – despite similarly increasing consumption. This can be explained largely by the fact that the development of new production technologies (e.g. fracking, which is needed to extract shale gas) means that ever larger quantities of fossil fuels can be extracted and consumed. As a result, resources are diminishing as the extractable quantities are now deemed to be reserves. Consequently, lifetimes are also increasing as consumption remains constant.

If the static lifetimes of fossil fuels are viewed in light of resources (i.e. all known deposits that at present cannot be extracted cost-effectively or technically), a significantly different picture emerges. The lifetimes for hard-coal and meta-lignite are 2,600 and 3,900 years respectively. From

Lifetime of fossil fuel reserves

	Crude oil in billions of barrels*			Natural gas in trillion m³			Coal in 10m tonnes		
	Reserve	Consumption per year	Lifetime in years	Reserve	Consumption per year	Lifetime in years	Reserve	Consumption per year	Lifetime in years
1980	667.5	21.8	30.6	81.0	1.4	56.3		367.3	
1990	1,003.2	24.2	41.5	125.7	2.0	64.1		454.7	
2000	1,104.9	28.0	39.5	154.3	2.4	64.0		480.5	
2010	1,622.1	31.9	50.8	196.1	3.2	62.2	86,093.8	725.4	118.7
2011	1,652.6	32.1	51.5	208.4	3.2	64.7	86,093.8	769.5	111.9

* 1 barrel = 159.1 litres

Fig. 3 Sources: BP Statistical Review of World Energy (2012); BP Statistical Review of World Energy (2011); HWWI.

today's perspective, these lifetimes should be considered as infinite, provided that further advancements can be made in technology and their extraction rate continuously increased. In comparison, the static lifetime of oil increases by around a factor of 2 to 81 years, while that of natural gas increases by a factor of 3 to around 180 years.[4]

Lifetime of fossil fuel reserves

	Crude oil in billions of barrels			Natural gas in trillion m^3		
	Resources	Consumption per year	Lifetime in years	Resources	Consumption per year	Lifetime in years
2011	2,583.4	32.1	80.5	577.3	3.2	180.4

	Meta-lignite in billion tonnes			Ortho-lignite in billion tonnes		
	Resources	Consumption per year	Lifetime in years	Resources	Consumption per year	Lifetime in years
2011	17,119	6.6	2,582.8	4,152.0	1.1	3,939.3

Fig. 4

Sources: BGR (2012b); BP Statistical Review of World Energy (2012); HWWI.

4 Worldwide deposits of shale gas

The improvement seen in production technologies has led in recent years both to an increase in the quantity and the scale of extraction of conventional sources of energy. It has also allowed the extraction of increasing quantities of unconventional fossil fuels (primarily shale gas and shale oil). In this study, we have focussed on shale gas deposits, as extraction is much more advanced, particularly in the US. This extraction is leading to structural changes in the American energy market, and will have long-term consequences for worldwide gas and oil prices. However, in the coming years, significant changes could also occur in the mining of shale oil.

The following presents an overview of conventional and unconventional natural gas resources (shale gas) worldwide. However, it should be noted here that the figures for unconventional natural gas and crude oil deposits are only really reliable for the US. For the rest of the world considerable uncertainty is still rife as deposits have only recently been discovered (see Fig. 5).

4 See BGR (2012b).

Global resources of natural gas and shale gas

Figures in trillion m³

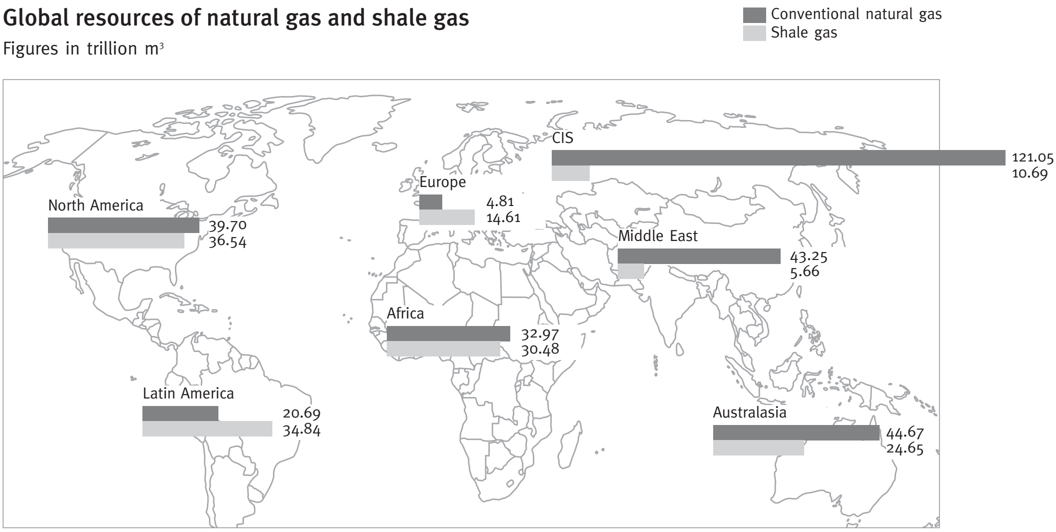

Fig. 5

Sources: BGR (2012b); BP Statistical Review of World Energy (2012); HWWI.

According to the BGR, the world's largest shale gas resources are in North America (USA, Canada, Mexico) with 36.5 trillion m^3. In Mexico, in particular, there is considerable potential. From 2.3 trillion m^3 in conventional natural gas resources, the total volume of gas resources increased more than ninefold (19.3 trillion m^3) to 21.6 trillion m^3 due to the discovery of shale gas deposits there. The US is the only country where shale gas has been extracted commercially since the start of the millennium (shale gas resources: 13.7 trillion m^3). The discovery of these deposits led to a more than 50% increase in the total volume of natural gas resources to 38.7 trillion m^3, when excluding other alternative natural gas resources.[5]

The largest conventional gas resources in the world are in the CIS states (Commonwealth of Independent States) (121.1 trillion m^3), but with »only« 10.7 trillion m^3, the shale gas potential here is comparatively small. Nevertheless, Russia, where the majority of deposits can be found (9.5 trillion m^3), will have to tackle the issue of competition arising from the global shale gas industry. After North America, the second largest shale gas deposits lie in Latin America (excluding Mexico). The largest deposits here can be found in Argentina (21.9 trillion m^3). This means that the total volume of natural gas in Latin America increased by 34.8 trillion m^3 in shale gas, from 20.7 trillion m^3 to 55.5 trillion m^3. Similar to North America, the total volume of natural gas also doubled in Africa due to the discovery of shale gas deposits. 30.5 trillion m^3 of shale gas was added to the 33.0 trillion m^3 of conventional natural gas. The majority of this is to be found in South Africa. Shale gas deposits there (13.7 trillion m^3) are 13× larger than conventional deposits (1 trillion m^3). The hope is that the extraction of shale gas will offer a way out of the country's constant energy problems. Other deposits are located in Australasia and the Middle East, although contrary to expectations, the Middle East has the smallest share of global deposits.

5 See ibid.

With 5.7 trillion m^3 of shale gas, natural gas resources only increased overall by just under an eighth, to 43.3 trillion m^3. All the deposits are to be found in Saudi Arabia. In Australasia, the potential amounts to 24.7 trillion m^3, meaning that the total deposits have increased by almost half to 69.3 trillion m^3. The main drivers to be noted here are Australia and China. In Australia, which up to now has mainly exported coal, 11.2 trillion m^3 of shale gas has been found, which is more than double the conventional resources (5.4 trillion m^3).

In China, shale gas extraction was included in the new five-year plan. The goal is to extract 6.5 billion m^3 of shale gas by 2015. Shale gas deposits in China are estimated at 8.6 trillion m^3 (total gas deposits = 29.6 trillion m^3). It remains to be seen how the Chinese government will handle the high population density and the continuing water shortage in the Sichuan and Tarim provinces, where the majority of deposits are to be found. However, due to the immense economic potential, it should be assumed that extraction will begin soon. Foreign companies have shown an interest in working with Chinese oil and gas companies and have announced joint ventures. In addition to shale gas, China also has considerable deposits of tight gas and coalbed gas. Tight gas is natural gas that is very difficult to extract due to the highly uneven permeability of the reservoir rock. Of particular interest now to Germany is the potential for shale gas extraction still to be exploited in Europe. Natural gas resources increased by 14.61 trillion m^3, from 4.81 trillion m^3 (conventional natural gas) to 19.4 trillion m^3. Here, the largest resources are to be found in France (5.1 trillion m^3). However, the country has imposed a moratorium until all environmental risks have been examined and conclusively evaluated.

There are also significant shale gas deposits in Germany. These are located primarily in northern Germany (North Rhine-Westphalia and Lower Saxony). In its 2012 study, the BGR estimated shale gas deposits of approximately 13 trillion m^3 when assessing the shale gas potential in Germany. Assuming that approximately 10% is extractable with our current technological capabilities, deposits of 1.3 trillion m^3 (shown in Fig. 5) are significantly more than Germany's conventional natural gas resources (0.15 trillion m^3). In addition to global shale gas deposits, considerable alternative oil deposits have also been found. These include oil sands, extra-heavy oil and shale oil.

Significant shale oil resources were found primarily in China (40.8 billion tonnes). Due to the continuing increase in energy demands in China, we should assume that shale oil extraction will be pushed forward as quickly as possible. Other large deposits are located in Venezuela, however there is not yet any data for this country regarding shale oil extraction. In Canada, there are considerable deposits of oil sand. In 2011, the oil sand resources there (50 billion tonnes) exceeded conventional oil resources (3.5 billion tonnes) 14 times over. Global natural gas resources increased by 157 trillion m^3 to 577 trillion m^3 due to considerable shale gas resources. Worldwide shale gas extraction emulating the US has the potential to effect far-reaching changes in the energy markets. This is true whether in view of the price trend in fossil fuels, changes to static lifetimes, or the potential impact on the environment.

5 Environmental risks and carbon footprint for fracking

The topic of fracking has received significant publicity due to potential risks to the environment. In particular, these include the pollution of drinking water and/or groundwater by the chemicals pumped into the rock strata and the risk of earthquakes triggered by drilling into high-pressure areas. Reference is often made to the situation in the US. There, shale gas extraction began without major environmental regulations, with, in some cases considerable, negative consequences for the environment. Research into this is still in its infancy and results are interpreted in different ways. The following is intended to provide a short overview of the status of research in Germany and, in closing, the carbon footprint of fracking is discussed.

Shale gas lies deep under rock strata that are difficult to reach or that only release a little gas due to low permeability. This is why the extraction of shale gas is more laborious than the extraction of conventional gas. The increased time and effort is reflected in the complicated drilling technology. Horizontal drilling is often required in order to better reach the trapped natural gas.[6] A greater burden may be placed on the local population, whether in the form of increased noise levels or more air pollution due to the drilling. In its »Gas: The Golden Rules Report«, the IEA recommends keeping in a continuous dialogue with the local population when preparing any new fracking operation in order to minimise any points of contention.

5.1 Water pollution

Probably the biggest criticism levelled by fracking sceptics is the handling of the fracking liquid. This mixture of water, quartz sand and chemicals is pumped into the rock under great pressure and in large quantities in order to create fissures through which shale gas can escape.

The fear here is that the water mixture may reach and pollute the water table. The BGR notes that protecting the bedrock depends largely on having a waterproof design for the cover of the drilling site. In order to ensure that no chemicals reach the groundwater, special safety precautions must be taken.[7] The concerns of the German Federal Environment Agency (UBA) that strata carrying drinking water may be contaminated have been countered by the BGR in its statement that shale gas is found at depths where there are no strata which carry drinking water. There is also debate regarding the disposal of »flowback«, i.e. the fracking liquid that is pumped back up. While a portion remains in the drill hole, the rest is pumped back to the surface over several days. In order to ensure that the mixture remaining in the rock does not reach the groundwater near the surface, the wall of the drill hole must be properly cemented.

The BGR notes that before putting a new drilling site into operation, any potential points of contamination must be checked and fully approved. In order to counter these fears, German politicians have decided to ban the extraction of shale gas in drinking water catchment areas. Furthermore, ministers Altmaier and Rösler have proposed in a new draft law that environmental impact assessments (EIA) must be performed before opening up any new areas for shale gas extraction.

6 See IEA (2012a).
7 See BGR (2012a).

The handling of the in-part toxic substances in fracking liquid has not been clarified up to this point. Research is, however, being conducted into whether and how it would be possible to reduce the quantities of toxic chemicals in the fracking liquid.

5.2 Seismic frequency

Other fears include the potential for earthquakes to be triggered by drilling in high-pressure areas. According to the BGR, the link between fracking and triggered earthquakes is very small. If earthquakes were to be triggered, these would generally not be of a noticeable size.[8] Risks can be minimised by undertaking a precise survey of the chosen area. To this end, there is sufficient data available in Germany regarding pressure conditions in the bedrock in different regions. As a result, areas where the risk of cracks forming is particularly high can be avoided. This is the case, in particular, in the Rhine rift. In contrast, the risk of noticeable earthquakes in the North German Basin, where there are large shale gas deposits, is very small. To date, no earthquakes have been triggered in Germany by any fracking activity.[9] However, in 2011 the US had an earthquake caused by pumping liquids into the bedrock.[10]

5.3 Carbon footprint

All of these are expected risks when undertaking fracking. When discussing the possibility of eco-friendly shale gas extraction, reference is often made to the positive carbon footprint of (shale) gas when compared to other fuels. In the Kyoto Protocol, ratified in 2005, industrialised countries including Germany committed to reducing CO_2 emissions (even though there are no sanctions). In the current debate, the argument is often made that shale gas extraction would contribute to reducing total CO_2 emissions, as in return, emissions-intensive coal extraction would decline. It is important, however, to look at both sides of the argument here. Burning coal to generate electricity is significantly more emissions-intensive in comparison to generating electricity from natural gas or shale gas.[11]

However, if the extraction of shale gas and conventional natural gas are compared, shale gas extraction exhibits greater emissions intensity than conventional gas. This can be attributed to the use of horizontal drilling and fracking. The Tyndall Centre for Climate Research points to three different sources of emissions: firstly, the burning of petrol to operate the drilling units and transport vehicles; secondly, fugitive emissions such as methane, which unintentionally escape from the drilling site and thirdly, emissions resulting from controlled gas combustion on site. Assuming that the extraction of conventional and unconventional natural gas is only differentiated by the use of horizontal drilling and fracking, the Tyndall Centre estimates that the CO_2 emissions from shale

8 See BGR (2012a).
9 Fracking has already been used for a long time in the extraction of conventional crude oil and natural gas. However, this has been to a much lesser extent than would be necessary for unconventional fuels.
10 See BGR (2012a).
11 No difference is made here between lignite and bituminous coal.

gas extraction are between 348 and 438 t CO_2 higher per drill hole than with conventional natural gas.[12] The quantity of additional emissions ultimately seen depends greatly on the condition of the drilling site as well as the composition of the shale. In order to reduce emissions, the replacement of diesel-operated drilling units or transport vehicles with low-emission production technologies has been suggested.

The higher concentration of emissions from shale gas extraction is put into perspective when compared to the life cycle values of various fossil fuels. While the production of one terajoule[13] from coal results in CO_2 emissions of approximately 93 t, the figure for conventional shale gas is almost 50% lower, at 57 t per terajoule. The average 400 t CO_2 emitted by fracking and horizontal drilling during shale gas extraction has only a slight impact when viewing the life cycle. With additional emissions of between 0.14 and 1.63 t CO_2 per terajoule, the absolute emission values from shale gas of approx. 58 t are only slightly above the figures for conventional gas. In comparison to coal, the use of shale gas or conventional gas consequently appears to generate significantly lower emissions.[14]

In summary, global emissions can only be reduced by shale gas extraction if the generation of electricity using coal-fired power stations declines, i.e. if coal is substituted for shale gas. However, if shale gas is increasingly used for electricity generation while the use of coal remains constant, the CO_2 concentration in the atmosphere would increase. When dealing with the environmental risks, the highest degree of caution must be exercised, particularly regarding the high population density in Germany. Pushing ahead too quickly with shale gas extraction without having thoroughly examined the effects on groundwater and drinking water could have irreversible consequences, particularly in regions with a high population density (Germany is one of the most densely populated countries in Europe).

12 See Tyndall Centre for Climate Change Research (2011).
13 1 terajoule (TJ) = 1012 J = 278×103 kWh.
14 See Tyndall Centre for Climate Change Research (2011).

6 Impact of the shale gas revolution on the US energy market

The extraction of shale gas began in the US at the start of the millennium and has increased sharply since 2005 (see Fig. 6). While American production at that time was 112 million m³ per day, this grew almost sevenfold by the end of 2011 to more than 694 million m³. The Marcellus field is the only deposit in the east of the country, while the other five shale gas fields are in the middle of the country or on the Gulf Coast.

Since the start of 2011, daily extraction in Haynesville has been significantly above the largest extracted quantities seen in one day up to now in Barnett. Taken together, the three fields of Haynesville, Barnett and Marcellus supply roughly 75% of shale gas. However, with a share of just under 10% and an average daily extraction of 71.6 million m³ in 2011, Fayetteville is also playing an increasingly important role in the shale gas industry.[15]

Shale gas production in the US, 2007–2012

Figures in million m³ per day

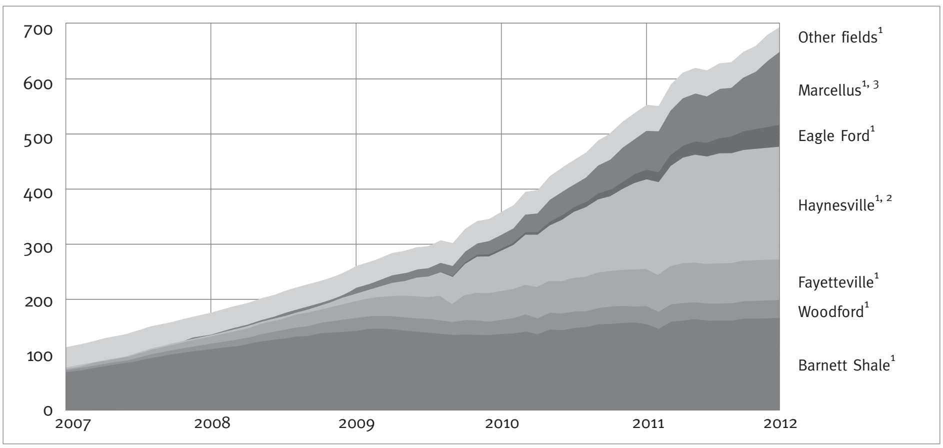

Fig. 6 1 Contains oil and gas
2 Includes Texas and Louisiana
3 Includes Pennsylvania and West Virginia

Sources: LCI (2012); HWWI.

As a consequence of increasing production, American gas prices have fallen sharply over and above the global average. For example, the gas price at the Henry Hub fell from USD 8.69/MmBtu (»million British thermal unit«)[16] in 2005 to USD 2.75/MmBtu in 2012 (see Fig. 7). In its 2013 energy forecast, the EIA expects the price of natural gas on the US market to level off at USD 4/MmBtu by around 2018. In Asian countries, the price of natural gas is approximately USD 16/MmBtu and is therefore more than four times higher than in the US. The gas price in Europe lies between the Asian and American prices. Within the last few years, the gas price in Germany has been consistently rising, despite the gas market opening up and there consequently being stronger competition between energy suppliers.

15 http://www.lciei.com/reports-listing-categories/gasproduction-database/annual-reports/
16 1 British thermal unit (Btu) = 1,055 kJ = 252 kcal.

Henry Hub Gulf Coast: spot price for natural gas, 2002–2012

Figures in USD/MmBtu

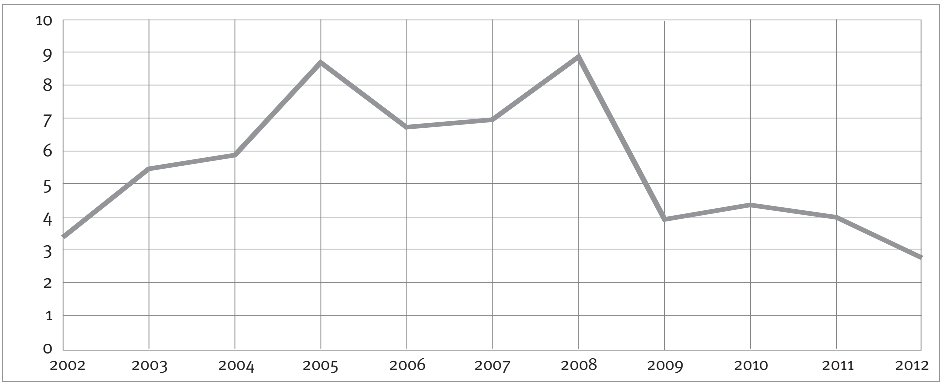

Fig. 7 Sources: EIA (2013); HWWI.

Natural gas import and export volumes, 2005–2012

Figures in billion m^3

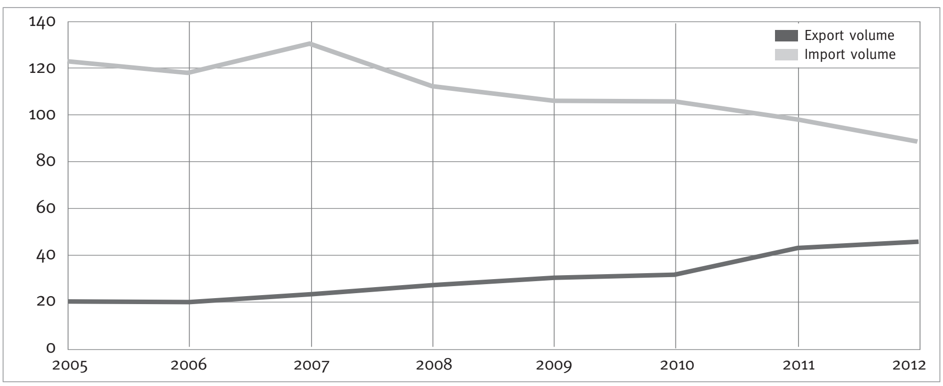

Fig. 8 Sources: EIA (2013); HWWI.

Utilisation nationwide of shale gas deposits in the US has enabled the country to become less dependent on imports of natural gas and to achieve a level of self-sufficiency in meeting their total gas demand. In order to eliminate the excess supply of natural gas in the US market and to achieve stabilisation in pricing, the possibility of exporting liquefied gas to Asia is currently being discussed. As the US government fears an increase in domestic natural gas prices, it is still hesitant to give approval for exports. At the same time, however, pipeline exports to Mexico and Canada are increasing. Exports to both countries more than doubled, increasing for Canada to 27.5 billion m^3 and for Mexico to 17.5 billion m^3. Overall, the export volume from 2005 to 2012 more than doubled to over 45 billion m^3. At the same time, natural gas imports fell from more than 122 billion m^3 in 2005 to 88 billion m^3 in 2012 (see Fig. 8).

In general, gas consumption in the US has increased slightly in recent years. This increase is explained by general growth in gas consumption in the sectors of industry, private households, trade/services and electricity generation from gas.[17] The share of gas in electricity generation grew from 2007 to 2012 by approx. 64.3 billion m^3 to 258 billion m^3.[18] This growth should be attributed to increased gas supply and simultaneously falling gas prices.

In the US we can expect that if the low price levels continue, gas consumption could also rise in other sectors. Already, more and more major companies that manufacture energy-intensive products (e.g. chemical and steel companies) are basing themselves in the US. The EIA expects an annual rise in industrial production of 1.7% until 2025 due to lower energy and raw materials prices.[19] However, there is also the possibility that there will be increased demand for gas in private households and transportation. For example, the increased use of gas heating and the mass production of vehicles run on natural gas could push future demand up further.

The increased share of natural gas in the process of electricity generation is a trend that began around the time when shale gas extraction was first introduced. Intensive extraction led to a decline in gas prices, which created incentives to use natural gas more widely to generate electricity, in order to take advantage of cost savings. This, in turn, led to a decline in the share of coal. While electricity generation remained constant at 400 terawatt hours (with the exception of a slight fall in 2009), the share of coal fell from 49.6% to 37.4% (see Fig. 9). As a result, coal is still in first place,

17 http://www.eia.gov/dnav/ng/ng_cons_sum_dcu_nus_a.htm
18 See EIA (2011).
19 See EIA (2013b).

Electricity generation by fuel type in the US, 2005–2012
Figures in TWh

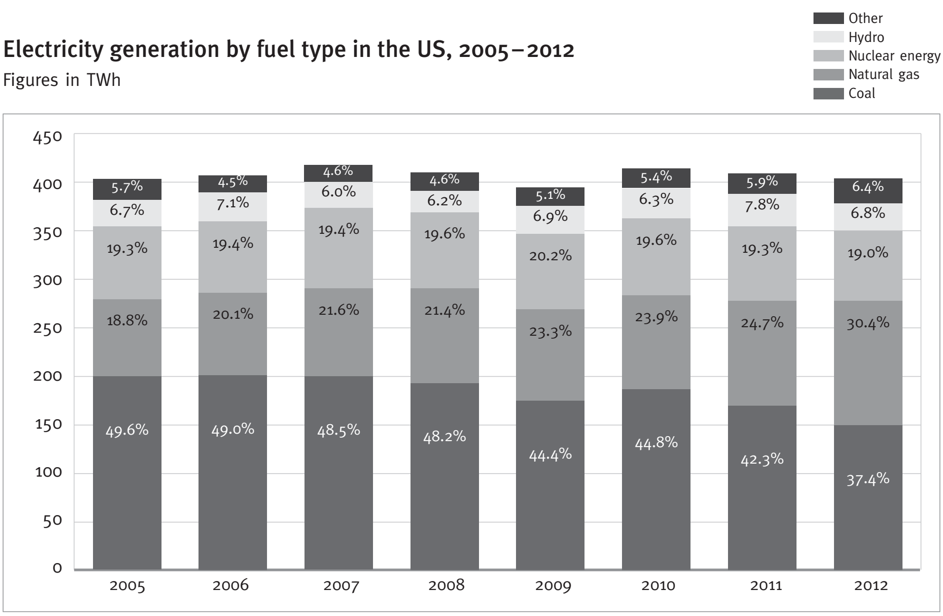

Fig. 9

Sources: IEA (2013a); HWWI.

Total US coal exports, 2002–2011

Figures in million short tons

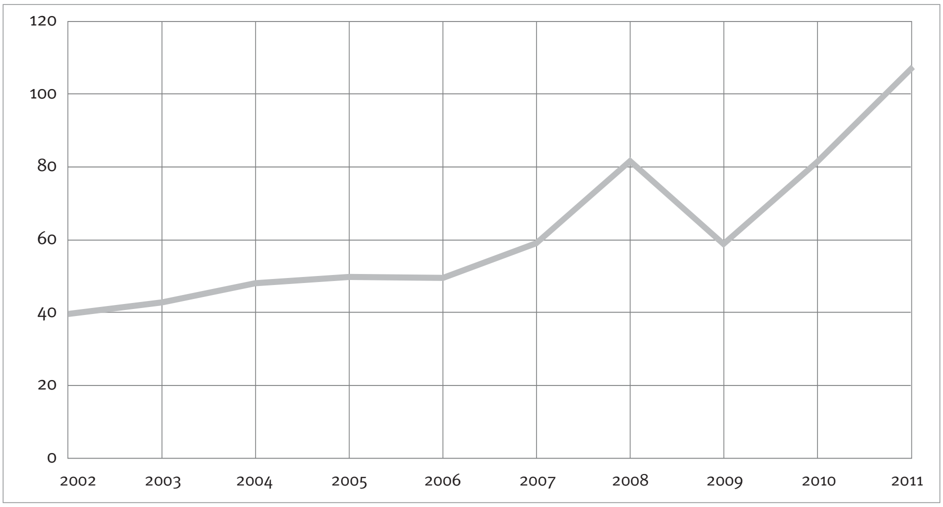

Fig. 10

Sources: EIA (2013); HWWI.

followed immediately by natural gas. In 2005, more electricity was generated from nuclear energy (19.3%) than natural gas (18.8%), though this relationship has reversed in recent years. The proportion of nuclear energy has hovered at around 19%, while the share of natural gas has increased by more than 10 percentage points to 30.4% in 2012, and as a result is only just behind coal. Despite the declining trend in the share of coal for generating electricity, no decline can be seen in total coal production. From 2005 to 2012, it hovered at around a billion short tons, seeing slight annual fluctuations.[20]

Any excess quantities are increasingly exported. Due to falling demand for coal in the US market, prices have dropped, which has improved the international competitiveness of American coal. As a result, exports doubled from 2005 to 2012 to 107.3 million short tons (see Fig. 10). Exports to Brazil, in particular, have increased since 2002, more than doubling to 8.7 million short tons in 2011. Although these figures are significantly below those for Canada, the main country of export (2008: 23 million short tons), we have seen a sharper decline in exports there since 2008, with levels falling to 6.8 million short tons.

Despite increasing shale gas extraction and low prices, it is not expected that coal will be completely dispensed with in the generation of electricity. The extent to which natural gas will replace coal in the future depends on how the US gas market develops. If gas prices remain at a low level, it is likely that natural gas will be chosen as a cheaper alternative to coal. It remains to be seen whether completely switching over to natural gas in the generation of electricity would be feasible from a political, economic and technical point of view.

20 1 short ton = 0,907 t.

Shale gas extraction has led not only to extensive independence from natural gas imports but also to an improvement in the global carbon footprint. The EIA reports that in the first quarter of 2012, the lowest level of annual CO_2 emissions was achieved since 1992. In addition to a lower demand for energy, the reason cited for this was the historically low natural gas prices as the result of a mild winter, which led to a decline in coal combustion. Although the proportion of coal in US electricity production is still only around one-third, coal is responsible for 90% of CO_2 emissions.[21] At 387 million t CO_2, it fell by more than 18% to the lowest quarterly level since 1983. This trend may also continue in the future.

Overall, the static lifetime of natural gas in the US doubled when taking shale gas into account, based on annual extraction in 2011 (690 billion m^3). If US consumption is compared to its own reserves, this lifetime is around 12 years (BP: 12.3 years; BGR: 11.2 years). Excluding shale gas reserves, this lifetime falls to 6.5 years. So, although there is increased security of supply in the US, there is no expectation that it will be completely independent and self-reliant in terms of energy supply in the future.

7 Impact of the shale gas revolution on international energy markets

7.1 China

The rapid development of shale gas extraction and the consequent surplus of gas in the US energy market has not only improved the national supply situation but also influences international energy markets. In addition to reducing the US gas price and the partial substitution of coal by natural gas, other countries with shale gas deposits could be undergoing their own »shale gas revolutions«. The BGR estimates shale gas resources in China of approx. 8.6 trillion m^3 as of the end of 2011. China has found itself in a comfortable situation here, as in addition to its shale gas deposits, it also still has deposits of coalbed gas (10.9 trillion m^3) and tight gas (12 trillion m^3).[22]

By extracting alternative gas reserves, the country could meet its increasing energy demands and, in the process, generate significantly lower emissions levels than if it were to continue using

21 See EIA (2012a).
22 See BGR (2012a).

coal for electricity generation, for example. The EIA reports that Chinese demand for natural gas (both conventional and unconventional gas) quadrupled between 2000 and 2011. It is expected to double again by 2015 to 260 billion m^3 (2011: 130 billion m^3).[23] Demand should also be able to be satisfied by extracting shale gas. The Chinese government announced that it wants to extract 6.5 billion m^3 of shale gas by 2015.[24]

In China, electricity is still mainly produced in coal-fired power stations, although here, too, the plan is to make increased use of gas-fired power stations. To date, China is the largest importer of coal and the fourth largest consumer of gas in the world. This move towards increased use of natural gas presents structural challenges for the country, as the pipeline network, in particular, needs to be expanded in order to be able to transport the natural gas to the end consumer. Overall, it should be expected that the discovery of shale gas deposits would create a major incentive to drive forward the development of the gas sector as quickly as possible. We can expect to see investments in the development of infrastructure in the form of pipelines and LNG terminals as well as more extensive collaboration with foreign energy suppliers.

7.2 Russia

With 100 trillion m^3, Russia has the largest resources of conventional natural gas. With extraction of 607 billion m^3 in 2011, Russia is in second place directly behind the US (651.3 billion m^3). While in 2011 the country exported the largest quantities of natural gas worldwide (207 billion m^3), it has been put under pressure by the US for several years now.[25] The excess supply of shale gas in the US market means that American companies are making greater efforts to export natural gas in the form of liquefied gas (LNG). It is expected that, if the US government approves the construction of liquefied gas terminals, major export volumes of liquefied natural gas will primarily reach Asia. Due to the significantly lower prices for US natural gas, Russia would be put under considerable pressure. However, the liquefaction and export of shale gas is only profitable if it can be sold at prices that cover the higher extraction costs (compared with conventional natural gas). There are further restrictions when it comes to exports to Europe: for historical and geographic reasons, Europe sources the majority of its gas demand from Russia.

In contrast to the majority of countries with large shale gas deposits, Russia does not plan to extract shale gas in the near future. This is because, as the largest Russian gas producer, Gazprom, points out, the reserves of conventional natural gas in Russia are still very large.[26] In contrast to Russia, Ukraine is actively pushing forward in opening up its deposits. In 2011, the EIA estimated Ukrainian shale gas reserves at 1.2 trillion m^3. At the meeting of the World Economic Forum in Davos at the start of 2013, the Ukrainian Minister for Energy and Coal and the CEO of Shell, Peter Voser, signed a production agreement for USD 10 billion.[27] The deal concerns the Yuzivska field, located in the east of the country, where large shale gas deposits are believed to be. Other deposits

23 See IEA (2012a).
24 http://english.gov.cn/2012-09/27/content_2234817.htm
25 See BP (2012).
26 http://www.gazprom.com/press/news/2012/october/article147310/
27 http://www.kmu.gov.ua/control/en/publish/article?art_id=246008446

are to be found in the west of the country in the Olezzka region. The country hopes to reduce its dependence on Russian gas imports through this major gas extraction. In past years, there have been persistent problems with the gas supply; Russia has twice shut down the gas supply to its neighbour. Since then, both countries have tried to reduce their mutual dependency. The first results from exploratory drilling are expected by 2015.

7.3 Middle East

Saudi Arabia, the country with the largest reserves of crude oil in the world, announced in April 2013 that it wishes to put a strong focus on developing renewable energies and extracting unconventional energy resources. According to the Saudi Minister for Oil, shale gas deposits are estimated to be approx. 16 trillion m^3 (conventional reserves: 8.1 trillion m^3). In addition to shale gas deposits, the country is also driving forward efforts to find shale oil.

To date, it is unclear when shale gas extraction will begin. It is also unclear from what source the desert country will find the quantities of water necessary for fracking. For some time, Saudi Arabia has been put under pressure by the increasing shale oil extraction in the US: the IEA estimates that the US will replace Saudi Arabia as the world's largest oil producer by 2020.

7.4 Europe

Due to the profound changes that shale gas extraction has triggered in the US energy market, there are more and more discussions in Europe regarding the political and economic potential of shale gas extraction. The decline in gas prices in the US and the consequent fall in demand for coal has also led to a drop in the global price of coal. This, in turn, has created an incentive for greater use of coal in electricity generation and industry, with negative consequences for Europe's carbon footprint.

The level of CO_2 emissions in Europe is regulated by the emissions trading system. According to German government targets, greenhouse gas emissions should be reduced by 20% by 2020. However, the collapse in emissions trading represents a problem at the moment.[28] The sharp drop in price for one tonne of CO_2 emissions (the price fell from more than EUR 15 at the end of 2011 to less than EUR 5 in 2013), which can be attributed to an excess supply of certificates, again increases the incentive to use coal more in industry and electricity generation. The low price of coal (an all-time low was reached in 2012) and the collapse in certificate prices has eliminated any incentives to invest in innovative and environmentally friendly technology. In general, European demand for gas fell sharply by 9.9%. In addition to high gas prices in Europe and the drop in coal prices, this can also be attributed to the warm winter of 2011/2012 and the continuing development of renewable energies.[29]

28 See DIW (2013).
29 See BP (2012).

If European countries with large shale gas deposits decided to emulate the US in extracting these, this could increase confidence in the supply chain in Europe for several years. For Germany, the BGR reckons on gas demand being met for 13 years. However, if shale gas resources in Germany (approx. 1.3 trillion m^3) are compared with worldwide deposits (157 trillion m^3), it is clear that German deposits will have no effect on the global static lifetime for natural gas. Further, effects on employment levels, as were observed to a great extent along the entire value chain in the US, are not expected in Germany. The deposits and extraction possibilities in Germany are too small to entail significant changes to the labour market, and are consequently not comparable to conditions in the US.

Overall, care should be taken to avoid acting hastily regarding shale gas extraction. In countries with a high population density, in particular, negative environmental impacts, such as groundwater pollution, would have considerable consequences for large portions of the population. Further, German gas supply is secured in the long-term from Russia, which gives the country enough time to weigh up the opportunities and risks of fracking and to potentially draw conclusions from observing how other countries handle unconventional energy sources.

In general, it can also be expected in the future that new production technologies will enable other fossil fuels to be extracted. The extraction of shale gas (and increasingly of shale oil) is just one of many examples of this.

Part B:
Fracking as an investment topic

Berenberg

Preliminary remarks
The extraction of alternative gas reserves and oil deposits is inextricably linked to a chain of uncertainties, beginning with the highly unstable data regarding the extent of proposed reserves, continuing with the uncertainty over when production will begin in countries other than the US, before ending with the substantial interference with other energy sources.

Investors should always be aware of these risks. Nevertheless, significant findings can be derived from the current situation in the US. We also think it advisable to move along a development timeline, which explains which country might begin extraction and from what date. Finally, the consequences of shifting cost curves and relative competitiveness should also be taken into account at sector level.

8 Drilling in the US

8.1 Macro trends

»Serious fracking« began in the US in 2004. Since then, gas extraction has quadrupled, while gas prices have dropped to approximately a third of what they were.

Further, there is a second dimension to alternative energy extraction, namely the production of shale oil. This produced around 111,000 barrels/day in 2004. In 2011, this had grown to 553,000 barrels/day. Between 2012 and 2014, output will again increase significantly, according to the IEA in its monthly report from March 2013.[30] The extraction of shale and tight oil deposits will then reach 2 million barrels/day. At that point, total US oil production should rise to 8 million units, which would be the highest level since 1988. At the same time, oil imports would fall to their lowest level since the same year, and this trend might well continue.

Estimates of US shale oil reserves have been increased in the course of continued extraction from an original 4 billion barrels to a revised 33 billion barrels.[31] This means that the US could replace Russia as the leading global gas producer from 2015, and possibly draw level with Saudi Arabia in terms of oil production from 2017. From 2020, the jump to becoming a net exporter of energy sources is likely. There are a variety of enormously positive consequences for the country, companies and consumers.

These include:

- *Job creation:* Around 1.7 million new jobs have already been created in the course of deploying fracking technology. By 2020, this number could double.
- *Capital expenditure:* The development, extraction and expansion of the necessary transport infrastructure received approx. USD 140 billion in 2012, equal to 1% of GDP or 10% of all investments in tangible assets.[32]
- *Pressure on oil prices:* The increasing oil supply from domestic extraction has put the WTI reference price (Western Texas Intermediate) under pressure. Since the interim high of summer 2008, it has fallen more sharply than its North Sea oil marker (Brent). This gap (»spread widening«) may continue and could even get bigger. The extractable North Sea reserves are, after all, dwindling, while US production is increasing.

At the global level, shale oil inventories are estimated at between 330 billion and 1,465 billion barrels. As part of a scenario analysis, PwC came to the conclusion that the »shale oil revolution« will put significant pressure on long-term price expectations (until 2035). Up to now, for example, the IEA has assumed an increase (in real terms, i.e. adjusted for inflation rates expected until 2035) to USD 133. Depending on the market behaviour of OPEC producer countries and the amount of Chinese shale oil extracted, crude oil prices ranging from USD 83 to USD 100/barrel are now being forecast.[33]

30 See International Energy Agency (2013).
31 See PricewaterhouseCoopers (2013), page 4.
32 See Credit Suisse Securities Research and Analytics (2012), page 6.
33 See PricewaterhouseCoopers (2013), page 10 ff.

This has resulted in enormous relief for consumers, whose purchasing power is increasing. Econometric model calculations put annual global gains in prosperity at USD 1,700 billion to USD 2,700 billion.[34] To compare: in 2012, global GDP was an estimated USD 71,600 billion. The countries that benefit most include the »oil have-nots« such as Germany, Japan and India. The relative losers include the OPEC nations and Russia, as significant oil exporters.

- *Balance of trade and the US dollar:* In March 2013, the US imported 6.9 million barrels of oil per day. That was the lowest amount since 1996 and equates to around USD 20 billion, or almost 10% of all import values. Measured against the trade balance deficit of that month of USD 56 billion, it made up 35.7%. In 2006, the year with the historically highest oil imports, one third more was imported with an average 10.4 million barrels/day. If these import quantities are valued using March 2013 prices (USD 95.6 instead of the 2006 annual average of USD 58), the proportion of oil back then would have reached the 47% foreign trade gap.[35] The change in trend is therefore clearly recognisable and is set to continue. Together with the strengthened competitive position of the entire US economy, we are expecting a significant further improvement in the balance of trade. This would not leave the US dollar untouched. Its ten-year period of weakness is coming to an end. It lasted from 2002 to 2012, as the following illustration of the trade-adjusted US dollar shows. This measures the performance of US currency compared to the currencies of the eight most important trading partners. As currency market trends are usually shaped by very distinctive and sustained cycles, the outlook for a coming »golden age» for the dollar is by no mean bad.

34 See ibid, page 13.
35 U.S. Census Bureau, Foreign Trade Division, own calculations

Trade-adjusted US dollar

March 1973 = 100

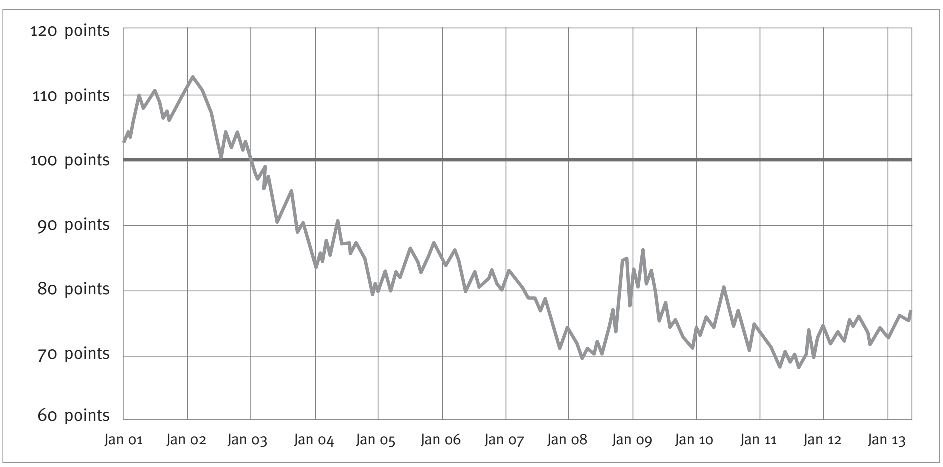

Fig. 11 Source: Bloomberg, Illustration: Berenberg.

8.2 Sector trends

As already mentioned, US companies are paying just under a third of what their European competitors are paying for gas. Fracking has triggered an energy revolution that has increasingly emerged as a competitive structural advantage for North America. The country is clearly at the start of a re-industrialisation boom. Lower energy prices are reducing costs for industrial firms and are also increasingly making the construction or reopening of factories an interesting and profitable proposition for foreign investors. The relative development of individual sectors and their top companies in the course of increasing availability of unconventional energy sources in the US could provide important indicators regarding the performance to be expected in Europe and Asia.

8.2.1 Industry favourites

We examined the period from 1 January 2006 to mid May 2013 and compared the Solactive Shale Gas TR Index[36] and various S&P sector indices with the performance of the S&P 500. The com-mon start time was fixed at 100 (left scale of chart). Fig. 12 compares the Shale Gas Index with the average of the 500 largest listed American companies. It makes it clear that companies who focus their main business on shale gas were able to achieve the best relative performance in 2008, and again at the start of 2011. Since then, outperformance has been declining slightly; nevertheless, over the entire period under review there is still outperformance of 9.1% (Index +33.6% vs S&P 500 +24.5%).

36 The Solactive Shale Gas TR Index contains 25 leading companies that are concerned with the development, extraction and commercialisation of shale gas.

Relative performance of S&P 500 vs Solactive Shale Gas TR Index
January 2006 = 100

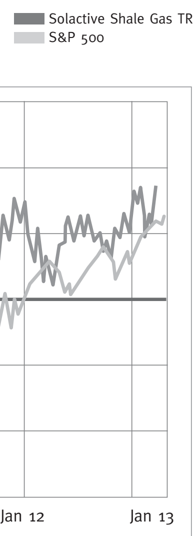

Fig. 12 Source: Bloomberg, Illustration: Berenberg.

Relative performance of S&P 500 vs chemical, supply and equipment, and service companies in the oil and gas industry
January 2006 = 100

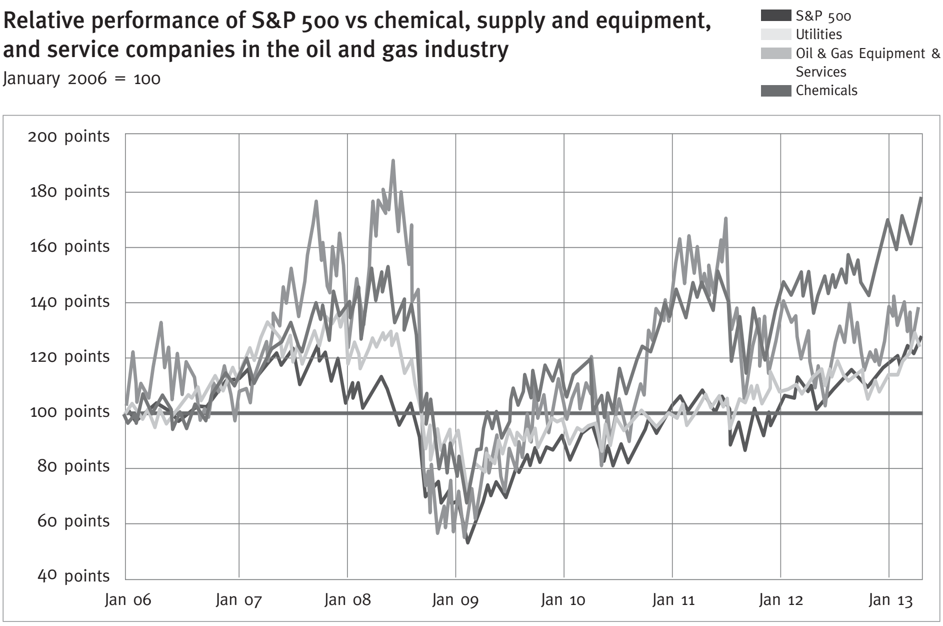

Fig. 13 Source: Bloomberg, Illustration: Berenberg.

Fig. 13 shows that the chemical industry and companies involved in the *equipment and maintenance of a smooth process for oil and gas extraction* have seen significantly better performance than the wider market as a whole. During the period under review, the S&P chemical sector index climbed by almost 80%, while equipment and service companies outstripped the S&P 500 by 14.7%.

The US chemical industry profited from low-priced liquefied gas, which is added as an input factor to the manufacture of petrochemical precursors. The production of ethylene is particularly important here as this compound is not just the basis for the manufacture of numerous organic compounds, but it is also used mainly in plastics manufacturing and, in the agricultural sector, serves as a pest control and to accelerate the ripening process. Ammonia can also now be produced more cheaply, which in turn benefits the manufacture of fertilisers. Based on these considerable opportunities, the sector is planning capacity expansions across all of North America. There is also a series of related activities.

For the drilling projects, the exploration companies are equipped by mechanical engineers and accessory specialists. Most sought after in this process are engineers who can further develop the technology and drive forward innovations. The goal is to shape the process so that it is even more efficient and, above all, less harmful to the environment. A leading company like Schlumberger, for example, is working on making a fracking liquid ready for use that only consists of water and sand. However, for the moment certain process chemicals are still needed when carrying out the procedure. These chemicals are manufactured by the chemical industry for shale gas producers. In this

Relative performance of S&P 500 vs oil and gas sector

January 2006 = 100

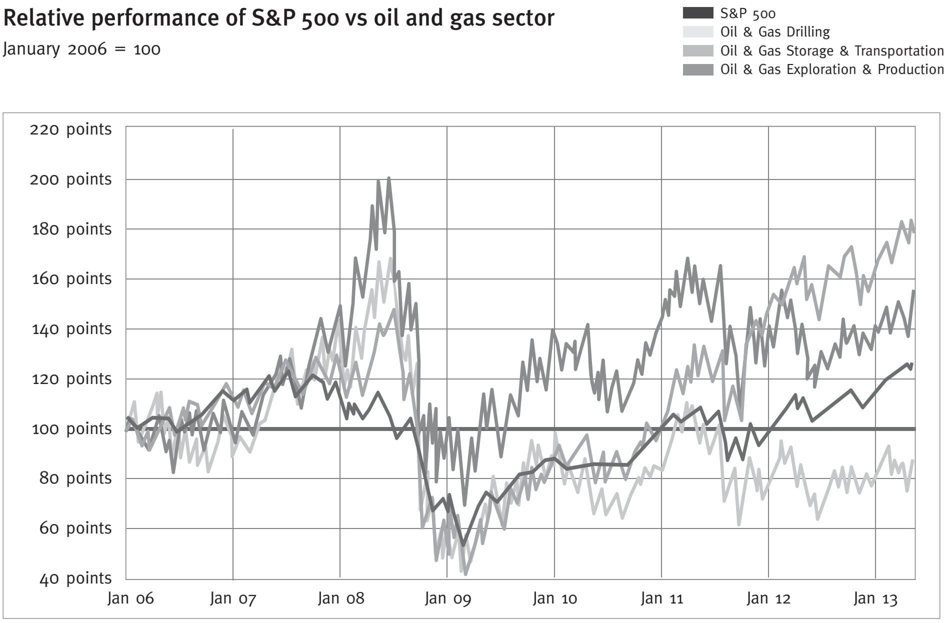

Fig. 14

Source: Bloomberg, Illustration: Berenberg.

case, *logistics companies* assume responsibility for transporting the fracking liquid and the required volumes of water to the site and, after the drilling, also take care of the disposal of the chemical and water mixture. An interesting fact here is that *operators of coal-fired and, in particular, gas-fired power stations* should have actually expected an increase in margin and revenue due to reduced prices for their raw materials. However, the market trend in this sector does not differ significantly from the market as a whole (»Utilities« index in Fig. 13).

Fig. 14 shows the clear outperformance of companies directly active in the shale gas business, firstly in the *oil and gas storage and transport* sector and secondly in the *oil and gas development/ extraction* sector. In the former case, outperformance was just under 60%. 31.3% more could still be earned by production companies (sector: +55.8%, S&P 500: +24.5%). Less surprising is the clearly below-average trend in *oil and gas companies* as well as large energy companies (sector: -13%). This is similar to the gold rushes in California and Alaska: it is not the owners of mining claims who were earning the largest amounts of money. The easy and safe money was made by the sellers of shovels, sieves and food, i.e. the service providers.

The indirect winners after this include the energy-intensive branches of industry, such as the *paper and steel industry.* For the steel industry, the opportunity will arise to switch their blast furnaces from coal to gas in order to improve their margins via savings in materials costs in the production process. Further, the demand for metal will increase, as it will be required for the expansion of oil and gas infrastructure and the construction of machinery.

An aside: In conflict with renewable energies?

The surplus quality of shale gas in the US has already led to a situation where prices for gas and coal have fallen significantly. As a result, electricity generation from these primary energy sources is considerably cheaper than using renewable energies. Politicians will need to create incentives if we are to avoid a decline in investment, which would mean, among other things, that the environmental targets that have been set would not be met. This is of particular importance in Europe and especially in Germany, as traditionally, greater value is placed on environmental and climate protection issues in European nations. One possible way to support renewable energies after introducing fracking could be through tax policies. Additional revenue from tax increases on fossil fuels could be used to further advance the development of renewable energies via subsidies. However, this would be accompanied by a loss in competitiveness for German industry. It would therefore make more sense to structure trading in carbon certification in a more efficient way, ideally at international level, but at least at EU level. On the one hand, this would involve reducing certification, while on the other it would entail a new awarding system.

In part, renewable energies actually make it necessary to develop gas-fired power stations. These would then act as lead regulators if too much or too little wind or solar energy entered the network. Under the German Renewable Energy Act, renewable energies always enjoy feed-in precedence over conventional energy. This means that the capacity of baseload power plants, for example, is reduced when there is very strong wind in order to avoid network overloads and blackouts.

Such baseload capacity will be increasingly needed in Germany from 2020 at the latest. However, it must be profitable for energy producers to operate them. If necessary, thought should also be given here to a new operator/payment model, where remuneration is no longer paid for quantities of electricity generated, but for the capacity provided. In order that incentives such as these do not lead to surplus capacity, diminishing price tiering could be used. The more expensive alternative would likely be accelerated network development and retrofitting as well as the creation of enormous storage capacity for the often highly variable feed-in from renewable energies.

9 Worldwide fracking …

… is not currently taking place to any remarkable degree outside the US. It is not expected that this will change significantly before 2018/2020. Only then will some countries be able to reach the level that the US has been at since 2006. Ahead of this, there are significant hurdles to overcome:

- Environmental protection requirements must be defined and then adhered to (water consumption and protection as the main challenges).
- Uncertainties over liability must be clarified.
- Transparency in mining royalties, taxation and property rights.
- Creation of the necessary infrastructure, requiring considerable capital investment.
- Trusted estimates of extractable reserves must be made available.

A view was taken in detail in Part A regarding the supposed shale gas reserves in individual regions. However, the example of Poland shows how alarmingly fraught with error this data can be. The original estimate of 187 trillion m^3 (144× the German potential) led political leaders to dream of their country becoming the future »Norway of Eastern Europe«. However, seismic surveys led in a single step to a reduction by 90%. In April 2013, the State Geological Institute then put the reserves at only 34–76 billion m^3, a tenth of the German reference value. Foreign investors withdrew completely from the country.

In other European countries with suspected large reserves, the development of a shale gas industry is being hampered by environmental protection associations. France has put a moratorium in place. In Catalonia, Spain, where most of the deposits have been mapped, the population has also turned against the idea of shale gas extraction. There is also strong opposition in the Netherlands, Germany and Romania.

Greater open-mindedness can be seen in Canada, Mexico, Argentina, Great Britain, Ukraine, Russia and China. Here, we can expect the first projects to start soon. Investors will naturally find the most reliable legal and property protection in Anglo-Saxon countries.

Conclusion: Shale gas and oil clearly have the potential to turn the global energy markets on their head. From this perspective, however, many investors may find it hard to remain focused on the associated risks. It is therefore advisable in the first instance to invest in US plants and/or in index or share basket certificates.

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