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# THE SHALE REVOLUTION IN THE U.S. AND ITS IMPACT ON ENERGY MARKETS, ENERGY SECURITY AND THE U.S. ENERGY TRANSITION

*Jan-Justus Andreas*

The energy world is experiencing profound changes. The last decade has been characterised by significant developments on the energy markets, which the International Energy Agency has summarised as follows: "many of the long-held tenets of the energy sector are being rewritten" as "major importers are becoming exporters, large exporters are becoming large consumers and previously small consumers are becoming the dominant source of global demand".[1] The latter statement relates particularly to the rising energy demand in developing regions, most notably Asia. At the same time, energy consumption is on the rise in countries such as Saudi Arabia, which has traditionally influenced the market primarily through vast oil exports. The most noticeable change, however, is taking place in the U.S., the largest energy importer in recent decades, which is transforming into an energy exporter. This has been facilitated by the expansion of the extraction of fossil fuels by unconventional methods in connection with the so-called shale revolution and fracking technology.

The shale revolution is an essential element and result of the U.S. government's efforts to achieve energy independence in order to improve the country's energy security. This has been dominating the energy and national security policies since the 1973 oil crisis at the latest, with far-reaching geopolitical consequences, for instance in connection with activities to defend U.S. interests in the

1 | IEA, *World Energy Outlook 2013*, Paris, 2013, p. 23.

Gulf Region. At the same time, billions of U.S. dollars were invested in domestic energy production. Financial support, tax breaks and joint projects involving the Department of Energy and the private sector allowed for developing and testing new technologies over decades before the first profitable operations to produce shale gas were set up in the early 2000s. Gas and oil extraction from shale has increased exponentially since 2008. Between 2007 and 2014, the proportion of shale gas contributing to U.S. natural gas production increased from five to 44 per cent.[2] Between 2007 and 2011 alone, total shale gas production increased more than sixfold: from 36.2 billion cubic feet to 223.8 billion cubic feet.[3] This meant that the U.S. replaced Russia as the world's largest natural gas producer in 2009 (total natural gas production in 2013: U.S. 687.6 billion cubic meters, Russia 604.8 billion cubic meters).[4] At the same time, U.S. shale oil production[5] rose from 100,000 barrels a day in 2003 to 3.5 million barrels a day in 2014.[6] As a result of this development, the U.S. was able to reduce its net oil imports from over 60 per cent in 2005 to approximately 30 per cent in 2013.[7] Total crude

**Between 2007 and 2014, the proportion of shale gas contributing to U.S. natural gas production increased from five to 44 per cent.**

2 | Cf. Daniel Yergin, "The Global Impact of US Shale", *Project Syndicate*, 8 Jan 2014, http://project-syndicate.org/commentary/daniel-yergin-traces-the-effects-of-america-s-shale-energy-revolution-on-the-balance-of-global-economic-and-political-power (accessed 10 Dec 2014).

3 | Cf. U.S. Energy Information Administration (EIA), "U.S. Shale Production 2007-2011", 12 Apr 2014, http://eia.gov/dnav/ng/ng_prod_shalegas_s1_a.htm (accessed 10 Dec 2014).

4 | Cf. BP, *Statistical Review of World Energy 2010*, http://bakerinstitute.org/media/files/event/fb8a8c2c/BP_SR_2011_-US-_secured.pdf (accessed 10 Dec 2014); BP, *Statistical Review of World Energy 2014*, http://bp.com/content/dam/bp/pdf/Energy-economics/statistical-review-2014/BP-statistical-review-of-world-energy-2014-full-report.pdf (accessed 10 Dec 2014).

5 | Shale oil is also called tight oil, as crude oil is also extracted from other dense types of rock. For reasons of coherence, crude oil extracted in connection with the shale revolution is referred to as shale oil in this paper.

6 | Cf. Ambrose Evans-Pritchard, "Oil and gas company debt soars to danger levels to cover shortfall in cash", *The Telegraph*, 11 Aug 2014, http://telegraph.co.uk/finance/newsbysector/energy/oilandgas/11024845/Oil-and-gas-company-debt-soars-to-danger-levels-to-cover-shortfall-in-cash.html (accessed 10 Nov 2014).

7 | Cf. IHS CERA, *Fueling the Future with Natural Gas: Bringing it Home*, 1/2014, pp. ES-10, http://www.fuelingthefuture.org/assets/content/AGF-Fueling-the-Future-Study.pdf (accessed 10 Dec 2014).

oil production is forecast to rise to 11.8 million barrels by 2025.[8]

Although the U.S. economy as well as the U.S. and international energy markets benefit from the shale revolution, it is subject to considerable controversy. The debate is dominated by two aspects which relate first and foremost to the environmental impact: the direct effects of the gas and oil extraction process on the environment and the consequences of declining natural gas prices and increasing carbon emissions on the role of renewable energies in energy generation.

## THE SHALE REVOLUTION IN THE U.S. – BACKGROUND AND IMPACT

The term shale revolution describes the unconventional extraction of gas and oil from shale formations. The term unconventional refers mainly to the untypical geology of the locations of the gas and oil reserves, possibly combined with lower rock permeability, which makes it more difficult for liquids or gases to rise to the surface. Consequently, special extraction techniques are required. However, there is no standardised unconventional gas and oil extraction as there is no uniform definition, for instance with respect to clear permeability values (measured in Darcy) or specific geological formations.[9]

Fracking is the special technique to extract natural gas and oil from shale. This involves two different technologies, hydraulic fracturing and horizontal drilling. Although these have both been known for some time, they have not been used in combination until several years ago. In the case of horizontal drilling, the vertical well is complemented by a horizontal well running across the rock layer containing

8 | Cf. Kirsten Westphal / Marco Overhaus / Guido Steinberg, "Die US-Schieferrevolution und die arabischen Golfstaaten", *SWP-Studie*, S15, 9/2014, p. 11, http://swp-berlin.org/fileadmin/contents/products/studien/2014_S15_wep_ovs_sbg.pdf (accessed 10 Dec 2014).

9 | Cf. Maximilian Kuhn / Frank Umbach, "Strategic Perspectives of Unconventional Gas: A Game Changer with Implications for the EU's Energy Security", *EUCERS Strategy Paper*, vol. 1, 1/2011, pp. 11-12, https://kcl.ac.uk/sspp/departments/warstudies/research/groups/eucers/strategy-paper-1.pdf (accessed 10 Dec 2014).

the gas and/or oil. This is necessary as the gas and oil are far more widely dispersed in the shale (approximately 0.2 to 3.2 billion cubic meters per square kilometer) than in conventional reserves (two to five billion cubic meters per square kilometer).[10] Furthermore, the permeability of the shale does not permit direct extraction. Instead, a mixture of water and chemicals is pumped into the rock in several phases to produce artificial permeability. The mixture is 99 per cent fresh water, with various chemicals making up the remaining one per cent. During the first phase, this liquid is pressed into the ground to create fractures in the rock. Then the pressure is increased in the next phase, followed by a third phase during which proppants, mainly sand, are added to the liquid to maintain the porosity. This fracking fluid fills the created fractures, which would otherwise close again immediately due to the enormous pressure from the layers of rock above. The liquid is subsequently pumped back out, leaving behind the sand with its high permeability values, thus facilitating the extraction of gas and oil.[11]

The revolutionary aspect of the shale revolution has less to do with the technology than with the significance for global natural gas and oil reserves and the noticeable direct impact on the economy, politics and energy security for the U.S. in particular. The development of the large-scale and largely cost-effective extraction of shale gas and oil has resulted in a considerable increase in the recoverable energy reserves of the U.S. and the world. Unconventional gas and oil extraction is not limited to the North-American continent, and gas reserves around the world have tripled. In this context, shale gas accounts for 64 per cent of total reserves. In the U.S., this has resulted in an increase in natural capital from 16 per cent of gross national income (GNI) in 2000 to 30 per cent of GNI in 2008. The development also means that according to current figures national natural gas reserves in the U.S. would

**The shale revolution has resulted in a considerable increase in the recoverable energy reserves of the U.S. and the world.**

10 | Cf. Paul Stevens, "The 'Shale Gas Revolution': Hype and Reality", *A Chatham House Report*, 9/2010, p. 10.

11 | Cf. CSUR, *Understanding Hydraulic Fracturing*, 2013, p. 12, http://chathamhouse.org/sites/files/chathamhouse/public/Research/Energy,%20Environment%20and%20Development/r_0910stevens.pdf (accessed 10 Dec 2014).

last 200 years instead of 50 to 60 on the basis of the gas consumption in 2012.[12]

Due to a lower permeability of the rock where shale gas and oil are located a mixture of chemicals and water is injected into the ground. Technological advances allow for fewer chemicals to be used. | Source: Joshua Doubek CC BY SA.

The exponential rise in the extraction of natural gas and oil in the U.S. has brought about enormous changes in the country's economy and energy market. According to calculations by IHS CERA, shale gas alone has led to a growth in GDP of 76.9 billion U.S. dollars, which is expected to reach 118.2 billion U.S. dollars in 2015. By 2035, this figure is forecast to rise more than threefold to 231.1 billion U.S. dollars.[13] Due to the fact that the U.S. is the market leader in all areas of the production chain of the shale industry, this is benefiting above all the domestic job market. Unemployment has fallen steadily over the last few years, most noticeably in the federal states where shale oil and gas are extracted. In North Dakota, for instance, where the Bakken field is located, the unemployment rate is 2.8 per

12 | Cf. Douglas Sutherland, "Making the best of new energy resources in the United States", *OECD Economics Department Working Papers*, no. 1147, 21 Jul 2014, http://dx.doi.org/10.1787/5jz0zbb8ksnr-en (accessed 10 Dec 2014).

13 | Cf. IHS CERA, "Shale Gas Supports More Than 600,000 American Jobs, Study Says", *Pipeline & Gas Journal*, vol. 239, 1/2012, http://pipelineandgasjournal.com/shale-gas-supports-more-600000-american-jobs-study-says (accessed 10 Dec 2014); IHS CERA, n. 7.

cent, far below the national average of 5.8 per cent (figures from December 2014).[14] In addition to the opportunities for employment in the shale industry, other companies involved indirectly in the production benefit as well. The U.S. Federal Reserve expects an increase in industrial output of close to five per cent by 2035 due to the shale revolution.[15] The reasons for this include falling gas and oil prices as well as stable electricity prices. The development has also produced a price advantage for the U.S. industry over the German industry, for instance, for which natural gas as a raw material and electricity are up to 25 per cent more expensive.[16] This means the shale revolution is having a direct impact on disposable household incomes in the U.S. as it affects both electricity and heating costs as well as consumer goods prices. According to estimates, household incomes are likely to rise by an average 2,000 U.S. dollars by 2015 and by over 3,500 U.S. dollars by 2025. The positive economic effects have produced billions of investments in the chemical, steel and fertiliser industries as well as in other energy-intensive sectors.

**The U.S. Federal Reserve expects an increase in industrial output of close to five per cent by 2035 due to the shale revolution.**

Further impacts relate to the U.S. oil market. Crude oil is traded on the global market. It is therefore subject to demand and supply dynamics, which influence price developments. However, there is, in fact, no standard global price as such; instead there are regional prices, so-called benchmarks, which are based on the quality of the main

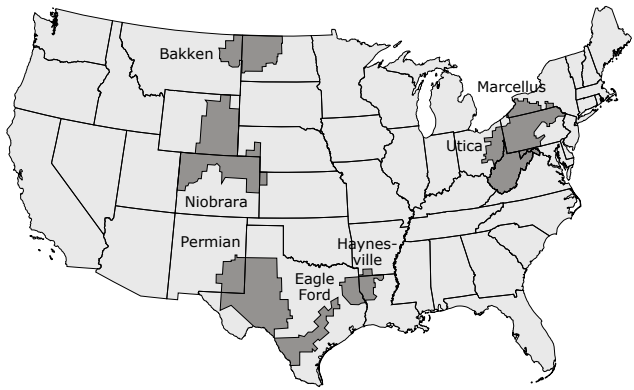
14 | In individual regions of the federal states where shale gas is extracted, unemployment is as low as one per cent. Cf. Bureau of Labor Statistics, "Labor Force Statistics from the Current Population Survey", http://data.bls.gov/timeseries/LNS14000000 (accessed 4 Dec 2014); Bureau of Labor Statistics, "Current Unemployment Rates for States and Historical Highs/Lows", http://bls.gov/web/laus/lauhsthl.htm (accessed 10 Dec 2014).

15 | During the period from 2013 to 2014 alone, industrial production has increased by 2.8 per cent. Cf. Board of Governors of the Federal Reserve System, "Industrial Production and Capacity Utilization – G.17", http://federalreserve.gov/releases/g17 (accessed 10 Dec 2014); IHS CERA, n. 13.

16 | Since 2007, gas prices fell from twelve U.S. dollars per million British thermal unit (BTU) to under two U.S. dollars in the summer of 2012, and they settled at approximately four U.S. dollars per million BTU in 2014. By contrast, prices in Germany are around eleven U.S. dollars per million BTU and in Japan approximately 18 U.S. dollars per million BTU. Cf. IEA, n. 1, p. 282.

product from the region. Under normal circumstances, price differences between the benchmarks solely reflect transport costs and differences in oil quality. However, the Western Texas Intermediate (WTI), the U.S. oil benchmark, fell to below 80 U.S. dollars a barrel for a period (September 2011), while the European Brent was at 105 U.S. dollars a barrel.[17] The cause of this discrepancy was a ban on crude oil exports, which continues to be in place in the U.S. since the 1970s. This prevented the increasing oil stocks from being traded on the international markets.[18] The ban did not cover refined oil products, and these could be sold internationally. However, the infrastructure initially proved inadequate for transporting the huge volumes of crude oil to the refineries. Also, U.S. refineries were set up to deal with Venezuelan and Arab heavy oil and not with shale oil (light oil). This resulted in oversupply and in domestic oil prices dropping significantly.

Fig. 1
**Drilling areas in the U.S.**




Source: EIA, *Drilling Productivity Report*, 8 Dec 2014, http://eia.gov/petroleum/drilling/#tabs-summary-2 (accessed 12 Dec 2014).

17 | Cf. EIA, "Spot Prices", 3 Dec 2014, http://eia.gov/dnav/pet/pet_pri_spt_s1_d.htm (accessed 10 Dec 2014).

18 | With the exception of crude oil extracted in Alaska, which can be exported to Canada.

By using unconventional extraction techniques the U.S. is able to access giant energy reserves. Commercialisation requires liquefaction and regasification facilities. | Source: Bilfinger SE ⓒⓘⓒ.

The benchmarks have since rebalanced thanks to improvements to the transport infrastructure and greater output by the refineries. However, the fact that refined products are still sold on the global market means that consumers in the U.S. have hardly seen any price advantages from the increase in domestic oil production, as petrol and diesel prices continue to follow international price trends. By contrast, refineries achieved huge profit margins as they were able to buy crude oil at the WTI price of 80 U.S. dollars a barrel and sell the refined products at global prices. Further winners include manufacturing industries that rely on crude oil such as the chemical industry. The American Chemistry Council has calculated that nearly 150 investment projects are directly linked to the shale revolution and that these would bring over 16 billion U.S. dollars into state coffers by 2023.[19]

19 | According to these figures, the investments amount to 100 billion U.S. dollars, 50 per cent of which are from international investors. Cf. American Chemistry Council, "U.S. Chemical Investment Linked to Shale Gas Reaches $100 Billion", 2/2014, http://americanchemistry.com/Policy/Energy/Shale-Gas/Fact-Sheet-US-Chemical-Investment-Linked-to-Shale-Gas-Reaches-100-Billion.pdf (accessed 10 Dec 2014).


An increase in oil supplies does not necessarily affect fuel prices which follow international trading mechanisms. Therefore, consumers might not see the positive impact at the gas station. | Source: m01229, flickr CC BY.

## U.S. ENERGY INDEPENDENCE AND GEOPOLITICAL IMPLICATIONS

The security concept of the U.S. includes economic and other non-military dimensions. This has resulted in comprehensive and cross-departmental strategies, which are being applied at a domestic as well as foreign policy level. Contrary to the situation in Europe, important global (economic) developments are therefore linked directly to national security in the United States. Resource and energy security plays a central role in this, including the factors of security of supply, energy prices as well as energy infrastructure. The level of dependence on imports is of considerable significance for the security of supply and therefore pricing. In response to increasing oil imports and the experiences from the 1973 oil crisis, the U.S. initiated "Project Independence", the aim of which was to boost the use of domestic natural resources through state support. The shale revolution is a result of this policy. The "Eastern Gas Shales Project" ran from 1976 to 1992 and involved a number of public-private partnership projects in shale drilling. In 1980, Congress adopted the "Windfall Profits Tax Act", which granted the industries a tax credit of 50 U.S. cents per 1,000 cubic feet of unconventional gas. By the

time the law expired in 2002, it had produced tax breaks for the sector amounting to over ten billion U.S. dollars. In addition, crucial technology tests were conducted by public-private partnerships, including the first multi-stage fracking at the Devonian shale field in 1986 and the first horizontal drilling in the Barnett shale field in 1991.[20] The IEA forecasts that the U.S. will achieve its energy and security-policy goal of energy autonomy by 2030 at the latest.[21] Wood Mackenzie expects the entire North-American continent to achieve energy independence by 2020.[22]

Due to the strongly declining gas prices, the export of natural gas was soon being considered as well. While a large number of import terminals for liquefied natural gas (LNG) were being planned and built back in 2005, these are now being converted for export. The first exports are expected to take place this year, and full capacity should be reached by the end of the decade. In view of likely higher profit margins in Asia, it is expected that the exports will go predominantly to China, Japan and South Korea. The associated increase in volumes of LNG on the global market may well produce significant geopolitical consequences in the medium term. Currently, the majority of natural gas deliveries are made on the basis of long-term pipeline projects and are therefore necessarily regional in character. As the building of pipelines is capital-intensive, natural gas exporters require security of demand guaranteed by long-term contracts. The price is frequently linked to the oil price in order to counter gas price volatility and obtain certainty of planning. A strong increase in the trade in LNG may allow this approach to be replaced by spot market trading. Greater competition in the gas market would also weaken the monopoly position of some suppliers and thereby strengthen the energy security of importing countries. Capacities for regasification (necessary to

**Greater competition in the gas market would also weaken the monopoly position of some suppliers and thereby strengthen the energy security of importing countries.**

20 | Cf. Alex Trembath et al., "Where the Shale Gas Revolution Came From", Breakthrough Institute Energy & Climate Program, 5/2012, http://thebreakthrough.org/blog/Where_the_Shale_Gas_Revolution_Came_From.pdf (accessed 10 Dec 2014).

21 | Cf. IEA, n. 1.

22 | Cf. "Geopolitical implications of North American energy independence", Wood Mackenzie, 9/2013, http://woodmacresearch.com/content/portal/energy/highlights/wk4__13/Wood_Mackenzie_Report_Geopolitical_implications_of_North_American_energy_independence.pdf (accessed 10 Dec 2014).

transform the liquefied gas back into its original gaseous form) used to be much greater than the global LNG supply. The reasons for this include existing pipeline contracts, which tie the natural gas to the importer, a lack in investment in costly gasification projects as well as the limited size of the similarly costly LNG tanker fleet. However, in 2014 alone, a further 31 tankers were added to this fleet, amounting to a total number of 388 tankers.[23]

Table 1
**Global regasification capacity, 2000 to 2015 (in million tons)**

| | 2000 | 2003 | 2006 | 2009 | 2012 | 2015 |
|---|---|---|---|---|---|---|
| Global | 255.6 | 289.7 | 362.3 | 648.3 | 983.8 | 987.4 |
| Japan | 158.7 | 163.0 | 168.0 | 168.0 | 193.0 | 169.3 |
| United States | 22.2 | 25.4 | 39.2 | 185.0 | 330.8 | 330.8 |
| South Korea | 35.9 | 46.1 | 54.1 | 84.6 | 84.6 | 84.6 |
| Spain | 10.6 | 19.4 | 35.7 | 46.4 | 53.9 | 53.9 |
| United Kingdom | 0.0 | 0.0 | 3.3 | 24.8 | 41.7 | 41.7 |
| France | 11.4 | 11.4 | 12.5 | 18.5 | 31.0 | 33.9 |
| Other Countries | 16.8 | 24.4 | 49.5 | 122.9 | 272.4 | 273.2 |

Source: Kable, "Global LNG Industry Heads Towards Supply Crunch", http://hydrocarbons-technology.com/features/feature50048/feature50048-3.html (accessed 12 Dec 2014) with data from GlobalData.

The prospect of increased competition in the Asian gas trade has since forced Qatar, one of the main suppliers of LNG, to lower the prices of its long-term contracts for LNG in order to undercut increasing competition from Australia, Papua New Guinea and soon the U.S.[24] According to Daniel Yergin, CEO of IHS CERA, the first geopolitical loser of the

23 | Cf. International Gas Union (IGU), *World LNG Report* – 2014 Edition, p. 6, http://www.igu.org/sites/default/files/node-page-field_file/IGU%20-%20World%20LNG%20Report%20-%202014%20Edition.pdf (accessed 10 Dec 2014).

24 | Cf. Oleg Vukmanovic, "Qatar cuts gas prices to keep competition at bay", Reuters, 8 Nov 2013, http://uk.reuters.com/article/2013/11/08/uk-qatar-lng-asia-analysis-idUKBRE9A70AD20131108 (accessed 10 Dec 2014).

shale revolution is Iran, which would not have been forced to the negotiating table without the exponential rise in gas production in the U.S.[25] In the medium term, Europe could also benefit from this development, as LNG from Qatar or Nigeria, for instance, which would no longer reach the Asian or U.S. markets, could be shipped to Europe.

The export ban on crude oil remains a fixed element of U.S. energy security policy. Therefore, it remains to be seen whether there will also be oil exports in the future – particularly in view of the domestic oil production's limited impact on the actual improvement of energy security. Crude oil and its derivatives depend on global production and global prices. An oil crisis in the Gulf states would also have far-reaching consequences for the U.S., in spite of its potential autonomy. Conversely, one can assume that Saudi Arabia's decision in early October 2014 to sell crude oil to Asia at lower prices was directly related to the shale revolution.[26] For the U.S., the global oil market and the increasingly global gas market mean that a stable, well-supplied global energy market for all actors worldwide would provide the greatest benefit in terms of energy security.

## CONSEQUENCES FOR THE ENVIRONMENT AND THE TRANSFORMATION OF THE U.S. ENERGY SYSTEM

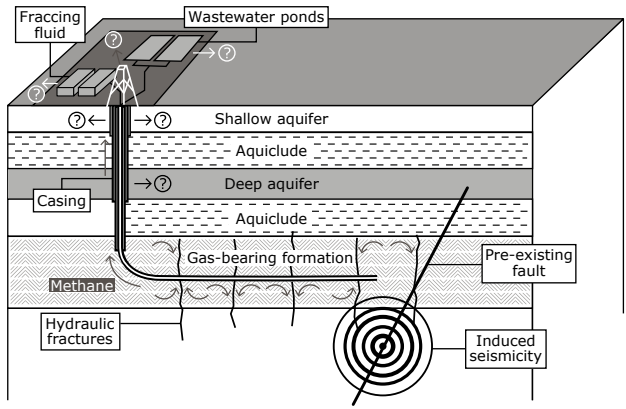
**The U.S. government stresses lower carbon dioxide emissions and the use of natural gas as a more environmentally friendly alternative to coal in energy generation.**

The increasing supply of gas and oil in the U.S. energy market has alarmed environmentalists and proponents of a more sustainable energy production. The U.S. government, however, stresses lower carbon dioxide emissions though the use of natural gas as a more environmentally friendly alternative to coal in energy generation. The environmental risks the shale revolution primarily entails include potential ground water contamination by chemicals from the fracking mixture and by naturally occurring radioactive and other toxic substances that are extracted in the process. The fracking of the rock can also cause minor seismic shocks. To date, investigations have not produced hard evidence of any environmental impacts.

25 | Cf. Yergin, n. 2.

26 | Cf. Pepe Escobar, "The Saudi oil war against Russia, Iran and the US", *Russia Today*, 15 Oct 2014, http://on.rt.com/y12xsh (accessed 10 Dec 2014).

Fig. 2
**Risks of fracking**




Source: Illustration according to Mike Norton, Wikimedia, http://de.wikipedia.org/wiki/Datei:HydroFrac_de.svg (accessed 11 Dec 2014).

Fracking technology has existed for decades, and it has also been used in Germany since the 1960s for the stimulation of conventional reserves. So far, there have been no reports of environmental damage or deterioration of the ground water in Germany. The present public debate on fracking relates mainly to the unconventional gas and oil production from shale. The current bill on fracking by the German federal government envisages the general permission for fracking in conjunction with conventional drilling to remain in effect, albeit under strict environmental regulation. During drilling, the upper meters of the well are always enclosed in a cement sheath to protect the fresh water. The industry further points out that the chemicals used pose no danger to people in the applied concentrations. Drilling company Baker Hughes stated in early October 2014 that it would disclose the composition of the fracking fluid in the future to increase public trust.[27] No other company has taken a similar step to date, as it is generally a matter involving trade secrets.

27 | Cf. Katie Valentine, "Major Drilling Services Company Will Now Disclose All Fracking Chemicals", *Climate Progress*, 2 Oct 2014, http://thinkprogress.org/climate/2014/10/02/3575249/baker-hughes-fracking-chemical-disclosure (accessed 10 Dec 2014).


Boom vs. protest: The extraction of shale gas also raises criticism. The State of New York has issued a moratorium because of the risks the technology is connected with. | Source: Adam S. Welz, CREDO Action, flickr CC BY.

Ultimately, there are no significant differences in the hazards posed by unconventional and conventional oil and gas extraction. Both can entail gas migration and affect ground water through faulty well construction as well as above-ground contamination through inadequate storage and disposal of waste water and toxic waste, for instance. The risk management is subject to pertinent conditions imposed by the relevant legislation. In the U.S., the George W. Bush government did, however, exclude fracking from the "Clean Water Act", the main instrument to protect the ground water. The risks related to fracking have caused individual federal states, such as New York and Vermont, to impose moratoria. Another criticism voiced by environmentalists relates to the enormous quantities of fresh water required for this extraction method. A single fracking well requires between 10,000 and 30,000 cubic meters of water, compared to 2,000 cubic meters for a conventional well. Furthermore, the Baker Botts law firm has calculated that the required truckloads can cause as much damage as 3.5 million car trips.[28] Industry statements indicate

28 | Cf. David Buchan, *Can Shale Gas Transform Europe's Energy Landscape?*, Centre for European Reform, 7/2013, http://cer.org.uk/sites/default/files/publications/attachments/pdf/2013/pbrief_buchan_shale_10july13-7645.pdf (accessed 10 Dec 2014).

that the use of recycled water would be possible thanks to technological advances. The proportion of chemicals in the fracking mix also continues to diminish. The U.S. Environmental Protection Agency is currently working on a study about the effect of fracking on drinking water. The analysis covers the entire water cycle and promises clear information about the environmental consequences of shale production.

Table 2
**Carbon dioxide emissions of the five largest economies, 2000 to 2010**

| | 2000 | | 2002 | | 2004 | |
|---|---|---|---|---|---|---|
| | $CO_2$ emissions in million metric tons | $CO_2$ emissions in metric tons per capita | $CO_2$ emission in million metric tons | $CO_2$ emissions in metric tons per capita | $CO_2$ emission in million metric tons | $CO_2$ emissions in metric tons per capita |
| United States | 5.713 | 20.25 | 5.651 | 19.65 | 5.791 | 19.78 |
| China | 3.405 | 2.70 | 3.694 | 2.89 | 5.288 | 4.08 |
| Japan | 1.219 | 9.61 | 1.217 | 9.55 | 1.259 | 9.86 |
| Germany | 0.829 | 10.10 | 0.828 | 10.05 | 0.826 | 10.01 |
| United Kingdom | 0.543 | 9.23 | 0.532 | 8.96 | 0.540 | 9.01 |

| | 2006 | | 2008 | | 2010 | |
|---|---|---|---|---|---|---|
| | $CO_2$ emissions in million metric tons | $CO_2$ emissions in metric tons per capita | $CO_2$ emissions in million metric tons | $CO_2$ emissions in metric tons per capita | $CO_2$ emissions in million metric tons | $CO_2$ emissions in metric tons per capita |
| United States | 5.738 | 19.23 | 5.657 | 18.60 | 5.433 | 17.56 |
| China | 6.414 | 4.89 | 7.035 | 5.31 | 8.267 | 6.19 |
| Japan | 1.231 | 9.64 | 1.207 | 9.45 | 1.171 | 9.19 |
| Germany | 0.809 | 9.82 | 0.783 | 9.54 | 0.745 | 9.11 |
| United Kingdom | 0.542 | 8.91 | 0.522 | 8.45 | 0.494 | 7.86 |

Source: World Bank, "World Development Indicators" (accessed 12 Dec 2014).

Aside from the consequences for the environment, one should also consider the changes to the energy mix in the U.S.. Many observers fear that the shale revolution may

have a negative impact in this area as the falling gas price may jeopardise the competitiveness of renewable energies. Experts expect that the large-scale investments in the extraction of fossil fuels, which go into billions, will cause use of these fuels to be extended in order to obtain the greatest possible financial benefit. At the same time, they fear that this expenditure may take away potential investment from renewable energies and thus have a negative impact on the competitiveness of wind power and photovoltaics.

The use of natural gas as a bridge fuel – a solution to serve for the transition from the era of coal and oil to the time when renewable energies become competitive – is a double-edged sword. Each transition to a new energy system took the U.S. between 50 and 60 years. Some proponents of the transition towards renewables and sustainability do not think that the present focus on shale gas is necessary and represents an intermediate step that wastes time. In spite of this, natural gas can serve as a new basis of the energy systems. The dependence of renewable energies on the availability of wind and sun and the fact that storage technologies and infrastructure are currently still inadequate mean that a reliable supply can currently not (yet) be guaranteed. Natural gas is both a lower-emission alternative to coal and oil and safer than nuclear energy. In absolute figures this means that a natural gas power plant on average produces 61 kilograms of carbon dioxide per megawatt hour (MWh) and 0.05 kilograms of sulphur dioxide per MWh. Compared to the average air emissions from coal-fired power plants, a plant burning natural gas produces half as much carbon dioxide, a third as much nitrogen oxides and less than one per cent as much sulphur oxides.[29]

**Natural gas is both a lower-emission alternative to coal and oil and safer than nuclear energy.**

In the U.S., the shale revolution has resulted in the proportion of natural gas in electricity generation rising from 649,908 thousand MWh to 1,113,665 thousand MWh. At the same time, electricity generation from coal has

29 | Cf. Laura Parmigiani, "The European Gas Market. A Reality Check", *Note de l'Ifri*, 5/2013, p. 6, http://www.ifri.org/sites/default/files/atoms/files/ifrinoteeuropeangasmarketvf176.pdf (accessed 10 Dec 2014).

fallen from its highest level of 2,016,456 thousand MWh in 2007 to 1,585,998 thousand MWh in 2013, a reduction of over 20 per cent, despite an overall rise in electricity generation.[30] The rapid transition from coal to gas was possible because many gas-fired power plants did not operate at full capacity as a result of the high gas prices. Coal-fired power plants, which are due to be closed down over the next few years under the emissions policy, are to be replaced by combined gas-and-steam power plants. The Obama administration has also issued some carbon dioxide restrictions for new and existing power plants for the first time in U.S. history.[31] In private households, carbon dioxide emissions dropped by 8.6 per cent between 2005 and 2012. While the financial and economic crisis and the associated decline in demand have had an impact on this trend, studies have shown that between 35 and 50 per cent of the reduction in carbon dioxide in the U.S. is due to the shale revolution.[32] Gas price increases following a low in 2012 have caused a slight resurge of coal in electricity generation, but still far below the 2007 level.

Developments took the opposite turn in Europe. Thanks to the shale revolution, U.S. coal exports increased considerably. Large parts reached the European market, where particularly countries such as Germany with high gas and electricity prices have gone back to using more coal. At the same time, natural gas, more of which has become available due to exports to the U.S. declining, is being sold to the Asian market rather than Europe for commercial reasons. So while gas consumption is on the increase and carbon dioxide emissions are on the decrease in the United

**While gas consumption is on the increase and carbon dioxide emissions are on the decrease in the United States, the opposite is the case in the European market.**

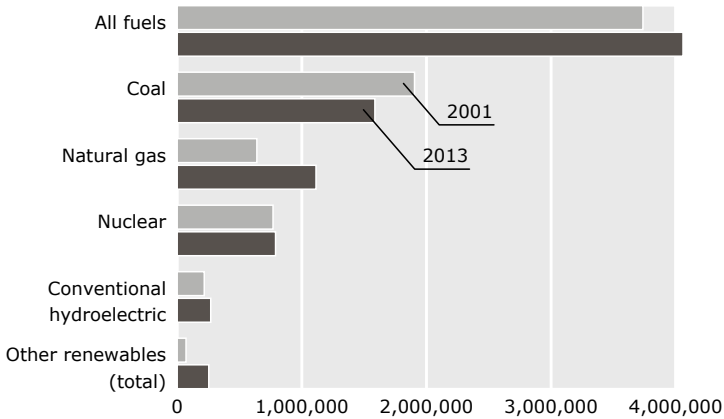
30 | Cf. EIA, *Electric Power Monthly*, 11/2014, http://eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_1_1 (accessed 10 Dec 2014).

31 | Cf. "US carbon emissions rise 2%", *Associated Press*, 14 Jan 2014, http://theguardian.com/environment/2014/jan/14/us-carbon-emissions-rise-coal-energy (accessed 10 Dec 2014).

32 | Cf. John Broderick/Kevin Anderson, "Has US Shale Gas Reduced $CO_2$ Emissions? Examining recent changes in emission from US power sector and traded fossil fuels", Tyndall Manchester, 10/2012, http://tyndall.ac.uk/sites/default/files/broderick_and_anderson_2012_impact_of_shale_gas_on_us_energy_and_emissions.pdf (accessed 10 Dec 2014).

States, the opposite is the case in the European market.[33] According to the German Federal Environment Agency, Germany experienced a further increase in emissions in 2013 to 951 million tonnes of carbon dioxide equivalent (an increase of 1.2 per cent compared to 2012).[34]

Fig. 3
**Net electricity generation for all sectors in the U.S., 2001 and 2013 (in thousand MWh)**




Source: EIA, "Electricity Data Browser: Net generation for all sectors, annual", http://eia.gov/electricity/data/browser (accessed 15 Dec 2014).

Besides the proportion of natural gas in electricity generation, the proportion of renewable energies has also increased in the U.S. Disregarding hydropower, these more than tripled in the period from 2003 to 2013.[35] The proportion of renewable energies in the total energy mix therefore rose to 12.2 per cent in 2013, although there was a slight reduction in electricity produced by hydropower. As that energy source does not offer much scope for expansion, the growth is generated from the wind, solar and biofuel

33 | Cf. BP, "On the global implications of shale: the environment", 2013, http://bp.com/en/global/corporate/about-bp/energy-economics/energy-blog/global-implications-of-shale/global-implications-of-shale-the-environment.html (accessed 10 Dec 2014).
34 | Cf. Umweltbundesamt, "Treibhausgas-Emissionen in Deutschland", 11 Aug 2014, http://umweltbundesamt.de/daten/klimawandel/treibhausgas-emissionen-in-deutschland (accessed 10 Dec 2014).
35 | From 79,487 thousand MWh to 253,328 thousand MWh. Cf. EIA, n. 30.

sectors. Total generation capacity of these fuels in the U.S. is approximately 93 gigawatt.[36] Investments are crucial for renewable energies, but they did, in fact, decline worldwide in 2013. In Europe, capital investments in these sectors have declined for two years in succession since 2012 after years of increases, falling by 44 per cent year on year in 2013 alone. This meant that the People's Republic of China invested more in renewable energies than Europe for the first time in history. In the U.S., investments fell by ten per cent. At a national level, however, it was still the country with the second-largest volume of investments at 40 billion U.S. dollars behind China (54.2 billion U.S. dollars), while Germany invested 9.9 billion U.S. dollars. Venture capital investments in the U.S. declined to just one billion U.S. dollars – the lowest amount since 2005.

Climate policy: Even though the shale revolution has been leading to larger energy reserves in the U.S., the expansion of renewable energies is striding ahead like here in California. | Source: John N. Weiss, flickr CC BY NC ND.

The reasons include both the low gas prices and therefore higher investments in natural gas projects as well as uncertainty about the future of state subsidies for renewable energies. In terms of quantity, the renewable energy

36 | This puts the U.S. in 2nd place globally, behind China (118 gigawatt) and ahead of Germany (78 gigawatt). Cf. REN21, *Renewables 2014. Global Status Report*, Paris, 2014, p. 26 et seq., http://ren21.net/ren21activities/globalstatusreport.aspx (accessed 10 Dec 2014).

market still receives the lion's share of the subsidies. In 2010, 2.8 billion U.S. dollars went to the oil and gas market and 14.7 billion U.S. dollars to renewable energies (disregarding direct funding and tax breaks in each case). The former subsidies support mainly consumers rather than industry.[37] A growing public interest and support for the transformation of the energy system were apparent in the public market, where there was an enormous increase in investment from 949 million U.S. dollars in 2012 to 5.3 billion U.S. dollars in 2013, mainly for solar and biofuels.[38]

## FROM POLITICAL REALISM TO POLITICAL IDEALISM?

Recognised as a part of national security, efforts towards greater energy independence have been a key element of U.S. policies and state funding for decades. These efforts promise to achieve the goal within a few years as well as providing greater economic growth and an improved carbon footprint (for the time being). In light of the recent crisis in Ukraine, the topic of energy security made a reappearance on the agenda of European decision-makers, with the debate centering mainly on the dependence on energy imports. Even though energy independence does not provide total protection against external crises in the era of globalised energy markets, it does place the United States in a stronger geopolitical position. As an ally in the Western world, Europe could become a beneficiary of the shale revolution where energy prices and import diversification are concerned. With the next generation of fracking technology (soon to be ready for application), expectations that the shale revolution will peak in 2020 are possibly also premature.

**In light of the recent crisis in Ukraine, the topic of energy security made a reappearance on the agenda of European decision-makers.**

It remains to be seen whether and to what extent fears that the shale revolution is slowing down the development of renewable energies and extending the use of fossil fuels will be realised. While lower gas prices have contributed to

37 | For each billion BTU, renewable energies receive 25 times the subsidies as fossil fuels. Cf. Kevin Begos, "Fracking Developed with Decades of Government Investment", *Huffington Post*, 23 Sep 2012, http://huffingtonpost.com/2012/09/23/fracking-developed-government_n_1907178.html (accessed 10 Dec 2014).

38 | Cf. Ren21, n. 36, p. 67 et seq.

the current caution to invest in renewable energies, this is a global phenomenon and may have other causes, such as the impact of the economic crisis as well as budget consolidation in many Western countries. Meanwhile, the U.S. has succeeded in improving its energy security, stimulating its economy and simultaneously reducing its carbon dioxide emissions. However, the growing economy and potentially increasing energy consumption in private households due to lower prices could cause emissions to rise again in the medium term, particularly as until now energy-saving measures do not receive the same attention in the U.S. as they do in Germany.

The shale revolution has shown the huge potential of innovative technological research. This gives rise to the fundamental question, however, as to whether investments in fossil fuels should still have a place in an era of transition towards sustainable energy generation. Whether the benefits of the shale revolution outweigh its external effects (the impact on the environment, which is not represented in the product price) remains to be seen. So far, the U.S. government has put forward many arguments in favour of the shale revolution – arguments that can only be viewed with envy from a European perspective considering the current situation regarding energy markets, the economy and energy security.