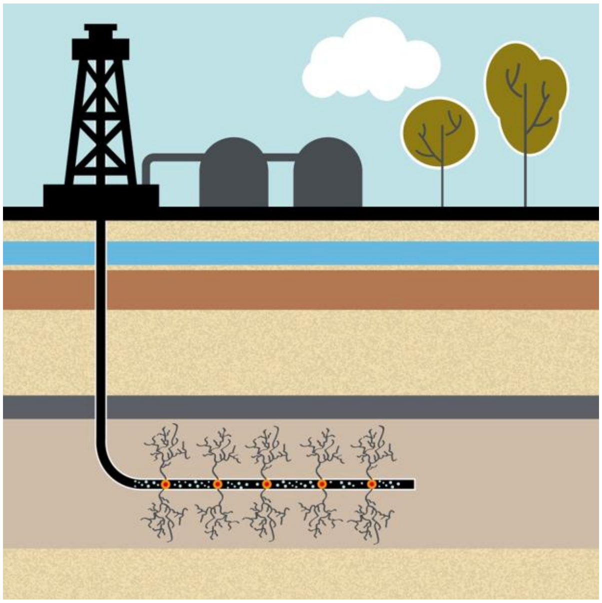
Unconventional gas and oil in North America

The impact of shale gas and tight oil on the US and Canadian economies and on global energy flows



IN-DEPTH ANALYSIS

EPRS | European Parliamentary Research Service
Author: Gregor Erbach
Members' Research Service
June 2014 — 140815REV1

EN

This publication aims to provide insight into the impacts of the North American 'shale revolution' on US energy markets and global energy flows. The main economic, environmental and climate impacts are highlighted. Although the North American experience can serve as a model for shale gas and tight oil development elsewhere, the document does not explicitly address the potential of other regions.

Manuscript completed in June 2014.

Disclaimer and copyright

eprs@ep.europa.eu
http://www.eprs.ep.parl.union.eu (intranet)
http://www.europarl.europa.eu/thinktank (internet)
http://epthinktank.eu (blog)

EXECUTIVE SUMMARY

The 'shale revolution'
Over the past decade, the United States and Canada have experienced spectacular growth in the production of unconventional fossil fuels, notably shale gas and tight oil, thanks to technological innovations such as horizontal drilling and hydraulic fracturing (fracking).

Economic impacts
This new supply of energy has led to falling gas prices and a reduction of energy imports. Low gas prices have benefitted households and industry, especially steel production, fertilisers, plastics and basic petrochemicals.

The production of tight oil is costly, so that a high oil price is required to make it economically viable. For this reason, analysts do not expect that the additional production capacity will lead to lower prices. However, it may well prevent oil prices from rising even higher.

Environmental and social concerns
Environmental concerns about fracking persist, and are being addressed by industry and regulators. The replacement of coal by gas for electricity production has led to a drop in US greenhouse gas emissions. The future climate impact of shale gas would be positive if it replaces dirty coal, and methane emissions can be minimised. On the other hand, it would be negative if cheap gas discourages investments in energy efficiency and renewable energy sources.

Global energy flows
The shale revolution in North America has changed global energy flows. North America imports less energy, so that more liquefied natural gas (LNG) is available for Asian markets. US coal is exported to Europe and Asia, as it has been replaced by gas for electricity generation in the US. To enable gas exports from the US, it is planned to convert LNG import terminals (which had been built in the expectation of rising gas imports) to export terminals.

Upcoming free-trade agreements will make it easier for US companies to export gas and to invest in shale gas and tight oil production overseas. US foreign policy encourages the development of unconventional energy sources abroad.

Outlook
The shale boom in the US has been enabled by specific geological, geographic, industrial, financial and regulatory factors in North America. The coming years will show to what extent the ‘shale revolution’ can be replicated in other regions and make a contribution to EU energy security.

In the light of considerable uncertainty about the extent of the ultimately recoverable shale gas and tight oil resources, analysts are divided about the longer-term outlook for North American energy production. Some believe that we look forward to a century of abundant energy supplies, and even North American energy independence. They see North America as a future net energy exporter. Others fear that the shale revolution is a short-lived financial bubble, and predict energy scarcity and rising prices. Clearly, how this plays out will have a major impact on energy policies and the engagement of the US in energy-producing regions such as the Middle East.

Table of contents

Glossary

Barrel (oil): standard measuring unit for petroleum products, approximately 159 litres.

Coal bed methane: natural gas trapped in underground coal seams. The gas is usually produced by pumping water from the coal seam to reduce pressure and release the gas.

Combined-cycle gas turbine: gas-powered electricity generator in which the exhaust heat from a gas turbine is used to drive a steam turbine, producing electricity with efficiency levels of up to 60%.

Drilling rig: equipment for drilling an oil or gas well.

EIA: US Energy Information Administration.

EPA: US Environmental Protection Agency.

IEA: International Energy Agency.

Feedstock: basic material from which a product is manufactured. Many feedstocks used in the chemical industry (e.g. ethane, propane, butane) are derived from natural gas.

Hydraulic fracturing (fracking): injection of water, sand and chemicals at high pressure into a rock formation, in order to break up the rock and extract gas or oil.

Mbd: million barrels per day, a measure of oil production or consumption.

MMBtu: a million British Thermal Units (Btu), generally used in the US as a measure of the energy content of natural gas; 1 000 cubic feet (28.3 m^3) of natural gas contains 1 MMBtu.

Natural gas: conventional and unconventional gas, consisting mostly of methane.

Natural gas liquids (NGL): By-products of oil and gas production, such as ethane, propane and butane. They are used as petrochemical feedstocks, in automotive fuels and for heating.

Liquefied Natural Gas (LNG): natural gas which is turned into a liquid by cooling it to –162°C, reducing its volume 600 times. It is transported in special ships.

Resources: the amount of oil or gas that is estimated to exist in a region.

Reserves: oil or gas resources which can be extracted technically and economically.[1] Higher gas or oil prices lead to higher reserves. Reserves are always smaller than resources.

Shale gas: natural gas which is trapped in shale, a fine-grained sedimentary rock consisting mostly of clay particles. It is extracted by horizontal drilling and hydraulic fracturing.

Tight gas: natural gas which occurs in low-porosity, impermeable sandstone or limestone formations. The production process is similar to that of shale gas.

Tight oil: light crude oil trapped in shale, limestone and sandstone formations.[2] Like shale gas and tight gas, it is extracted by horizontal drilling and hydraulic fracturing.

Unconventional gas: collective term for shale gas, tight gas and coal bed methane.

[1] Not to be confused with 'strategic oil reserves' – oil that is stockpiled to deal with disruptions of supply. IEA members are required to hold oil stocks equivalent to at least 90 days of net oil imports.

[2] Tight oil is sometimes referred to as 'shale oil', a term which can also refer to kerogen oil produced from oil shale rocks.

1 The 'shale revolution' in North America

1.1 Introduction

Over the past decade, the US and Canada have experienced a revolution in the production of gas and oil. Production of shale gas in the US has grown from 12 million m^3 in 2002 to 275 million m^3 in 2012, and accounts for 40% of natural gas production.

The most important unconventional fossil fuels for the US are shale gas and tight oil, produced by horizontal drilling and hydraulic fracturing ('fracking').

Only the US and Canada produce natural gas and oil from shale formations on a commercial scale. However, several other countries have conducted exploratory test wells, and China is just starting commercial production. The North American experience can therefore serve as an example for the development of unconventional energy resources in other regions.

The US and Canadian energy markets are tightly integrated. Canada is a net energy exporter, and provides about 9% of energy consumed in the US, its principal customer.[3] Energy trade between the two countries totalled nearly US$100 billion in 2010.

Mexico

Thanks to its conventional oil reserves, Mexico is among the top 10 oil producers in the world, but its production is declining. 71% of Mexico's oil exports go to the US.[4] The Mexican state is heavily dependent on tax revenue from Pemex, the state-owned oil monopoly.

Although Mexico is believed to have large shale gas and tight oil reserves, these have not yet been commercially exploited. This is set to change with a new law that ends the monopoly of Pemex, the state oil company, and allows foreign investment in Mexican energy resources. However, property rights, lack of road and pipeline infrastructure and drug-related violence are barriers to development.

For the time being, Mexico imports natural gas from the US. A new pipeline for exporting shale gas from the US to Mexico has recently been approved.

Massive production of shale gas has resulted in gas prices in the US being much lower than in other world regions. High oil prices have made the production of tight oil economically viable. The increased domestic production of oil and gas has helped the US reduce its dependence on energy imports. Relatively lower energy prices in the US are regarded as a basis for prosperity and increased industrial production. The increased use of gas for electricity production has helped the US reduce its CO_2 emissions. On the other hand, there are environmental concerns about water pollution, land use and methane leaks.

Public opinion about fracking is divided: 44% of Americans favour increased use of fracking, while 48% oppose it, according to a September 2013 survey by the Pew Research Center. More Republicans (58%) than Democrats (33%) favour increased fracking.

[3] The US-Canada energy relationship: joined at the well / Paul W. Parfomak and Michael Ratner, Congressional Research Service, June 2011.

[4] EIA analysis brief: Mexico, April 2014.

1.2 Unconventional fossil fuel resources and reserves

Many parts of North America contain shale 'plays' – natural gas deposits trapped in shale formations that were formed 300 to 400 million years ago. The gas is not evenly distributed in the shale plays, but concentrated in highly productive 'sweet spots'. Progress in 3D seismic imaging has made it possible to locate shale gas and tight oil resources with ever increasing precision.

Unlike 'conventional' natural gas, which is found in permeable rocks through which the gas can easily flow, and from which it can be easily extracted, gas trapped in shale is extracted by hydraulic fracturing. Both shale gas and conventional gas are natural gas, consisting mainly of methane.

According to EIA estimates the US has about 14 trillion m³ of unproven technically recoverable shale gas resources. However, it is unlikely that all of this gas can actually be produced. Commercially viable US gas reserves, including conventional reserves, increased to 9.3 trillion m³ in 2013 – about 13 times annual US consumption. The recent growth in reserves came mostly from shale gas.

Figure 1: Shale plays in North America

Source: EIA

Commercially viable US reserves of oil, including conventional oil, increased to 33.4 billion barrels in 2012 – around five years of US oil consumption – with tight oil accounting for 22% of the total.

Table 1: Shale gas and tight oil resources

Shale gas		
Country	**trillion m^3**	**% of total**
China	32	15.3%
Argentina	23	11.0%
Algeria	20	9.7%
U.S.	19	9.1%
Canada	16	7.9%
Mexico	15	7.5%
Australia	12	6.0%
South Africa	11	5.3%
Russia	8	3.9%
Brazil	7	3.4%
Rest of the world	*43*	*21.0%*
World Total	**207**	**100.0%**

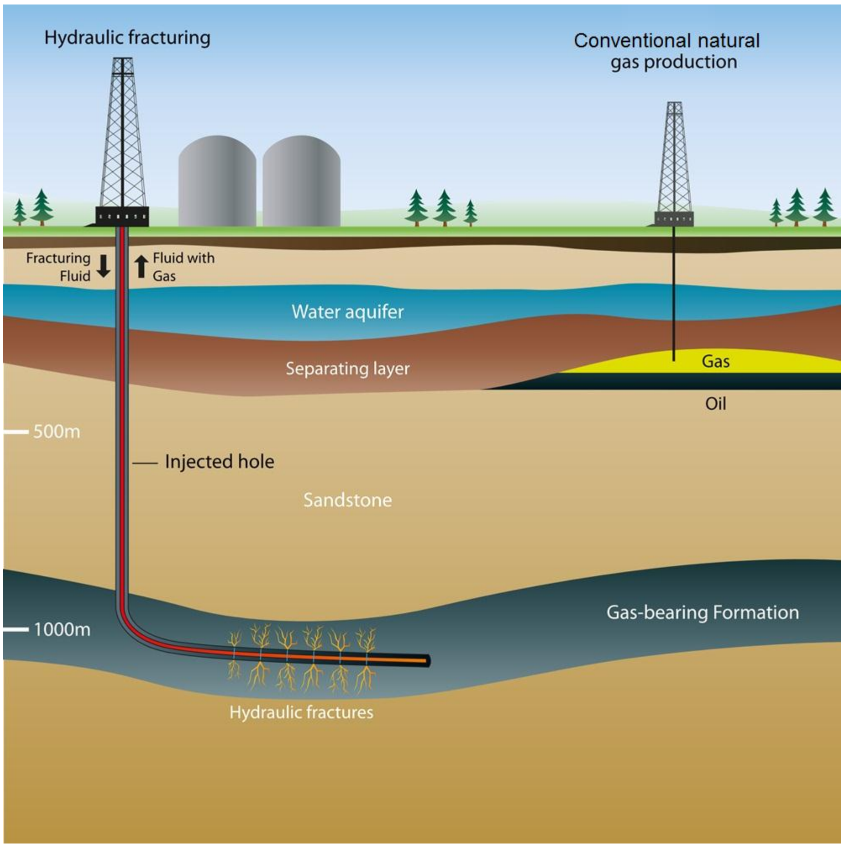
Tight oil		
Country	**billion barrels**	**% of total**
Russia	75	21.7%
U.S.	58	16.8%
China	32	9.3%
Argentina	27	7.8%
Libya	26	7.5%
Australia	18	5.2%
Venezuela	13	3.8%
Mexico	13	3.8%
Pakistan	9	2.6%
Canada	9	2.6%
Rest of the world	*65*	*18.8%*
World Total	**345**	**100.0%**

Source: Technically Recoverable Shale Oil and Shale Gas Resources, EIA, 2013.

Estimates of resources and reserves come with a lot of uncertainty and are subject to regular revisions, both upward and downward. For example, the estimated reserves of recoverable oil in California's Monterey shale – previously believed to be the largest in the US – have recently been revised downward by 96%.[5] Oil and gas companies may be tempted to provide optimistic reserve estimates, as their valuation depends partly on their declared reserves.

1.3 Production process: horizontal drilling and hydraulic fracturing

Figure 2: Horizontal drilling and hydraulic fracturing



[5] EIA cuts Monterey shale estimates on extraction challenges, Bloomberg, 21 May 2014.

Conventional gas is contained in porous rocks. As the gas can move around in such rocks, only a few wells need be drilled, and the gas flows for a long time. Fracking has been used since the 1950s to boost the production of conventional gas wells.

Shale gas has remained trapped in the rock where it was formed. The production process is more complicated. As the gas cannot move within the rock, it is necessary to drill horizontally along the gas-containing rock, typically at a depth of 1 500 to 3 000 metres. The rock in which the gas is trapped is then fractured by injecting a mixture of water, sand and chemicals at high pressure. This process is known as hydraulic fracturing, or 'fracking'. The sand serves to keep cracks open, so that the gas can flow to the surface.

In addition to gas, some shale gas wells produce valuable natural gas liquids (such as ethane, propane, butane, natural gasoline), which can be very important to the economics of shale gas production.

In contrast to conventional oil or gas wells, which can maintain a high level of production for a long time (the average decline is about 5% per year), production from fracked wells declines rapidly in the initial years of production. The average decline of tight oil wells in North Dakota's Bakken shale field is 44% per year, with some wells losing 70% or more of their production in the first year.[6]

The same production process is used for tight oil. Tight oil yields high levels of gasoline and naphtha, a feedstock for the plastics industry. Often, both oil and gas are produced from the same well.

Unconventional oil from Canada's tar sands

Canada is among the world's five largest energy producers.[7] Besides tight oil (10% of Canadian oil production), 56% of the country's oil production come from tar sands (or 'oil sands'), a combination of clay, sand, water and bitumen, a heavy and extremely viscous oil. In contrast to tight oil, which is a light oil, bitumen can also be refined into diesel fuel.

Producing bitumen from oil sands is a very energy-intensive process which uses natural gas as a heat source.[8] The price difference between cheap natural gas and expensive oil makes the process profitable, despite the high energy inputs.

Due to the energy-intensive production process, the greenhouse gas emissions of tar sands oil are 5-15% higher than those of conventional oil. While the import of tar sands oil may enhance the EU's energy security, it conflicts with its climate targets, embodied in the EU Fuel Quality Directive which aims at a 6% reduction of the carbon intensity of transport fuels by 2020. The EU has labelled tar sands oil as carbon intensive, but Canada disagrees with the calculations. As the European Commission does not plan to renew the Fuel Quality Directive after 2020, the door may be open to the import of tar sands oil.

Canadian oil production from tar sands amounts to roughly 2 mbd, about the same level as US tight oil production. TransCanada Corporation has proposed a pipeline (Keystone XL) that could carry 0.83 mbd to US refineries. The project, which is opposed by environmentalists because of its climate impact, has not yet been approved by the US administration.

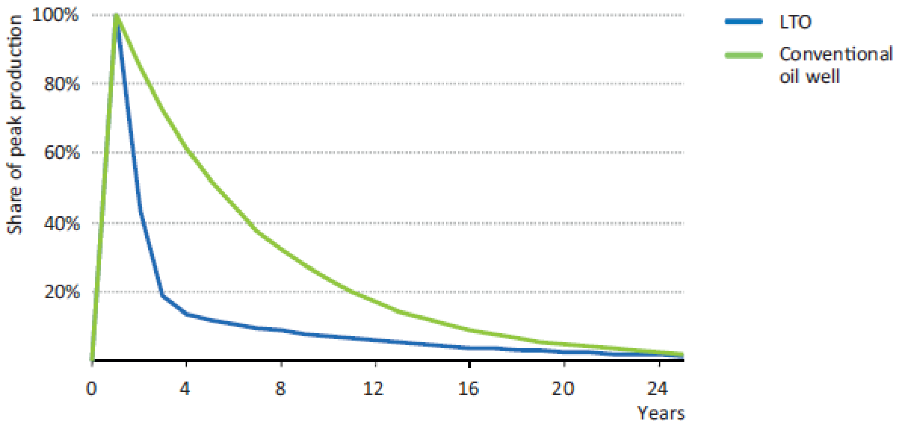
[6] Is the US shale boom going bust? / Tom Zeller Jr., BloombergView, 22 April 2014.

[7] EIA analysis brief: Canada, December 2012.

[8] The EROEI is about 3:1. Source: The cost of production and energy return of oil sands / Robert Rapier, Energy Trends Insider, 9 December 2013.

Therefore, in order to maintain production, new wells must be drilled all the time. In 2012, 45 468 oil and gas wells were completed in the US, and there were 1 861 drilling rigs (equipment needed for drilling) in operation in May 2014.

Figure 3: Typical production curves of different kinds of oil well.



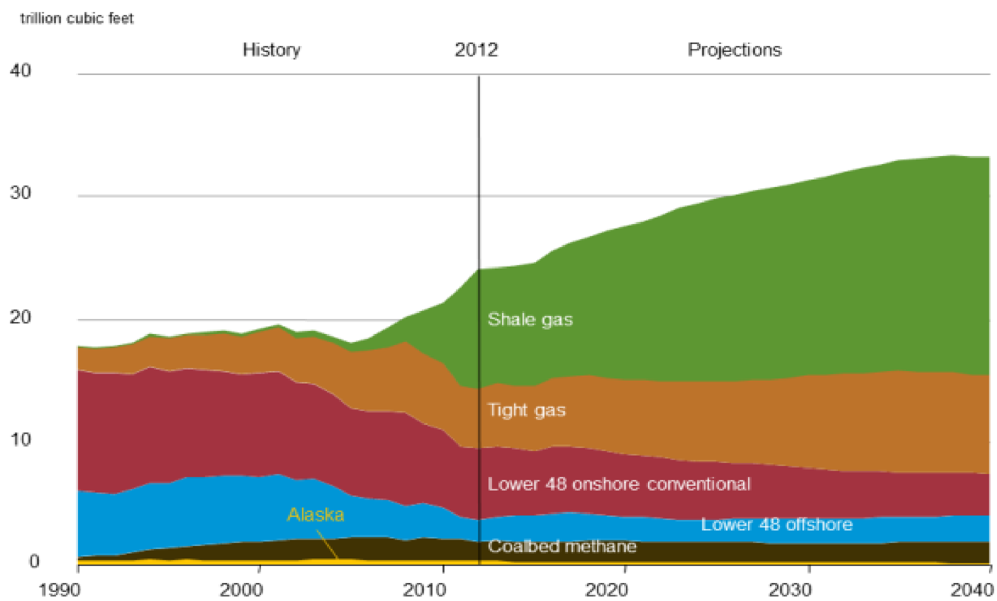
Source: IEA , World Energy Outlook 2013

1.4 Production volumes

The US has experienced a rapid increase in shale gas production in recent years. Production almost tripled from 2009 to 2012. Indeed in 2012, the US became the world's largest producer of natural gas. It accounted for almost 20% of global gas production, slightly ahead of Russia (19%). Unconventional gas accounted for two thirds of US gas production.[9] The US and Canada together produce as much gas as they consume.

This development came as a surprise. Only ten years ago, the US expected to become a major importer of LNG, constructing LNG import terminals which now largely stand idle.

Figure 4: US natural gas production



Source: EIA

9 Shale gas: 40%, tight gas: 20%, coal bed methane: 7%. Data sources: IEA Key World Energy Statistics 2013 and EIA Annual Energy Outlook 2014

Table 2: Gas and oil producers, 2012

Gas producer	billion m^3	% of total
United States	681	19.8%
Russia	656	19.1%
Qatar	160	4.7%
Iran	158	4.6%
Canada	157	4.6%
Norway	115	3.3%
China	107	3.1%
Saudi Arabia	95	2.8%
Netherlands	80	2.3%
Indonesia	77	2.2%
Rest of the world	*1149*	*33.5%*
World	**3435**	**100.0%**

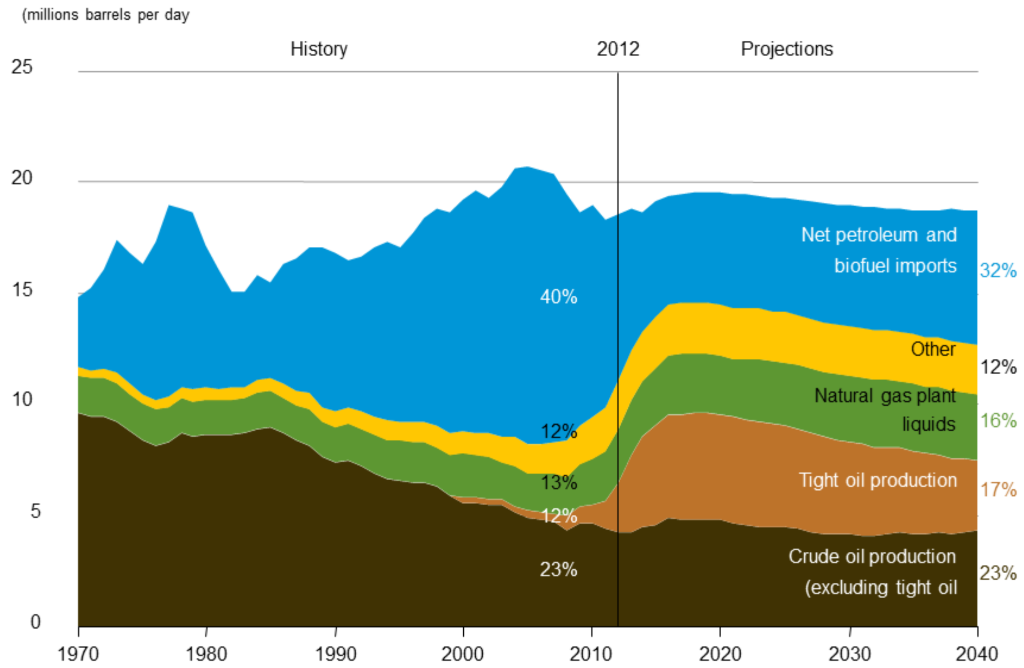
Oil producer	million tonnes	% of total
Saudi Arabia	544	13.1%
Russia	520	12.6%
United States	387	9.3%
China	206	5.0%
Iran	186	4.5%
Canada	182	4.4%
United Arab Emirates	163	3.9%
Venezuela	162	3.9%
Kuwait	152	3.7%
Iraq	148	3.6%
Rest of the world	*1492*	*36.0%*
World	**4142**	**100.0%**

Source: IEA Key World Energy Statistics 2013

The US and Canada together accounted for 14 % of global oil production in 2012, more than Saudi Arabia (13%). Tight oil accounts for more than a third of US crude oil production. About 10% of Canada's oil production comes from tight oil, and 56% from tar sands (see text box above). Natural gas liquids make a significant contribution to the US liquid fuels supply, comparable to the share of tight oil.

The US is dependent on imports for roughly 40% of its oil consumption, while Canada is an oil exporter, with the US as its main customer. Together, the two countries produce around two thirds of their combined oil consumption.

Figure 5: US petroleum and other liquid fuels supply



Source: IEA Key World Energy Statistics 2013

Recent oil and gas production growth has been driven by higher productivity of new wells and higher drilling efficiency. The time needed for drilling a well has been halved to around 30 days.

2 The economic dimension

2.1 The shale gas and tight oil industry

About 7 000 US companies are active in onshore gas production, including some 2 000 drilling operators. The industry directly employs over 2 million people, who earn over US$175 billion in labour income. The US has over 1.1 million active oil and gas wells, and Canada 170 000.

The development of the shale gas and tight oil industry in North America was enabled by a number of factors:

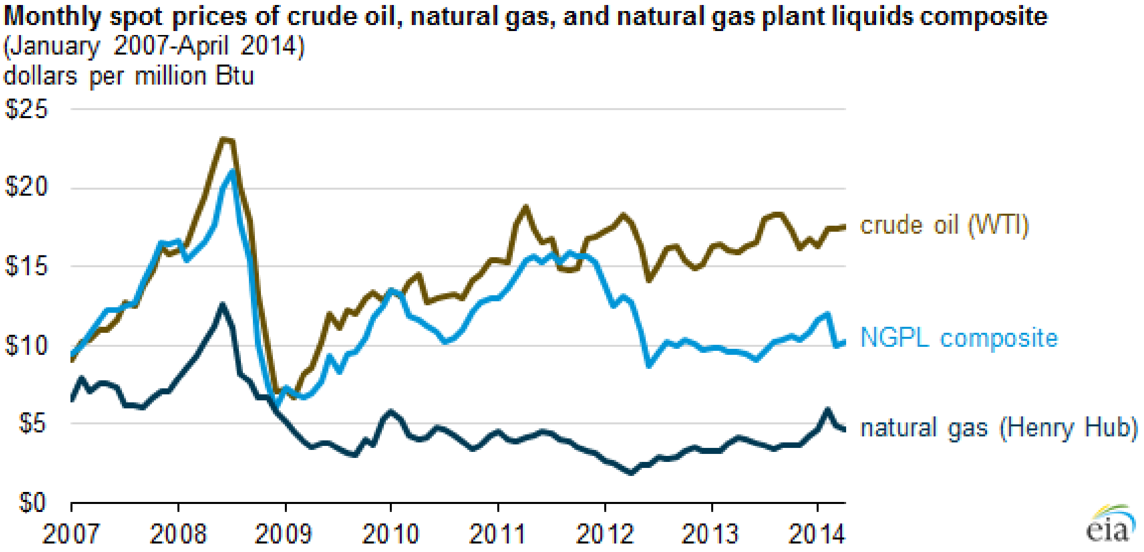
- US government support through research and development (R&D) programmes and tax credits in the early stages, in response to gas shortages in the 1970s.[10]
- Private ownership of underground resources by landowners.
- Easy access to an extensive pipeline network.
- Favourable geology.
- Supportive regulation.
- Private entrepreneurship, and a network of service companies.
- Access to equity and debt finance.

2.2 Oil and gas prices

2.2.1 Gas prices

In contrast to other gas markets where long-term contracts linked to oil prices dominate the gas prices, the US has a spot market, where prices are fixed daily depending on demand and supply. The commonly quoted Henry Hub[11] spot price fell below US$2/MMBtu in 2012, but has since risen to above US$4.

Figure 6: Development of gas and oil prices



Source: EIA

[10] Some key technologies were developed by the oil industry, and subsequently used for gas production.

[11] Price for the delivery of gas to the Henry Hub, a distribution hub on the US gas pipeline system.

As the average cost of producing shale gas is estimated to be around US$4-7/MMBtu, the period of low prices caused financial difficulties for some producers, resulting in sales of assets and a wave of mergers and acquisitions.[12]

A number of reasons have been given to explain why companies kept up their production with the gas price below production cost. First of all, many gas deliveries were contracted at a higher price in the futures market, so that they were not forced to deliver at the spot price. Where gas production was combined with oil production, profits from the oil could make up for losses from the sale of gas. The same goes for natural gas liquids. Some companies made more money from the sale of drilling licences than from the sale of gas. In some cases companies were obliged to produce to meet growth targets or to prevent the expiry of drilling licences. Cheap loans provided companies with the capital needed to expand their drilling activities, and contributed to soaring debt levels and large interest payments for independent producers. However, Ivan Sandrea, a senior partner at EY London, worries that finance for drilling hundreds of thousands of wells might be harder to find in the future, in the light of the worsening financial performance of many shale gas and tight oil companies. He expects further industry restructuring and a focus on the most promising areas.

On the other hand, the situation of the industry has recently improved due to higher gas prices, and lower costs resulting from increased productivity of shale gas and tight oil production.[13] In May 2014, Devon and Chesapeake, two of the largest shale gas and tight oil producers, reported sharp rises in profits.

2.2.2 Oil prices

Compared to conventional oil, tight oil is costly to produce, making the US a high-cost producer. Analysts expect the oil industry to invest US$15 billion in the Bakken shale formation[14] alone in 2014. Indeed, high oil prices (above US$80-100 per barrel, according to estimates) make the production of tight oil economically viable.[15] Leonardo Maugeri, a former oil industry executive, considers US$65 as the critical level. Therefore, one should not expect increased production to result in falling prices. But analysts argue that the increased production capacity from tight oil prevents oil prices from rising even higher.[16] With increasingly less time needed to drill new wells, the US could be in a position to increase production in periods of rising prices. The quick decline rates of tight oil wells will lead to falling production when no new wells are drilled.

2.3 Economic impacts

2.3.1 Overall economic impact

Medium-sized industrial consumers in the US paid only a quarter as much for natural gas as their EU counterparts in 2012. Gas prices for US households were less than half

[12] With a total value of US$46.5 billion in 2011. Source: Shale and Wall Street: Was the decline in natural gas prices orchestrated? / Deborah Rogers, February 2013.

[13] Drilling Productivity Report, EIA, 9 June 2014.

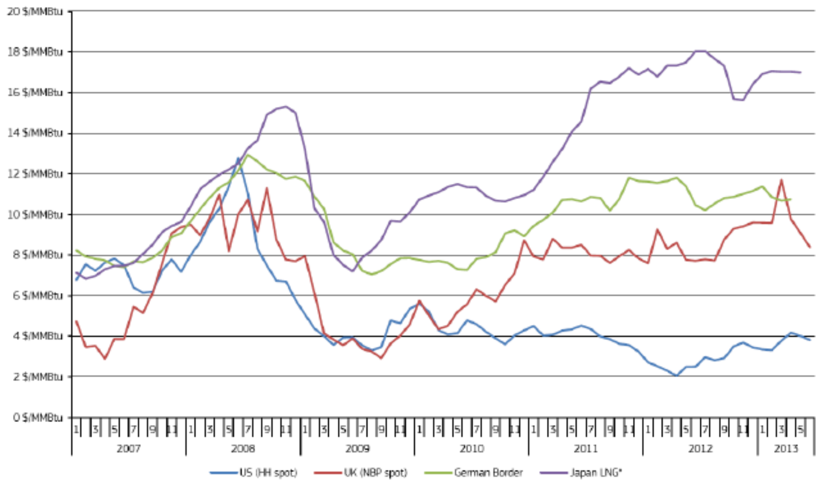
[14] The largest tight oil field in North America, which straddles the US and Canadian border.

[15] The economics of deep-water oil production or drilling in the Arctic is similar (Marginal oil production costs are heading towards $100/barrel, FT, 2 May 2012).

[16] Oil prices tend to rise when global spare capacity falls below 2 mbd, and tend to fall then it exceeds 6 mbd, according to analysts.

of the average EU price.[17] With low gas prices, the share of natural gas in US primary energy consumption has risen from 22% in 2006 to 27% in 2013.

Figure 7: Gas prices in the US, UK, Germany and Japan



Source: Commission staff working document: Energy prices and costs report /SWD/2014/020 final

Such comparatively low prices improve industrial competitiveness and reduce household expenses, resulting in overall economic benefits. Reduced energy imports improve the US trade balance.

Low energy prices have made the US an attractive location for industrial investments in the petrochemicals, fuel, fertiliser and steel sectors. IHS, a consultancy, expects a 3.5% increase in industrial production by 2020 due to unconventional energy sources.

McKinsey Global Institute estimates that unconventional oil and gas production could raise US GDP by 2-4% by 2020, and create up to 1.7 million new jobs.[18] IHS makes similar projections, and expects unconventional energy sources to contribute US$2 700 to the average US household disposable income in 2020, compared to US$1 200 in 2012.

However IDDRI, a Paris-based policy research institute, comes to different conclusions about the economic impact of shale gas. According to its report, shale gas has had only minimal macro-economic impact, and will raise US GDP no more than 0.84% over the period 2012-2035.[19] The report sees competitive advantages only in basic petro-chemicals, but not for the chemical industry as a whole or manufacturing industry. It also doubts that shale gas will drive decarbonisation or contribute to energy security.

2.3.2 Impact on the electricity generation sector

The use of natural gas in US electricity generation has risen from 19% in 2005 to 30% in 2012, while the use of coal dropped from 50% to 39% in the same period. One factor in the rise of gas was record low gas prices in 2012. With rising gas prices in 2013 and the first quarter of 2014, the share of gas in electricity production has fallen again and the share of coal increased.

[17] Electricity prices are also lower in the US. In 2012, EU households and companies paid more than twice as much for electricity as US or Canadian companies. (Source: Commission staff working document: Energy prices and costs report SWD/2014/020 final).

[18] Game changers: Five opportunities for US growth and renewal / McKinsey Global Institute, July 2013

[19] Over the whole period, not per year. (Unconventional wisdom: economic analysis of US shale gas and implications for the EU / IDDRI, 2014)

IHS predicts a growing share of gas in US power generation, rising to 40% by 2035, with coal falling to 23%. They expect that environmental standards, such as the proposed Clean Power Plan,[20] will lead to the shut-down of less efficient older coal plants and discourage investment in new coal plants. Modern gas plants with combined-cycle gas turbines are cheaper, more efficient and more flexible than comparable coal plants. They can be powered up more quickly to react to fluctuations in electricity demand and to compensate for variations in supply from renewables such as wind and solar.

2.3.3 Impact on the manufacturing sector

According to PwC estimates, the use of shale gas could lead to the creation of 1 million manufacturing jobs by 2025, as manufacturers reduce their annual natural gas expenses by US$11.6 billion. This increased manufacturing activity is due both to reduced energy prices, and to increasing demand for shale gas equipment such as pipes and drilling rigs.

The petrochemical and plastics industries, which use natural gas and natural gas liquids both as a feedstock and as an energy source, benefit from low prices. Chemical companies have invested an estimated US$15 billion in US ethylene plants that use ethane, a natural gas liquid, instead of oil-based naphtha, as a feedstock. This increased production capacity makes the US a global supplier of chemicals and plastics.[21]

In the steel industry, several companies have made investments in direct reduced iron (DRI) plants that use gas to reduce iron ore for steel manufacture.

The fertiliser industry, which uses natural gas as a feedstock, stands to benefit from increased supplies and low prices: 80% of the cost of producing nitrogen-based fertilisers is related to natural gas. In the US, 26 companies were constructing or expanding fertiliser production capacity at the end of 2012.

Increased availability of cheap plastics could lead to a substitution of plastics for other manufacturing materials, and the manufacturing of goods with high plastics content might return to the US.

Other sectors such as aluminium, cement and flat glass production may benefit from cheap natural gas, but possibly not enough to compete with low-cost producers outside the US.

2.3.4 New uses for natural gas

There has been a lot of discussion about substituting expensive oil with cheap natural gas in the transport sector. To date, only a few companies have made the switch; for example, Fedex has started using trucks powered by natural gas. However, the oil and gas industry itself has started using cheap gas to power its drilling operations.

3 Climate impacts of shale gas

The estimated greenhouse gas emissions of shale gas delivered by pipeline are slightly above those of conventional gas delivered by pipeline. They are lower than the emissions of conventional gas shipped as LNG.[22]

---

[20] Clean Power Plan proposed rule / EPA, June 2014

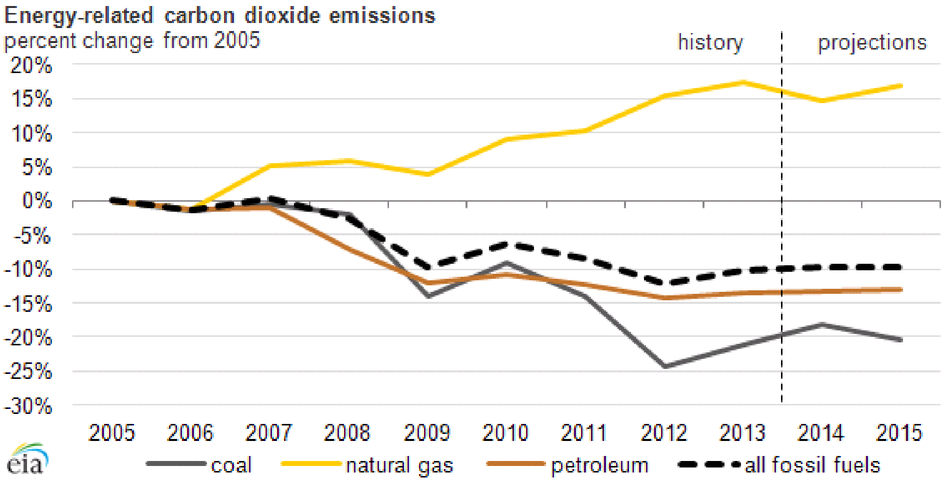
[21] Shale gas: Reshaping the US chemicals industry / PwC, February 2013.

[22] Report for the European Commission: climate impact of potential shale gas production in the EU, AEA Technology plc, July 2012.

3.1 CO_2 emissions

Both coal and natural gas produce CO_2 when burned, but the CO_2 emissions of gas used for heating or electricity generation are around 45% lower than those of coal. This number may vary depending on the efficiency of the conversion process.

Figure 8: Energy-related CO_2 emissions in the US



Source: EIA

The US reduced its CO_2 emissions (the dashed line in figure 8), and met its Kyoto targets – although it never ratified the Kyoto Protocol – thanks to switching electricity production from coal to cheap gas. However, with rising gas prices, the share of coal has grown again, resulting in a 2% increase in US energy-related CO_2 emissions in 2013.[23] The EIA's Annual Energy Outlook 2014 foresees no major change in US energy-related CO_2 emissions for the period until 2040.

In addition, the domestic reductions in CO_2 emissions are partly offset by increased exports of American coal to Asia and Europe, where cheap coal displaces more expensive gas for electricity generation.

3.2 Methane emissions

In addition to CO_2 produced from the burning of natural gas, the gas itself contributes to global warming if it is released into the atmosphere. Natural gas consists mostly of methane, a powerful greenhouse gas. Over a 100-year timescale, methane causes 28 times more global warming than CO_2, according to IPCC estimates. Over a 20-year timescale, it is even 84 times more potent than CO_2.[24]

It is therefore urgent to reduce leaks of natural gas as much as possible. Leaks can occur at the gas well, during pipeline transport, in storage, and in distribution networks. They are not limited to shale gas, but occur with conventional gas as well. There is considerable controversy about the extent of gas leaks in the US,[25] and the contribution of the shale gas industry. Recent research suggests that gas leaks in the US

[23] As gas prices rise, US utilities to burn more coal / Reuters, 12 December 2013.

[24] Methane causes very high global warming initially, but breaks down faster than CO_2.

[25] A deeper look at a study finding high leak rates from gas drilling / Andrew C. Revkin, New York Times, 23 April 2014; A bridge to nowhere: methane emissions and the greenhouse gas footprint of natural gas / Robert W. Howarth, Energy Science & Engineering, May 2014.

are higher than the official estimates, and casts doubt on the potential climate benefits of using natural gas as a transport fuel.[26]

Properly constructed shale gas wells are not considered a major source of gas leaks. However, there is disagreement about the frequency of well failures which lead to leaks (see section 4.1).

Where the gas (as a by-product of oil production) cannot be economically brought to market (e.g. due to the lack of pipelines) it is usually flared (burned) and thereby converted to CO_2. Gas may also be released into the atmosphere for operational reasons (venting), especially in the early stages of gas production. Industry has developed methods to capture this gas, in order to sell it or use it as an energy source (see also section 4.3 below). Some oil and gas service companies have already started to convert truck engines and drilling equipment to run on natural gas in order to lower costs and improve environmental performance.

In March 2014, the White House released a new strategy[27] to reduce methane emissions and improve their measurement. Among other sectors, the strategy targets the oil and gas industry for which methane emissions also represent lost product. It should be noted that methane emissions are not unique to gas and oil production, but also occur in coal mines, landfills and agriculture.

On a positive note, fracking may even help in the development of geothermal energy, a virtually carbon-free energy source. The same technology that is used to let gas flow from shale rocks can be used to inject water into hot underground rocks to produce steam for electricity generation.[28]

4 Environmental, social and health aspects

The environmental and public health impact of shale gas and tight oil development is highly controversial. Opponents warn of water pollution, earthquakes and methane emissions, while the industry claims that it can prevent these problems with appropriate techniques. The Council of Canadian Academies and the US Government Accountability Office note gaps in the knowledge of environmental and health impacts of shale gas production.[29] A coalition of public-health professionals calls for comprehensive health impact assessment on high-volume horizontal hydraulic fracturing before any decision is made to end the moratorium on fracking in New York State.

Regulation of the oil and gas industry is primarily the responsibility of the US states. Eight federal and numerous state and local environmental and public health laws apply to conventional oil and gas production and to fracking operations. However, fracking is exempted from EPA regulation under the Safe Drinking Water Act.[30]

---

[26] Anthropogenic emissions of methane in the United States / Scot M. Miller et al., PNAS. 2013; Methane leaks from North American natural gas systems / A. R. Brandt, Science 343:6172, February 2014.

[27] Climate action plan: strategy to reduce methane emissions, The White House, March 2014.

[28] Fracking could help geothermal become a power player, Scientific American, 29 July 2013.

[29] Information on shale resources, development, and environmental and public health risks/ GOA, 2012; Environmental impacts of shale gas extraction in Canada / Council of Canadian Academies, 2014.

[30] The exemption is known as the "Halliburton loophole" since it was reportedly introduced into the 2005 Energy Policy Act by then Vice-President Dick Cheney, the former CEO of Halliburton, an oilfield services company.

The IEA warns that shale gas development could be held back or stopped if operators do not properly address environmental issues. It proposed a series of 'golden rules' whose application can ensure that operators have a 'social licence to operate'.[31] The IEA estimated that good environmental practices would increase the cost of shale gas wells by 7%.

4.1 Water use and potential for water pollution

A typical well uses around 25 000 cubic metres of water. Although fracking operations use less water than some other energy technologies (e.g. cooling thermal power plants or irrigating plants for producing biofuels), their water use can become problematic in situations of water scarcity and competition with other water users.[32]

Some 20-25% of the injected water flows back to the surface. This water is placed into evaporation ponds, injected into deep formations or released into surface waters after treatment. Increasingly, the water is treated and reused, thereby reducing the overall amount of water required for fracking. In addition, potentially saline or contaminated water may continue to flow from the bottom of the well to the surface during the entire lifetime of the well, and must be treated.

Potentially hazardous chemicals, which are added to the water to ensure successful fracking operations, give rise to environmental concerns. It is often not known exactly which chemicals are used, since some operators treat the composition of fracking fluids as a trade secret. Although they could use patents for protection,[33] violations might be hard to prove. However, there has been a trend towards more transparency. Many operators disclose the chemicals used in the national hydraulic fracturing chemical registry, Fracfocus. Some US states require disclosure, and in May 2014 the EPA launched a consultation concerning new rules for the disclosure of chemicals.

Contamination of groundwater with chemicals or methane is unlikely to result from the hydraulic fracturing of the shale rocks, as it normally takes place at a depth of 1 500 to 3 000 metres, far below the groundwater. However, failure of well casings can lead to the contamination of groundwater, as well as methane leaks. The extent of the problem is unknown; one dataset shows that 506 of 8 030 wells in the Marcellus shale were reported to have internal or external well barrier failures.[34] During the drilling phase, methane may also contaminate groundwater.

The EPA is conducting a study on the potential impacts of fracking on drinking water resources, and plans to publish a draft in 2014.

The rocks in which oil and gas are found may also contain naturally occurring radioactive materials, such as radium, which may come to the surface together with water.[35] These radioactive materials may also contaminate drilling equipment, pipes and storage tanks. Some US states have regulations for measuring radioactive material in oil and gas production and for minimising risks to workers and the public.

[31] Golden rules for a golden age of gas, IEA, 2012.

[32] Energy-water nexus: The energy sector's water use / Congressional Research Service, August 2013.

[33] Fracking secrets: The limitations of trade secret protection in hydraulic fracturing / John Craven, Vanderbilt Journal of Entertainment & Technology Law 16:2, 2014

[34] Oil and gas wells and their integrity: Implications for shale and unconventional resource exploitation / R. Davies et al., Marine and Petroleum Geology, March 2014

[35] Naturally occurring radioactive materials: oil and gas production wastes / EPA

4.2 Land use

A large number of wells must be drilled to exploit a shale gas play – up to six per km². In the US Barnett shale play in Texas, almost 15 000 wells had been drilled over an area of 13 000 km² up to 2010. Wells, roads and pipeline infrastructure may disrupt natural habitats.

A drill pad, a temporary drilling site, is roughly the size of two football pitches. Land use can be reduced by drilling multiple wells from a single drill pad. In 2013, multi-well pads made up 58% of wells drilled in the US, compared to only 5% in 2006. The drill pad can be partially removed and the land restored after completion of a well.

4.3 Air pollution

Natural gas production results in emissions of methane, smog-forming volatile organic compounds and nitrogen oxides, as well as toxic air pollutants including formaldehyde and hydrogen sulphide. Emissions come from normal operations, maintenance, system disruptions and leaks.

In 2012, the EPA issued standards to reduce air pollution associated with oil and gas production.[36] These will result not only in environmental but also economic benefits, as the natural gas captured can be used or sold. In April 2014, the EPA published white papers asking for comments on the future regulation of emissions of methane and volatile organic compounds (VOCs).

4.4 Earth tremors

Injection of wastewater from oil and gas production into underground wells poses some risk of causing small earthquakes. The fracking process too may cause small earthquakes under certain geological conditions, a recent geological study suggests. In response to these findings, the state of Ohio tightened its fracking permit conditions.[37]

Environmental impacts of other energy sources

All energy production has potential environmental impacts, which in some cases exceed those of shale gas production.

Coal: CO_2 emissions exceeding those of gas; large-scale land use and ecological disruption in the case of surface mining or mountaintop removal; air pollution including mercury and particulates, ashes and other waste; high water use for coal production and electricity generation.

Nuclear: risk of catastrophic accidents like Chernobyl and Fukushima, radioactive waste, risk of nuclear proliferation, radioactive contamination of air and water from uranium mining.

Oil: oil spills from accidents, ecological disturbance in the case of surface mining of tar sands or drilling in nature reserves, water use, higher CO_2 emissions than gas.

Hydro: land use, disturbance of river ecosystems, methane emissions from reservoirs.

Wind and solar: land use, environmental impacts of mining for raw materials such as neodymium for wind generators or rare earths for solar panels.

Biofuels: land use, extensive water use for irrigation, eutrophication (nutrient pollution) of water bodies, pesticide pollution, soil erosion.

[36] Overview of final amendments to air regulations for the oil and natural gas industry / EPA, 2012

[37] Induced Seismicity Potential in Energy Technologies, National Research Council., 2013; Ohio geologists link small quakes to fracking, Associated Press, 11 April 2014

4.5 Social impacts

Disturbance to rural communities includes noise and exhaust gases from truck traffic, diesel-powered pumps and other equipment. A single fracking operation requires 600 to 1 100 one-way truck trips, to bring equipment, water and sand to and from a well site. Heavy trucks often cause damage to rural roads. The influx of workers causes social issues such as rising rents and stress on local infrastructure.

There are anti-fracking movements in some regions, and a number of US cities and counties prohibit fracking on their territory.

5 Prospects for energy independence and energy exports

5.1 Projections of productions and consumption

The oil and gas company BP projects that the US will be energy self-sufficient by 2035, remain the world's top producer of gas and oil and reduce its energy-related CO_2 emissions by another 6%. This should be the result of growing production of oil, gas and renewable energy, in combination with improvements in energy efficiency.

The EIA and OPEC expect US oil production to grow in the coming years, and to decline after 2020.[38] The IEA expects US oil production to peak in 2021 and decline thereafter, while Canadian production is expected to keep growing at least until 2035.[39]

As far as gas is concerned, the IEA expects production in North America to keep growing at least up to 2035, and the EIA foresees low prices and production growth until at least 2040. IHS claims that US natural gas supplies are abundant, and that prices will remain in the range of US$4-5 per MMBtu until 2035.[40]

On the contrary, some geologists warn that these forecasts are too optimistic. In case of lower than expected gas production, LNG export capacity may not be needed. [41] Even if the US may achieve energy independence and become a gas exporter, analysts agree it will remain dependent on imports of oil.

5.2 Global energy flows

The development of unconventional fossil fuels in North America has led to a reversal of global energy flows. As American gas imports have dropped, more LNG has become available for European and Asian markets. Most West African oil now flows to Asia rather than the US. From 2005 to 2013, US net imports of crude oil and petroleum products have fallen by 51% from 12.55 mbd to 6.2 mbd.

---

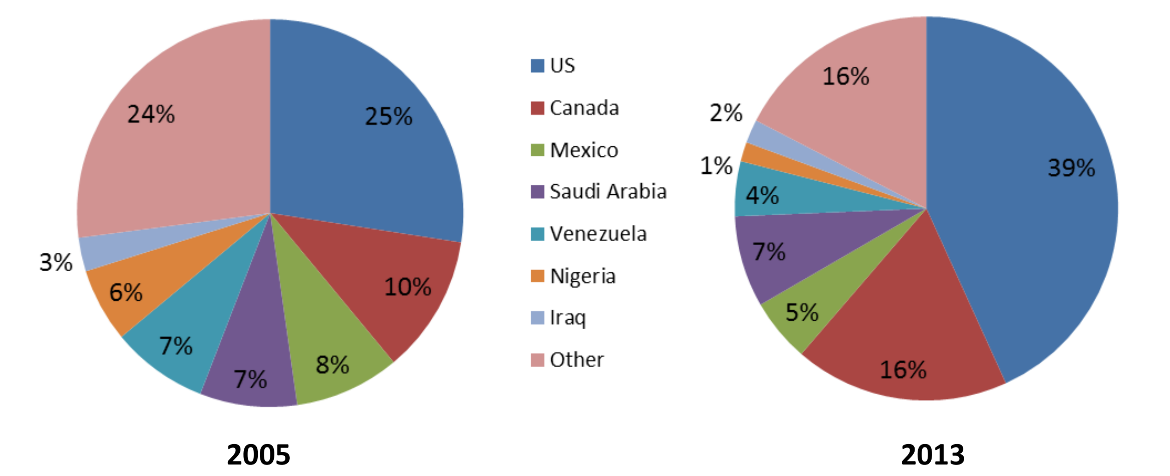
[38] World Oil Outlook 2013, Organisation of the Petroleum Exporting Countries, 2013.

[39] World Energy Outlook 2013, IEA, November 2013.

[40] Fueling the future with natural gas: bringing it home, IHS, January 2014.

[41] Scientists wary of shale oil and gas as US energy salvation / Geological Society of America, 25 October 2013; Energy: A reality check on the shale revolution / J. David Hughes., Nature 494:7437, February 2013; From boom to bust? A critical look at US shale gas projections / Philipp M. Richter, DIW Berlin, 2013.

Figure 9: Sources of oil consumed or processed in the US, 2005 and 2013



Data Source: EIA

As the use of cheap gas in US electricity generation has increased, reduced demand for coal has led to falling coal prices. More US coal is now exported to Europe and Asia, where cheap coal for electricity generation competes with relatively more expensive gas and renewables.

5.3 Prospects for energy and technology exports from the US

5.3.1 LNG exports

US natural gas exports (other than gas transported by pipeline to Canada and Mexico) would be in the form of liquefied natural gas (LNG). Import terminals built in the expectation of rising LNG imports are now idle and could be converted to LNG export terminals. US LNG export projects will have a cost advantage over projects in other parts of the world because much of the required infrastructure is already in place.

All exports of natural gas from the US must be authorised by the Department of Energy, in a slow two-stage process. Exports to countries with which the US has no free trade agreement are only allowed if it can be shown that they are in the national interest.

In the US, 43 applications for LNG export licences have been made. Seven US projects have been approved,[42] and exports are expected start in late 2014. Several European energy companies (Iberdrola, Fenosa, Endesa) have recently signed long-term LNG supply contracts with Texas-based Cheniere Energy, despite analysts' expectations that US producers are likely to export LNG to East Asia, where gas prices are higher.[43]

Two studies carried out in 2012 on behalf of the US Energy Department find that natural gas exports would lead to somewhat higher domestic gas prices (US$0.22 to US$1.11), an increase in gas production and a slight decrease in gas consumption. A 2013 NERA report on macroeconomic impacts finds that allowing exports will lead to net economic benefits for the US. Gas producers stand to benefit the most, while only 10% of US manufacturing, accounting for less than 1% of the US workforce, may suffer from rising gas prices. Some US-based petrochemical companies, gas users and gas

---

[42] For total daily export capacity of over 250 million m^3 or 12.5% of current natural gas production. Sources: Summary of LNG export applications, Department of Energy; US LNG exports update, EY, April 2014

[43] The European companies remain free to resell the gas to markets outside the EU.

distributors, which benefit from low gas prices, are therefore opposed to exports which may result in rising gas prices in the US.

When US gas can be exported, the Henry Hub spot price could become a global benchmark for gas prices. In case of LNG transport, the cost of liquefaction, transport and regasification must be added (estimated to be around US$6 per mbtu for transport to Europe, and around US$5-8 for north-east Asia).[44]

In Canada, 11 LNG export applications have been approved and three are under review.

5.3.2 Oil exports

Exports of crude oil from the US to countries other than Canada have been prohibited since the 1970s with the intention of securing supplies for American consumers. Although the US President may permit crude oil exports if it is in the national interest, this has not happened since it could result in rising gasoline prices for US consumers.

However, the export of refined petroleum products is permitted. Rising US gasoline exports are taking away market share from European refineries (the traditional gasoline suppliers of Africa and Latin America). Other products associated with tight oil production (naphtha, propane and butane) are also exported.

5.3.3 Technology exports and overseas investment

Shale gas exploration outside the US often involves US companies which possess the necessary experience, skills and equipment. Several US companies explored shale resources in Poland, but the results were disappointing.

Future free-trade agreements (TPP for the Asia-Pacific region, TTIP for Europe) would not only allow energy exports from the US, but also make it easier for American companies to invest in shale gas exploration and exploitation overseas. The US State Department helps foreign countries identify and develop their unconventional natural gas resources safely and economically.[45]

Since 2009, the EU and US cooperate on energy issues in the framework of the EU-US Energy Council. At the April 2014 meeting in Brussels, Daniel Poneman, US Deputy Secretary for Energy, encouraged the EU to boost its energy security by developing domestic energy sources, including shale gas.

6 Outlook

6.1 North American energy independence or interdependence?

Shale gas and tight oil have helped North America reduce its dependence on energy imports, and low gas prices have benefitted industry and households. This has caused great interest in other parts of the world, although the geological, regulatory and socio-economic conditions may be different. More exploration is needed to assess the potential of unconventional fuel development outside North America. This opens up new business opportunities for American firms that possess the required equipment, technology and expertise.

[44] After the US shale gas revolution / Thierry Bros , Editions Technip, 2012

[45] The Unconventional Gas Technical Engagement Program has assisted Mexico, Colombia, Chile, Poland, Ukraine, Bulgaria, Romania, Lithuania, Jordan, Kazakhstan, Morocco, India, China, Indonesia, Vietnam, South Africa, Botswana and number of other countries.

LNG exports from North America are likely to raise incomes for American gas producers, but will also lead to higher gas prices in the US as foreign buyers compete with domestic American customers. However, gas will remain cheaper for North American consumers, as they will not have to pay the cost of LNG transport. LNG exports from the US to European markets are likely to be limited as long as pipeline gas from Russia, Norway and Algeria is cheaper. However, the option for consumers to import US LNG helps to limit the ability of other gas exporters to raise prices.

There is considerable uncertainty about resources and reserves. Estimates are subject to disagreement, and revisions of estimates are quite common. Some analysts, like Daniel Yergin of IHS, believe that there will be no shortage of oil, and look forward to a century of abundance. Others, like geologist Art Berman, believe that shale gas and tight oil is a short-lived financial bubble, and that production will peak and decline after a few years. Naturally, these conflicting predictions lead to quite different outlooks on North America's energy future. Where the optimists expect 'energy independence' and growing prosperity, the sceptics foresee energy shortages, rising energy prices and economic crises. How this plays out will have a significant impact on energy policies and on the US engagement in energy-producing regions like the Middle East. The Center for a New American Security takes a middle ground by arguing that unconventional fossil fuels contribute to energy security, but will not lead to full energy independence. It urges a rethink of US strategy, in order to ensure energy and national security in a world of energy interdependence.

6.2 Unconventional fossil fuels and EU energy security

Energy security is back on the political agenda. At the request of the March 2014 European Council, the European Commission proposed a European Energy Security Strategy.[46] Besides energy efficiency and completion of the internal energy market, the strategy proposes to increase domestic energy production in the EU and to diversify supplier countries and routes.

The EU depends on imports for two thirds of its gas consumption. The EU's main suppliers are Russia, which accounted for 32% of EU net gas imports in 2012, Norway (31%), and Algeria (14%). Some Member States are completely dependent on Russia for their gas supply.

Following the Russian annexation of Crimea and conflicts in parts of Ukraine, the EU has strengthened its resolve to diversify its gas suppliers and reduce its dependency on Russian gas, much of which is transported through Ukraine. Due to unresolved disputes over prices and payments, Russia cut gas supplies to Ukraine in June 2014. Although there are other transit routes, such as the Nord Stream pipeline under the Baltic Sea, disruption of gas transit through Ukraine could have impacts on the EU's gas supply. Russia aims to further reduce its dependence on Ukraine for gas transit by building the South Stream pipeline. However, this project has been suspended because the contracts did not comply with EU internal market rules. Moreover, Russia recently concluded a long-term gas supply contract with China, which helps reduce its dependence on the EU as a gas purchaser.

[46] European Energy Security Strategy COM(2014) 330 final, European Commission, 28 May 2014

A recent European Parliament study[47] identifies and analyses a number of alternative gas suppliers. In the longer term, the US and Canada could become an alternative supplier of LNG to the EU, although the volumes would not be sufficient to replace supplies from Russia, so that further diversification is needed. In any case, the Asian market with its higher gas prices is a more likely destination for US LNG exports.

During his March 2014 visit to Brussels, US President Barack Obama encouraged Europeans to increase domestic energy production. Some EU Member States possess considerable shale gas resources, but face issues such as high population density, public opposition, and strict environmental standards. Drawing on the US experience and in line with the European Parliament's resolutions on the economic and environmental aspect of shale gas, the European Commission issued a Recommendation aimed at ensuring that gas production companies adopt best environmental practices in EU countries that decide to develop their shale resources.[48] North American companies, which possess the required technology and expertise, are likely to be involved in EU shale gas projects.

Shale gas and tight oil enhance energy security, but they are fossil fuels that contribute to climate change – although not as much as coal. Their continued use is thus in conflict with the decarbonisation of the economy that is considered necessary to keep global warming below a rise of 2°C. The European Parliament will have an important role to play in addressing this dilemma in the on-going debate about the EU's post-2020 climate and energy policies and in defining the European position in the negotiation of a globally binding climate agreement in 2015.

[47] The EU's energy security made urgent by the Crimean crisis / Pasquale De Micco, European Parliament DG EXPO, April 2014

[48] EP resolutions of 21 November 2012 on Industrial, energy and other aspects of shale gas and oil and Environmental impacts of shale gas and shale oil extraction activities; Commission Recommendation 2014/70/EU on minimum principles for the exploration and production of hydrocarbons (such as shale gas) using high-volume hydraulic fracturing.

7 Main references

After the US shale gas revolution / Thierry Bros, Editions Technip, 2012.

Annual Energy Outlook 2014 / EIA, May 2014.

Canada's energy future 2013: energy supply and demand projections to 2035 / National Energy Board, 2013.

Technically recoverable shale oil and shale gas resources: an assessment of 137 shale formations in 41 countries outside the United States / EIA, 2013.

Cold, hungry and in the dark. Exploding the natural gas supply myth / Bill Powers and Art Berman, Art. New Society Publishers, 2013.

Drill baby drill / J. David Hughes, Post Carbon Institute, 2013.

Energy rush: shale production and U.S. national security / Elizabeth Rosenberg, Center for a New American Security, February 2014.

Environmental impacts of shale gas extraction in Canada / Council of Canadian Academies, 2013.

The shale oil boom: A U.S. phenomenon / L. Maugeri , Harvard Kennedy School, June 2013.

The shale gas 'revolution' in the United States: global implications, options for the EU / European Parliament DG EXPO, April 2013.

The US tight oil revolution in a global perspective / Bassam Fattouh and Amrita Sen, Oxford Institute for Energy Studies. September 2013.

US shale gas and tight oil industry performance: challenges and opportunities / Ivan Sandrea, Oxford Institute for Energy Studies. March 2014.

The 'shale gas revolution': developments and changes / Paul Stevens, Chatham House, August 2012.

Natural gas from shale: questions and answers / US Department of Energy, April 2013.

Unconventional wisdom: economic analysis of US shale gas and implications for the EU / Thomas Spencer, Oliver Sartor and Mathilde Mathieu, IDDRI, February 2013.

Energy-water nexus: the energy sector's water use / Nicole T. Carter, Congressional Research Service, August 2013.

Shale gas and climate change / Neil Hirst, Cheng Seong Khor and Simon Buckle, Grantham Institute for Climate Change, October 2013.

Shale gas: A renaissance in US manufacturing? / PwC, December 2011.

Shale gas: Reshaping the US chemicals industry / PwC, February 2013.

America's new energy future: the unconventional oil & gas revolution and the US economy / IHS, September 2013.

Effects of increased natural gas exports on domestic energy markets / EIA, January 2012

Macroeconomic Impacts of LNG exports from the United States / W. David Montgomery and Sugandha Tuladhar, NERA, April 2013.

The EU's energy security made urgent by the Crimean crisis / Pasquale De Micco,, European Parliament DG EXPO, April 2014

America's energy edge: the geopolitical consequences of the shale revolution / Robert D. Blackwill and Meghan L. O'Sullivan, Foreign Affairs, March/April 2014.

Shale gas and the revival of American power: debunking decline? / David Hastings Dunn and Mark JL McClelland, International Affairs, November 2013.

New Energy, New Geopolitics (3 reports) / Sarah O. Ladislaw et al., Center for Strategic and International Studies, 2014

Over the past decade, the United States and Canada have experienced spectacular growth in the production of unconventional fossil fuels, notably shale gas and tight oil, thanks to technological innovations such as horizontal drilling and hydraulic fracturing (fracking). This new supply of energy has led to falling gas prices, benefitting households and industry, and a reduction of energy imports and a drop in US greenhouse gas emissions.

Environmental concerns about fracking persist, and are being addressed by industry and regulators. The climate impact of shale gas can be positive if it replaces dirty coal and methane emissions can be minimised. It can be negative if cheap gas discourages investments in energy efficiency and renewable energy sources.

The shale boom in the US has been enabled by specific geological, geographic, industrial, financial and regulatory factors in North America. The coming years will show to what extent the 'shale revolution' can be replicated in other regions and make a contribution to EU energy security. Moreover, considerable uncertainty about the extent of the ultimately recoverable shale gas and tight oil resources means analysts are divided about the longer-term outlook for North American energy production. Clearly, how this plays out will have a major impact on energy policies and the engagement of the US in energy-producing regions such as the Middle East.

This is a publication of the
Members' Research Service

Directorate-General for Parliamentary Research Services, European Parliament