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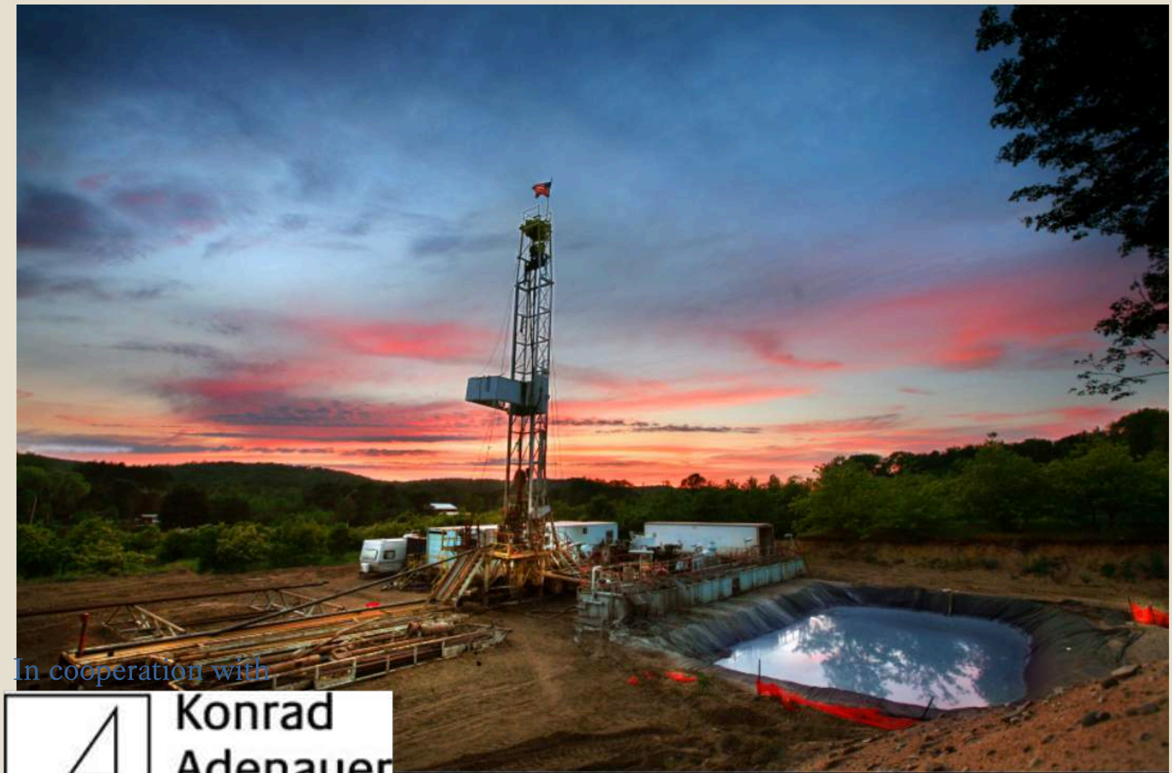
FRACKING FOR FREEDOM

THE ECONOMIC AND GEOPOLITICAL IMPLICATIONS OF THE US DRIVE FOR ENERGY INDEPENDENCE IN LIGHT OF THE SHALE REVOLUTION

EUCERS/KAS ENERGY SECURITY FELLOWSHIP 2013-14

JAN-JUSTUS ANDREAS



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IMPRESSUM

EDITORIAL
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Table of Content

Figures & Maps

Figures

Maps

Glossary

b/d – Barrels per day

Btu – British Thermal Unit

Cf – Cubic feet

Cm – Cubic meter

CNG – Compressed Natural Gas

CNOOC - China National Offshore Oil Company

CNPC - China National Petroleum Corporation

DOE – US Department of Energy

EIA – US Energy Information Administration

EGT – European Gas Target

EPA – US Environmental Protection Agency

EPCA – Energy Policy and Conservation Act (1975)

EROEI – Energy Returned on Energy Invested

ETS – Emission Trading System (EU)

FDI – Foreign Direct Investment

FTA – Free Trade Agreement

HDV – Heavy-Duty Vehicle

IEA – International Energy Agency

IHS (CERA) – Information Handling Service (Cambridge Energy Research Associates)

IPE – International Petroleum Exchange

ISA – Iran Sanctions Act

JKM – Japan Korea Marker (LNG Spot Price Benchmark of Japan & South Korean markets)

KOGAS – Korea Gas Corporation

LNG – Liquefied Natural Gas

Glossary

LPG – Liquefied Petroleum Gas

MMb/d – Million barrels per day

Mcf – Million cubic feet

MMBtu – Million btu

MMt/y – Million tonnes per year

MWh – Megawatt hours

NEA – Chinese National Energy Administration

NGL – Natural Gas Liquids

NGV – Natural Gas powered Vehicle

NYMEX - New York Mercantile Exchange

OECD – Organisation for Economic Co-Operation and Development

OAPEC - Organisation of Arab Petroleum Exporting Countries

OPEC – Organisation of Petroleum Exporting Countries

TAFTA – Transatlantic Free-Trade Area

Tcm – Trillion cubic meter

UNSC – United Nations Security Council

USGS – United States Geological Service

WMD – Weapons of Mass Destruction

WTI – West Texas Intermediate (Crude Oil Benchmark)

Foreword

Dr Gerhard Wahlers, Deputy Secretary General of Konrad-Adenauer-Stiftung in Berlin, Germany and **Professor Dr Friedbert Pflüger**, Director, EUCERS, King's College London

For the second year in a row, the Konrad Adenauer Stiftung (KAS) and the European Centre for Energy and Resource Security (EUCERS) at the Department of War Studies, King's College London, supported a young researcher with an innovative research proposal in the field of energy security. This year's fellow, Jan-Justus Andreas, again had the opportunity to spend two semesters at King's College London, one of Britain's oldest and most prestigious universities to conduct his research under a given topic, jointly decided by EUCERS and KAS. For the 2013/2014 fellowship Jan-Justus wrote the study on "The Economic and Geopolitical Implications of the US drive for Energy Independence in light of the Shale Revolution".

The US has considered energy a strategic commodity ever since the 1973 oil crisis and US energy independence hence has been a core policy of the country's energy and national security for decades. Although measures taken to reduce consumption and increase production domestically have for a long time only reduced the energy dependence' rate of increase, the exponential growth in domestic production levels of gas and oil over the past years - through what has been coined the Shale Revolution - have finally rendered US energy self-sufficiency a feasible goal to be achieved within the next decade. This revolution is part of the tectonic shifts in the global energy system currently underway, and has had expansive repercussions for the US economy, global energy markets and geopolitics.

In his study, Jan-Justus explores these exact political and economic implications of the revolution as well as the concepts of energy independence and self-sufficiency in times of global interdependence. He sheds light into the revolutionary character of the shale explorations in the US and outlines their causes, reasoning and associated doubts. By analysing the revolution's effects on domestic and international energy markets, as well as the wider economic developments, the study depicts the vast range of implications connected with the shale explorations on the North American continent. Drawing from contemporary events, Jan-Justus also outlines the geopolitical potentials and dangers that the Shale Revolution entails, thereby completing a comprehensive picture of the current and pressing developments on global energy markets.

We would like to thank Jan-Justus also for his support of EUCERS and KAS in implementing the jointly organised EUCERS/KAS/ISD workshop series on the changing political and economic dynamics of global energy flows. His ongoing engagement as EUCERS' newsletter editor is much appreciated.

EUCERS and KAS are delighted to host this exceptional Fellowship. We would like to take this opportunity to thank Hans-Hartwig Blomeier, Director of the London Office, KAS, and Carola Gegenbauer, Operations Coordinator, EUCERS, for their unwavering support of our joint projects and are looking forward to our continued cooperation.

Introduction

With the concept of energy security rooted in the supply of fuels for the military in the beginning of the 20th century, it is only consistent for the first major global crisis in energy security to have taken place in connection to a war.

During the first two World Wars, energy security revolved primarily around the increasing dependence of the war machinery on fuels such as oil, and the consequent vulnerability to the enemy's occupation of crucial oil fields and attacks on supply lines. In the post-war period this susceptibility expanded through entire industrialised societies. Following the economic upturn at the end of the Second World War, developed nations increased their consumption of oil exponentially through the advent of motorised vehicles and the general transport sector, food production, health care, the production of plastics, heating, and electricity generation. However, most industrialised countries did not produce sufficient amounts of oil to balance their needs, with even the US becoming a net-importer in 1970 which had been the world's largest oil producer for much of the 19th and early 20th century.

Hence, when in 1973, the Organisation of Arab Petroleum Exporting Countries (OAPEC) – consisting of the Arab members of the Organisation of Petroleum Exporting Countries (OPEC) as well as Egypt, Syria and Tunisia – used an embargo on oil as a political tool in an attempt to deter Western support for Israel in the Yum Kippur War, energy had become more than the basis for developed militaries; it had become a weapon itself against entire nations' economies. Coinciding with the exit of major industrial countries from the Bretton-Woods-System and OPEC's consequent pricing of oil against gold instead of the depreciating dollar, Western countries were heavily affected by real and perceived petroleum shortages and a consequent extreme rise in oil prices lasting throughout the 1970s. This in turn had severe economic implications, disrupting market systems and leading inter alia to the 1973/74 stock market crash. Although the political goal of the embargo did not succeed, it had a lasting impact on US energy security perception. By utilising the Western dependence on foreign petroleum to their advantage, OAPEC had made visible the gaping hole in the US' national security that could not be closed through nuclear deterrence.

For the US, energy has been considered a strategic commodity ever since 1973. In light of the 2014 Ukrainian crisis and the continuous rise in energy demand especially in developing Asia, energy security is increasingly also becoming a top priority for other governments across the world. Combined with several energy transitions underway due to climate change fears, energy in the 21st century can no longer be considered just another commodity. It has become the corner stone of development and, put dramatically, the future of our planet. Adding to the already changing international energy system is the rising production of unconventional hydrocarbons primarily in the US, further altering the global supply and demand balance. While for decades, energy independence seemed to remain an elusive goal, the stark increase in domestic output of natural gas and oil since 2008 has fostered the belief that in the near future US energy self-sufficiency might finally be achieved. The IEA hence summarised these global changes in energy markets by stating, ‘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.’

With such tectonic shifts in the global energy system underway, the study aims to analyse the driving forces for the US energy independence, the shale revolution and its impacts on the US economy and energy markets. The first part covers the origin of "Project Independence" and the driving forces, costs and risks of the shale revolution. The second part then outlines the effects of the increased domestic output of gas and oil in the US, regarding its direct and indirect economic implications, as well as its consequences for global energy markets and geopolitics.

Part 1 – The Pursuit of US Energy Independence: What drives the Shale Revolution?

The Origin of Project Independence

Energy and power are two inherently close-related concepts. This goes both for the natural sciences as well as the realm of international politics, though in obviously differing meanings of the word. History has shown that energy is directly linked to human development and a source of economic growth. Major revolutions in industry and technology have consistently been paralleled with advances and changes in the utilisation of energy sources; from fire and water, to coal, to oil and gas, nuclear power and solar. Such advances towards more powerful or sustainable energy sources enabled these civilisations to develop, sustain and exert increased economic as well as military power. Yet the simultaneous dependence on the food-stock of power, rendered energy resources themselves a tool of influence. The scarcity or regional limitation of resources such as oil and gas implied that countries without (sufficient) domestic access to indigenous energy sources depend on those countries that would supply their economies. As Michael Klare summarised: 'we live in an energy-centric world where control over oil and gas resources (and their means of delivery) translates into geopolitical clout for some and economic vulnerability for others'.[1] This increasing vulnerability on the fundamental fuel of nations' economies affected even the largest superpowers, such as the US, in the 20th century and required them to secure their interest in regions beyond their borders, as a country that cannot sustain its own demand for energy must utilise its acquired power to defend its energy interests abroad.

This susceptibility was never before as visible as during the above outlined 1973 Oil Crisis. The response to this realisation was the initiation of "Project Independence" by President Nixon,[2] with the primary aim to provide the US with immunity from such external shocks.[3] These shocks could be both "accidental" (e.g. in cases of natural disasters or civil unrest) but more importantly, as in 1973, they could be deliberate political actions undermining US power. This experience of US vulnerability to external developments necessitated a diverse policy approach both in US domestic and foreign policy. On the one hand, as the name suggests, the long term goal of the US government was to regain self-sufficiency in its energy consumption. This was to be achieved through reducing consumption and increasing production domestically. These approaches are commonly known under the slogans "conserve baby conserve" and "drill baby drill". Since independence was not to be acquired

[1] Energypost, *Twenty-first century energy wars: how oil and gas are fuelling global conflicts*, July 15, 2014

[2] Nixon, *323 - Address to the Nation About Policies To Deal With the Energy Shortage,* November 7, 1973

[3] Congressional Research Service, *U.S. Oil Imports and Exports*, p.17

overnight, the US was required to attempt to control its dependencies. Hence, on the other hand, the Carter doctrine suggested the projection of military and political power in oil producing countries to defend US national interests. In practice this meant, inter alia, the militarisation of the Persian Gulf to ensure the 'free movement of middle eastern oil'.[4] Furthermore, the US strove for a unified global oil market in order to enable any country to buy oil from another. By effectively creating a pool of oil, and therefore a global oil price, oil embargos against a single country or a group of countries – as experienced in 1973 – would be rendered ineffective.

"Project Independence" was hence inherently focused on the securing of the supply of crude oil to meet the US demand. The primary focus on oil within "Project Independence" owes to its source monopoly in the transport sector; while the electricity sector is comprised of a variety of fuel choices, ranging from coal, natural gas, nuclear power as well as hydropower and other renewables. However, also natural gas has become a crucial hydrocarbon resource over the past decades. Although long considered a premium fuel, too costly to be burnt, natural gas increased in importance as an alternative fuel in the 1990's due to the beginning of climate change debates and the call for cleaner energies, and as a safer alternative for power generation following the Chernobyl disaster. Hence, with increasing demand for natural gas, expectations for rising imports in the mid-2000s induced the Bush administration to pursue the goal of a global gas market, similar to the existing oil one.[5] This included deals between Qatar Petroleum of $7 billion with Shell and $12 billion with ExxonMobil to export natural gas to the US.[6] First supply decreases in natural gas had already been experienced in the 1970's with the consequent policy of reducing its consumption. The outlook of increased LNG imports into the US consequently entailed the construction of multiple LNG import terminals on its eastern coast, as expectations saw the US turning into a major LNG importer by 2015 with natural gas prices linked in international oil markets.[7]

The combination of these actions both for oil and gas are expected to increase US energy security, and thereby eliminate the leverage energy rich exporting nations have over the US economy and consequently its politics. Actual developments in the US energy sector in the decades from 1950-2009, however, show that independence remained a far-fetched goal, with the taken measures

[4] Carter, *The State of the Union Address Delivered Before a Joint Session of the Congress.* January 23, 1980

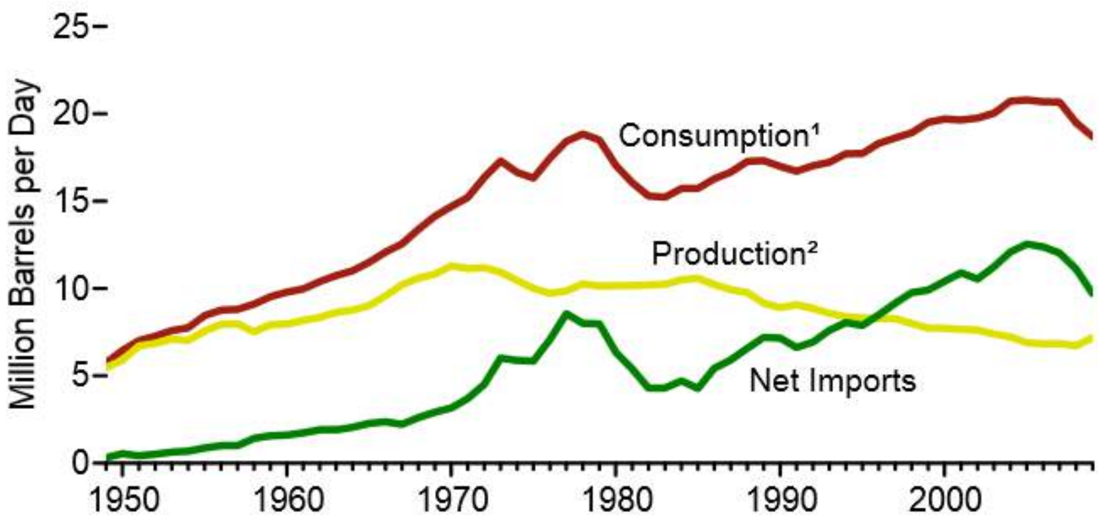
[5] Carter, *The State of the Union Address Delivered Before a Joint Session of the Congress.* January 23, 1980

[6] Congressional Research Service, *Qatar: Background and U.S. Relations*, 2008, CRS-7

[7] IHS CERA, *Fueling the Future with Natural Gas: Bringing it Home,* 2014, p.ES-3

only lowering the energy imports' rate of increase.[8]

Figure 1:
US Petroleum Consumption, Production, and Net Imports, 1950-2009



¹ Petroleum products supplied is used as an approximation for consumption.
² Crude oil and natural gas plant liquids production.
(Source: EIA, Annual Energy Review 2009, p.xxiii)

As Figure 1 shows, between 1950 and 2000, US oil consumption quadrupled. However, domestic production was never able to balance out consumption after having reached its peak in 1970 when the US produced 9.6 million barrels per day (MMb/d). By 2008, this had reduced to 5 MMb/d, implying a loss of over 40% of production capacity in less than 40 years.[9] This development naturally provided net imports with an almost constant rise. Hence, instead of reducing foreign dependency on oil, dependency grew continuously with 60% of crude oil being imported in 2005.[10] Since global transport and crucial synthetic and chemical productions remain highly dependent on oil, crude oil and petroleum remain vital and pricy import goods.

As mentioned above, the US has been relatively energy independent in its power generation for decades. However similarly to its crude oil output, conventional natural gas production peaked in 1970's at 14 trillion cubic feet (tcf) and steadily decreased to a level of about 4 tcf.[11] As natural gas' importance grew especially as an alternative and less carbon intensive source for electricity and in the industrial sector (petrochemicals, fertiliser, etc.), it was regarded as the fuel of the 21st century. A New York Times article in 2005 remarked, 'as the 19th

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[8] The Boston Globe, *'American energy independence: the great shake-up'*, May 26, 2013
[9] EIA, *US Field Production of Crude Oil*, 2014
[10] EIA, *Petroleum Statistics,* 2014
[11] USGS, *Natural Gas Production in the United States*, 2001

century was shaped by coal and the 20th century by oil, ... , this century will belong to natural gas.' [12] It hence appeared that the US would end up in a similar position to most of its European allies with regard to their extensive dependence on foreign energy imports. Consequently, in 2006 experts of the Council on Foreign Relations criticised that US energy policy remained 'plagued by myths' surrounding the 'feasibility of achieving "energy independence" through increased drilling or anything else' and that the US should finally begin to 'manage its dependencies rather than pursue the chimera of independence'.[13]

This chimera, however, had turned into a potential reality almost overnight. In 2008, the so-called shale revolution was able to increase the US domestic output of natural gas and oil multi-fold. This induced various financial services, including Goldman Sachs and Citigroup, to begin foreseeing a golden age for gas, as well as the US economy.[14] According to the IEA's latest World Energy Outlook, the US may achieve full self-sufficiency by 2030.[15] Wood Mackenzie expects the North-American continent to be energy independent even before that and a net energy exporter by 2020.[16] This outlook however begs the question of what one can expect economically and politically from gaining energy independence in the contemporary interconnected and interdependent world.

[12] The New York Times, *'Demand for Natural Gas Brings Big Import Plans, and Objections'*, June 15, 2005

[13] Council on Foreign Relations, *National Security Consequences of US Oil Dependency*, 2006, p.xi

[14] Citigroup, *Energy 2020: North America, The New Middle East?,* 2012; Goldman Sachs, *The US Energy Revolution: How Shale Energy Could Ignite the US Growth Engine,* 2012

[15] IEA, *World Energy Outlook 2013,* 2013

Does Energy Independence Matter in the 21st Century?

Based on the above outlined energy-centric world we live in, one would expect the acquisition of self-sufficiency by the US not only to impact general economics domestically as well as trade flows globally, but also to shape US power perception and its perception by others. The long-standing pursuit of energy independence in the US has given the impression that once reached the US would no longer be vulnerable to external shocks and associated price hikes. However, although continuously used almost synonymous by politicians, energy independence and energy security are far from coextensive and their implications not what their names might suggest.

Generally, equating energy independence with energy security must be considered rather short-sighted and simplistic. Energy independence is but one part of energy security, which has developed into a complex state of affairs, as it has a

[16] Wood Mackenzie, *Geopolitical implications of North American energy independence,* 2013

different meaning to different countries, depending on their geographic location, geological endowment, political system, economic disposition and international relations. Energy security for energy importing nations refers to the security of supply and affordability, while exporters require secure long term revenues through security of demand.[17] The security of supply is crucially based on the degree of dependence, including the rate of self-sufficiency and the reliability of supply. This implies the stability and diversity of suppliers as well as energy carriers. Crucial for energy security is also the security of energy infrastructure networks essential for the delivery of energy such as power plants, electric grids, pipelines as well as trading terminals. Environmental sustainability and eco-friendliness of energy sources has become another core interest, especially for the developed world. Renewable energies also bear considerable potential in decreasing import dependencies. Succeeding in these areas within a competitive free energy market leads to adequate domestic price levels as well as security of supply and increases the level of energy security.[18]

On a basic theoretical note, it is important to mention that energy security as any security-connected concept has to be considered inherently contested and relative; while the notion of security is absolute in meaning it is practically relative as there is no existence of absolute security.[19] There are, hence, two main factors that undermine the actual acquisition of both independence and energy security.

Firstly, energy independence neither renders a country independent from global developments nor energy secure. While in a perfect competitive free market, self-sufficiency might create desired low price levels and increased security, especially with regard to global oil trade, there is no perfect competitive free market. Furthermore, as a globally traded good domestic prices are inherently linked to prices in other parts of the world. Hence, predictions that see the US isolated from global energy developments through independence from imports are neither realistic nor feasible in today's international and interdependent energy market structure. This might seem ironic considering that this interdependence and the creation of a global energy market were primarily promoted by the US in order to increase its security. In this international energy system, however, energy independent countries may not only still suffer from force majeure and technical stoppages, but also market failures, disruptions in other regions with effects on global supply, and most importantly – especially with regard to oil – global pricing.[20] In

[17] Luft & Korin, *Energy Security Challenges for the 21st Century,* 2009, pp.4-5
[18] Yergin, *Ensuring Energy Security,* 2006, pp.70-71
[19] Buzan, *People, States & Fear,* 1983, pp.5-7
[20] European Commission, *Unconventional Gas: Potential Market Impacts in the European Union,* 2012, p.141

addition, while increased domestic production levels of energy sources must be considered a boon for the country's improvement for the security of supply, this can also be achieved without acquiring autarky. Indeed, one can generally differentiate between absolute and strategic energy independence. Both refer to the level of self-sufficiency of a country's energy mix. Absolute independence implies the ability of a country to produce all of its energy itself, meaning there is no necessity to import. Strategic independence connotes that there remains an import of energy; however these imports do not create vulnerabilities in form of adverse political implications through dependencies. In short, although energy independence from unstable and politically questionable countries such as Saudi Arabia and Russia has to be considered desirable, this would not necessitate for the US to become independent in absolute terms. There is no apparent need for the US to i.e. end imports from Canada or for the EU from Norway.[21]

Secondly, American foreign policy over the past decades has been shaped by its strong sense of global leadership, rooted in its superpower stand-off with the Soviet Union during the Cold War. Throughout the 1990's and 2000's where the US was left the only remaining superpower this leadership role has continued and consolidated, as the US used its influence trying to impact civil wars and injustice, as well as defend its national security and other interests beyond its sovereign borders, within and outside the UN framework.[22] This included the securing of trade routes and critical energy production facilities – in line with the Carter Doctrine. Governmental political ambitions, paired with economic necessities hence will render global US security involvements to safeguard its national interests abroad a continuous imperative. This is furthered by the fact that key US allies remain heavily dependent on energy imports. Developments threatening international security and global trade, hence, cannot and most likely will not be ignored by the US.

Based on these factors, the relevance of energy independence in the 21st century is questionable. For market reasons, this assessment differs between globally traded and priced crude oil and primarily regionally traded and priced natural gas. For natural gas, being one of many sources for power generation and with limited utilisation as a heating source in the US, increased domestic production output entails primarily economic rather than security advantages. The greater need for increased security lies therefore with crude oil, considering its retaining monopoly in the transport sector. However, increased domestic production of crudes and the development towards greater independence from imports do

[21] Bengston, *American Energy Independence*, 2010, p.2

[22] Department of Defense, *Sustaining Global Leadership: Priorities for 21st Century Defense*, 2002

not fulfil the main goal of "Project Independence", namely the immunity from external shocks. Nonetheless, energy independence in either resource implicates various economic advantages and provides the country with a greater degree of political leverage.

How will growing energy independence actually affect US foreign policy?

Looking at how growing energy independence could actually impact US foreign policy in the near future, it must be noted that a return to US non-interventionism, as seen during the 1930's and sporadically called for in the aftermath of the 2008 economic crisis and the War on Terror, are rather unlikely. As the US will not be unaffected by developments beyond their borders a disentanglement from international developments would be highly disadvantageous for US energy and national security. Instabilities, production disruptions, and especially the danger posed to global trade through strategic chokepoints continue to threaten US interests. A conflict in the Suez Canal or the Strait of Hormuz would still result in global price spikes of oil with extensive implications for US domestic oil and gasoline prices. Neglecting international relationships and isolating its energy household from global markets would deprive the US from the real potential of the increase in indigenous resource output - to use energy as a tool of economic statecraft to support or coerce other countries - and would in the end render the US less secure. 'The United States can best promote energy security by advocating for and enabling stable, well-supplied global energy markets for all global players'.[23]

While the public debate on energy independence has caused unrealistic expectations on its political implications and energy prices, the reasonable prospect of renewed US energy independence, and the expected economic implications of the shale revolution, will nonetheless affect the international system in various ways. With changing energy foundations due to the shale revolution, the exertion of US power can be expected to shift as well. Geopolitically, the shale revolution has eliminated US gas imports for at least two decades while also reducing the overall share traditional major gas suppliers such as Russia, Venezuela and Iran would have had in 2040 from 33% without the shale revolution, to an expected 26%.[24] Although regions already of strategic interest to the US are likely to continue to remain critical for US security, the incentives for and resultantly, the forms of engagements are likely to change. Furthermore, dealing with an economically and politically stronger US affects global power dynamics, and hence the positioning and actions of other

[23] Centre for a New American Security, *Energy Rush. Shale Production and U.S. National Security*, 2014, p.9

[24] Medlock et. al., *Shale Gas and U.S. National Security,* 2011, p.13

actors. Daniel Yergin argued for example in early 2014 that without the shale revolution in the US, Iran would not have taken the step to re-engage with the West regarding its nuclear program. A major contemporary geopolitical implication of increasing US energy independence and the subsequent implications for global energy markets might hence become the peaceful re-integration of Iran into the international society and energy markets.[25]

A probable geopolitical result stemming from the generally changed power positioning through the increased independence from foreign energy sources also comes with regard to the Carter Doctrine. Domestic energy output levels and decreasing US defence budgets paired with a shifting strategic focus towards Asia have made the sustaining of a large military presence in the Gulf countries more difficult to defend in front of the public eye. Simultaneously, EU-27 import dependence on oil has reached an average of 83%, up from 73% in 1999.[26] As the US continues to have strategic interests in the region due to global oil markets and its regional allies (such as Israel) as well as security linked interests regarding terrorism, proliferation, and political stability, a complete withdrawal of US troops must be considered improbable in line with the above argument on non-interventionism. However, an increased burden sharing among the US and its allies for the securing of Western interests in the Middle East would be a logical consequence of the above developments. This will presumably affect also Europe, due to its economic and political power, energy dependence, and proximity to the region.

The Shale Revolution – Technicalities

The basis for the growing energy independence lies in the exponential increase in the indigenous oil and gas production and resource base in the US. Deposits of oil and gas are commonly referred to in terms of resources and reserves. Resources are the estimated hydrocarbon accumulation, whether these are actually recoverable or not. Reserves are the portion of the resource that is recoverable. This could on the one side imply it is technically recoverable, meaning current technology is able to extract them, and on the other side, reserves can also be economically recoverable, which means they can be profitably brought to market under current conditions. [27] A further differentiation is made between conventional and unconventional

[25] Project Syndicate, *'The Global Impact of US Shale'*, January 8, 2014

[26] Center for a New American Security, *Energy Rush. Shale Production and U.S. National Security*, 2014, p.26

[27] EIA, *Technically Recoverable Shale Oil and Shale Gas Resources*, June 2013, p.10

resource extraction. As Dr Maximilian Kuhn and Dr Frank Umbach already outlined in a previous study by EUCERS on shale gas, there is no "typical" unconventional resource.[28] The distinction between conventional and unconventional extraction includes a variety of factors revolving around the general accessibility of the resource. Unconventional reserves are hence characterised by their atypical geological location, occasional lower permeability, implying the decreased ability of the rock to transmit fluids, varying pressures and temperatures, and hence the general requirement to utilise further stimulatory processes to extract the resource. However it must be noted that also conventional resource extraction includes a variety of recovery technologies to enable and improve recovery, for example if the pressure of the basin drops or has been too low from the outset.[29] Fundamentally, conventional and unconventional natural gas and oil refer to the location and partly differing ways of extraction, rather than the commodity itself, which is exactly the same in both deposits.[30]

Crucial for the shale revolution – as the name already suggests – has been the extraction of resources from shale formations. Shale rock differs from other geological formations based on its fissility, which implies the existence of breaks along thin laminae or parallel layering, which enable an easier and more efficient utilisation of fracking. Furthermore, in comparison to other unconventional oil resources, such as tar sands, where oil is extracted in form of heavy oil, 'shale oil is light and sweet, meaning it is low in sulfur, and the size of the molecules is on average small. These characteristics by and large make it a refinery darling because it is less costly to convert to gasoline.'[31]

[28] Compare: Kuhn, Maximilian & Umbach, Frank (2011), Strategic Perspectives of Unconventional Gas: A Game Changer with Implications for the EU's Energy Security, EUCERS Strategy Paper, Volume 01, Number 01, 01 May 2011, pp.11-12

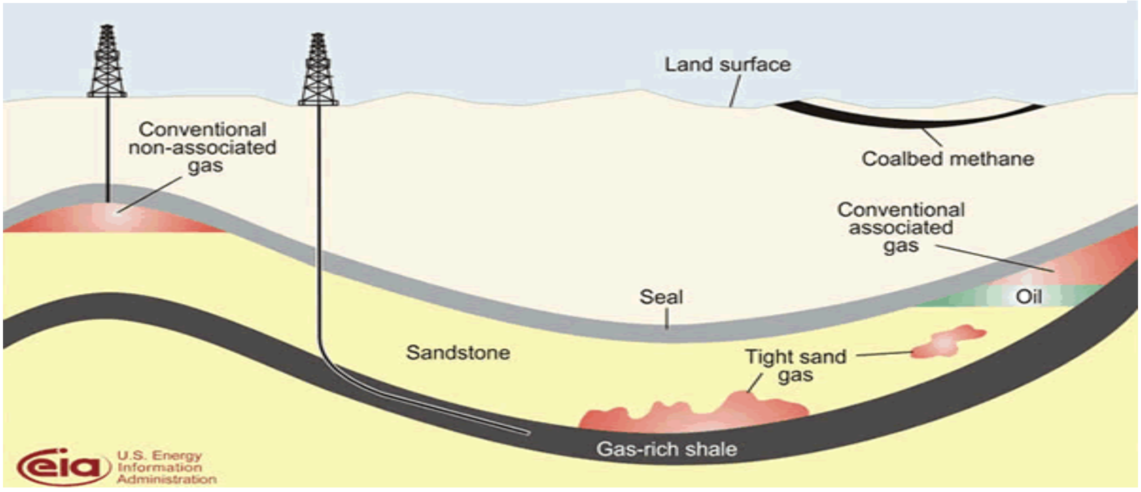
[29] Total, *Why is it called unconventional gas?,* 2014

[30] IHS CERA, *Fueling the Future with Natural Gas: Bringing it Home*, 2014, p.ES-3,

[31] Rao, *Shale Gas: The Promise and the Peril*, 2011, loc.443

Figure 2:
Conventional and Unconventional Gas Sources

This is a schematic of different types of gas and their relative geological locations. Right below the surface is coalbed methane, which is natural gas found in coal seams. Associated gas is natural gas that is found on top of crude oil deposits, making crude oil wells often produce crude oil, natural gas, as well as natural gas liquids (NGLs). If natural gas is found in separate deposits, this is called non-associated gas. Further below, tight gas is natural gas that has migrated upwards into sandstone formations which due to the low permeability, cannot migrate further. Below this lies shale gas.[1]



(Source: EIA, What is shale gas and why is it important?, 2012)

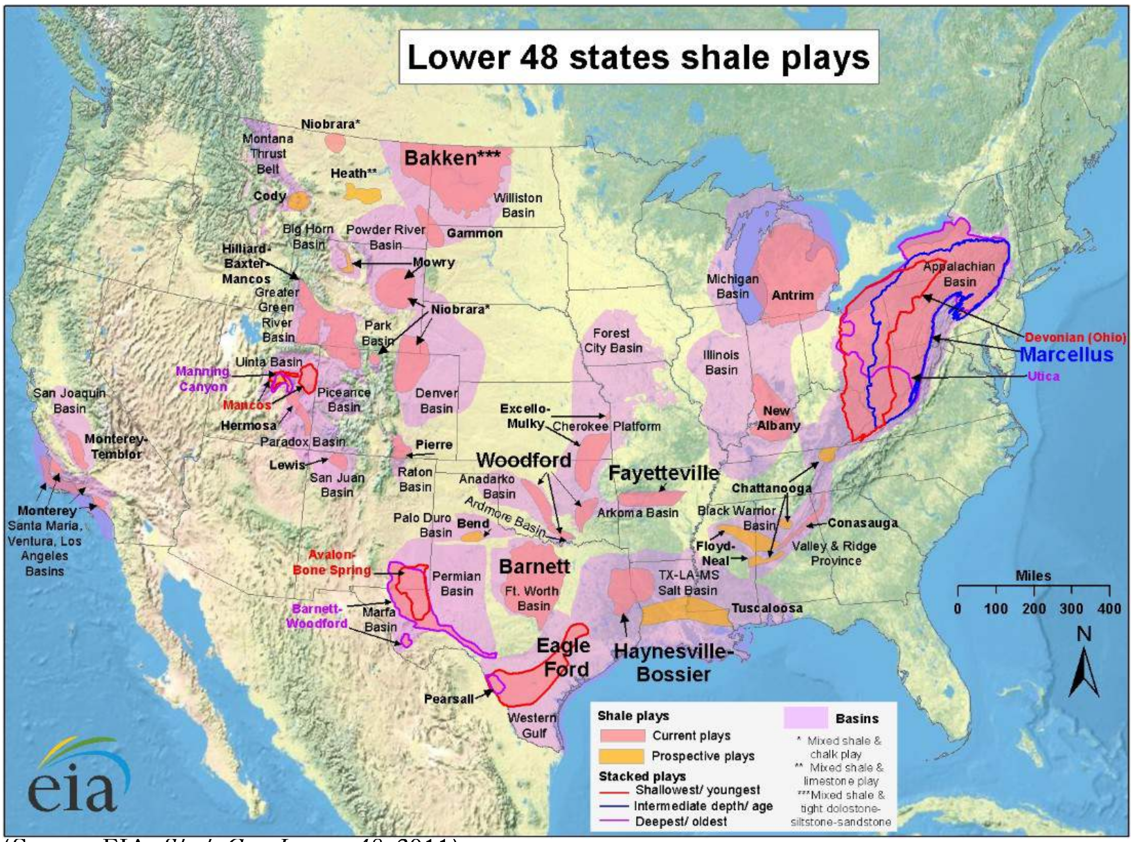
As mentioned above, unconventional resources are found in less permeable rock formations with resource accumulations distributed over a much larger area than conventional sources. While this also implies that shale gas deposits can be found in areas with no conventional reservoirs, their distribution density is estimated around 0.2 to 3.2 billion cubic metres (bcm) per km² compared to conventional ranging from 2 to 5 bcm per km².[32] Map 1 gives an impression of the distribution of shale plays in the US. Furthermore, the divergence of accessibility and concentration has had negative implications for the respective recovery rates. For shale resources, the early recovery rates ranged around the one-digit percentage mark. However, developments of the past years have increased the average estimated by the EIA in 2013 to around 30%, with exceptional cases being as low as 15% and high as 35%.[33] In comparison, conventional extractions from defined discrete reservoirs through vertical wells may reach a recovery rate as high as 80%.[34]

[32] Stevens, *The 'Shale Gas Revolution': Hype and Reality,* 2010, p.10

[33] EIA, *Technically Recoverable Shale Oil and Shale Gas Resources,* 2013, p.16

[34] European Commission, *Unconventional Gas: Potential Market Impacts in the European Union,* 2012, p.1

Map 1:
Lower-48 Shale Gas Plays



(Source: EIA, *Shale Gas: Lower-48,* 2011)

Due to this wider areal distribution of the resource, combined with the mentioned characteristics of unconventional deposits with respect to their additionally required extraction measures, two distinct difficulties arise. Firstly, to recover the resources, more wells need to be drilled in order to cover the entire reservoir. Secondly, before the trapped gas or oil can be extracted, the rock formations need to be made accessible through stimulation.[35] The two processes solving these difficulties are horizontal drilling and hydraulic fracturing. Both are no new technologies, however only their combination has made large-scale extraction possible.[36] They are commonly referred to as "fracking".

Horizontal drilling refers to the technique to add a horizontally drilled well to the initially only vertically drilled one. This means that the well runs horizontally through the rock formation below the earth and hence through the stretched-out resource deposit (compare Figure 2). Following the construction of the well, the rock needs to be stimulated before extraction is possible since the permeability of shale rock formations is

35 Stevens, *The 'Shale Gas Revolution': Hype and Reality,* 2010, p.10

36 Kuhn & Umbach, *Strategic Perspectives of Unconventional Gas: A Game Changer with Implications for the EU's Energy Security,* 2011, p.13

about a million times worse than that of conventional gas reservoir rocks.[37] The stimulation of the rock through hydraulic fracturing is essentially a four step process (hence also referred to as "multi-stage hydraulic fracturing").

In a first step, the reservoir rock is pressured by using a fluid to create a fracture. This fluid commonly consists of 99% fresh water and 1% various chemicals supporting the stimulation. After the continuous increase in pressure through fluids to further open this fracture, in a third step, proppant materials are pumped into the fracture as part of the fluid. This is taking place in form of a slurry, commonly consisting of sand, and is necessary to keep the fractures opened, which otherwise would be closed by the sheer weight of the thousands of feet of rock above. Finally, by stopping the pumping process, the flowback to the well is recovered while leaving the proppant materials in place.[38] As Vikram Rao put it: 'The propped open fractures now constitute a network of artificially induced permeability, allowing the gas to flow out of the formation and up the borehole'.[39]

In order to further improve productivity and decrease costs in the recovery of resources over large areas of a gas or oil play, two further techniques have been utilised in recent years: multiple well-pads and batch drilling. Well-pads are drilling towers situated on a pad, which is able to move across the field of wells, saving the costs and time for disassembling and reassembling the rig on the next well ("rigging down" and "rigging up").[40] Some well-pads entail the technique of batch drilling, 'where wells are divided into segments and a rig drills surface on all pad wells, then comes back and drills the intermediate section on all wells, then finishes the laterals.'[41] This technique 'generates additional time savings and provides incremental efficiencies by allowing operators to drill vertical portions of the well with one set of fluids, then finish out the horizontal lateral with a different set. The result is less time cleaning tanks and switching over.'[42] General productivity of wells has been further aided through improved 3-D seismic imaging technology, which addresses the issue of variability in well performance related to the heterogeneity of the targeted shale formations. The advance of surface micro-seismic monitoring capabilities is able to further provide increasingly accurate spatial descriptions of fracture networks, and have recording-geometries that support larger scale fracture monitoring in the development phase.[43]

[37] Rao, *Shale Gas: The Promise and the Peril,* 2011, loc.323
[38] CSUR, *Understanding Hydraulic Fracturing,* 2013, p.12
[39] Rao, *Shale Gas: The Promise and the Peril,* 2011, loc.322
[40] EIA, *What is shale gas and why is it important?,* 2012
[41] Mason, *The Bakken Moves to Pad Drilling,* 2013
[42] Mason, *The Bakken Moves to Pad Drilling,* 2013
[43] Usher, *3-D Data Aid Shale-Field Development*, 2012

What is Revolutionary about Shale?

As hinted at in Figure 2, there is a multitude of existing unconventional deposits of natural gas and oil. While these forms, such as coal-bed methane or tight sand are also utilised for the extraction of gas and oil, their associated costs and recovery rates have not enabled them to become a large-scale alternative to conventionals; unlike shale. While shale gas constituted only 1% of total natural gas production in the US in 2000,[44] by 2007 this had risen to 5%, increasing to 30% by 2011,[45] and reaching 44% in the first quarter of 2014.[46] From 2007 to 2011 alone, US shale gas output increased more than six-fold from 36.2bcm to 223.8bcm.[47] By 2013, all imports of liquefied natural gas (LNG) from western Africa had ceased.[48] At the same time, oil productions in the late 2000s began to significantly increase again – for the first time since the 1960s. In less than ten years, tight oil production had multiplied from 100,000 barrels per day in 2003 to around 2,000,0000 barrels per day in 2012 and 3.5 MMb/d in 2014.[49] Following this growth in domestic production, net US oil imports declined to less than a third of total demand, down from the abovementioned >60% in 2005.[50]

A new age of abundance?

The implication of what this data suggest is that former theories about the imminent depletion of fossil fuels have become severely scrutinised. Over the past decades, the ideas of "peak oil" paired with “oil depletion” have been dominating the debate over fossil fuels. Oil depletion generally refers to the eventual exhaustion of in this case oil reserves, yet applies to essentially all non-renewable fossil fuel resources that are mined (compared to renewable energies). Peak oil is based on the peak theory by geophysicist Marion King Hubbert, which proclaims that oil well production follows a bell-shaped curve. The notion of peak oil hence implies the reaching of a world production peak with a consequent terminal decline. The recent rise in unconventional resource output paired with decades of technological advances to prolong the lifetime of well production have however rendered these ideas unsustainable for the time being.

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[44] IHS, *Fuelling North America's Energy Future*, Cera Special Report, 2010

[45] EIA, *Technically Recoverable Shale Oil and Shale Gas Resources*, June 2013

[46] Yergin, *The Global Impact of US Shale*, 2014

[47] EIA, *U.S. Shale Production 2007-2011*, 2013

[48] EIA, *U.S. Natural Gas Imports by Country*, 2014

[49] The Telegraph, *'Oil and gas company debt soars to danger levels to cover shortfall in cash'*, August 11, 2014

[50] IHS CERA, *Fueling the Future with Natural Gas: Bringing it Home*, 2014, p.ES-10

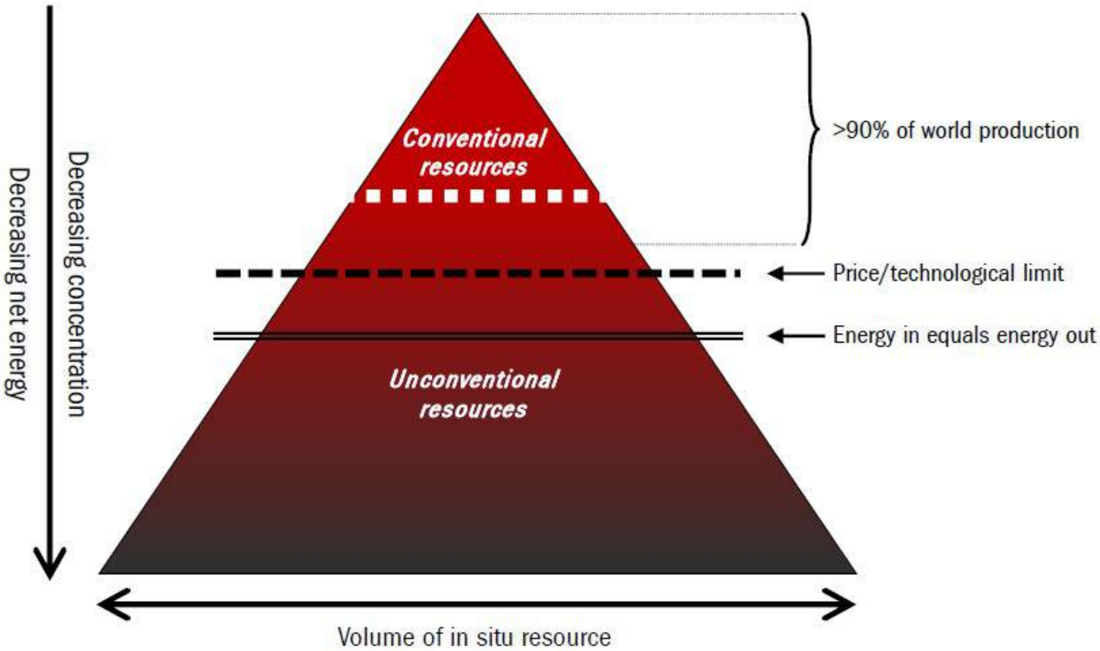
While arguably, anything that is mined will eventually come to a point of exhaustion, this event has been moved further into the future. As the IEA states, 'technology unlocks new types of ... resources and improves recovery rates in existing fields, pushing up estimates of the amount ... that remains to be produced'.[51] In fact, just considering the events in the natural gas industry, unconventional gas has almost tripled the global economically recoverable resource base of which shale constitutes about 64%. This has overall extended the resource life from the former 50 to 60 years to more than 200 years at 2012 consumption levels.[52] It must therefore be noted that what is called conventional resource extraction only reaches the tip of the ice-berg that is the world's overall resource volume in fossil fuels.

Figure 3 represents the proportional distribution of conventional and unconventional resource deposits in the world. Since conventional resources have

Figure 3:

Pyramid of resource volume versus concentration and net energy return.

The pyramid represents the proportional distribution of *in situ* resources with respect to their degree of concentration and associated increasing difficulty of extraction, leading to a decrease in net energy. The white dashed line represents the transition from easily accessible, low cost conventional resources to less concentrated, higher cost unconventional ones. The dashed black line, called "Price/technological limit", refers to the fact that due to increasing energy prices, lesser accessible reservoirs become exploited furthered by technological advance. The straight black line represents the point when energy recovered is equal or less to the amount of energy required to recover them.



(Source: Hughes, *Drill, Baby, Drill,* 2013, p.44)

[51] IEA, *World Energy Outlook 2013 Factsheet*, 2013

[52] EY, *Global LNG*, 2013, p.7

the largest concentrated accumulation (including higher permeability) they can commonly be accessed at the lowest cost with the greatest net energy yield.[53] They constitute, however, only a small fraction of the overall *in situ* resource volume. The greatest resource volumes instead lie with unconventional resources. As represented through the pyramid, they are less concentrated in their deposits with a decreasing accessibility. Due to the associated increase in exploration costs, net energy gains reduce the further one moves down the pyramid. Through their easier accessibility and hence lower associated costs in recovery, conventional energy sources continue to dominate worldwide production today. They account for about 85% of total marketed output.[54] The continuing depletion of conventional deposits combined with the rise in demand, however, increasingly makes unconventional deposits economically viable. However, due to their less concentrated deposits and decreasing accessibility, unconventional recovery increases basic exploration costs. Net energy gains therefore reduce the further one moves down the pyramid. Nonetheless, consequent investments in technological advances make the unconventional resource base increasingly technologically accessible, and increasing prices potentially also economic to explore.

While abundance might be a strong word, mining fossil fuels has become neither a question of availability nor in part of accessibility of resources, but rather of technological advance and the willingness to pay the higher costs. The shale revolution has arguably been but one event – though a major one - in the future of unconventional recoveries. Shell, for example, has already been working on a new technology called mono-diameter for more than a decade. By dropping one steel casing through another and expanding it to the same dimensions this would facilitate the drilling of much deeper wells. However, issues regarding the melting of the steel at such depths continue.[55] Simultaneously, Japan announced in 2013 that as part of an attempt to achieve commercial production within six years it had been able to extract gas from offshore methane hydrate deposits for the first time in the world.[56] Both developments reiterate the vast potential that lies in unconventionals.

Shifting Energy Tenets

The result of this reality has been the abovementioned tectonic shift in long-hold energy tenets. In 2013, the US surpassed Russia and Saudi Arabia as the largest combined petroleum and natural

[53] The net energy yield is considered as the difference between the energy input required and the overall energy gained in production. This is commonly referred to as "energy returned on energy invested" (EROEI).

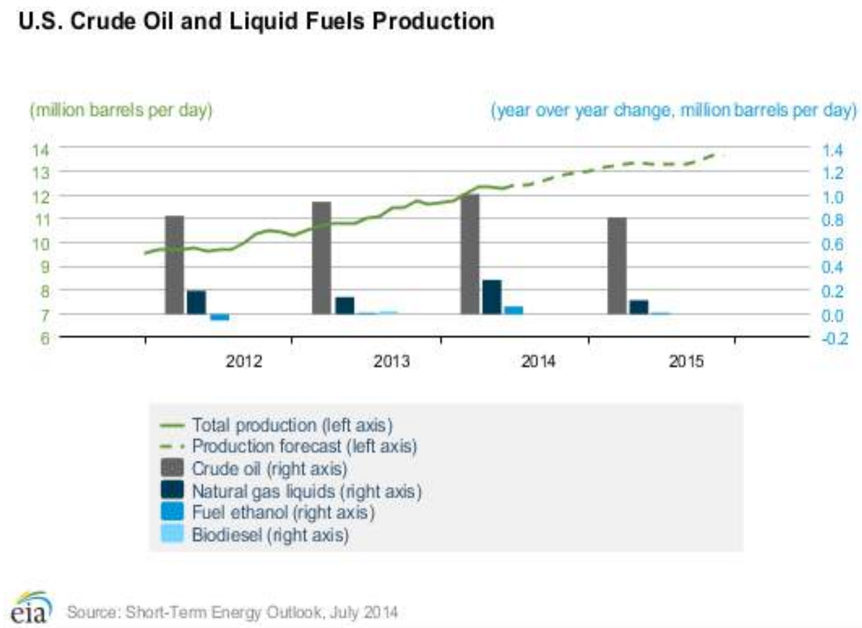
[54] European Commission, *Unconventional Gas: Potential Market Impacts in the European Union,* 2012, p.1

[55] The Telegraph, *'Why the World isn't running out of oil'*, February 19,2013

[56] Reuters, *'Japan achieves first gas extraction from offshore methane hydrate'*, March 12, 2013

gas hydrocarbons producer.[57] According to the BP Statistical Review, the US had already surpassed Russia as the largest natural gas producer in 2009, when the US was producing a total of 582.8bcm of natural gas and Russia 527.7bcm.[58] The exponential increase in oil production has also raised the expectations for the US to surpass Saudi Arabia as the largest oil producer by 2015. Some current data even suggests this could already have been the case in the first quarter of 2014. According to the EIA, following the low-point of only 5 MMb/d in 2008, overall US domestic crude oil production had increased to 7.8 MMb/d in 2013, and 8.1MMb/d in the first quarter of 2014. Combined with natural gas liquids, fuel-ethanol and biodiesel, total oil and fuel productions are said to have increased to 12.3MMb/d in April 2014, and are expected to increase by another 1MMB/d over the next year.[59] While this number is exceeding the amount of 11.6MMb/d of total liquid fuels produced in Saudi Arabia in 2013,[60] sole crude oil production in Saudi Arabia ranges at around 9,6MMb/d.[61] This means that the US crudes production levels remain about 1.7MMb/d lower. With an expected production growth of 0.8MMb/d, US crude oil could surpass Saudi Arabian production levels by the end of 2015, beginning of 2016, also depending on Saudi Arabian developments (compare Figure 4). Other assessments paint a slightly different picture in numbers yet similar tendencies. The BP Statistical Review suggests that crude oil production alone constituted for more than 10MMb/d in 2013 while Saudi Arabia produced around 11.5MMB/d the same year.[62]

Figure 4:
US Crude Oil and Liquid Fuels Production



(Source: EIA, *Short term Energy Outlook*, July 2014)

[57] EIA, *US expected to be largest producer of petroleum and natural gas hydrocarbons in 2013*, 2013
[58] BP, Statistical Review 2010, p.
[59] EIA, *US Crude Oil Production*, 2014
[60] EIA, *Short term Energy Outlook*, July 2014
[61] OPEC, *Annual Statistical Bulletin*, 2014, p.29
[62] BP, *Statistical Review 2014*, 2014, p.8

Hence, according to the IEA, 'the world's remaining resources of natural gas are more than sufficient to meet any conceivable level of gas demand for the next several decades'.[63] Overall global proven reserves of natural gas were estimated at 196 tcm in late 2012, which already included some non-conventional reserves primarily from the US and Canada. In the most recent World Energy Outlook of 2013, the IEA established the remaining recoverable natural gas resources, which include known reserves, reserves growth and undiscovered resources, at a global total of 810 tcm. The conventional natural gas portion was estimated at 468tcm and unconventional at 343tcm (including tight gas, shale gas and coalbed methane). For the IEA, these estimates are however only a starting point as the report stresses that 'unconventional gas resources in regions that are richly endowed with conventional gas, such as Eurasia or the Middle East, are often poorly known and could be much larger.'[64]

Can the revolution be repeated elsewhere?

What makes shale even more revolutionary is the fact that it is not geographically limited to places already known for large conventional resource bases. This could hence support the energy security and economics for a multitude of states that are currently dependent on imports to sustain their domestic demand. Globally, shale resource estimates remain considerably vague except for the North American continent, as a better understanding and hence increased certainty in recoverable reserves fundamentally only comes through drilling, which has so far not taken place on a large scale outside of the North American continent.[65]

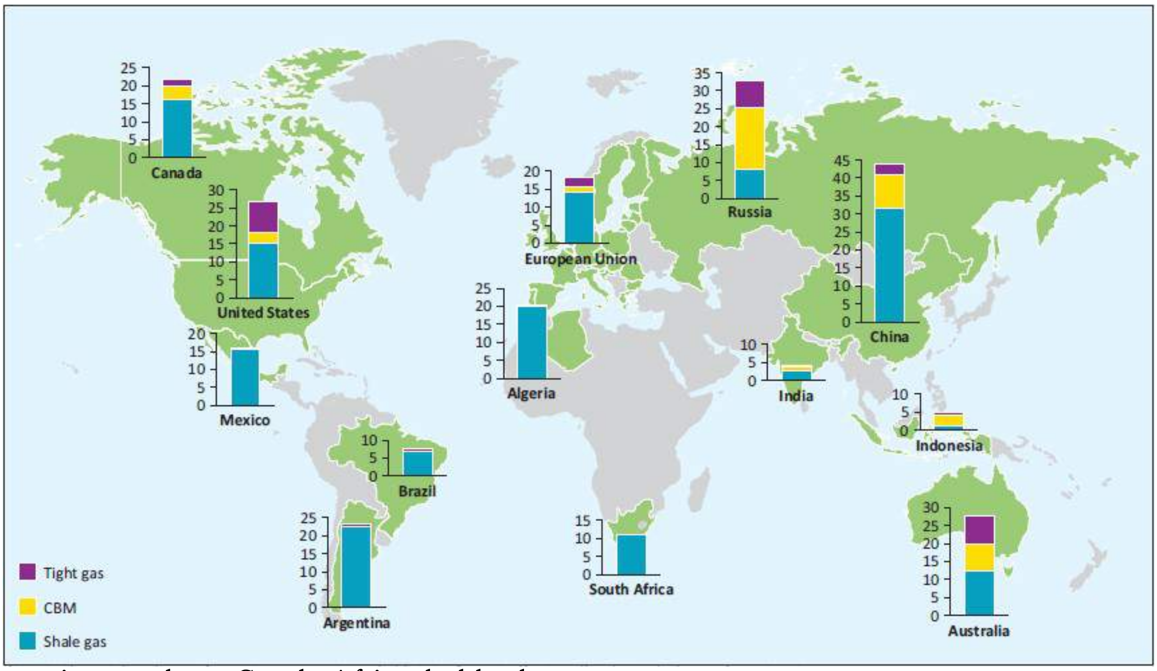
With an estimate of 1,115 tcf of shale gas, China potentially holds the world's largest shale resources and the government is willing to utilise these. However, although the Ministry of Land Resources (MLR) targeted to produce 230 bcf of shale gas by the end of 2015 and at least 2,100 bcf by 2020, actual shale gas production in 2012 was only 1.8 bcf. This slow progress is primarily due technical and water resource challenges, a more complex geology than in its American counterpart, regulatory hurdles, transportation constraints, and competition with other fuels and conventional natural gas.[66]

The second largest potential lies in South America and in Argentina, Mexico and Brazil in particular. However, a major impediment in exploring these bases has been the subsoil rights which reside with the government. Additionally, explorations suffer from issues in finances

[63] IEA, *The World Energy Outllok 2013,* 2013, p.107
[64] IEA, *The World Energy Outlook 2013,* 2013, p.108
[65] Warren, *Oil Markets and the Shale Boom 2014*, 2014
[66] EIA, *China*, 2014

(lack of investment), contracts (security of terms), domestic markets (profitability), export markets (governmental regulations), and environmental concerns (contamination of ground water, seismic shocks, and water shortages). Another factor complicating shale developments is the security of production. Since shale gas exploration requires continuous and expensive drilling, stoppages could have detrimental effects on the productivity and hence profitability of a play, which could be caused by workers' strikes or criminal action. [67] This is also a considerable fear for the African continent where South Africa holds the world's fifth largest resource base of 485 tcf technically recoverable shale gas. The country's largest play is found in the Karoo semi-desert, an area of 100,000 sq miles primarily inhabited by sheep and ostriches. RoyalDutchShell has been working hard to acquire permission from the government to explore the field, and also worked closely with local communities to gain their support.[68] The South African government had imposed a moratorium in April 2011, which was lifted in late 2013, however any future shale exploration will have to follow newly imposed regulations.[69]

Map 2:
Global Unconventional gas resources, end-2012 (tcm)



(Source: IEA, *The World Energy Outlook 2013*, 2013, p.116)

[67] Inter American Dialogue, *Shale Gas in Latin America: Opportunities and Challenges*, 2013, pp.11-13

[68] Shell, *The Karoo: an answer to South Africa's energy needs?*, 2014

[69] GlobalResearch, *Will South Africa Allow Shale Gas "Hydraulic Fracking" in the Karoo?*, 2014; The Financial Times, 'South Africa warms to shale gas', September 24, 2012

While Europe holds significant shale gas reserves, its exploration enjoys little public support in most countries. The matter is considered part of a larger debate between the EU's energy and climate policies, which is 'increasingly cast in terms of "cheap shale gas versus expensive renewable energy"'. [70] Since shale explorations are essentially a 24/7 operational industry with high levels of noise, fumes and traffic, these unavoidable effects are far more relevant in Europe considering its higher population density. As a country's energy mix in the EU continues to be a national prerogative shale gas explorations are also matter of state regulation. France, which is estimated to hold the second largest deposits in Europe after Poland, has already banned fracking in 2011, as has Bulgaria. Poland, in contrast, had been eager to utilise its domestic resources, however with disappointing results so far. Most drilling companies, such as ExxonMobil, Marathon, Talisman, and ENI, have hence left the country due to poor recovery results, unsuitable geology for available technologies, and uncertainty over tax policies.[71] European shale plays are generally smaller, tectonically more complex, its geological units more compartmentalised, and its product deeper, hotter and more pressurised, and generally with a higher clay content.[72] Crucial for the success of shale gas is the price level, for it would require being at least as cheap as conventional gas imported from other actors. Several estimates for the break-even of European shale calculate it to range from \$6-16/mcf and \$5-12/mcf. This compares to US break-even prices of \$3-7/mcf. With the IEA's golden rule adherence aimed to ensure responsible shale exploitation, those prices would rise by another 7%.[73]

Overall, shale deposits bear considerable potential for exploration in various parts of the world. Especially China could profit immensely from exploring its resource base. With stricter regulatory frameworks, differing market structures and more complex geologies of the deposits for example in the EU, extraction costs of unconventional explorations, however, are likely to be far above those in the US.

What are the Costs of the Revolution and will it last?

There is no way of denying that shale gas and oil have revolutionised the US

[70] Buchan, *Can Shale Gas Transform Europe's Energy Landscape?*, 2013, p.1

[71] The Financial Times, *'Eni joins shale gas exodus from Poland'*, January 15, 2014

[72] BGR, *Abschätzung des Erdgaspotenzials aus dichten Tongesteinen (Schiefergas) in Deutschland*, 2012

[73] (1) measure, disclose and engage; (2) watch where you drill; (3) isolate well & prevent leaks; (4) Treat water responsibly; (5) Eliminate venting, minimise flaring, & other emissions; (6) Be ready to think big; (7) Ensure a consistently high level of environmental performance. Compare: IEA, *Golden Rules for a Golden Age of Gas*, 2012

energy market. As outlined above, this revolution also has the general potential to be repeated elsewhere, considering for example the vast amounts of shale in China which are even greater than in the US. This hence raises the question why such a revolution has not taken place yet, and why it did in the US. Though partly sold to the public as a great free-market story in which small companies in a niche industry achieved the break-through by diligently and innovatively working towards their goal, there are several distinct reasons why the shale revolution took place in the US, and not anywhere else. Indeed the shale revolution could be seen as an example of a successful balance between government support in encouraging new technologies and private industry's development of it. Central to this development remains the drive for US independence, and the willingness of the government to bear the costs of such independence.

Although shale gas and afterwards shale oil only entered the public mind following its breakthrough in the late 2000's, the shale development has been an undertaking of almost 40 years. The federal subsidies both in natural gas and oil developments in the US especially starting in the 1970's were crucially targeted at the commercialisation of unconventional domestic resource extraction to facilitate the objectives of "Project Independence". With the first shortages of natural gas beginning in the 1970's, federal investments and involvement in the developing of unconventional gas began with the Eastern Gas Shales Project that lasted from 1976 until 1992 and conducted a series of public-private shale drilling demonstration projects. Furthermore, in 1980, the US congress passed the Windfall Profits Tax Act, which created a production tax credit for unconventional gas under Section 29 by providing an incentive of $0.50 per thousand cubic feet of unconventional gas. The act has amounted to a tax credit for drilling companies of an estimated $10 billion until its expiration in 2002. Further federal involvement and investment continued to support critical steps throughout the development towards large-scale shale explorations. Both the 1986 first multi-stage hydraulic fracture in the Devonian Shale as well as the 1991 first horizontal well in the Barnett Shale were joint ventures between the Department of Energy (DOE) and private companies. The government also invested in basic non-shale technologies that later proved critical for the success of shale. This included the already mentioned seismic imaging as well as diamond-studded drill bits, which 'proved more effective at drilling through shale than conventional tools'.[74] Overall involvement of the DOE between the 1970's and the early 2000's have been estimated at $137 million in research funding, in addition to

[74] Breakthrough Institute, *Where the Shale Gas Revolution Came From*, 2012

governmental tax breaks and discounted drilling fees.[75]

Questioning what actual role these federal subsidies have played in facilitating the shale revolution brings us back to the initial question – why it took place in the US. As depicted, other countries including China, Russia and Poland also hold considerable shale deposits, however without exploring these on a large-scale. It was hence the US public innovation system and its investments in the oil and gas industries to research, develop and commercialise unconventional resource production that enabled the large-scale production of shale gas and later oil. However, while the shale revolution bears considerable economic and political potential, it has not taken place without its share of contestation, risks and criticism. This comes both from an environmental point of view and regarding its economic viability.

What are the environmental implications of shale?

General environmental issues regarding shale explorations include the usage of vast amounts of fresh water, fears of groundwater contamination, air pollution and seismic shocks. Though there already have been several studies on these matters, a comprehensive analysis of all environmental externalities of fracking has so far not been conducted.[76] The Environmental Protection Agency is currently producing a study on the impacts of fracking on drinking water including a full lifespan analysis of water used in hydraulic fracturing. The study is expected to be published by the end of 2014 and has already caused opposition from the industry lobby. US Chamber of Commerce President Thomas Donohue feared that the study could 'short-circuit America's absolute explosion in energy opportunity that is creating millions of jobs'.[77] With states such as Vermont and New York (at least until 2015) already having moratoriums in place, fears of other states following are real, as there is no federal policy on shale explorations and hence hydraulic fracturing is essentially state regulated.

Federal policies are primarily affecting fracking through exemptions in environmental regulations. The respective policies are ranging from clean water and air protection, to preventing the release of toxic substances and chemicals into the environment.

[75] Huffington Post, *'Fracking Developed With Decades Of Government Investment'*, September 23, 2012

[76] such as Zoback et. al. (2010), *Addressing the Environmental Risks from Shale Gas Development*, Worldwatch Institute, Natural Gas and Sustainable Energy Initiative, July 2010; IRGC (2013), *Risk Governance Guidelines for Unconventional Development;* Jenner & Lamadrid (2012), *Shale gas vs. coal: Policy implications from environmental impact comparisons of shale gas, conventional gas, and coal on air, water, and land in the United States*.

[77] Huffington Post, '*U.S. Chamber Of Commerce Leader Warns EPA Fracking Study Could Jeopardize 'Millions Of Jobs'*, December 3, 2013

According to ATKearny, the exemption of shale explorations from for example the Clean Water Act during the George W. Bush era was actually crucial in giving the shale revolution a jumpstart. [78] The response to growing public opposition has been the introduction of the FRAC Act (Fracturing Responsibility and Awareness Chemicals Act) aimed to regulate fracking processes. The act was first introduced in 2009, and has been repetitively reintroduced to both houses in 2011 as well as in 2013, and currently stands at a 9% chance to get past the committee and 1% chance to be enacted.[79]

A central issue for environmentalists is the vast amounts of fresh water required in the process of fracking. This continues to be a debated issue as a single well may require between 10,000 to 25,000 cubic metres (cm) of water, compared to mere 2,000 cm in a conventional well. [80] Furthermore, a recent study has equalled the abovementioned amount of water required for a single well-bore to some 1,000 initial truckloads with an additional 350 a year to maintain production[81] – the decreasing number is due to the fact that around 70% of fracturing water can be reused.[82] The US law firm Baker Botts nonetheless compared the consequent damage to a road to resemble around 3.5 million car trips.[83] Other issues commonly connected with the fracking process are generally 'similar to those associated with conventional onshore gas including gas migration and groundwater contamination due to faulty well construction, blow-outs and above ground leaks and spill of waste water and chemicals used during drilling and hydraulic fracturing'. [84] They become, however, all the more severe as shale explorations also take place in urban areas in close proximity to residential areas, schools and hospitals. The industry repeatedly referred to its own safety standards regarding well construction as well as the long-standing experience with fracking. The process of hydraulic fracturing has been used in the US since the 1940s and also in i.e. Germany since the 1960s, without any significant environmental complications or repercussions.[85]

Decreasing GHG Emissions?

One of the key advantages raised by the government and the industry regarding the environmental implications of the shale revolution is the replacement of coal with gas as a source for power generation.

[78] ATKearney, *The Future of the European Gas Supply*, 2011, p.4
[79] GovTrack, *S.1135: FRAC Act*, 2013
[80] Buchan, *Can Shale Gas Transform Europe's Energy Landscape?*, 2013, p.6
[81] Buchan, *Can Shale Gas Transform Europe's Energy Landscape?*, 2013, p.6
[82] Kuhn & Umbach, *Strategic Perspectives of Unconventional Gas: A Game Changer with Implication for the EU's Energy Security*, 2011, p.30
[83] Buchan, *Can Shale Gas Transform Europe's Energy Landscape?*, 2013, p.6
[84] Zoback et al., *Addressing the Environmental Risks from Shale Gas Development*, 2010, p.1
[85] BGR, *Abschätzung des Erdgaspotenzials aus dichten Tongesteinen (Schiefergas) in Deutschland*, p.33

Electricity generated through natural gas almost doubled within ten years, from 649,908 thousand Megawatthours (MWh) in 2003 to 1,113,665 thousand MWh in 2013, while coal decreased from a peak of 2,016,456 thousand MWH in 2007 to only 1,585,998 thousand MWh in 2013.[86] Many of the coal plants that are to retire based on emission policy grounds are also expected to be replaced with combined cycle gas turbines (ccgt). Natural gas, being the least polluting fossil fuel, [87] has hence received renewed support to become the base-load power generator for the future US energy mix. The already rapid shift to gas had been facilitated by the fact that built natural gas plants were operating at low capacity factors, due to comparatively higher gas prices. [88] Critics, however, fear that natural gas plants could draw off critical investments from the renewables sector. Furthermore, GHGs could still increase due to the expected increase in energy demand.[89] Recent data however suggest that investments in renewable energies has not faltered so far. Power generated through renewable energy sources, excluding hydropower, more than tripled in the above timeframe from 2003 to 2013, from 79,487 thousand MWh to 253,328 thousand MWh. [90] Similarly, coming back to the above outlined federal subsidies of energy sources, according to the DOE, in the fiscal year of 2010 the petroleum and natural gas industries together acquired about $2.8 billion in federal energy subsidies while renewable energies acquired about $14.7 billion. Both numbers include direct expenditures and tax credits. [91] Nonetheless, whether the environmental benefits of increasingly shifting towards natural gas in power generation outweigh the externalities of the shale revolution continues to await a comprehensive analysis.

Is the shale revolution economically viable?

The other core issue with the shale revolution comes from an economic viability side. This concerns the operating costs of shale wells, its returns and general price dynamics on the market. It is important to firstly recognise that shale plays are by no means homogenous. Indeed, each play has essentially its own set of particular geological, geo-

[86] EIA, *Electric Power Monthly*, 2013

[87] While natural gas is still a fossil fuel, it produces fewer emissions in combustion than for example coal or oil. In absolute terms, this means 135 lbs/ Megawatthours (MWh) of carbon dioxide, 0.1 lbs/MWh of sulphur dioxide, and 1.7 lbs/MWh of nitrogen oxides. Compared to the average air emissions from coal fired generation, natural gas hence produces half as much carbon dioxide, less than a third as much nitrogen oxides, and one percent as much sulphur oxides at the power plant. Numbers are regarding average contemporary power plant efficiencies.

[88] Broderick & Anderson, Has US Shale Gas Reduced CO2 Emissions?, 2012

[89] European Commission, *Unconventional Gas: Potential Market Impacts in the European Union*, 2012, pp.150-54

[90] EIA, *Electric Power Monthly*, 2013

[91] Huffington Post, *'Fracking Developed With Decades Of Government Investment'*, September 23, 2012

mechanical, geo-chemical and petro physical characteristics, and varies in factors including reservoir pressure, total organic content, thermal maturity, porosity, and the potential presence of natural fractures. This implies that the performance of individual wells can differ substantially both within and between plays.[92] Nonetheless, there are two common issues with shale explorations. Firstly, highly productive shale plays are extremely rare, with analysts expecting that the most profitable deposits are already being explored – as is common in the exploration cycle. Secondly, shale plays follow a depletion profile of high initial production levels with a consequent rapid decline of about 60% in the first 12 months. This is commonly followed by a moderate decline of 30-20% per year.[93] Critics hence see that many of the newly drilled wells are simply to offset the loss, which is commonly referred to as the "Red Queen issue", in which 'it takes all the running you can do, to keep in the same place'.[94] The lifespan of shale plays has therefore been estimated at around 7 to 12 years compared to 30 to 40 years of conventional reservoirs.[95]

Considering the first aspect, comparing overall production of plays in 2012 shows that 80% of total shale gas production came from only five plays, and 66% from only three; the Barnett, Haynesville, and Marcellus Shale (compare Figure 5). Regarding shale oil, the top five made up 92% of overall production and the top two plays, the Bakken and Eagle Ford, 81% (compare Figure 6). Furthermore, to put the actual productivity of a single shale well into perspective with conventional wells: Initial flow rates from the Ormen Lange gas field in Norway were ranging around the 350 mcf/day per well mark.[96] An average well in the Marcellus shale – one of, if not the most productive shale play in the US – initially produces around 4 mcf/day. It would therefore require around 88 shale wells to replace a single conventional offshore well. Also, Marcellus is the only shale play that is currently growing, while all other plays are in decline or flat. The situation looks slightly different for the major oil plays, due to their exploration inception at a later time, nonetheless the EIA is expecting slower increase until later in the decade followed by decline.[97]

[92] O'Sullivan & Paltsev, *Shale Gas Production: Potential versus Actual GHG Emissions*, Appendix, 2012, p.1

[93] O'Sullivan & Paltsev, *Shale Gas Production: Potential versus Actual GHG Emissions*, Appendix, 2012,p p.1-3

[94] Carroll, *Through the Looking-Glass and What Alice Found There,* 1960, p.46

[95] Stevens, *The 'Shale Gas Revolution': Hype and Reality,* 2010, p.11

[96] Rigzone, *'Norsk Hydro Tests First Ormen Lange Gas Production Well'*, July 23, 2007

[97] Energypost, ' Interview Arthur Berman: "Shale is not a revolution, it's a retirement party"', March 21, 2014

Figure 5:

Shale Gas production divided by play from 2000-2012

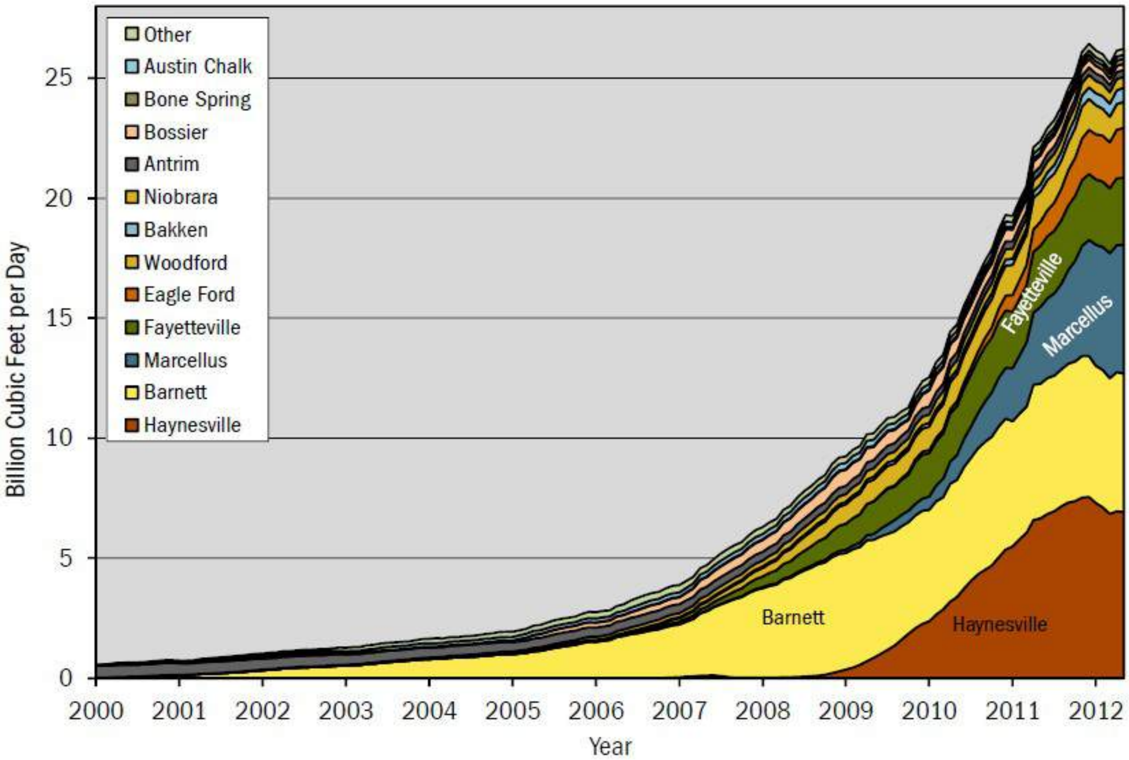
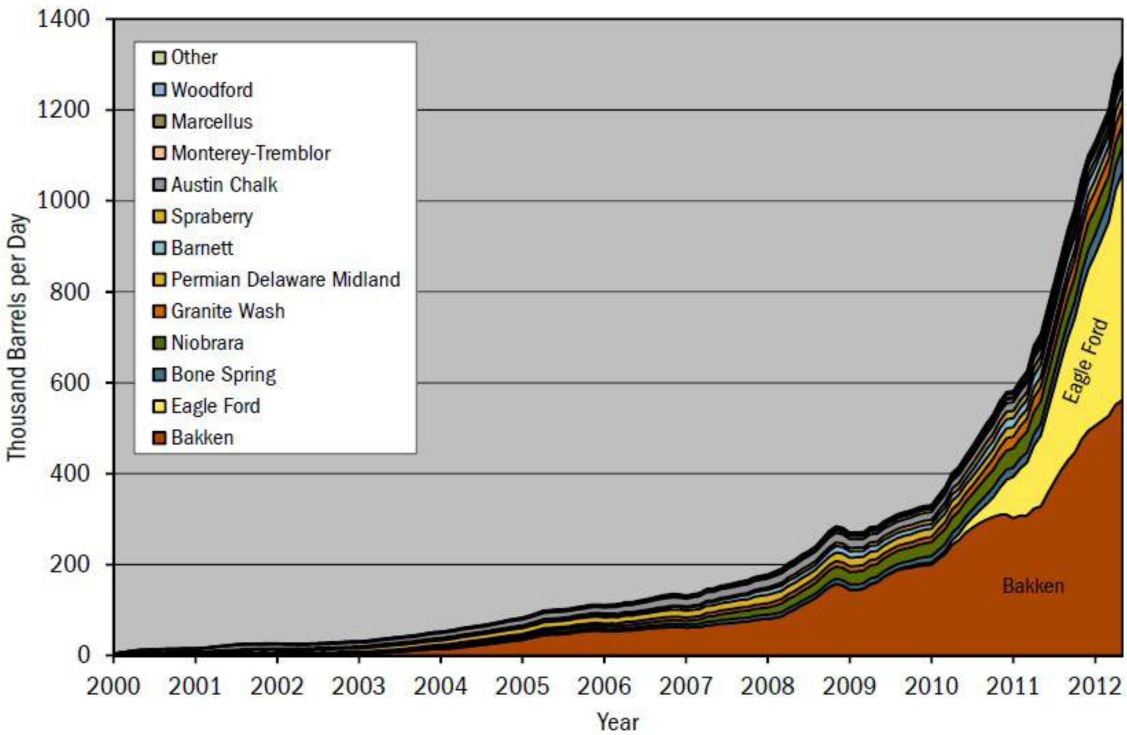


Figure 6:

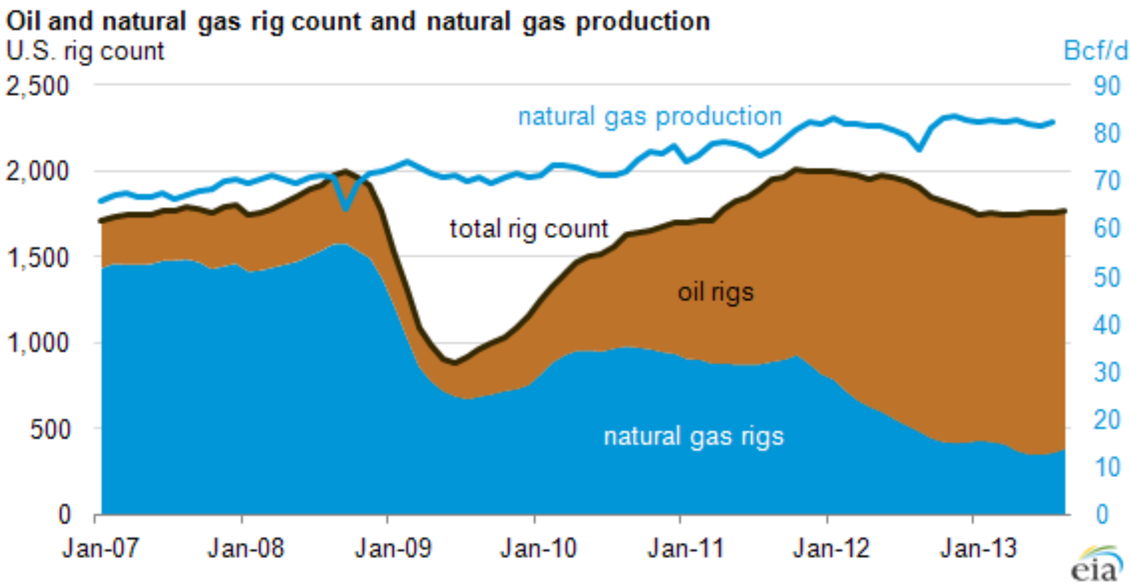
Shale Oil production divided by play from 2000-2012



(Source: Hughes, *Drill, Baby, Drill,* 2013,pp.51 & 79)

To counteract these doubts and sustain investor's interest, the industry has continuously referred to efficiency gains through technological advances and greater expertise and assessment capabilities. According to them, overly pessimistic production curves could potentially hint at the omitting of efforts to improve recovery in known fields.[98] Their primary example in this respect is the Marcellus Shale, which was able to more than double its 2012 level of production in 2013. Output topped 3tcf while at the same time reducing the quantity of new drilled wells. According to the DOE, Marcellus alone is now providing about 18% of total US natural gas production.[99] Similarly, the IHS CERA reported that since 2008, each year as seen a decrease in new drilled wells, combined with a stable to increasing output.[100] This has been affirmed by the consulting firm Wood Mackenzie, as emerging technologies and techniques have also made it easier and cheaper to drill more wells from every rig on a shale play, enabling companies to recover more oil and gas.[101] As such, rig counts have become a weaker indicator for shale production (compare Figure 7).

Figure 7:
Oil and natural gas rig quantity and natural gas production



(Source: EIA, *Rethinking rig count as a predictor of natural gas production*, 2013)

As technology continues to improve, it apparently does so at increasingly lower costs, which have fallen to around $7 million to $8 million per well in 2013 from $9.5 million in 2012.[102]

[98] Forbes, *'Shale Gas Production and High Decline Rates'*, Feburary 9, 2013
[99] Yahoo! Finance, *'Pa. Marcellus Shale Production Increases'*, February 20, 2014
[100] IHS CERA, *Fueling the Future with Natural Gas: Bringing it Home* , 2014, p.I-9
[101] Eaton, *Shale well depletion raises questions over US oil boom*, 2013
[102] IHS CERA, *Fueling the Future with Natural Gas: Bringing it Home*, 2014, p.I-12

Furthermore, companies already drilling in a shale increasingly find "stacked plays", meaning not yet tapped reservoirs situated underneath or above already tapped ones.[103] A 2014 IHS study in its most updated analysis of various plays stated that 'as producers have gained experience, each well and each play has been developed much quicker and with better performance characteristics than its predecessor.'[104]

According to Ivan Sandrea, research associate at the Oxford Institute for Energy Studies and senior partner of Ernest & Young London, 'what is not clear from higher-level company data is if the industry (both large players and independents) can run a cash flow-positive business in both top-quality and in more marginal plays and whether the positive cash flow could be maintained when the industry scales up its operations'.[105] Sandrea further noted that asset write-downs were approaching $35 billion since the shale boom began among 15 of the main operators. Challenges for the industry remain above-ground reasons including the acquisition and operation of drill leases, as well as infrastructural needs, transportation costs, and also increasing costs to manage environmental considerations as operations grow. Crucial for the overall economic viability remains the fact that 'drilling and hydraulic fracturing costs respond to fluctuations in gas and oil prices as well as demand', which according to Sandrea leaves 'little excess profit for long'.[106]

Market prices and the question of profit

Crucial for the assessment of the economic viability of shale plays is the establishing of an average break-even price for shale wells. This however proves to be rather difficult due to the mentioned heterogeneity of shale deposits and the differences in production rates among and within plays. Operational cost assessments are further aggravated as the multitude of drilling companies in a single play each differ regarding costs of drilling, fracking, wellpad facilities, upstream gathering and treatment, transport, as well as administrative and other operational costs.[107] Opinions on break-even prices hence vary. The Canadian geoscientist David Hughes claimed that in mid-2012, most of the wells at the Haynesville Shale failed to break even at prices below $4.00/mcf,[108] while some wells' breakeven price at the Marcellus was at $7/mcf[109] and for the Barnett even around $8.96/mcf.[110] The 2014 IHS study on natural gas stated that half (900tcf) of the North American unconventional gas resource base from 17

[103] Reuters, *'Analysis: Bakken drillers undaunted by local oil prices under $80'*, November 21, 2013

[104] IHS CERA, *Fueling the Future with Natural Gas: Bringing it Home*, 2014, p.I-10

[105] Oil & Gas Journal, *'Financial questions seen for US shale gas, tight-oil plays*', March 25, 2014

[106] Oil & Gas Journal, *'Financial questions seen for US shale gas, tight-oil plays*', March 25, 2014

[107] European Commission, *Unconventional Gas: Potential Market Impacts in the European Union,* 2012, p.159

[108] Hughes, *Drill, Baby, Drill,* 2013, p.55

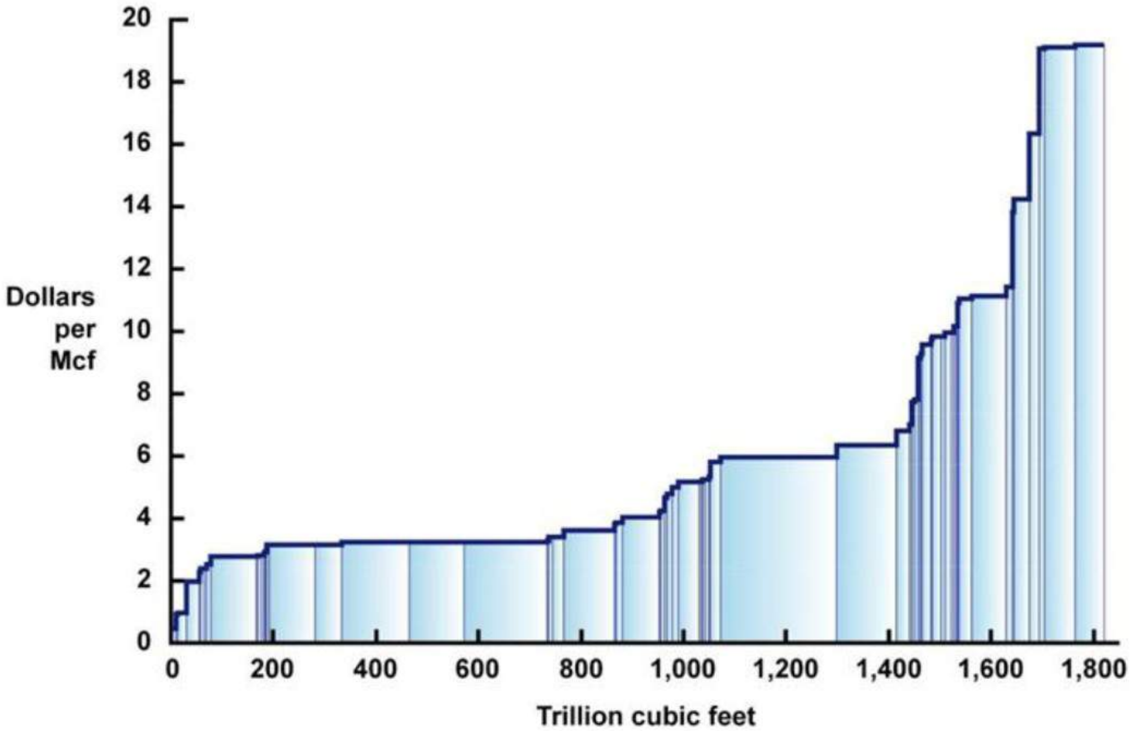
[109] Ibid., p. 66

[110] Ibid., p.55

evaluated plays could produce economically at Henry Hub Prices of $4/mcf or less (compare Figure 8). The study argued that this was primarily due to the abovementioned greater efficiency of production, thereby reducing capital costs dramatically.

While the weighted average break-even price of shale gas was also considered around $4.04/MMBtu in a Harvard study from May 2013,[111] critics, such as Arthur Berman, claim that data suggesting wells can produce commercially at $4.00/mcf are ignoring overhead, G&A, and other additional operating costs, which – if included – would raise the break-even closer to $6.00/mcf.[112]

Figure 8:
Full-cycle breakeven prices for 17 unconventional gas plays in North America (two in Canada)



(Source: IHS, *Fueling the Future with Natural Gas: Bringing it Home*, 2014, p.ES-7)

Either way, as seen in the above figure, there are obviously large amounts of wells that struggle to produce economically at natural gas prices of $4/mcf or even $6/mcf. Considering therefore the price level developments of the Henry Hub Spot Price in the US over the past years, one can see the initial effects of the "drilling spree" in mid-2008, reaching its

[111] Cohen, *The Shale Gas Paradox: Assessing the Impacts of the Shale Gas Revolution on Electricity Markets and Climate Change*, 2013, p.24

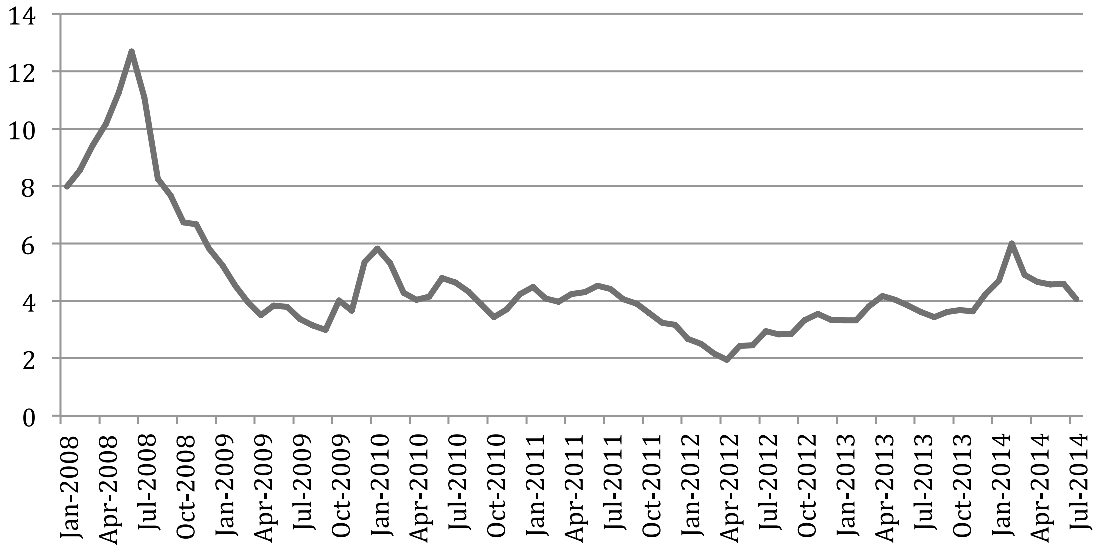
[112] Energypost, *'Interview Arthur Berman: "Shale is not a revolution, it's a retirement party"*, March 21, 2014

overall low-point in spring 2012 at $1.95/MMBtu. It therefore becomes obvious that at prices around $2-3/MMbtu in 2012, very few wells must have actually been producing economically.

Figure 9:
Henry Hub Natural Gas Spot Price 2008-2014 (Dollars per Million Btu)

adding reserves, holding leases and company growth are among the main factors particularly with the low cost of capital. The inevitable result has been the collapse of prices as supply exceeded demand.'[114]

Also analyst Deborah Rogers considers the root causes for the decreasing economics to lie in these lease obligations,



(Source: EIA, *Henry Hub Natural Gas Spot Price*, 2014)

The reasons for the initial overproduction and the consequent dive of gas prices are the so called "drill or lose lease" conditions, implying that much of the early drilling was tied to the need to retain leases, and the extensive investments by Wall Street in the sector.[113] Arthur E. Berman explained that 'operators have indulged in over-drilling these plays for many reasons but

as well as investor politics. Based on her analysis, critical for the initial shale hype was the common practice of bundling leases – similar to the practice in real estate mortgages leading to the 2008 financial crisis. This meant leases of different qualities were packaged and sold off to investors, with only few of those being economically viable.[115] The effect of increased investment combined with "drill or lose lease" conditions was the drilling boom observable from 2008

[113] Kuhn & Umbach, *Strategic Perspectives of Unconventional Gas: A Game Changer with Implications for the EU's Energy Security,* 2011, p.18

[114] Berman, *After The Gold Rush: A Perspective on Future U.S. Natural Gas Supply and Price*, 2012

[115] Rogers, *Shale and Wall Street: Was the Decline in Natural Gas Prices orchestrated?,* 2013, p.11

onwards. Nonetheless, based on the abovementioned depletion profile of most shale plays, drilling companies had to deal with decreasing energy returned on energy invested (EROEI) while having to fulfil their lease obligations, deal with a plummeting market and appease their shareholders.

The consequence of the above factors have been detrimental for the industry. As an example, one of the main drilling companies, Chesapeake Energy, which owns several leases in major shale plays such as Eagle Ford, Marcellus, Barnett and Haynesville, tried to renegotiate their "drill or lose lease" condition for the Utica play in early 2012 (so far futile). The changes would allow them to drill less rigs while still maintaining their lease. This was due to the severe plummet in gas prices and increasing pressure by shareholders to reduce spending. [116] Chesapeake, while the US' second largest gas producer, has had severe economic troubles since the outset of the "shale revolution" in 2008, when prices fell from above $12/MMbtu to below $5/MMBtu. In 2010, the company announced it would need to sell $5 billion in assets to reduce its acquired debt, consequently selling its holdings in an Arkansas gas field to BHP Billiton, an Australian company, for $4.75 billion. In September 2012, the board agreed to sell further $6.9 billion in assets in order to repay $4 billion in loans during the fourth quarter of the year. In February 2013, the company continued to sell stakes in an Oklahoma Oil field to China's Sinopec for $1.02 billion, among other sales.[117]

The plummeting gas prices and the associated losses experienced by companies have induced a growing shift towards shale oil and natural gas liquids (NGL). With gas prices around $4/MMbtu and crude oil around $80/barrel (WTI) in 2013, oil prone plays yielded an estimated internal rate of return greater than 100%, compared to even highly profitable shale gas plays such as the Marcellus of 12-28%.[118] The consequent shifts rendered shale gas a mere by-product. [119] However, the increased ability to also recover so called "associated gas" along oil in some tight oil plays, are said to have increased overall revenues and hence economic viability as well. With improved technologies, natural gas production levels were hence maintained with fewer gas rigs (compare Figure 7) while new rigs were increasingly focussed to produce oil and natural gas together.

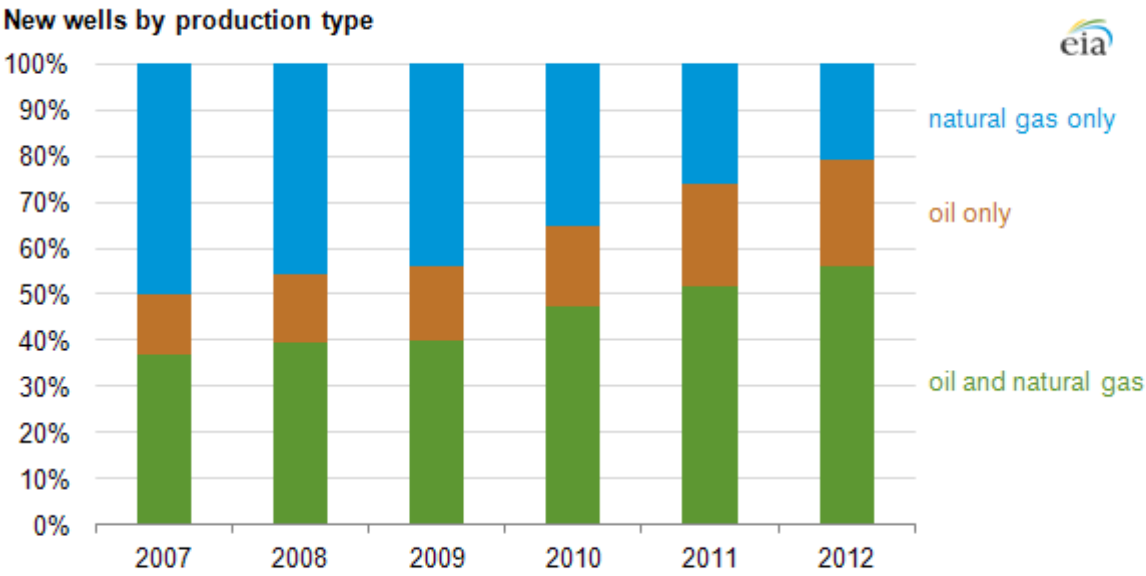
116 'Chesapeake Irks Landowners As It Renegotiates Leases', *The Wall Street Journal*, July 15, 2012.

117 'Troubled Times at Chesapeake', *The Wall Street Journal*, 2013

118 ATKearney The Future of the European Gas Supply, 2011, p.5

119 IHS CERA, *Fueling the Future with Natural Gas: Bringing it Home*, 2014, p.I-11

Figure 10:
New Wells by production type



(Source: EIA, *Rethinking rig count as a predictor of natural gas production*, 2013)

Nonetheless, the general gas and oil industry continues to struggle to create profit. The EIA reported that a review of 127 oil and gas companies across the globe found an increased net debt of $106bn in the year to March. Revenues from oil and gas have plateaued since 2011 while production costs have been increasing constantly. The spread between cash earnings and expenditures has widened from $18bn in 2010 to $110bn in 2013, forcing companies to sell off a net $76 billion in assets. However, according to the EIA, the 'increased debt load is anticipated to be met with increased production, generating more revenue to service future debt payments'.[120]

Despite the justifiable doubts stemming from the outlined depletion profiles, rarity of highly productive shale plays and unprofitable market developments, it is probably too early in the evolution of the shale industry to deem its business model flawed. Based on the production levels and overall output of the past years, the most recent studies of the EIA, IHS, and IEA all depict the trend that the shale revolution will continue to provide the US with valuable energy resources well into the 2030's. A key reason for the continuation in confidence for the shale future by investors is the apparent technological advances and the fact that reserve estimates are now based on actual results from known plays and increased drilling explorations, and are thereby no longer dependent on mere estimates of "yet-to-find" resources.[121] In contrast to

[120] EIA, *As cash flow flattens, major energy companies increase debt, sell assets*, 2014

[121] IHS CERA, *Fueling the Future with Natural Gas: Bringing it Home*, 2014, p.I-13

the "gas bubble" of the 1980's which was essentially a (de)regulatory phenomenon, the shale revolution today is based on technological progress instead of mere finance tools, which according to the industry will continue to drive unconventional production.[122]

[122] IHS CERA, *Fueling the Future with Natural Gas: Bringing it Home*, 2014, p.I-13

What are the direct economic implications?

The increase in the domestic natural gas and crude oil resource base as well as output levels entail various associated, predicted, and actual economic benefits. In a first place, the increased amount of reserves in the US has led natural capital share to rise; from 16% of GNI in 2000, to 30% in 2008 at the outset of the shale revolution. Such a boost and the associated expanded resource life are expected to generate increase wealth derived from oil and gas. Considering above outlined price developments, this wealth is currently greater in crude oil than natural gas.[123] Furthermore the shale revolution has the potential to inherently improve the US' trade balance. This is based on two developments. Firstly, fewer to no imports of crude oil and natural gas reduce trade spending. While at the same time, large utilisation of gas domestically has freed up vast amounts of coal, which are currently being exported, increasing cash flow into the country. [124] Other direct and indirect benefits include the creation of jobs, the return and expansion of electricity and gas intensive industries, and lower consumer prices.[125] The largest growth resulting from the shale revolution being projected to take place in the power generation sector, as already outlined with regard to the environmental implications. Overall, shale gas alone contributed to the U.S. gross domestic product (GDP) by more than $76.9 billion in 2010, which is expected to reach $118.2 billion in 2015, and might triple to $231.1 billion by 2035.[126]

Since the US is a leader in all aspects of the shale gas industry, most of its suppliers are domestically based. This implies that it is primarily US jobs in trucking, steel fabrication, aggregates, heavy equipment manufacturing, hotels, and restaurants, among others, that experience a positive impact of the new industry. This also has distinct impacts on unemployment levels, with the country's lowest unemployment rates being in North Dakota, with 2.6% far below the 7.4% US average, where counties associated with the Bakken play have the lowest levels countrywide of around 1%. [127] Furthermore, lower gas prices achieved through the shale gas revolution also reinvigorated the international competitiveness of domestic manufacturers, expected to result in 2.9% higher industrial production by 2017 and 4.7% higher production by 2035 of the 2011 levels. [128] The Federal Reserve recorded an overall domestic industrial production increase of 2.8% between

[123] OECD, *Making the best of new energy resources in the United States*, 2014
[124] OECD, *Making the best of new energy resources in the United States*, 2014
[125] Taheripour, et. al., *Assessment of the Economic Impacts of the Shale Oil and Gas Boom*, 2013
[126] IHS CERA, *Shale Gas Supports More Than 600,000 American Jobs, Study Says*, 2012
[127] Expert Market, *Unemployment rates by county,* 2014
[128] IHS CERA, *Shale Gas Supports More Than 600,000 American Jobs, Study Says*, 2012

2013 and 2014 alone.[129] However, this is not to say that the shale revolution stimulated extensive demand in the US industries sector as a whole. This is primarily due to efficiency gains, GHG emission regulations, and productivity drops due to the global recession.[130] Consequently, energy consumption in the commercial and industry sectors have continued to decrease over the past years both in primary and total energy terms.[131]

This positive economic impact of the shale revolution is furthered by multi-billion dollar investments in chemical, steel (further aided through low coal prices), and other gas and electricity intensive industries.[132] This is particularly visible for the petrochemical industries, due to extremely low feedstock prices of natural gas and crude oil. Oil, in fact, is currently prohibited of being exported which has created a large spread between the domestic and international benchmarks, enabling the industry to buy crudes below the global price.[133] The industry consequently announced significant expansions for the first time in decades in as early as 2011,[134] reviving mothballed facilities, relocating plants from overseas, and expanding domestic operations.[135] The American Chemistry Council stated that the economic impact of the shale revolution for the chemical industry saw $8.5 billion investments for the state of Texas, and $3.2 billion for West Virginia, Pennsylvania and Ohio respectively. Together, these investments are expected to generate additional $59.4 billion in chemical industry output, providing these states with a total amount of $267 billion in revenues. Furthermore, about 127,000 new jobs are generated in the chemical industry alone, constituting for more than $8.4 billion in wages.[136] Pharmaceuticals and petroleum manufacturers also receive considerable shares of Foreign Direct Investments (FDI), as do petrochemicals and steel and equipment manufacturing that are required for gas extraction. Overall, manufacturing was the largest FDI sector, receiving a total share of 45%.[137] However also the US energy sector continues to be highly attractive for investors in general. Indeed it has been the most active sector in the world regarding mergers and acquisitions in 2013, with a share of over 31%.[138]

Similarly, the nitrogen fertiliser production, which had been in decline for decades, has experienced a new boost

[129] Board of Governors of the Federal Reserve System, *Industrial Production and Capacity Utilization – G.17*, 2014

[130] European Commission, Unconventional Gas: Potential Market Impacts in the European Union, 2012, p.153

[131] EIA, *Energy Consumption by Sector*, 2014

[132] IHS CERA, *Fueling the Future with Natural Gas: Bringing it Home*, 2014, p.ES-3

[133] Compare part on shale oil implications.

[134] European Commission, *Unconventional Gas: Potential Market Impacts in the European Union*, 2012, p.152

[135] IHS CERA, *Fueling the Future with Natural Gas: Bringing it Home*, 2014, p.ES-18

[136] American Chemistry Council, *Economic Impact of Shale Gas*, 2014

[137] Whitehouse, *Foreign Direct Investment in the United States. October 2013*, 2013, pp.1,4,7

[138] Zawya, *'Mideast energy giants invest in North American shale'*, February 4, 2014

through cheap and available natural gas, which accounts for about 70-90% of production costs. Natural gas is required to produce ammonia, 'the primary ingredient in most nitrogen fertilizers and an essential ingredient in many finished phosphate fertilizers [sic.]'. [139] Several renewed ammonia plants are now under development, for which North Africa and the Middle East had been primary markets until now, due to their low-cost feedstock.[140] The IEA sees most of the natural gas use in the future in feedstock directly for the production of ammonia and methanol, used primarily in the chemical sector, which is expected to grow most in volume terms (340bcm).[141] Considering that especially before 2020, most of this growth is expected to take place in the US, the implications for the US economy are expected to be extensive. Furthermore, with the reduced costs of agricultural inputs, the exponential implications shale gas may have for food security are also a matter of contemporary discussion.

Overall, the quantitative direct implications of the shale revolution on the US job market were assessed by IHS CERA as having created more than 600,000 jobs in 2010. This was estimated to increase to 870,000 by 2015. [142] In energy-related chemical manufacturing, the IHS in their major study in 2014 stated that the shale revolution was directly or indirectly responsible for 2.1 million jobs, constituting nearly $284 billion in value added to GDP and more than $74 billion in government tax revenues in 2012. 'By 2025, these contributions are expected to grow to 3.9 million jobs, $533 billion (constant 2012 $) in value added to GDP, and $138 billion (constant 2012 $) in government revenues.' [143] Overall expected increases in real GDP range from 2.0% to 3.2% per year and translate into an increase in GDP of $500 - $600 billion. [144] US GDP over the entire period of 2008-2035 is considered to be 3.5% on average higher than it would have been without the shale revolution. [145] For the consumer, an increase in real disposable income per household of approximately $1,200 in 2012 is expected to steadily increase to $2,000 (constant 2012 $) in 2015 and more than $3,500 (constant 2012 $) by 2025. This is due to lower costs for natural gas used for heating, lower costs of various consumer goods due to lower manufacturing costs, and higher wages due to the increase in industrial and manufacturing activity.[146]

[139] The Fertilizer Institute, *Energy*, n/a
[140] ICIS Chemical Business, *Market outlook: Shale gas boom fosters growth for fertilizers*, 2013
[141] IEA, *World Energy Outlook 2013,* 2013, p.106
[142] IHS CERA, *Shale Gas Supports More Than 600,000 American Jobs, Study Says*, 2012

[143] IHS CERA, *Fueling the Future with Natural Gas: Bringing it Home*, 2014, p.ES-11
[144] IHS CERA, *Fueling the Future with Natural Gas: Bringing it Home*, 2014, p.ES-11
[145] Taheripour, et. al., *Assessment of the Economic Impacts of the Shale Oil and Gas Boom*, 2013
[146] IHS CERA, *Fueling the Future with Natural Gas: Bringing it Home*, 2014, p.ES-11

How does the "economic renaissance" impact Europe?

Lower gas prices in the US have stirred fears in Europe to lose shares of its industrial production to the American market.[147] Considering that in 2012, US gas prices were more than four times cheaper than in Europe, the "economic renaissance", as coined by President Obama, has given the US a growing sector advantage, as the EIA estimated costs for energy-intensive firms to be 5-25% lower compared to other developed nations, including Germany and Japan.[148] Generally, the degree to which Europe's petrochemical, chemical, fertiliser, and aluminium industries will be affected by the shale revolution will depend on European as much as on American price levels.

The recent Green Paper of the European Commission on climate and energy policies points out that critical for the maintenance of competitive electricity price levels in Europe will be the completion of the European gas market, and the serious assessment of its own indigenous resource potentials, paired with further diversification of energy sources. Higher electricity prices could also be caused by higher levels of the Emission-Trading-System (ETS), although this would be favourable for the transition from coal to gas powered plants. In order to ease the pressure on the industries, the Commission implemented state aid rules related to the ETS. These rules are aimed to allow compensation for part of the indirect ETS costs and targeted exemptions for electricity-intensive industries from energy related taxes.[149] The Green paper also notes that cheaper energy elsewhere does not always imply the loss of industry at home as it could also further energy-efficient industries. The paper stresses in this respect that 'the EU is a frontrunner in clean and more energy-efficient technologies, products and services and eco-technologies which together are expected to generate some 5 million jobs in the period up to 2020'.[150]

German Fears

The European country most affected by the new competition across the Atlantic is Germany. The industry sector comprises around 30% of Germany's GDP, and exports for more than 50%. [151] The country belongs to the world's largest and most technologically advanced producers of iron, steel, coal, cement, chemicals, machinery, vehicles, machine tools, electronics, and automobiles; industries that are electricity intensive, with some also requiring natural gas as a feedstock.[152] While in the US, industrial

[147] Buchan, *Can Shale Gas Transform Europe's Energy Landscape?*, 2013, p.1

[148] IEA, *World Energy Outlook 2013,* 2013, p.282

[149] European Commission, *Green Paper: A 2030 framework for climate and energy policies*, 2013, p.11

[150] European Commission, *Green Paper: A 2030 framework for climate and energy policies*, 2013, p.10

[151] CIA, *The World Factbook. Germany.*, 2014; IHS, *A more competitive Energiewende*, 2014

[152] CIA, *The World Factbook. Germany.*, 2014

feedstock prices for natural gas have dropped significantly since 2008, from $9.65/cf to around $5/cf in 2014, and industrial electricity costs have remained largely stable around $6ct/kwh, Germany, in contrast, entertains one of the highest energy prices in the world. This is primarily due to the ongoing costs of the *Energiewende* and the projected exit from nuclear energy. [153] One of the core assumptions of the *Energiewende* has been the outlook for gas and oil prices to continue to rise. The shale revolution, however, has rendered these expectations void.[154]

The Boston Consulting Group has estimated that between 2007 and 2013, German industrial electricity prices increased by almost 50€/MWh, or about 60%. This implies that by 2015, feedstock prices in the US will be 29% cheaper than in Germany, and production costs of electricity intensive industries 15%. [155] German companies, such as the world's largest chemicals producer BASF and the Linde Group (the world's largest industrial gas company by market share as well as revenue) have hence voiced concerns about increasing energy and natural gas prices in Germany. Energy costs, including gas and oil, are the largest cost factors in the industry's production. [156] Compared to the dropping energy prices in the US, the German chemical company Wacker Chemie reported an increase of 70% in energy costs over the past five years. [157] The Linde Group naturally announced its decision in 2013 to build the world's largest factory for the production and processing of syngas in Texas rather than Germany. Between 2010 and 2013 German chemical companies invested about 6.6€ billion in the expanding or constructing of plants in the US.[158]

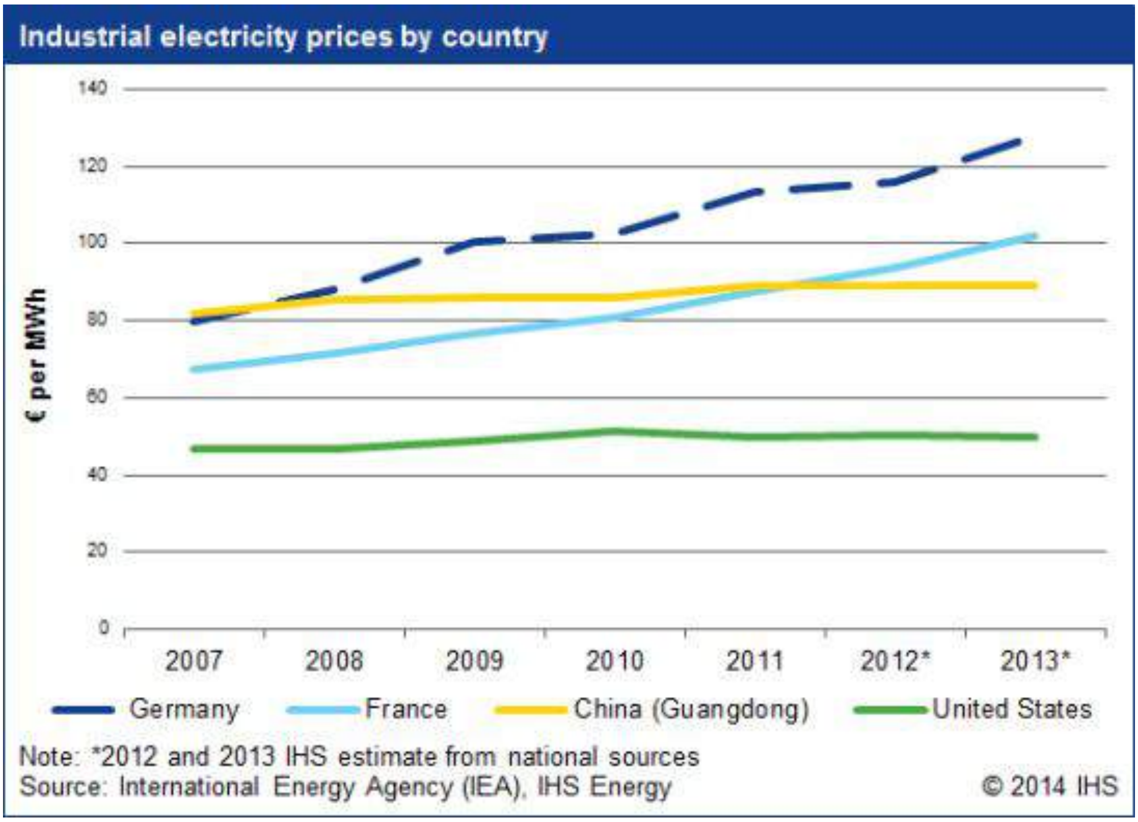
To counteract the loss in industrial competitiveness, Germany is currently rethinking its *Energiewende* and the exploration of its own indigenous resources. The German government for example reduced renewable subsidies in August 2014, to stabilise the rising energy costs.[159] Furthermore, a recent IHS study has forecasted that a development of shale-gas in Germany could add 138€ billion ($189 billion) to the country's GDP by 2040, which translates into an extra 847€ per year in disposable income for each German citizen.[160] In July 2014, a new policy regarding unconventional

[153] Germany Trade & Invest, *Die USA ziehen Chemieunternehmen an*, October 2, 2013
[154] IHS, *A more competitive Energiewende,* 2014
[155] Germany Trade & Invest, *Die USA ziehen Chemieunternehmen an*, October 2, 2013

[156] Frankfurter Allgemeine Zeitung, *"Wer Wachstum verbietet verhindert das Denken"*, April 21, 2014
[157] Format, *Fracking: US-Chemiefirmen laufen Deutschen den Rang ab*, July 9, 2014
[158] Chemietechnik Online, '*VCI: Verstärkte Abwanderung der Deutschen Chemie*', November 26, 2013
[159] Bloomberg, '*German Lawmakers Vote to Reduce Renewable-Energy Subsidies'*, June 27, 2014
[160] IHS, *A more competitive Energiewende,* 2014

explorations was passed which allows natural gas recovery from shale deposits below 3,000m. These test drills are however only allowed when the fracking process does not endanger the ground water, and hence require a comprehensive Environmental Impact Assessment. Conventional fracking methods continue to be exempt from the policy. Both policy changes regarding renewable subsidies and unconventional fracking methods in Germany take place in light of the events in the Ukraine in 2014 as well as the outlined contemporary economic and industry concerns.

Figure 11:
Industrial electricity prices by country



(Source: IHS, *A more competitive Energiewende*, 2014)

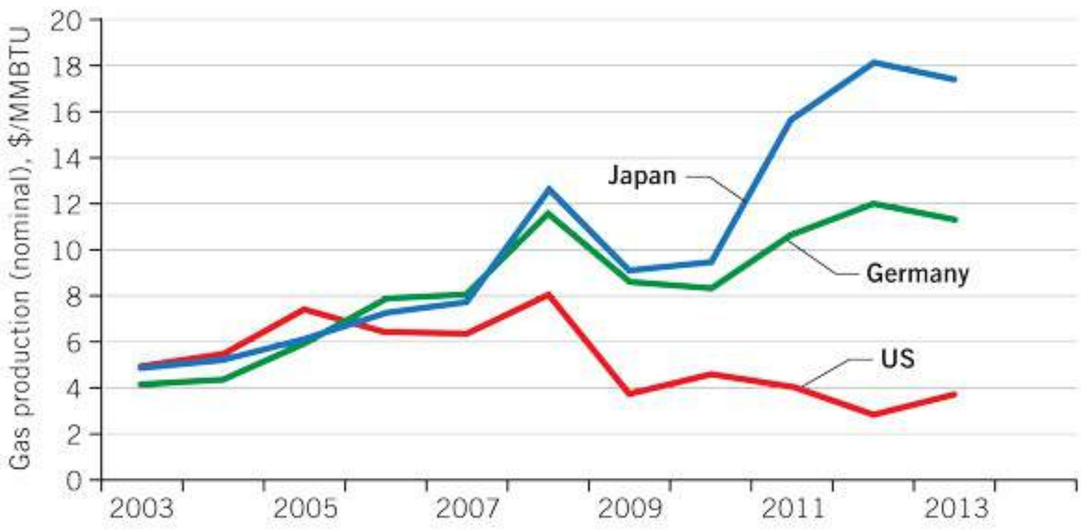
Implications of Shale Gas

Coming back to the development of price levels, one can observe that following the low point in summer 2012, prices steadily increased back to "healthier" levels of above $4/MMbtu in 2013 (compare Figure 9). This is due to the general increase in demand for natural gas, the industry's shift to recover shale gas primarily as a by-product during tight oil explorations, and especially due to the long and cold winter of 2013/2014. Gas prices hence remained around the $5/MMbtu mark for the first quarter of 2014, before returning to seasonally lower levels of about $4/MMbtu in July.[161] However, these dropping price levels compared to $12/MMbtu in 2012

[161] The Wall Street Journal, *'High natural gas prices are a taste of what's to come'*, January 27, 2014

as a result of the oversupply of natural gas were limited to the US. This is due to the fact that although large-scale natural gas output was suddenly available on the US regional market, it did not enter the global market due to the lack of necessary Liquefied Natural Gas (LNG) export infrastructure and the general governmental prohibition to export. The result was an increasing spread between regional benchmark prices (compare Figure 12).

Figure 12:
World Natural Gas Prices Compared,
2003-2013



(Source: Aguilera & Radetzki, *Shale gas and oil: fundamentally changing global energy markets*, 2013)

Considering the above outlined poor economic viability of shale gas at prices around $4/MMbtu, exporting LNG has received growing interest in the US, with multimillion dollar projects for export terminals having been approved by the DOE. Generally, the amendment to the Natural Gas Act has deemed LNG exports to Free Trade Agreement (FTA)-countries to be in the US' public interest and export applications are considered to be approved and export initiated in a timely manner. At the same time, export to Non-FTA countries requires the DOE to post "a notice of application in the Federal Registry for comments protests and motions to intervene, and to evaluate the application to make a public interest consistency determination." [162] The US has currently 19 FTAs of which 6 currently import LNG (Canada, Mexico, the Dominican Republic, Chile, Singapore and South Korea).[163]

[162] Department of Energy, *Applications Received by DOE/FE to Export Domestically Produced LNG from the Lower 48 States (as of March 24, 2014)*, 2014
[163] EY, *Global LNG*, 2013

According to the DOE, total approved FTA exports are expected to be around 38.51bcf/d, which equals around 393bcm/year. With only seven of the thirty-seven applications for Non-FTA export having been approved (at the same time with occasionally lower export amounts), only around 9.3bcf/day, constituting 95bcm/year, will be available to the non-FTA market.[164] Generally, the US has the world's largest LNG terminal project queue at the time of writing with 28 proposed projects, most of which are situated in the Gulf of Mexico. Considering the time factor in this respect, only one of the seven non-FTA project has received final approval and can be expected to begin exports by late 2015. Other projects – if approved – will only commence exports by 2017, at the earliest, but 2019 is generally considered more likely.[165] Crucial in this regard will be the stance taken by the Federal Energy Regulatory Commission, the second instance of the decision making process. Approval must be considered far from certain due to the energy independence ambitions and global demand constraints. The next round of approvals is expected for the third quarter of 2014. Also, capital investment for most projects has not been finalised.[166]

However, considering increasing domestic demand paired with scepticism about natural gas production rates following the current output levels, a premature export of natural gas might dramatically reverse the associated economic advantages of shale gas. Since demand for LNG exports is primarily connected with a low Henry Hub spot price and high oil-linked prices especially on the Asian markets, a rise in domestic prices due to the gradual downturn of gas production present a commercial risk for future export projects. This is further aggravated through the shift towards tight oil rather than shale gas explorations.[167] On the other hand, higher gas prices might also push the industries to return and explore plays currently considered uneconomic. A study by Deloitte on the impacts of US LNG exports estimated that prices were to fall significantly in regions importing US LNG, while natural gas prices in the US would rise only marginally.[168] Although potentially questionable from an energy security and the general domestic economic perspective, the export of LNG makes very much sense from a business point of view. Considering that domestic price levels are projected by the IEA as well as the EIA to remain at around $4.50-6/MMbtu for most of the next two decades, the profit margin for companies,

[164] Department of Energy, *Applications Received by DOE/FE to Export Domestically Produced LNG from the Lower 48 States (as of March 24, 2014)*, 2014

[165] Oilprice, *'US Green Lights 7th LNG Export Project'*, 25 March, 2014

[166] IGU, *World LNG Report*, 2014, p.23

[167] IGU, *Global LNG Report*, 2014, p.23

[168] Deloitte, *Exporting the American Renaissance. Global Impacts of LNG exports from the United States*, 2013, p.2

who in average breakeven at in the same price range, remains small at best.[169]

The Silent Export Revolution – Natural Gas Liquids

But even without the large scale export of LNG, the shale revolution has already caused the change of some existing patterns with regard to the market of Natural Gas Liquids (NGL). Liquefied Petroleum Gas (LPG), such as propane and butane, are used for example in rural home heating, cooking, agriculture, as an alternative transport fuel and in form of propene (won through propane dehydrogenation) as the second most important raw material in the petrochemicals industry. While domestic demand in LPG in the US is expected to increase as part of the petrochemical industry's expansion plans and as part of a potential long-term shift as a fuel in transportation, LPG production is estimated to continue to exceed demand in the medium-term, giving producers an incentive to find export markets for surplus supply. NGLs are extracted from the natural gas production stream in natural gas processing plants and production has been boosted to an all-time high as part of the shale revolution. Exports have hence increased from 67 thousand b/d in 2008 to 0.33 million b/d in 2013.[170] Introducing the US a new major player on the global LPG market has already had wide repercussions on trade dynamics. As the Oxford Institute for Energy Studies established in a study from July 2014, the rise in US LPG exports has 'allowed Asian players to have access to new sources of supply', while the impact on regard price levels remains 'less clear', with expansive developments in the Middle East further increasing overall supply.[171]

Will there be a global gas market?

Overall demand for natural gas has experienced a rapid growth over the past decades. For example in Asia, the Middle East and Latin America it has exceeded demand growth of oil. This development was furthered in the developed world by the potential of natural gas to be used as a flexible back-up for intermittent energy supplies of solar and wind, particularly for countries also sceptical about nuclear power.[172]

Regarding natural gas as a commodity for trade, in contrast to other primary energy sources, such as crude oil and coal, there continues to be no global market. This is rooted in the difficulty and hence the associated costs of transporting natural gas and has caused severe differences in regional price levels (compare Figure 10). While transport costs for oil range in the one-digit percentage of overall costs, for natural gas these may account for up to

[169] IEA, *World Energy Outlook 2013*, 2013, p.118

[170] The Oxford Institute for Energy Studies, *The US Shale Revolution and the changes in LPG Trade Dynamics: A Threat to the GCC?*, 2014

[171] The Oxford Institute for Energy Studies, *The US Shale Revolution and the changes in LPG Trade Dynamics: A Threat to the GCC?*, 2014, p.12

[172] Melling, Natural Gas Pricing and its Future, 2010, p.7

80%. [173] Consequently, there are disparate regional natural gas benchmarks also following different pricing mechanisms. On the one hand side, to counteract natural gas' volatility, most European and Asian countries have indexed gas to oil. On the other hand side, there is the mechanism based on hub pricing and traded markets of natural gas, originating from the US, and also used i.e. in the UK. [174] Furthermore, although natural gas is primarily marketed regionally, prices have many external and global factors, such as oil and coal prices (due to indexation and as alternative fuels), carbon dioxide prices (i.e. in the case of the EU emission trading system), and weather conditions (mild vs. extreme winters and its implications for demand).

Traditionally, natural gas has been brought to markets via pipelines, hence creating primarily regional markets, but also requiring large amounts of capital investment to facilitate these projects considering their high fixed costs. Consequently, natural gas trade normally requires long-term contracts to become feasible, since these projects require the guarantee of full-capacity operation with a long-term payback period. Large-scale infrastructural projects combined with long-term contractual obligations therefore have rendered flexible replacement of supply routes complicated. In addition, for safety concerns and the integrity of the gas grid it is difficult, expensive and dangerous to simply turn gas supplies on and off.[175] Especially the long-term binding character and regional limitation of natural gas contracts have rendered it an ideal coercive political tool. With commonly limited choices of suppliers, high rates of dependence and consequently prices have been inevitable thereby increasing political leverage of the exporter over its customers.

With technical limitations inhibiting the construction of a pipeline between i.e. the North American and the European and Asian continents, since the 1960s the liquefaction and transport of gas via tankers enabled a natural gas trade over longer distances. LNG trade however remained a niche market, only comprising about 5% of globally consumed natural gas in 2001. This is due to several reasons. Firstly, similar to pipeline projects, LNG trade requires high up-front capital investments for the construction of import and export terminals. Secondly, the liquefaction and regasification processes are associated with further high costs, as well as the general transport costs of shipping. Thirdly, with long-term pipeline contracts in place and natural gas being considered a "premium fuel" too valuable to be just burnt, for decades there was little excess demand. However, following the weakening of legal restrictions for the

[173] World Energy Council, *Energie für Deutschland*, 2013, p.19

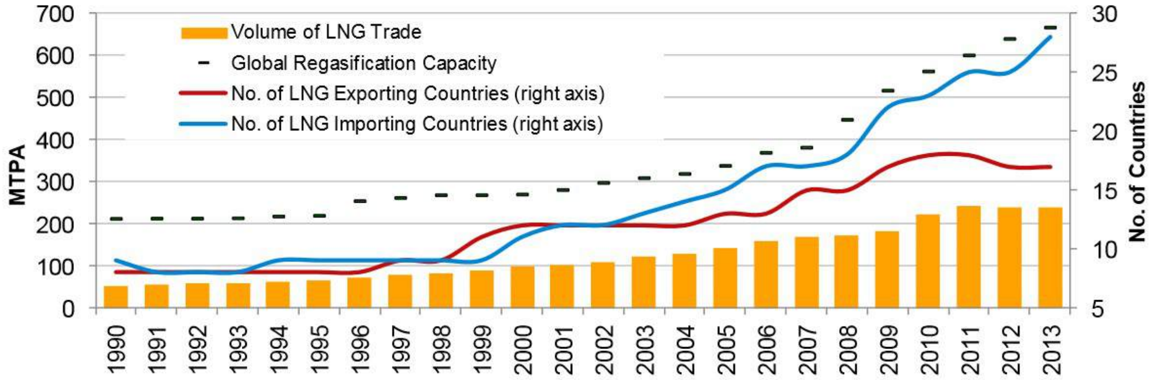
[174] Melling, Natural Gas Pricing and its Future, 2010, p.7

[175] Stevens, *The 'Shale Gas Revolution': Hype and Reality,* 2010, pp.2-3

utilisation of natural gas for power generation both by Washington and Brussels in the 1990s, paired with the increasing awareness of climate change and CO2 emissions, as mentioned above, natural gas moved to be considered the less carbon intensive bridge fuel of the future, and hence increased in importance and demand.

LNG generally bears considerable advantages over pipelines, also beyond the mere expansion of accessible markets, since once import and export terminals are in place and have excess capacity, natural gas trade does not necessitate long-term contracts anymore but can simply be bought at spot prices when needed, with tankers changing routes towards the highest bidder. Consequently, the global yearly LNG trade volume more than doubled from 143 bcm in 2001 to 330 bcm in 2011 with the number of exporting and importing actors as well (compare Figure 13). However, the bulk of this trade continued to take place within the existing regional submarkets rather than inter-continentally.[176]

Figure 13:
LNG Trade Volumes, 1990-2013



(Source: IGU, *World LNG Report*, 2014, p.7)

The current global LNG demand of almost 250 million tons per annum (mtpa) is expected to grow to 400 mtpa in 2020 and might reach 500 mtpa by 2030.[177] As a result, in 2013 overall liquefaction plants reached a capacity of 290.7 mtpa, overall regasification increased to 688 mtpa, and overall tanker fleet capacity to 54 mmcm, with 31 additional carriers expected by the end of 2014 (currently 357).[178]

Growing Competition will boost Spot Pricing

As can be seen from the above numbers, LNG trade has been primarily determined by supply constraints, rather than import capacities. While this is likely to continue until 2015, several developments in natural gas producers,

[176] World Energy Council, *Energie für Deutschland*, 2013, p.20
[177] EY, *Global LNG,* 2013, p.10
[178] IGU, *World LNG Report*, 2014, p.6

including the US, are expected to decisively increase the amount of LNG available on the market.[179] Growing trade competition, paired with potentially also increased indigenous recovery of unconventional outside the US, could shift the current pricing regimes of natural gas decisively.

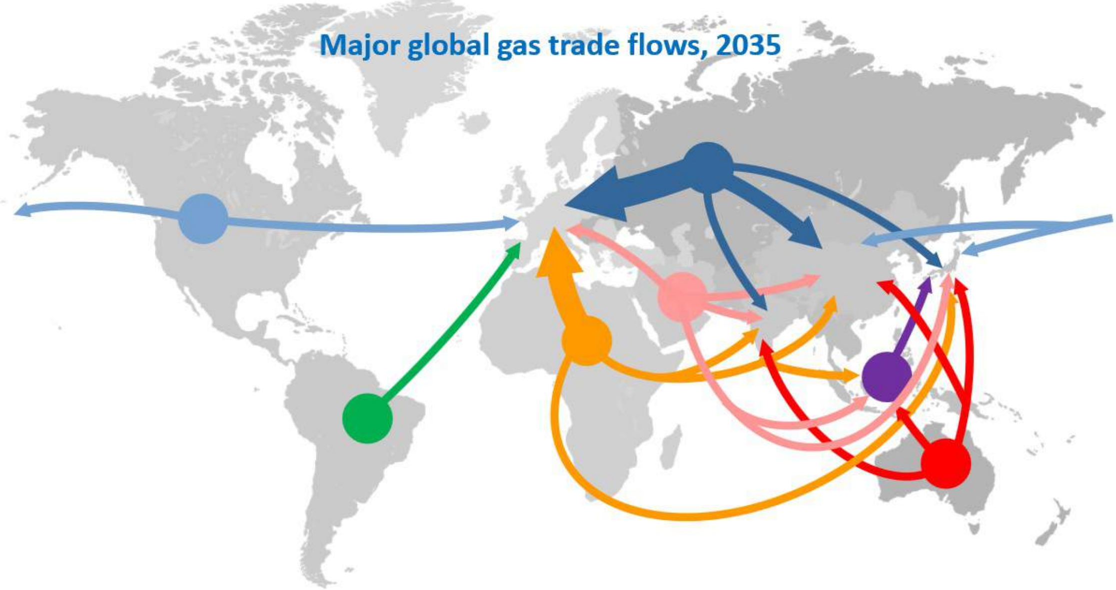
From a supply side, the next decade will see several actors expanding and new actors entering the market for LNG. Australia, which already has three LNG terminals in operation and another seven planned, is expected to supplant Qatar as the largest exporter of LNG by 2018.[180] The US is estimated to take the second place, from virtually no exports at the moment.[181] A study by David Ledesma of the Oxford Institute for Energy Studies concluded that Mozambique and Tanzania (though Mozambique in particular) bear great potential for future LNG exports. Despite the factor of domestic politics and policies, first LNG exports from Mozambique can be expected by the end of this decade, and LNG from Tanzania in the early 2020's. [182] These developments, paired with LNG expansion plans also in Algeria and Nigeria will lead to greater global competition on the LNG market. To illustrate growing global competition, while Algeria, Malaysia and Indonesia constituted about 60% of total traded LNG in 2003, this is expected to reduce to 20% by 2020. Instead, Qatar and Australia are projected to take about 50% of the global market share. The remaining 30% could be divided among as many as 25 other countries, including Mozambique, as well as the US and Canada.[183] A study by Rice University therefore estimated that shale gas combined with expansion plans of other natural gas producers will provide the global gas market with a 'wide diversity of sources instead of being concentrated in any one geographical region, and no single supplier gains significant market leverage'.[184]

Growing availability of gas has the potential for the regional gas markets to increasingly move away from oil-indexation in favour of spot pricing and a more globally set price for natural gas, similar to oil. Associated transport and processing costs will however remain an influencing factor in regional price differentials. Greater competition between sellers could nonetheless have far-reaching implications for the natural gas trade including 'more price-sensitive buyers; increasing energy deregulation; increasing gas-on-gas competition from new pipeline infrastructure; increasing spot market liquidity; and, most important, increasing availability of spot-price-based LNG exports'.[185] While spot price traded LNG before 2000 accounted

[179] IGU, *World LNG Report*, 2014, p.15
[180] The Globe and Mail, '*U.S. LNG export can have large impact overseas'*, April 27, 2014
[181] IGU, *Global Gas Report*, 2014, p.23
[182] Ledesma, *East Africa Gas – Potential for Export*, 2013, pp.31-32
[183] EY, *Global LNG,* 2013, p.8
[184] Medlock et.al., *Shale Gas and U.S. National Security*, 2011, p.28
[185] EY, *Global LNG,* 2013, p.15

for less than 5% of total traded LNG volumes, this had increased to 8% by 2005, 20% by 2010 and 33% in 2013 (compare Figure 14).[186]

Map 3:
Major global gas trade flows, 2035



(Source: IEA, *World Outlook 2012 - Presentation*)

As the historical reasoning behind oil-indexation was the security of supply, with increasing availability of gas on the market through an increasing variety of actors and a growing tanker fleet, this rationale becomes difficult to sustain. The general attractiveness of spot-pricing for buyers lies in the supply not linked to high and presumably increasing oil prices, and for sellers through the arising margin opportunities. However, the associated risks namely the volatility of prices currently continues to exist. While due to reasonably stable Brent crude prices of around $111/b during the second half of 2012 the German oil indexed gas price remained relatively flat, the British NBP rallied from a seasonably driven low of $8.53/MMbtu in August to $10.58/MMbtu in December. Nonetheless, this was still lower than the German oil-indexed price (just below $12/MMbtu).[187]

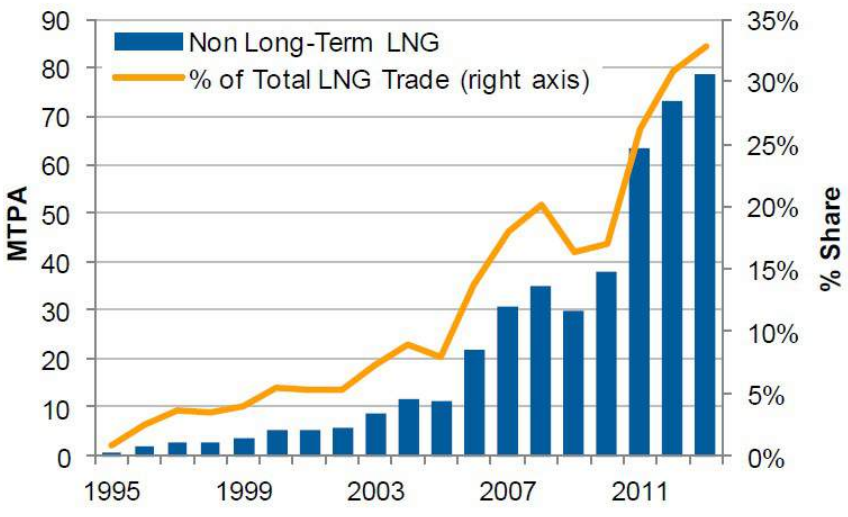
Generally, when spot prices are above oil-indexed prices there is little problem with the exception of potential upward price revision at the next re-opener opportunity. While also temporary oversupplies in spot markets present little threat to oil-indexed markets, the outlook for increased supply and hence heavily discounted spot and future prices constitutes a serious concern since it would lead to losses for utilities for those

[186] IGU, *World LNG Report*, 2013, p.13

[187] IGU, *World LNG Report,* 2013, p.14

players with long oil-indexed positions.[188] Consequently, for example Statoil, Europe's second largest supplier of natural gas, has announced it will increasingly move to spot-pricing contracts, as 'gas markets have gradually changed in Europe, from being based on long-term contracts and oil-indexed price formulas to being a more liquid and fully traded market, such as crude oil'.[189] A recent report on a potential new way of processing natural gas into liquid products could further reduce LNG costs in the future and further the development towards a global gas market and overcome the current large differences in regional prices.[190]

Figure 14:
Non Long-Term LNG Volumes, 1995-2013



(Source: IGU, *World LNG Report*, 2014, p.13)

[188] Melling, *Natural Gas Price and its Future*, 2010, p.32
[189] Bloomberg Businessweek, *'Statoil Merges Gas Trading with Oil to Suit Freer EU Market'*, February 18, 2014
[190] Reuters, '*Experts see cheaper, easier way to turn natural gas into fuels*', March 13, 2014

While in summary a global gas market with global pricing mechanisms is still far in the future, growing market competition over the next decades are expected to constitute crucial first steps towards increased spot pricing and decreased spreads between regional benchmarks. Such developments are likely to favour consumers, however also mean that natural gas may become increasingly volatile similar to oil in case of disruptions or the like.

What are the implications of US LNG for European energy security and Russia?

The US shale revolution has generally been observed with great envy from its allies across the Atlantic. Although Europe itself also holds considerable shale gas reserves, their exploration in the near future remains improbable. At the same time, growing dependence on imports and political conflict with its largest supplier Russia, have led Europeans to increasingly focus on their energy security again. As indigenous natural gas output has decreased by 25% from 2003 to 2013, this has increased the EU's energy import dependency of natural gas between 1995 and 2011 by

20%.[191] The dependence on overall energy imports is expected to rise to 80% by 2035.[192] In the newest Commission Communication regarding a European Energy Security Strategy, the EU reiterates the importance of energy efficiency as the first line of defence and the importance of increased interconnection between member states. In the long-run, renewable energies bear the greatest energy security potential due to their 96% indigenous production (4% are primarily biomass), while in the short-run, diversification of energy sources is considered critical.[193]

Considered a less carbon intensive alternative source for energy and less dangerous than nuclear power, gas-fired power generation in Europe began to set off in the 1990's.[194] By 2008, one quarter of gas consumed in Europe was used for power generation, compared to almost zero in 1988.[195] Generally, the EU's gas market is segmented among states and hence consists of 28 isolated markets under their respective national rules and prices. Consequently, it has been in the EU's primary interest to create a common European gas market both to enhance energy security through improved availability of gas as well as ensure lower prices through greater competition. The so-called European Gas Target (EGT) is set to be completed in 2014 and aims to facilitate 'the creation of a well-functioning EU market, consisting of national or cross-border interconnected entry-exit zones with virtual trading points'.[196]

While over the past years gas price levels had been the primary concern for the EU-28 policy makers, since the outset of the Ukrainian Crisis, energy security has been brought back to the table. This becomes all the more sensible considering tax receipts from Russian gas exports account for 30% of the Russian defence budget.[197] Europe is therefore eager to lessen its dependence on Russian imports and further diversify its energy sources also from a geopolitical point of view and in order to improve its political positioning. Generally, the bulk of European gas imports comes from four main producers: Russia (39%), Norway (33%), Algeria and Libya (22%

[191] European Commission, *EU energy in figures*, 2013, p.22

[192] EWEA, *Rising Energy Dependence Endangers Europe's economy*, 2013

[193] Energypost, *'Ten take-home messages from the new European Energy Security Strategy'*, May 30, 2014

[194] While natural gas is still a fossil fuel, it produces fewer emissions in combustion than for example coal or oil. In absolute terms, this means 135 lbs/ Megawatthours (MWh) of carbon dioxide, 0.1 lbs/MWh of sulphur dioxide, and 1.7 lbs/MWh of nitrogen oxides. Compared to the average air emissions from coal fired generation, natural gas hence produces half as much carbon dioxide, less than a third as much nitrogen oxides, and one percent as much sulphur oxides at the power plant. Numbers are regarding average contemporary power plant efficiencies.

[195] Melling, *Natural Gas Price and its Future*, 2010, p.36

[196] DG Energy, *Study on Entry-Exit Regimes in Gas*, 2013, p.4

[197] Chyong, et. al, *The Economics of the Nord Stream Pipeline System*, p.1

combined).[198] Although Russia continues to supply more than 30% of European gas, much has changed since the last two crises with respect to Ukraine as a transit country. In contrast to for example the 2006 crisis, when about 80% of total Russian gas to Europe transited through Ukraine, in 2014 this had been reduced to a mere 15%, primarily due to the Nord-Stream pipeline.[199] Nonetheless, especially Central and South-Eastern Europe remain highly dependent on Russian gas transiting through Ukraine. However, the majority of European gas is marketed in six countries (UK, Germany, Italy, France, Belgium and the Netherlands), which in 2010 together constituted 360bcm of the 492bcm of total consumption. While Eastern and Central European markets are hence the most vulnerable to security of supply disruptions they only compose a small portion of the European market. Considering the envisaged enhanced security of supply through greater competition through the EGT, it must be noted that the most vulnerable markets are unfortunately also the most unattractive ones from a mere economic perspective. Hence, their security of supply problem will most likely not be solved through economic liberalisation alone. Instead, it will require state or European involvement.[200]

The Russian Situation

For Russia, Europe remains the primary market for natural gas. About 76% of its natural gas exports is sold to western European markets.[201] The political differences between Europe and Russia, manifested through the recent crisis, paired with the freed up LNG through US growing self-sufficiency as well as the outlook of a largely increased global LNG trade from 2015 onwards, are decisive factors threatening Russian resource export revenues. One of the first casualties of these developments has been the Shtokman natural gas field in the Arctic Barents Sea, which was targeted to produce LNG for US market and was abandoned in August 2012.[202] Russian natural gas production must hence be considered in a difficult situation from a market perspective. Generally, about 74% of Russia's natural gas output comes from state-owned Gazprom which produces and holds more than 65% of proven reserves, with further reserves held through joint ventures with other companies.[203] However, Gazprom's continuous mismanagement and domestic subsidised gas prices eventuated in Gazprom selling 60% of its gas domestically at a loss. Furthermore, Gazprom's greenfield investment

[198] Parmigiani, *The European Gas Market,* 2013, p.12; European Commission, *European Energy Security Strategy*, 2014, p.15
[199] The Guardian, '*Is Europe's gas supply threatened by the Ukraine crisis?*', March 3, 2014
[200] Parmigiani, *The European Gas Market,* 2013, p.16
[201] EIA, *Russia*, 2013
[202] Bellona, *Russia's Gazprom mothballs Shtokman gas field for 'future generations*, 2013
[203] EIA, *Russia*, 2013

capabilities are crucially hampered through highly expensive pipeline projects of the Kremlin, such as Nord Stream (official cost: € 5.7billion),[204] and the primarily geo-strategically motivated South Stream (estimated at €28 billion),[205] both circumventing Ukraine as a transit state. Gazprom generally attempts to balance out its domestic losses through its exports, which are sold at around 66% profit.[206] It is therefore generally estimated that Gazprom requires a price of $12/mcf to break-even, however due to the increased pressure of lower spot prices, the company had been forced to continuously renegotiate delivery prices of its contracts to levels closer to the spot market.[207] Nonetheless, despite Gazprom's discount on prices of up to 10%, its share of the European market decreased by 8% in 2012, while its direct competitor Norway's Statoil increased its share by 16%. Overall, Gazprom's profits fell by 12% in the first nine months of 2012, while its operational costs increased by 18%.[208]

In addition, by the end of last year, the prospect of Russia's supply of gas to the Ukraine had been brought into question. This was due to Kiev's plans to explore shale gas in its eastern and western parts of the country,[209] as well as expanding its offshore gas projects in the Black Sea combined with an LNG terminal to further diversify its energy sources by importing LNG from countries such as Qatar and Azerbaijan.[210] Ukraine is estimated to hold the third largest shale gas deposits in Europe (after France and Poland) of an estimated 42 tcf,[211] and is the second largest importer of Russian gas (after Germany).[212] Although putting the current Ukrainian crisis – and Russia's role in it – in causal relation with this outlook might be farfetched, the current security situation in Ukraine has put most of these projects (with the exception of its western shale deposits) on hold for the near future. This in return could imply that by the time the current contract with Gazprom runs out (in 2019), Ukraine will not have had the chance to diversify enough to not remain highly dependent on Russian gas – something that plays into Russian hands.

US LNG to Europe?

Whether LNG from the US will enter the European market is inherently dependent on market price levels. There are, however, other aspects also important to consider. To reiterate, energy resources

[204] Natural Gas Europe, *Russia Plans Massive Expansion of Nord Stream Pipelines*, 2013

[205] The Wall Street Journal, *'Gazprom Raises Price of South Stream Pipeline Project'*, January 29, 2013

[206] Aron, *The Political Economy of Russian Oil and Gas,* 2013, p.5

[207] Bloomberg, *'RWE Renegotiating Gazprom Contract to Seek Market-Based Solution'*, January 30, 2014

[208] Aron, *The Political Economy of Russian Oil and Gas,* 2013, p.5

[209] The Financial Times, ' Ukraine signs shale gas deal with Chevron', November 5, 2013

[210] Hydrocarbons-technology.com, Ukraine LNG Terminal

[211] European Parliament, The Shale gas 'revolution' in the United States: Global implications, options for the EU, 2013, p.11

[212] EIA, *Ukraine*, 2014

are considered a strategic commodity in the US. While exports to FTA countries are considered in line with the public interest, exports to non-FTA countries need special approvals. President Obama stated during his visit to Brussels in March 2014 that 'we've [the US] already licensed, authorized the export of as much natural gas each day as Europe uses each day. But it's going into the open market; it's not targeted directly'. [213] However, this statement on the capacity of exports must be considered slightly exaggerated. Current LNG projects in the US, if approved, would have an overall capacity of around 393bcm/year – around 38.51bcf/d, as mentioned above. Furthermore, the seven of the thirty-seven approved applications that allow exports to countries without a free trade agreement (Non-FTA) constitute about 95bcm/year or 9.3bcf/day. In contrast, the yearly natural gas consumption in the EU is in fact around 480bcm, so around 46.43bcf/day, and therefore far above total planned US exports. Expectations that see US LNG replacing Russian imports are hence unfounded as the EU imports a total of around 125bcm of natural gas per year from Russia. It is also important to recognise that US LNG will not be directly targeted for Europe but sold against other regional markets – divided among FTA and non-FTAs. Considering that no European country, let alone the EU, has a FTA with the US, under current conditions, Europe would have to compete for the currently allowed 95 bcm/year with other non-FTA markets, such as Japan, the world's largest LNG importer, and China, which are far more attractive markets due to their higher regional price levels.[214]

To increase the possibility of US natural gas entering the European market, negotiations over a FTA have hence received new impetus, which had somewhat slowed down following the NSA revelations, and considering general scepticism about the consequences of such an agreement.[215] As the statement of the US-EU summit in March 2014 stressed:

> 'The situation in Ukraine proves the need to reinforce energy security in Europe and we are considering new collaborative efforts to achieve this goal. We welcome the prospect of US liquid natural gas exports in the future since additional global supplies will benefit Europe and other strategic partners'.[216]

However, even if negotiations progress by the time the first LNG exports enter the global market (by 2015 at the

[213] Obama, *Press Conference by President Obama, European Council President Van Rompuy, and European Commission President Barroso*, 2014

[214] Office of the United States Trade Representative, *Free Trade Agreements*, 2014

[215] Todhunter, *The US-EU Trans-Atlantic Free Trade Agreement (TAFTA). Devastating Social and Environmental Consequences*, 2013

[216] The Guardian, '*European leaders ask Obama to allow increased exports of US shale gas*', March 26, 2014

earliest), prices will continue to determine its destination.

LNG contracts are generally based on Henry Hub spot price, plus about 15% for fuel use/shrinkage and a fixed liquefaction charge of around $2-3/mcf.[217] Hence, considering both export (liquefaction) and import costs (regasification), as well as shipping, the IEA calculated that LNG trade between the US and Europe could be between $4.3/MMbtu and $7.5/MMbtu. For US trade with Japan, this would only be $1/MMbtu higher: $5.3/MMbtu to $8.5/MMbtu.[218] Considering average gas prices in Europe at $11/MMbtu, and in the Asian market of $16/MMbtu the profit margin would be exponentially higher on the latter. While, of course, there remains the possibility that for strategic reasons the US government decides to directly target gas to the European market, US LNG might still have indirect positive effects for Europe without such governmental interference. The lack of import demand in the US, as well as the already outlined growing competition due to various LNG export projects have already and will continue to free up significant amounts of natural gas for the global LNG trade. With US gas most likely reaching primarily the Asian market, gas from Qatar and West and North Africa may be freed up to enter the European market. At the same time, with greater competition on the Asian market through the abovementioned actors, prices may reduce significantly enough for the European market to become attractive also for US LNG.

In addition to larger amounts of natural gas available on the global market, the shale revolution has also freed up a vast number of coal, no longer used for power generation in the US, and caused severe price drops. While questionable from an environmental perspective, coal demand has already been increasing Europe over the past year, replacing natural gas. Paired with the economic crisis of 2008 and continuous efficiency improvements, demand growth for natural gas has slowed down significantly and in fact has been decreasing for the third year in a row (10% decrease in 2011, 2% in 2012, and 1.4% in 2013).[219] The development has also shown the unsuccessfulness of the EU's Emission-Trading-System (ETS). While in early 2013, according to the IEA, a carbon price of around 45€/tonne of CO^2 (tCO^2) would have been necessary to trigger switching from an average efficient coal plant to an average efficient gas-fired plant, actual ETS allowances were traded at around 4€/tCO^2.[220] The European Commission has, however, already reacted and proposed a so-called "backloading" in November 2012, entailing the deferral of

217 EY, *Global LNG,* 2013, p.10
218 IEA, *World Energy Outlook 2013,* 2013, p.133

219 Eurogas, *Drop in 2013 EU gas demand emphasises need for swift change*, 2014
220 DG Energy, *Quarterly Report on European Gas Markets*, 2013

certificate issuing until 2019/20 instead of the originally planned 2013/14/15.[221]

Nonetheless, while US LNG from the US might only reach the European market in small numbers, the outlook for the global LNG market paired with cheaply available coal (though negative from a transition to gas and climate change perspective) are a definite support for the European energy markets and its security of supply. The expected growing role of renewables in the European future energy mix and a growing availability of natural gas on the world market are likely to have positive impacts both for European energy security as well as consumer prices. With the current tensions between Europe and Russia continuing, in the long-term the situation has the potential to play more in favour of Europe. For Russia, these developments must be considered highly disadvantageous. With the EU, Russia's main export destination, having shown decreasing demand over the past years and with the IEA not expecting major growth in its 2035 scenario (only a 6% annual growth rate) Moscow is increasingly shifting its focus towards Asia.

The Strategic Pivot: What are the Effects for Asia?

Considering the global economic, trade and population dynamics, it becomes apparent that the stage for the 21st century will be the Asia-Pacific region, and the US – similar to Russia – is eager to also play a central role in that drama, confirmed through the US' shifting "strategic pivot". Most recent data compiled by the International Comparison Program sees China to take over as the world's leading economic power in 2014; about five years earlier than previously predicted.[222] China also recently surpassed the US as the most electrically powered nation in the world with 1.25 trillion watts (compared to 1.16 trillion watts in the US), although the US has still a four-time higher per capita power consumption.[223] From a geostrategic point of view, however, conflict between regional actors i.e. considering the island disputes between China and Japan or Vietnam could threaten US interests in the region including the vital trade route through the Malacca Straits. Energy, both through direct trade of the resource as well as the trade of the technology for shale recovery, could and should hence be used as a tool by the US to strengthen its relationship with China. The facilitation of mutual energy-sector investments (as already taking place) could further increase interdependence with positive implications for US national security, i.e. regarding potential cyber-

[221] World Energy Council, *Energie für Deutschland*, 2013, p.67

[222] The Financial Times, *'China poised to pass US as world's leading economic power this year'*, April 30, 2014

[223] Energypost, 'China's continuing renewable energy revolution: global implications', April 3, 2014

attacks against US infrastructure. Generally important for exports towards Asia will however be the completion of the expansion of the Panama Canal, which was scheduled for the end of 2014 but experiences delays of at least a year.[224] With the first completed export terminal in 2015, the Sabine Pass, being situated on the Gulf of Mexico, the timely expansion of the Panama Canal will be essential since only 4% of the current LNG tanker fleet can fit through the canal under current conditions.[225] Hence, the voyage from the Sabine Pass to the Asian market would be extended by approximately 10 days with further associated costs.[226]

As mentioned above, with far more attractive prices for natural gas on the regional markets, the bulk of US LNG is expected to reach the Asian markets. Following the sharp increases in domestic demand paired with the lack of domestic output, the regional benchmark, the Japan Korea Marker (JKM), surged from $9/MMBtu before 2011 to over $16/MMBtu in 2012.[227] In early 2014, prices even skyrocketed beyond the $20 mark, rendering electricity production costs higher than its selling prices.[228] Generally, South Korea relies for at least 93% of its overall energy consumption on imports,[229] while Japan's import dependence soared especially in the aftermath of the Fukushima disaster; nuclear power constituted about 30% of the electricity generation mix in 2010, by 2012 this had reduced to a mere 2%, causing LNG imports to increase from 29% in 2010 to almost 50% in 2012.[230] Today, Japan meets less than 15% of its total primary energy use with indigenous production.[231] This has led the government to reconsider the complete exit from nuclear power. However in the past Prime Minister Abe has repeatedly changed his position in this respect.[232] Geo-strategically, both countries are highly dependent on fossil imports from Indonesia and the Middle East, passing through the crucial trade chokepoint of the Malacca Straits. A diversification of imports from across the Pacific could hence fundamentally enhance the national security of the two countries.

Japan and South Korea, as the two largest LNG importers in the world, have already made preliminary contracts with the US. In May 2013, when the DOE approved the export of LNG to non-FTA countries from its Freeport LNG terminal situated in the Gulf of Mexico, Japan's Chubu Electric and Osaka Gas signed preliminary agreements to import over 100 bcf/y each for 20 years from 2017

[224] The Wall Street Journal, *'Progress seen on Panama Canal Impasse'*, February 14, 2014
[225] Bloomberg, *'Panama Canal's LNG Surprise to Redefine Trade in Fuel: Freight'*, November 5, 2013
[226] IGU, *Global LNG Report*, 2014, p.48
[227] National Bureau of Asian Research, *Energy Mix in Japan – before and after Fukushima,* 2013
[228] Nikkei Asian Review, *'Cold snap heats up LNG spot prices in Japan'*, February 22, 2014
[229] EIA, *South Korea*, 2014
[230] National Bureau of Asian Research, *Energy Mix in Japan – before and after Fukushima*, 2013
[231] EIA, *Japan*, 2014
[232] Reuters, *'Japan approves energy plan reinstating nuclear power'*, April 11, 2014

onwards. At the same time, the Sumitomo Group (Japan's third largest keiretsu, meaning a set of companies and shareholdings with interlinked business relationships) holds an agreement to buy 110 bcf/y for 20 years from Cove Point LNG on the U.S. East Coast.[233] Similarly, South-Korean KOGAS is eager to import an already agreed amount of 3.5bcm of gas from the Sabine Pass terminal in the Gulf Coast. The agreement had been favoured by the fact that the US and South Korea entertain a FTA. KOGAS also held stakes in Canadian shale plays since 2010 and is part of the "LNG Canada" joint venture, together with inter alia Shell, Mitsubishi, and CNPC – though KOGAS announced it sold 5% of its shares to Shell in May 2014, in order to reduce its debt as demanded by the government.[234]

This outlook for US LNG exports to Japan and South Korea is already exerting pressure on the currently largest exporter of LNG, Qatar. By undercutting the current contractual price levels, these contracts forced Qatar to reduce long-term contract prices indexed to oil. The so called slope, the percentage amount of 1 MMBtu against the barrel price, was reduced to the 14.6-14.7% range, effectively undercutting the Australian and Papua New Guinean prices, whose long-term contracts are at an average of 14.85%.[235] It is likely that with more LNG entering the Asian market, such competitive measures will be seen more frequently, exerting downward pressure on prices. As outlined above, while Qatar continues to advocate oil-indexed long-term contracts due to their predictability and security of demand, their share can be expected to decrease further, giving way to increased spot price trades due to an increasingly global LNG trade.

In order to profit and impact global trends in the natural gas sector, Qatar has also been an important investor in North American shale gas ventures. In May 2013, Qatar Petroleum International and ExxonMobil announced to jointly develop a $10bn export terminal at Golden Pass Texas, which had been initially planned as a US import terminal, inter alia for Qatari gas.[236] Qatar also bought a $1bil stake of Suncor Energy Inc's natural gas assets.[237] Although, however, much of US gas exports are expected to compete with Qatari gas on the Asian market, there are several strategic aspects underpinning the move by Qatar to financially support the shale revolution, and thereby America's export ambitions. Firstly, by buying into the North American gas sector, Qatar is

[233] EIA, *Japan,* 2014

[234] Natural Gas Asia, '*Kogas Sells Part of its Stake in LNG Canada to Shell*', May 2, 2014

[235] Reuters, '*Qatar cuts gas prices to keep competition at bay*', November 8, 2013: Bloomberg, '*A Little Less Rich: Qatar Gas Dominance Challenged*', April 1, 2014

[236] Global Arab Network, '*Qatar investing in shale-related projects in North America*', August 19, 2013

[237] Zawya, '*Mideast energy giants invest in North American shale*', February 4, 2014

bolstering its role along the entirety of the production chain. Secondly, increasing LNG capabilities on the American continent might also have positive effects for existing Qatari investments in currently underutilised regasification plans in the UK, with the expectation of future transatlantic LNG trade. Thirdly, supporting Europe's energy security through multiple investments in the North American continent strengthens Qatar's geopolitical position.[238] Finally, by effectively supporting the export of LNG from the US that would coincide with newly built LNG plants in Australia, price levels might lead to make Australia's coal-bed methane LNG unprofitable, hence reducing Qatar's loss of market share to Australia.

Coming back to the key player on the Asian market, the current Chinese gas demand stands at around 16 bcf/day, and imports account for 31.6% of total consumption.[239] However, unlike other players in the region, such as South-Korea and Japan, China actually holds considerable amounts of indigenous reserves, including shale. The Chinese gas market itself is essentially a fixed-price model and in one dominated by long term contracts with gas indexed to crude oil. According to the EIA, China's natural gas prices, similar to retail oil prices, are hence government regulated and generally below international market rates.[240] While most of China's imported natural gas enters the country via pipelines, since the construction of the first regasification terminal, Dapeng LNG, in 2006, LNG imports have risen dramatically, rendering China one of the largest LNG consumers in the world. In 2012, LNG imports reached 706bcf, a rise of 20% from 2011 levels (581 bcf). Overall LNG capacity currently stands at 1.5 tcf/year (4.1 bcf/day), with an expected increase of 2 bcf/day by 2016.[241] To further diversify its energy sources, China has begun to invest heavily in LNG from North America, through shale plays or directly in LNG projects, i.e. in Canada. 'CNPC [China National Petroleum Corporation]owns a 20% share in the LNG Canada project, and CNOOC [China National Offshore Oil Company], through its wholly-owned Canadian company, Nexen, recently purchased land in western Canada to explore opportunities to develop a liquefaction terminal'.[242] Due to the contango market situation of the Henry Hub, combined with the associated costs of LNG and strong competition from the Japanese and Korean gas markets, it is questionable how much LNG from the US will actually reach the Chinese market. Nonetheless, overall North American LNG exports will affect the competitive scene of the Asian market, further freeing up gas from other actors,

[238] Global Arab Network, *'Qatar investing in shale-related projects in North America'*, August 19, 2013

[239] RT, *'The birth of a Eurasian century: Russia and China do Pipelineistan'*, May 20, 2014

[240] EIA, *China*, 2014

[241] EIA, *China*, 2014

[242] EIA, *China*, 2014

and potentially exerting downward pressure on overall price levels. Furthermore, Chinese investments in shale plays in the US also follow the strategy to acquire valuable technological know-how for domestic shale explorations in China. Between January 2011 and February 2013, CNOOC, Sinopec, Sinochem, and Petrochina invested a total of more than $30 billion in assets, funding, joint ventures, stakes and acquisitions in shale companies across the Atlantic.[243] Considering the already outlined vast shale reserves in the country, their large scale exploration could shift future market trends decisively.

LNG from the US is not the only factor for the rather positive supply outlook of the Asian markets. Prices are likely to be affected by increased exports from the mentioned other actors in East Africa and Australia. For example, South Korea also plans to expand imports coming from Australia through the new Prelude LNG and Gladstone LNG projects, and has voiced interest to secure imports from the offshore LNG fields in Mozambique.[244] Russia, as already mentioned, has also moved several plans of supplying the Asian continent forward. Most notable has been the agreement for a Sino-Russian pipeline earlier in 2014. The $400 billion deal between Russia's Gazprom and CNPC, which had been negotiated for 10 years, includes a yearly Russian gas delivery of around 38 bcf via the 'Power of Siberia' pipeline, which would roughly equal a quarter of contemporary gas exports to Europe. Under the 30 year deal, Gazprom will begin exports in 2018.[245] The deal will provide Russia with the necessary funds to expand its projects in eastern Siberia, and the possibility to counteract some of the abovementioned struggles in current production outlooks with regard to the European market. These combined regional developments could also have expansive long-term implications for East Asia as Russia strives to act as an energy hub also for South-Korea and Japan. The Russian government in fact wrote off North-Korean debts from the Soviet Era, in order to smooth the political situation and facilitate the construction of a 10bcm pipeline through North to South Korea.[246] The combination of the above factors is likely to lead to greater competition among suppliers and lower prices for consumers.

What about Iran?

As the already mentioned potential first geopolitical "casualty" of the shale revolution, the return of Iran to the international gas market could further increase the outlined competition on

[243] CIEP, *Development Strategies of the Chinese Natural Gas Market*, 2014, p.39
[244] Cheung, *South Korea: A paradigm shift in energy policy,* 2013, p.80
[245] RT, *'The birth of a Eurasian century: Russia and China do Pipelineistan'*, May 20, 2014
[246] Natural Gas Asia, *'Russia Writes Off North Korea Debt to Facilitate Gas Pipeline to South Korea'*, April 19, 2014

future global gas markets. In fact it is not unlikely that the shale revolution and the outlook of an increasingly competitive global gas market were decisive factors in bringing the Iranian government back to the negotiation table on its nuclear program. This certainly was also paired with the country's need to acquire critical revenues for its stagnating economy. The country generally bears tremendous resource potential, with an estimate of 1,187 tcf of conventional gas and 154bn barrels of crude oil.[247]

Since the 1970's, Iran has been subject to various sanctions regimes both mandated and non-mandated through the UNSC (United Nations Security Council). Sanctions have been reasoned by the US through 'Iran's continued illicit nuclear activities' and aimed 'to censure Iran and prevent its further progress in prohibited nuclear activities, as well as to persuade Tehran to address the international community's concerns about its nuclear program'.[248] The most extensive regime from the US is the Iran Sanctions Act (ISA) of 1996, formerly known as the Iran and Libya Sanctions Act, with Libya however being removed from the Act in 2006. US sanctions were extended through the naming of Iran as a "state sponsor of terrorism" following the 9/11 attacks, triggering sanctions such as the restriction of sales, prohibition of arms trade and US financial assistance[249] – with the exclusion of emergency aid, as seen in the offer of US aid following the severe earthquakes in Iran 2012, which were however rejected by the Iranian government.[250] The contemporary US trade sanctions regime against Iran has been codified through the Comprehensive Iran Sanctions Accountability and Divestment Act (CISADA) of 2010.[251]

The sanctions' targeting of Iran's energy sector is founded in the country's high reliance on energy revenues, with oil exports constituting 20% of the country's GDP, 80% of its foreign exchange earnings and about half of government expenditures – before the initiation of oil export sanctions in 2012. These sanctions were combined with cutting the country's access to the international banking system, resulting in limited accumulation of and access to foreign exchange reserves. Furthermore, sanctions against US investments in Iran's energy sector not merely banned equity and royalty arrangements but any contract that included 'responsibility for the development of petroleum resources of Iran, including pipelines, and contracts regarding construction, upgrading or expansions of energy projects'.[252]

[247] EIA, *Iran*, 2014

[248] U.S. Department of State, *Iran Sanctions*, 2014

[249] Congressional Research Service, *Iran Sanctions*, 2014, pp.3-5

[250] NationalJournal, *'Iran Declines U.S. Aid Offer After Earthquakes'*, August 13, 2012

[251] Congressional Research Service, *Iran Sanctions*, 2014, p.5

[252] Congressional Research Service, *Iran Sanctions*, 2014, p.9

Consequently, by late 2013 Iranian oil exports had decreased to 1MMb/d from 2.5 MMb/d in 2011, the Rial had reached an inflation rate of 50%, and the Iranian economy had contracted by 5%.[253]

Furthermore, since Iran lacks the refinery capacity to process its vast domestic crude oil into gasoline, the country relies on imports for 30-40% of its consumption.[254] However, due to the continuing sanction regimes, many traditional suppliers have terminated their business with Iran. Nonetheless, import quantities were recorded around 50,000b/d in early 2014 coming primarily from Asian countries, circumventing Western sanctions.[255] However, in 2007, Iran mandated for all domestically manufactured cars to have a dual-fuel capacity, also running on Compressed Natural Gas (CNG), to counteract the increasing costs. Hence, with 3 million Non-Gasoline Vehicles (NGVs) on the streets, Iran has the largest NGS fleet in the world, however with a ratio of 1,262 cars per refuelling station.[256] Overall, since Iran's existing natural gas reserves exceed those of oil, gas prices are also generally lower (around 1ct per gallon, compared to 38cts per gallon of gasoline) as well as subsidised to support increased demand in gas in order to free up crudes for export. This has been aided through the fact that CNG has no refill limit, unlike gasoline, where Tehran imposed maximum rations of 21 gallons per month.[257]

Natural gas as a good has been relatively unsanctioned, with only the EU directly targeting Iranian natural gas exports. However, the lack of foreign investment and adequate financing have caused a slow growth in the country's natural gas production and its high inefficiency.[258] Generally, of the overall produced natural gas (7.9 tcf), about 67% is marketed (abovementioned 5.4 tcf) with 16% (1.2 tcf) being re-injected to enhance oil recovery. The remaining 0.6tcf or 17% are lost in shrinkage and flaring – indicating the abovementioned inefficiencies.[259] The sanctions regimes are also crucial for the absence of a single operational LNG export facility in Iran, despite its continuous aspiration to enter the global LNG market since the 1970s. While ISA did not directly target LNG, CISADA sanctioned LNG investments in Iran, or the supply of LNG tankers or pipelines. Hence, the absence of any LNG development is essentially caused by the lack capital investments. In addition and even more importantly, the

[253] Congressional Research Service, *Iran Sanctions*, 2014

[254] Foundation for Defense of Democracies, '*Another Way to Sanction Iran: Natural Gas*', May 28, 2014

[255] Foundation for Defense of Democracies, *'Iran Gasoline Imports at Nearly 50,000 bpd-Sources*', May 29, 2014

[256] The New York Times, ' *In Oil-Rich Iran, Natural Gas Turns Wheels*', October 23, 2012

[257] Foundation for Defense of Democracies, '*Another Way to Sanction Iran: Natural Gas*', May 28, 2014

[258] EIA, *Iran*, 2014

[259] EIA, *Iran*, 2014

necessary technology to construct and operate LNG terminals is patented by US firms, and hence inherently unavailable for sale to Iran.[260]

Following the detrimental effects of the continuous sanction regimes, and by increasingly losing its power in "energy diplomacy" to support its nuclear ambitions inter alia through the shale revolution, Iran's leaders agreed to a Joint Plan of Action on November 23, 2013, concurring to the initiation of negotiations to formulate an agreement for Iran's peaceful utilisation of nuclear power and including the country's termination of its nuclear weapons and WMD programs. Should these negotiations be successful, and international sanctions against Iran be lifted, the country would most likely still need several years to develop significant export capacity, combined with vast capital investments. Current plans to further develop the South Pars gas fields shared with neighbours in the Persian Gulf alone require $14bil capital investments. Over the past two decades, the South Pars has been plagued by 'technical problems, contractual disputes and the imposition of sanctions that forced international oil companies (IOCs) to step back'.[261] The deadline for the nuclear talks has been extended until November 2014 after talks failed to reach agreement in July.

A return of Iran to the gas market could however become another "game changer" for global energy markets, and particularly for Europe. While any future trade with the continent would face several obstacles, it could also transform regional geopolitics. In order for Iran to however export gas, it would either need to begin the construction of LNG terminals, or further connect its southern gas fields with the Turkish border. From there, Iranian gas could enter the Southern Corridor and via the Trans Adriatic Pipeline enter the European market. Turkey is already looking to double its imports of natural gas from Iran from 10bcm to 20bcm, potentially solely to re-sell it to Europe. Whether Iran will be able to meet these targets in the short-term is questionable considering their contemporary import of natural gas to inter alia meet existing contractual obligations.[262] Nonetheless, any greater role of Iranian gas for the European market could further undermine Russian dominance. As Russia remains one of the few allies of the Iranian government, such a development could however strain the relationship between Tehran and Moscow.

[260] Congressional Research Service, *Iran Sanctions*, 2014, p.18

[261] The Telegraph, *'Iran offers Europe gas amid Russian energy embargo fears'*, May 4, 2014

[262] International Policy Digest, ' *How Iran can save Europe from Russian Energy Dominance'*, March 10, 2014

Implications of Shale Oil

With natural gas prices plummeting, drilling companies in the US increasingly shifted to tight oil plays, continuing to recover natural gas in associated form. With crude oil and its refined products being sold on a global market, combined with the commodity's monopolistic role in the transport sector and consequent robust demand growth, the exploitation of tight oil has been far more lucrative than shale gas, balancing out some if not all losses experienced by the industries. In contrast to the difficulty of natural gas to be transported, crude oil and its derivatives are produced, refined, and marketed globally as well as denominated to the dollar.

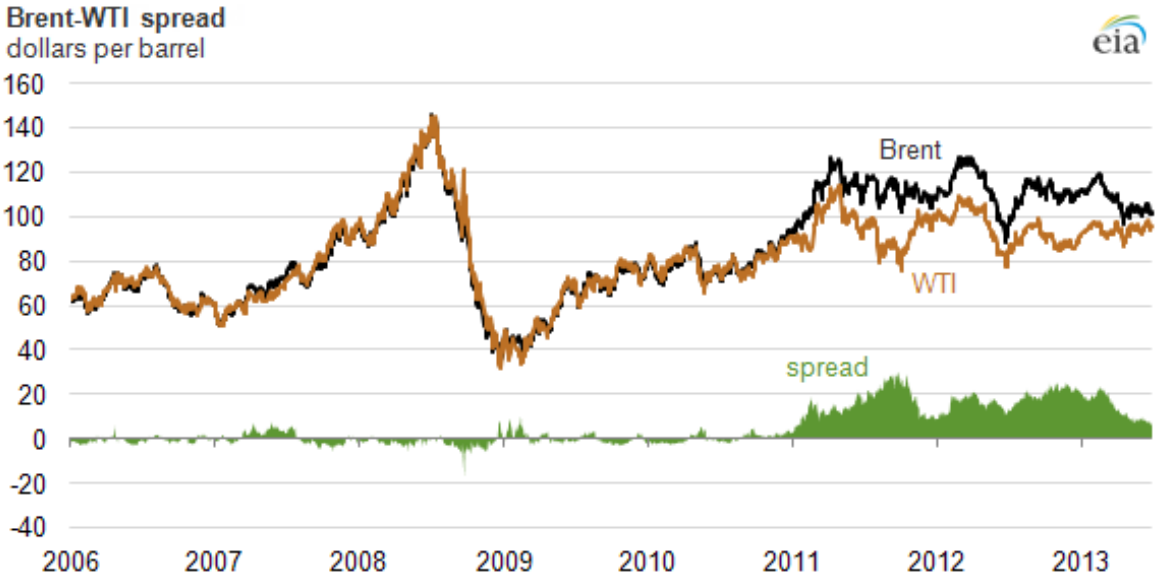
Crude oil essentially comes in many varieties, with heavy and light being the most important ones. Other factors include the degree of sulfur content, which impacts the cost of refining crudes into fuels, such as gasoline. Lower sulfur content in light oils, such as shale oil, are hence generally cheaper to refine. Due to these various kinds and grades of crude oil, and since oil is traded across the world, there are multiple international oil price benchmarks. These benchmark prices focus only on a limited number of reference crude oils, with other varieties being priced at a discount or premium against it, respective to their quality. There are essentially three main benchmark indexes: First of all, there is the Brent Crude price of North Sea sources, which is used price for two thirds of the world's traded oil supplies and sold at London's International Petroleum Exchange (IPE). Second of all, for the US, the primary benchmark is the West Texas Intermediate (WTI). Hence oil sales in the US are commonly priced in relation to the WTI at the New York Mercantile Exchange (NYMEX). Based on the characteristics of Texan oil (the largest source of crude oil in the US, and hence the benchmark crude oil grade of the WTI), the WTI is generally referring to light, sweet crude oil with a sulfur content of less than 0.5%. Third of all, there is also the OPEC basket price, including the average of 15 different crudes of all its 12 current members. In order to maintain the basket price within a determined range favourable to its economies (and political systems), OPEC aims to control the amount it recovers.[263]

Shale Oil and the Global Spread

As oil is a globally traded and effectively globally priced good, the WTI and Brent crude indexes, as well as the OPEC basket price, used to be tracking each other closely, the spread normally only indicating transportation costs and their respective grade. However, several factors led to an increasing spread between the WTI and the Brent following the increased output of tight oil in the US.

[263] BBC, '*Oil Markets Explained*', 2007

Figure 15:
Brent – WTI spread



(Source: EIA, *Price difference between Brent and WTI crude oil narrowing*, 2013)

The main reason for the spread lies in the existing export ban on crude oil. The ban was part of the 1975 Energy Policy and Conservation Act (EPCA) as a response to the 1973 crisis, however does neither affect imports of crude oil and its derivatives, nor the export of refined products.[264] As a consequence of the ban, currently produced oil from unconventional plays cannot enter the global crude oil market. This together with a lack of efficient refining and transport infrastructure had created a glut, which in turn caused WTI prices to tumble from $105 a barrel in Spring 2011, to $80 in summer 2013.[265]

As mentioned above, crude oil is a "primary energy source", which, however, needs to be refined into a "secondary energy source" to be utilisable, such as fuel oil, diesel or gasoline.[266] Due to the fact that crude comes in the abovementioned varieties, and increasing amounts of oil are sold in form of heavier and more sour (higher sulfur) crudes, there are few refineries in the US that can deal exclusively with tight oil. Most refineries are targeted to handle heavier imported oils from Canada, Mexico and Venezuela, and although they can also process light oil, they are underutilising their facilities at inefficient rates of production. Since especially the Midwest lacks transport infrastructure regarding pipeline capacity, and has been highly reliant on railroad transportation of oil –

[264] Austin, *Oil Export Ban Hurts US Oil Industry*, 2014

[265] The Financial Times, *'US shale revolution triggers oil derivatives upheaval'*, July 30, 2013

[266] Wagner, *Energy. The World's Race for Resources in the 21st Century*, 2007, p.7

which has its associated dangers as recent accidents carrying Bakken oil have shown[267] – the exponential production increase has resulted in a regional excess supply of light tight oil.[268]

These excess supplies were also enabled since the tight oil industry continued to increase their output despite the immense drop in crude oil prices going below the $80-a-barrel "sweet spot". Wood Mackenzie estimated the Bakken breakeven at $62 a barrel at averaged well costs in 2013. For highly productive fields within the play, this even goes down to $38-$40. Hence, even at prices below $80/barrel, companies still made profit. However, despite the much lower break-even price, the Bakken needs prices in the $80 - $85 range to attract capital from other shales. Other tight oil plays are even estimated to require prices of $100 to $120 in order to receive positive cash flows (which goes back to the question of actual economic viability of the revolution).[269] Especially considering that US crude producers are selling large amounts of their output in advance to guarantee revenues, they are effectively putting downward pressure on future oil prices, thereby simultaneously aggravating the possibility for those companies to enter crucial hedging contracts. While it is primarily the smaller less productive shale companies that future their sales in order to cushion against short-term price drops, it is also these companies that will suffer the most if they fail to hedge above their cost of production.[270] Hence, generally, the glut was due to the 'falling operational costs, increasingly efficient well technologies, rising reserve estimates and aggressive forward hedging programs'.[271]

As an overall consequence, however, the excess light crude oil was firstly, unable to be transported effectively to respective refineries, secondly, could not be exported due to the still existing 1975 ban, and thirdly, when refined, the process was largely inefficient. Greatest gainer from the tight oil revolution so far have nonetheless been the refineries. Due to the crude oil ban not including refined produces, they were able to buy crude oil products at the low WTI prices, only to sell them in refined form such as diesel at higher prices on the global market, earning high profits. The global marketing of refined products, however led to the fact that domestic gasoline prices in the US were not positively affected by the shale revolution. Hence, refiners have generally seen higher profit margins and crude producers lower ones.

Considering recent market developments, the spread between the WTI and Brent

[267] compare: ' Fiery oil train accident raises new safety issues', *CBS Moneywatch*, January 2, 2014

[268] Brown et. al., *Crude Behavior: How Lifting the Export Ban Reduces Gasoline Prices in the United States*, 2014, pp.4, 6

[269] The Telegraph, *Oil and gas company debt soars to danger levels to cover shortfall of cash,* August 11, 2014

[270] 'US shale revolution triggers oil derivatives upheaval', *The Financial Times*, July 30, 2013

[271] 'Analysis: Bakken drillers undaunted by local oil prices under $80', *Reuters*, November 21, 2013

has been decreasing steadily since 2013 (compare Figure 13). From a gap of almost 30 points in September 2011 to just above 6 points by May 2014.[272] Although especially tight oil output in the US is steadily increasing, the rising WTI (fluctuating around the 100$/barrel mark) is caused by decreasing stockpiles of crude at Cushing, Oklahoma, the delivery point for New York traded futures. Stockpiles were close to reaching minimum levels in the early months of 2014, due to the infrastructural and refining improvements and expansions of the past and the consequent increasing demand by refineries for crudes, resuming to full operation.[273] The UK Brent has been relatively stable over the entire time, ranging around the 108$/barrel mark.[274]

Lifting the existing export ban, which must be considered a general economic inefficiency, could have positive implications for both refiners as well as crude producers. For producers, this would mean that they can decide whether to sell the crude to refiners on the domestic or international market. This would further realign global price benchmarks to the before mentioned minor differences in grade and transport costs, and give producers a larger share of profit. In contrast to North America, many refineries in Europe and Asia lack the capacity to refiner heavier, sour crudes, which was one of the key reasons why the loss of Libyan light and sweet oil during the Arab Spring had a significant impact on global markets, despite the fact that in quantitative terms it only accounted for a minor part of overall global supply.[275] The export could also relieve some refiners on the US gulf coast from investing large capital into a restructure or expansion of their light crude refining capacity, which hence could continue to focus on the still imported heavier crudes.[276] For consumers however, little would actually change as gasoline prices have continued to follow global pricing with or without the export of crudes.

How has shale oil impacted global oil markets and could it weaken OPEC?

First of all, it is important to recognise that although crudes from the US are unable to enter the global market and hence do not exert direct downward pressure on prices, they still impact global markets by freeing up oil that is no longer imported in the US. This has been the

[272] YCharts, *Brent WTI Spread - June 2011-2014*, 2014

[273] McKinsey & Company, *Perspectives on Downstream Oil and Gas, Implications of Light Tight Oil Growth For Refiners in North America and World Wide*, 2014; Bloomberg, *'WTI-Brent Oil Spread Shrinks on Cushing Forecast'*, May 6, 2014

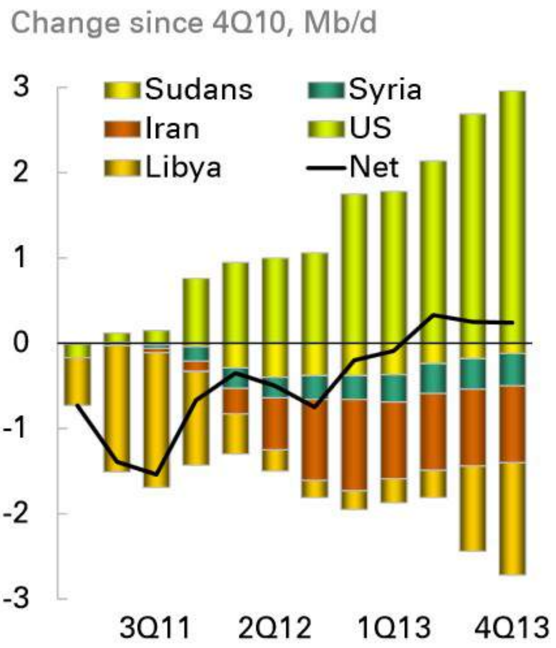
[274] Statista, *UK Brent crude oil price development from March 2013 to March 2014 (in U.S. dollars per barrel)*, 2014

[275] Maher, *The Arab Spring and Its Impact on Supply and Production in Global Markets*, 2013

[276] McKinsey & Company, *Perspectives on Downstream Oil and Gas, Implications of Light Tight Oil Growth For Refiners in North America and World Wide*, 2014

case especially with regard to heavier crudes as refineries increasingly shifted their operation to the light oil available domestically.

Figure 16:
Recent Disruptions



(Source: BP, *Energy Outlook 2035*, January 2014)

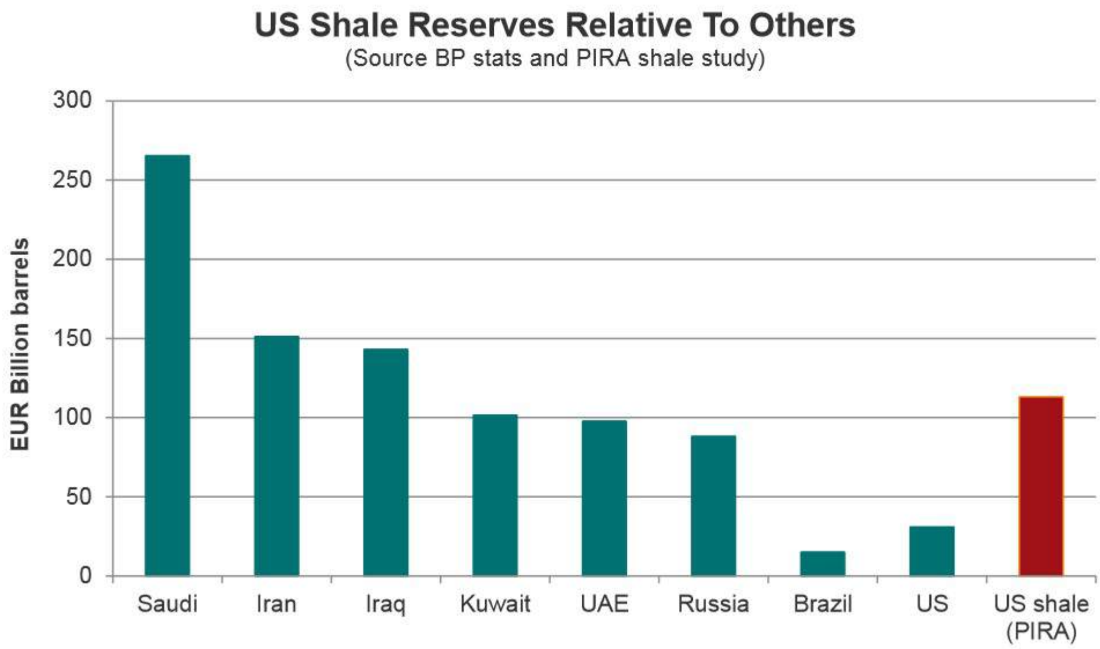
In fact, as Figure 16 depicts, it must be considered a fortunate coincidence that the US domestic output almost exactly matched the loss of essential producers in Iran, Libya, Sudan, and Syria between 2011 and 2013. As mentioned above, since US crude oil imports fell from more than 60% in 2005 to 33% in 2013 and are expected to reach 24% by 2015, globally available oil was able to balance disruptions caused by instabilities inter alia caused through the Arab Spring, and global sanction regimes.[277] Consequently, despite the domestic issues in prices, refineries, and the export ban, it is a fallacy to believe that the increase in tight oil output in the US has not had an impact on oil markets. Without the shale revolution in the US, global oil prices would not have been as stable as they have been over the past years.

One of the core arguments in favour of the ban on US crude oil exports has been the idea that drove the shale revolution to take place in the first place: energy independence. However, reiterating the fact that both crude oil as well as refined products respond to global market dynamics, as mentioned before, this independence from imports has little actual security or pricing implication for the commodity itself. This theoretical improved energy security is further aggravated as history has shown that OPEC could respond to an increase in supply on the market by reducing their own production in order to maintain their desired price levels. Although the share of non-OPEC oil on the global market is estimated to increase over the next decades, OPEC's ability to regulate supply paired with growing global demand for crudes have the potential to mitigate tight oil's influence. This is first and foremost based on the overall availability of tight oil in the US compared to the conventional oil reserves in the rest of the world. While US shale oil reserves must be considered significant as they surpass Russia's, the UAE's and Kuwait's reserves, they do not have the dominant resource base to single-

[277] Bloomberg Businessweek, ' *U.S. Crude Oil Imports Decrease Below 7 Million Barrels a Day*', January 15, 2014

handedly counteract OPEC (compare Figure 17). With reserves exceeding those of the US, OPEC is likely to respond to any non-OPEC challenge as they have done for decades; by utilising their staying power.

Figure 17:
US Shale Reserves Relative to Others
(Source: DNB, *Oil Market Outlook*, 2013)



Generally, OPEC has an estimate of 78% of conventional oil reserves. It however produces only about one third of globally marketed crude. This is possible due to the fact that oil producing companies in OPEC countries are largely if not completely state run, and hence follow governmental policy rather than free market dynamics. As Gal Luft, co-director of the Institute for the Analysis of Global Security, pointed out: 'If Exxon, BP, Shell, and Chevron were sitting on top of 78% of the world's conventional oil reserves, they wouldn't account for but a third of global supply. They'd probably account for 68 percent, or 82 percent [...]. And if not, they'd be slapped with an anti-trust lawsuit. Anti-trust lawsuits, however, don't work against sovereign regimes.'[278] Overall, OPEC's production costs are low enough for it to manipulate prices by withholding output. This implies that the final basket price is oriented on the difference between the lifting-price and the revenue required to sustain state budgets and secure social stability. The basic rule of OPEC is hence to balance out global supply and demand of crude oil to maintain their basket price at a level they desire and need to sustain their political systems and economies. Although over the past 40 years, the world population grew by 70%, global GDP grew fourteen-fold and the number of cars quadrupled with oil demand

[278] Korin & Luft, *Petrolopy: The Collapse of America's Energy Security Paradigm*, 2012, loc.512

growing by 60%, OPEC currently produces the same quantities of oil as it did then – around 30 MMb/d.[279] It is, however, only conducive to business for someone who owns a monopolistic and strategically important commodity to extract as much profit from this good for as long as possible. At current production levels, conventional reserves-to-production render the remaining reserves to last for 70 years in Saudi Arabia, 82 in Iran, 90 in the United Arab Emirates, and 91 in Venezuela. Iraq and Kuwait's ratio stand at above 100 years, while the US ratio is around 11. [280] While these numbers are bound to be inaccurate based on technological advances and further tight oil explorations, they do indicate essential tendencies. The IEA, therefore, expects OPEC's production share to fluctuate around 30% of global supply over the next two decades, followed by an increase after 2035 due to their greater and more easily accessible reserves. [281] OPEC Secretary General Abdulla al-Badri consequently downplayed the effect of the shale revolution, saying it will 'not affect' OPEC.[282]

Adding to the argument that the US share in production is too small and too costly to undermine OPEC's power comes the factor of supply demand trends. The IEA is predicting oil demand to increase from currently 86.7 MMb/d to 101.4 MMb/d by 2035. Regional changes in demand are expected to shift, with decline in OECD countries and increased growth in non-OECD countries. Primary growth will come from the transport sectors in developing Asia, where the heavy duty vehicle fleet alone will constitute one third of global oil demand by 2035. [283] Doubts however linger above the continuous disruptions of producing countries. With Syria, Libya and Iraq caught in civil war (as of summer 2014) little relief can be expected for Saudi Arabia, which has been producing at essentially maximum capacity over the past years to counterbalance these shortfalls. Some easing of the situation could come through the lifting of the sanction regimes over Iran. The country has already depicted its confidence in the return to global markets by announcing to double its oil production by 2018, with an increased output target of 5.7MMb/d.[284] The IEA observed a rise of 265,000 b/d in early 2014, reaching an overall of 1.65MMb/d, exceeding the limit of 1MMb/d set by the West in the interim deal that came into effect in January this year.[285]

[279] Bloomberg, 'OPEC Keeps Output Level Below Second-Half Demand Forecast', June 12, 2014

[280] Korin & Luft, *Petrolopy: The Collapse of America's Energy Security Paradigm*, 2012, loc.865

[281] IEA, *World Energy Outlook 2013*, p.481

[282] Shale Daily, *'OPEC 'Not Affected' by U.S. Shale Oil, But UAE Weighing Gas Imports'*, January 27, 2014

[283] IEA, *World Energy Outlook 2013*, p.61

[284] The Telegraph, *' Commodities: Iran challenges US sanctions with plans to double oil output by 2018'*, April 13, 2014

[285] Reuters, *'Iran's oil exports surge above West's sanctions cap: IEA'*, April 11, 2014

Overall, it is important to stress that while the global gas market's outlook is looking at favourable supply demand balance for consumers, the oil market must be considered rather tight. Prices are hence not expected to fall any time soon. However, while this is not necessarily good news from the consumer perspective, both competitive oil and gas companies as well as so called petro states in fact desire and require such higher oil prices. In Saudi Arabia, 75% of the budget revenues, and 90% of export earnings come from oil, as there is no personal income tax, no property tax, no sales tax, and no value added tax. In addition, there is also no corporate tax, with the exclusion of foreign companies.[286] Similarly, crude oil exports account for about 93% of Iraqi governmental revenues and more than half of total Russian export income, as well as around 30% of Russia's GDP, and half of its GDP growth between 2000 and 2013.[287] It is hence estimated that Saudi Arabia requires an oil price of $90/barrel, Russia of $105/barrel, Venezuela of $110/barrel, Iraq of $125/barrel and Iran even of $144/barrel to maintain their social contract.[288] At the same time, as abovementioned, gas and oil companies have been suffering from a lack of sufficient cash flow and rising debt for years, with an estimated half of the companies requiring oil prices of $120/barrel to acquire positive free cash flow.

A continuous drop in oil prices would hence have detrimental impacts for gas companies and export revenue dependent states. This is especially the case for the latter as it bears severe risks for international peace and security. While in its best outcome, consequent political shifts and uprisings could provide a democratisation of the respective regions, probably and more likely considering the recent events following the Arab Spring, it could lead to increased sectarian violence, civil wars, and a general regional destabilisation. Especially in Middle Eastern countries this could become a breeding ground for extremist groups, threatening also national securities in the West. In any case, such developments would lead to long-term disruptions of oil supply, and re-elevate price levels.

However, there is also competition taking place within OPEC. Iran and Iraq have seemingly been collaborating in early 2014 to produce above the cartel's quotas in order to increase their market share, crucial for domestic economic growth - an act that could undermine Saudi Arabia's position as the main "swing state" within OPEC. Saudi Arabia, holding almost one fifth of global proven crude reserves and being the largest producer and exporter of oil, is the core of OPEC

[286] Korin & Luft, *Petrolopy: The Collapse of America's Energy Security Paradigm*, 2012, loc.633-636
[287] Gustafson, *Putin's Petroleum Problem*, 2012
[288] Korin & Luft, *Petrolopy: The Collapse of America's Energy Security Paradigm*, 2012, loc.544; Center of a New American Security, *Energy Rush. Shale Production and U.S. National Security*, p.27

which has also rendered it a central player in the global oil market. This is represented through its net oil revenues compared to other members. According to the EIA, Saudi Arabia acquired a nominal oil revenue of $311 billion in 2012, which constitutes almost one third of total OPEC revenues (12 members, excluding Iran).[289] This cooperation and defiance towards OPEC quotas could in turn subvert Saudi Arabia's power to impact the market sufficiently to maintain price levels of above $100/barrel, as combined Iraq and Iran hold a larger share of global reserves than Saudi Arabia (compare Figure 15).[290] Also, Iraq and Iran could supply as much as 15-16 b/d (9-10 b/d from Iraq, and about 6 b/d from Iran) by 2020, about equal to Saudi Arabia's plans to expand current production of 12.5b/d to 15 b/d by the same year.[291] Such plans are, however, currently improbable as both the continuing sanction regimes against Iran as well as the security situation in Iraq (concerning the advent of the Islamic State of Iraq and Syria) hinder the countries from reaching the targeted production levels.

In summary, the impacts of shale oil on the global market are not as ground breaking and severe as hoped for and sometimes portrayed. As mentioned in the beginning of the study, energy independence in an interconnected and interdependent world with global trade and pricing means little in form of an actual energy security benefit. The increasingly tight global oil market with the commodity's continuing monopoly in the transport sector has so far only seen stabilising effects through the revolution in the US and it will most likely see little else. Whether or not crude oil is exported from the US will have minimal effects for the consumer and is only a matter of whether to allow producers a larger share of the profits that currently go primarily to the refiners. OPEC's analysis that the shale revolution will not impact them is correct in so far, as the production levels in the US are simply to meagre to seriously threaten its power. If, however, similar shale revolutions are initiated across other countries with similar exponential output increases, the revolution might after all threaten OPEC. Yet this remains far from certain. Hence, as long as oil remains the core fuel of our civilisations, the US shale oil will neither lower global prices significantly, nor improve US energy security.

Breaking Oil's Monopoly

With the continuing dependence on oil and its associated vulnerability to disruptions and prices despite increased domestic production levels, the only possibility to increase energy security

[289] EIA, OPEC Revenues, 2013

[290] The Telegraph, *'Iraq and Iran plot oil revolution in challenge to Saudi Arabia'*, 28 January, 2014

[291] OilPrice, *'Saudi Arabia Aim to Increase Oil Production to 15 Million Barrels a Day by 2020'*, May 2, 2013

remains to break oil's monopolistic power in the transport sector. Generally, 'almost anything - fuel or chemical - that can be made from petroleum also can be made from natural gas, but it is not done today because the cost of converting natural gas into those materials is much higher.'[292] With increasingly available amounts of natural gas and large potentials of domestic production for previously energy resource poor countries and regions, new opportunities open up to use alternative fuels for vehicles. This includes both NGVs as well as electric cars. Hence, with possibly decreasing prices, the large-scale introduction of flexi-fuel vehicles could seriously undermine the monopolistic position of oil on the global market, and thereby OPEC's leverage. It furthermore could also have positive implications for global GHG emissions both considering NGV emissions but also the increasing use of gas and renewables for electricity generation, the source for electric cars.

Taking the current developments on the oil market into account, there is little potential for a significant enough decrease of barrel prices in the next decade that could weaken the economic incentives for alternative fuels (from a non oil and gas company incentive). Even global prices around $90/barrel (constant 2012 $), which would equal about $16/MMBtu, would still render oil prices around three to four times more expensive than natural gas as a source of energy (at prices of around $4-6/MMBtu expected in the US).[293] Additional costs arise nonetheless, as in order for natural gas to be used as a fuel source in vehicles further processing and investments in car engines to run on LPG, LNG or methanol is required. While LNG is cheaper than methanol, the high upfront costs for engines are higher. Hence, LNG is especially relevant for the heavy-duty vehicle (HDV) market. Given the high vehicle-miles travelled, payback times are reduced to three years or less. This is based on the expected lower cost of LNG fuel over diesel fuel costs. Furthermore, fuelling infrastructure is less problematic for HDVs than for other vehicle types. In the US, plans to increase the amount of the existing 66 fuelling stations providing LNG across the country are already in progress.[294] This is however expected to only make up about 3-5% of the overall transportation mix in the US by 2035.[295] Nonetheless, considering that the IEA projected that one-third of global net energy growth until 2035 comes from freight trucks and light-commercial vehicles in developing Asia alone, an increased technological advance in NGVs combined with i.e. China's own shale gas potentials, and NGV plans, could have

[292] Reuters, '*Experts see cheaper, easier way to turn natural gas into fuels*', March 13, 2014

[293] IHS CERA, *Fueling the Future with Natural Gas: Bringing it Home*, 2014, p.ES-7

[294] IHS CERA, *Fueling the Future with Natural Gas: Bringing it Home*, 2014, p.ES-19

[295] European Commission, *Unconventional Gas: Potential Market Impacts in the European Union*, 2012, p.152

tremendous implications for the oil market and global GHG emissions.[296]

While LNG powered vehicles are considered suitable primarily for HDVs, also passenger cars can profit from the shale gas revolution. With methane being the chief constituent of natural gas and found in large quantities in shale gas exploration, CNG or methanol as an alternative fuel could increase in importance in years to come. The mechanical price to build a flexi-fuel car that can drive on gasoline and methanol amounts to only $70 per vehicle, according to GM Vice Chairman Tom Stephens.[297] Hence, costs that would enable a car to drive on any composition of gasoline, ethanol and methanol would only account for an average additional 0.5% of the car's retail price. Especially methanol has distinct characteristics that could render it the fuel of the near future while purely electric powered cars lack technology or are too expensive to become large scale products.

As a basic alcohol, methanol is not only found in natural gas deposits, but can be produced from any resource that can be converted into synthesis gas, which in turn can be produced from anything that is or derives from a plant. Hence, methanol is won from all types of biomass, coal, waste, as well as CO_2 pollution from power plants. At the same time, methanol is soluble in water and burns clean. It is highly suitable for blending with all grades of gasoline due to its higher volatility, which can increase engine efficiency and reduce emissions.[298] Being generally cheaper to produce sustainably compared to corn-based ethanol, methanol is a less expensive alternative to reduce the carbon footprint while at the same time potentially breaking-up the monopoly of oil in the transport sector by effectively creating a larger fleet of flexi-fuel cars.[299]

Consequently, through the increased natural gas production and presumably greater and on average cheaper availability of natural gas globally, methanol bears great potential to become a transition fuel for the transport sector. Its use could have far reaching environmental spill-over effects as companies could profit from recycling wastes, or factory pollution into methanol. As, therefore, methanol could be largely available for countries without oil or gas deposits, its utilisation as a fuel or blended with gasoline can have expansive effects on countries' energy security, balance of trade, and reduces costs for consumers. At the same time, by effectively creating a competitive market for transport fuels, oil would lose its source monopoly thereby freeing consumers from the dependence on high priced oil derivatives, as already seen in Brazil through the flexi-fuel use of

[296] IEA, *World Energy Outlook 2013*, 2013, p.512
[297] OpenFuelStandard, *Inexpensive Solution: Flex-Fuel Cars Only Add $70 to Cost*, 2011

[298] Methanol Institute, *Methanol Gasoline Blends*, 2010
[299] For more on the possibilities and the rationale for flexi-fuel cares, read: Korin & Luft, *Petrolopy: The Collapse of Amercia's Energy Security Paradigm*, 2012

ethanol. In addition, as mentioned above, the potentially easier, cheaper and cleaner way to turn natural gas into usable fuels and chemicals might have exponential implications in the future of both the chemical industry, fertilisers, but also with respect to alternative fuels for transport in the US and the world.[300] A break-up of the monopolistic power of oil in the transport sector would therefore lead to decreasing prices of crude oil and its derivatives.

While all the above outlined potentials hence would favour consumers immensely, fossil energy companies and exporting countries would suffer severe losses including the already mentioned political consequences. Hence, whether these potentials will be realised depends primarily on incentives by governments, as the market, its lobbies and crucial exporting countries do not favour a development away from crudes. The fact that also the US could now re-enter the global market for oil has potentially pushed the day when oil becomes a mere alternative fuel further into the future.

[300] Reuters, '*Experts see cheaper, easier way to turn natural gas into fuels*', March 13, 2014

Concluding Remarks

"Project Independence" is within reach – at least from a quantitative perspective. The decades of supporting and funding innovative fossil fuel extractions amounted to the exponential increase in domestic resource extraction in oil and gas from primarily shale deposits that have provided the North-American continent with the outlook to acquire energy independence by the end of the decade. However, while self-sufficiency is likely to be achieved in the medium-term, the core of "Project Independence" namely immunity from external shocks has become a fallacy over the past decades of increased interdependence of global energy markets. While having improved the domestic security of supply, the US will continue to be susceptible to production disruptions beyond its borders and threats to crucial trade channels; be it for the growing LNG market or oil and its refined products. Hence, the US remains to be required to defend its national interests abroad as it can best promote energy security by enabling a stable, well-supplied global energy market for all global players. A greater amount of burden sharing among the US and its allies will however likely be the case.

Nonetheless, by superseding assumptions of peak oil, the shale revolution has added to the fundamental shifts in global energy markets. With unconventional resources spread across the planet in countries previously not blessed with large oil and gas deposits, the revolution depicted the vast potential that lies in investing in alternative extraction technologies, even if they may take 40 years to pay off. Although the process of shale recovery has not been without contestation from environmental and economic viability standpoints, it nonetheless bears considerable political and wider economic benefits.

While the positive effects of increased domestic oil production have so far been limited to an improved trade balance and a more stable global oil market, especially the shale gas output and its impact on domestic prices has had significant implications for the US economy and a shift in the country's energy mix. Providing jobs, reducing electricity costs and reinvigorating industrial production has given the US a much needed economic upturn following the financial crisis of 2008. This has become all the more important for actors such as Europe in light of the Ukrainian Crisis and rising electricity costs on the continent. While the continent might enter a time of competitive dis-advantage towards the US, the outlook of several actors expanding their LNG export capacities, and the US entering the market by the end of the decade as potentially the second largest supplier of LNG, means that global gas markets are facing times of improved security of supply. This gives importers a greater chance for the diversification of suppliers and thereby reducing the power leverage of regionally dominant exporters, including Russia. Such growing competition is destined to improve price levels for consumers and re-balance the global spread of regional gas prices in the medium-term. Although the oil market, in contrast, remains extremely tight – especially in light of the ongoing political conflicts in the Middle East – the US shale oil revolution has played a central part in securing stable oil prices over the past years; despite the fact that oil prices are unlikely to fall and OPEC's cartel powers cannot be broken by the US single-handedly. Geopolitically, the shale revolution is likely to continue to shift global trade flows and has rebalanced the power of major energy exporters in favour of (former) importers. Overall, the revolution has spectacularly reaffirmed the role of the US as a global superpower at the outset of the 21^{st} century.

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