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The Economic and Investment Implications of Shale Gas

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Joan Abebe
abebe@cernocapital.com

Fay Ren
ren@cernocapital.com

Natural gas production from hydrocarbon rich shale formations, known as "shale gas," is one of the most rapidly expanding trends in onshore domestic oil & gas exploration and production today. The extent of the supplies of shale oil and gas found in the US over the last several years, and the advances in drilling techniques, have brought production and activity to regions of the country that had previously seen little or no activity. This could mean that the US ceases importing crude oil entirely by 2020.

Natural gas plays a key role in meeting US energy demands: whilst coal, oil and natural gas supply about 85% of the nation's energy, gas makes up 22% of that total. The US Energy Information Administration's Annual Energy Outlook 2013 Early Release projects US natural gas production to increase from 23.0 trillion cubic feet in 2011 to 33.1 trillion cubic feet in 2040 - a 44% increase[1]. Almost all of this increase in domestic natural gas production is due to predicted growth in shale gas production, forecast to expand from 7.8 trillion cubic feet in 2011 to 16.7 trillion cubic feet in 2040. The EIA estimates that shale gas production will increase from 5.0 trillion cubic feet per year in 2010 to 13.6 trillion cubic feet per year by 2035[2].

The arguments over shale gas exploration through the technique of 'fracking' can sometimes get as pressured as the process itself. Living close to shale gas reserves raises the understandably controversial issues of water contamination and seismic activity (still yet to be wholly proven). However, protagonists in the US point to the economic advantage that a move towards energy self-sufficiency would give in terms of the country's financial standing, as well as the increased competitiveness of a dollar rally if the US economy revives, and lower energy prices worldwide due to the shale revolution. In addition, it would considerably reduce dependency on the Middle East at a time when political tensions between the US and Syria are heightening.

It has been claimed that unconventional oil and gas from shales is a revolutionary game changer. It is therefore an exciting time to be analysing its implications for investors. Much of the world is looking with a mix of envy and excitement at the

[1] Energy In Brief: http://www.eia.gov/energy_in_brief/article/about_shale_gas.cfm
[2] Invesco Perpetual: Fracking...a revolutionary process, *March 2013*

recent boom in the US, and countries from China, Poland, France to the UK are beginning to launch their own ventures in shale gas extraction.

Introduction: What is Shale Gas?

Shale gas refers to natural gas trapped within formations of shale – fine grained sedimentary rocks that can be rich sources of natural gas and petroleum. The main constituent of shale gas is methane (90%), with low amounts of propane and other substances. Shales are different from other sedimentary rocks in that they are finely layered and can be broken and easily fractured. They are typically composed of variable amounts of clay minerals and quartz grains, and the usually of a grey colour. Until recently, much of this resource was considered uneconomical to produce. However current interest has been fuelled by technological advances, particularly concerning hydraulic fracturing, and rising gas prices in the early 2000s which prompted drillers in the US to pursue development more vigorously.

According to the Energy Information Administration (EIA), US shale gas production has increased 12 fold over the past decade, and the estimated unproved technically recoverable resource is 482 trillion cubic feet – about 19 percent of technically recoverable domestic natural gas[3]. By 2035, EIA predicts that shale gas production will rise to 13.6 trillion cubic feet, representing nearly half of all US natural gas production.

How is Shale Gas extracted?

The advent of new extraction technologies, such as hydraulic fracturing and horizontal drilling, means that shale gas is now increasingly accessible. Through the use of these technologies, US oil and natural gas operators are converting previously uneconomic oil and natural gas resources into proved reserves and production. The key technologies that were developed in the US and are required for shale gas exploration, development and production include:

Horizontal drilling

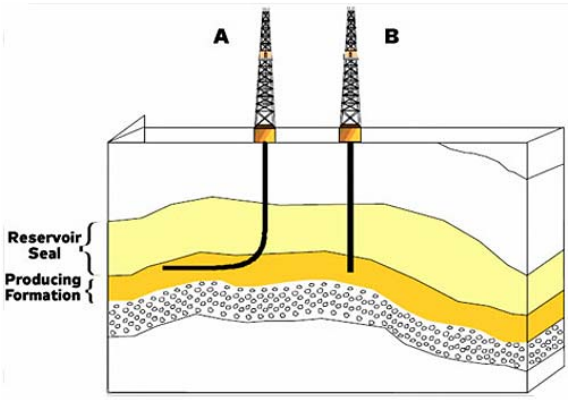
Horizontal drilling is the process of drilling and completing, for production, a well that begins as a vertical bore. This extends from the surface to a location below ground, just above the target oil or gas reservoir called the "kickoff point," then bears off on a tangent to intersect the reservoir at the "entry point." Thereafter, drilling continues horizontally to remain within the reservoir until the desired bottom hole location is reached[4]. The technical objective of horizontal drilling is to

[3] Producing Natural Gas from Shale research: http://energy.gov/articles/producing-natural-gas-shale

[4] Journal of Petroleum Technology: Drilling and Production of Horizontal Wells in the Austin Chalk, *July 1991*

expose significantly more reservoir rock to the well bore surface than can be achieved in drilling a conventional vertical well.

Exhibit 1: Greater Length of Producing Formation Exposed to the Wellbore in a Horizontal Well (A) than in a Vertical Well (B).



Source: Energy Information Administration, Office of Oil and Gas

Hydraulic fracturing

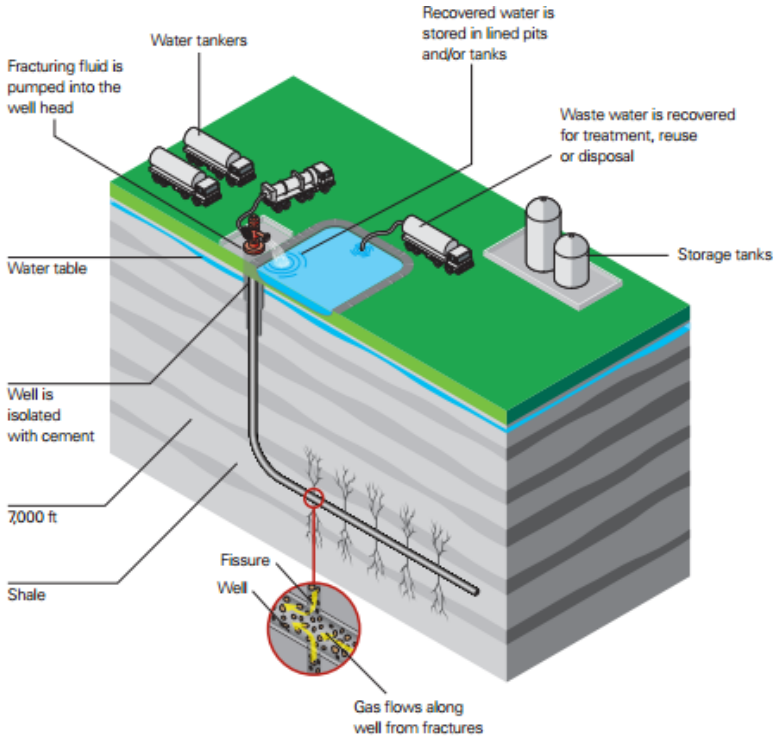
Hydraulic fracturing is the process of injecting millions of gallons of water into a well at high pressure. As the pressure in the wellbore increases to a value that exceeds the breakdown pressure of the target shale formation, a crack or fracture is formed in the formation, and the injected fluid begins moving down the fracture[5]. This fracture stimulates the flow of natural gas, increasing the volumes that can be recovered. More than 98% of the frack fluid is water, but other chemicals may also be present. Proppants such as sand or ceramics are used to open and enlarge fractures within the rock formation, thereby allowing the gas to flow into the well.

Once the injection process is completed, the internal pressure of the rock formation causes fluid to return to the surface through the wellbore. This fluid is known as both “flowback” and “produced water” and may contain the injected chemicals, plus naturally occurring materials such as hydrocarbons. The flowback and produced water is typically stored on site in tanks before treatment, disposal or recycling. In many cases, it is injected underground for disposal. In areas where that is not an option, it may be treated and reused, or processed by a wastewater treatment facility, then discharged as surface water.

When used in conjunction with horizontal drilling, fracking enables gas producers to extract shale gas economically. This process is responsible for the recent boom revolutionising the US energy industry, as the huge amounts of shale gas and oil which fracking releases have become commercially viable, resulting in plunging US natural gas prices and soaring US oil production.

[5] Department of Energy: Hydraulic Fracturing White Paper, *June 2004*

Exhibit 2: Hydraulic Fracturing Process



Source: BP

Where are the Shale Reserves?

The largest recoverable reserves in the world are in China, which has 1,275trn cubic feet, followed by the US, with 862trn cubic feet, and Argentina, with 774trn cubic feet. [6] The presence of shale gas has also been confirmed in parts of Europe, but active commercial production is currently only taking place in North America.

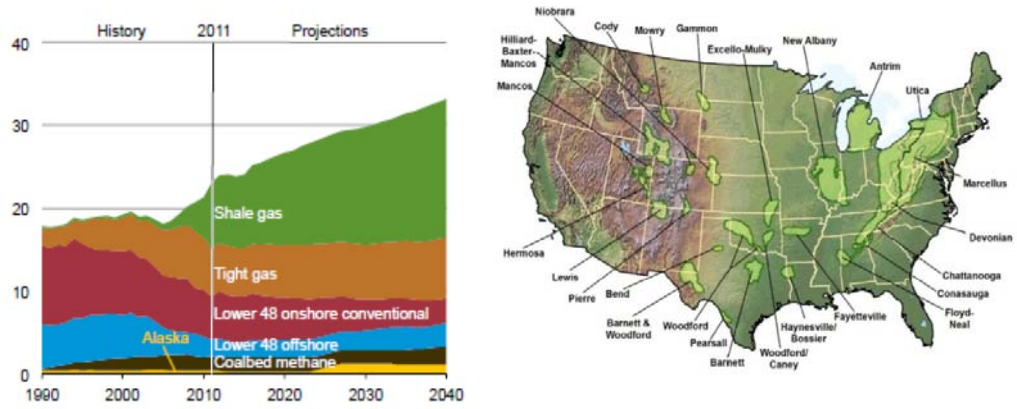
US

Although the presence of shale gas in the US was confirmed more than a century ago, high technical hurdles and lack of economic capability prevented progress on development. However, in the 2000s there were advances in key technologies including hydraulic fracturing, horizontal drilling, and micro-seismic technology, bringing a rapid increase in productivity and making low-cost production possible. In the US, shale gas is present across much of the lower 48 states. It is found in shale "plays", which are shale formations containing significant accumulations of natural gas and which share similar geologic and geographic properties. In North America, major development areas include Barnett, Haynesville, and Eagle Ford

[6] UBS: Shale Gas and Tight Oil, *7 September 2012*

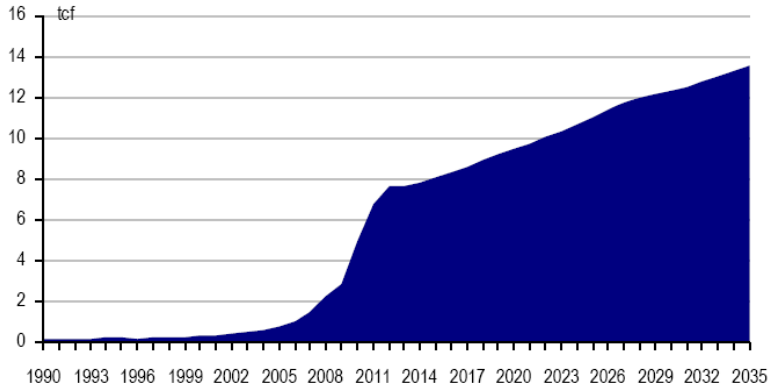
in Texas, Fayetteville in Louisiana, Marcellus in and around Pennsylvania, and Niobara and Bakken in and around North Dakota. Each of these gas shale basins is different, and each has a unique set of exploration criteria and operational challenges. According to the EIA's Annual Energy Outlook 2013, shale gas provides the largest source of growth in US natural gas supply. Shale gas production, which grows by 113% from 2011 to 2040, is the greatest contributor to natural gas production growth. Its share of total production increases from 34% in 2011 to 50% in 2040.

Exhibit 3: US Natural Gas Production & US Shale Basins



Source: EIA, Annual Energy Outlook 2013

Exhibit 4: Shale Gas Output



Source: EIA, EIA estimates

Developing domestic natural gas resources means additional jobs and economic growth when wells are drilled, pipelines are constructed and production facilities are built and operated. In addition, higher volumes of available domestic natural gas mean lower fuel or feedstock prices for industries that use natural gas to

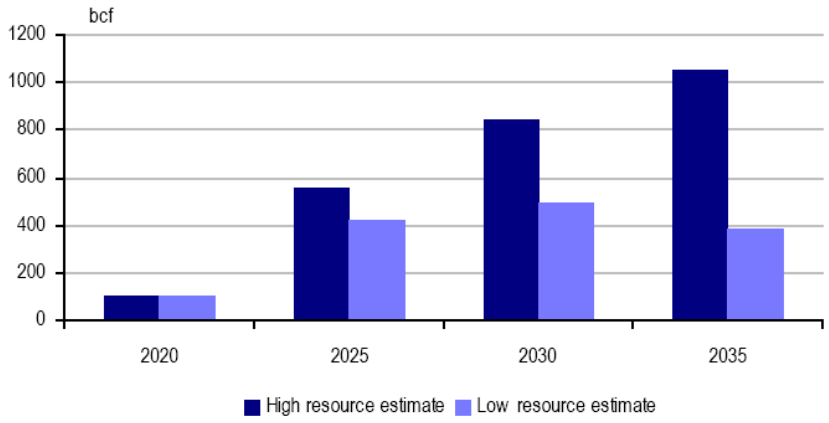
process or manufacture products. This means fewer jobs lost to lower-cost overseas competitors, as well as lower prices for consumers.

Europe:

European countries including Poland, France and Great Britain are now assessing shale gas reserves. By far the largest technically recoverable reserves appear to be in Poland and France, but many of the most promising regions are densely populated, and there has been almost no large-scale exploitation because of environmental concerns. France is particularly sensitive to environmental issues, and concerns about the dangers of hydraulic fracturing have already led to a ban on the practice in the low-lying areas that surround Paris.

Poland has been interested in development and has remained active from a comparatively early date, having found a shale layer similar to the Barnett deposit in the US. The IEA projects 100bn cubic feet of shale gas production in Poland by 2020, 400bn by 2025, 850bn by 2030, and 1trn by 2035. If production rises to 1trn cubic feet, Poland's output will be about one-fifth that of the United States.

Exhibit 5: Shale Gas Output in Poland



Source: IEA estimates

In April 2013, the Polish finance ministry announced that it is preparing a new tax regime for the oil and gas industry. The proposed tax rates will have a massive impact on the industry, because the new rate caps out taxes at nearly 60%, as opposed to an earlier promise of 40%. PKN Orlen, one of the country's state-controlled refiner's, has stated that the taxes on exploration and extraction of unconventional oil and gas reserves could reach as high as 130%.[7] These new rates are important when discussing the country's shale gas potential, because Poland has high hopes of finding significant amounts of shale gas over the next few years. Poland relies on Russia for 90% of its natural gas supply (largely from

[7] Energy tax measures in Poland research: http://blogs.ft.com/beyond-brics/2013/04/15/poland-frightening-the-frackers/#axzz2QpmzPVs0

Gazprom), and the Polish government is hoping that the country could become energy independent as a result of developing these new gas resources. Only 42 test wells have been drilled in the hunt for shale gas, but the government is encouraging both domestic and foreign companies to continue the search. With this new unfavourable potential tax regime, more than 20 energy companies currently holding the 109 exploration concessions could be swayed against continued development.

British reserves have been greatly under-investigated, although the UK is thought to have a large accumulation of shale gas in northwest England, in an area known as the Bowland Basin. However, George Osborne's recent March budget provided one major economic fillip: it fired the gun that finally kick started the UK's dash for shale gas. The Chancellor told Parliament: "Shale gas is part of the future and we will make it happen.[8]" The government has promised tax breaks in order to promote investment in exploration, and fracking companies will get a tax allowance for developing gas fields and will now be able to offset their exploration spending against tax for a decade. The proposed taxation measure will be a catalyst for increasing UK fracking activity, thereby attracting new investment.

Emerging Markets:

China has the world's largest technically recoverable reserves, and the Chinese government has made aggressive plans to expand shale gas production, under the Twelfth Five Year Plan of the Ministry of Energy, to 6.5bn m3, or 2.3trn cubic feet, by 2015, 15bn m3 (5.3trn cubic feet) by 2020 to 110bn m3 (39trn cubic feet) in 2030, by accelerating its pace in surveying and exploring the unconventional energy source. [9] Large reserves are said to exist in Szechuan Province, in Xinjiang Uighur Autonomous Region, and in other interior regions. Although almost no shale gas is now in production in China, Shell is working with PetroChina and BP is working with Sinopec to evaluate possibilities. However, technically recoverable supplies have been found mostly in interior regions where infrastructure is lacking. It will be necessary to build a network of pipelines and to secure the large quantities of water required for development.

The reason why the country's economic planners are suddenly so interested in what lies beneath the Chinese countryside, is because air pollution caused by coal-burning power stations used to produce 70% of China's energy needs. Pollution has become a major political headache for the Chinese government. With shale gas reserves estimated to be bigger than the US and Canada's combined, the government sees an opportunity. However, the high volume of water needed for fracking will be a big challenge for a country that already has serious shortages. Some estimates suggest that even for the 6.5 billion cubic metres target, the fracking industry would need to consume more than a third of the total amount of water already used by China's entire industrial sector. There is also a potential technological challenge. America's shale deposits lie around

[8] UK Budget 2013 research: http://www.hm-treasury.gov.uk/budget2013_statement.htm
[9] Energy Policy of China research: http://en.wikipedia.org/wiki/Energy_policy_of_China

2,000 metres below the surface. In China, they lie much deeper - up to 4,000 metres - which could make the gas much more costly to extract. UBS analysts believe there will be difficulty in China replicating the US success story, because of China's unique challenges:

i. Open industry structure: The diversity of the US oil and gas industry ultimately facilitated the country's shale revolution; in contrast, the onshore market in China is dominated by PetroChina and Sinopec. For China to have the same amount of success, the market has to open up to participants other than NOCs.

ii. Land ownership and market access to resources**:** In the US, the rights to underground resources accrue to landowners, so leasing rights to land can be traded on a private basis. In China, land is government-owned, and UBS analysts estimate that about 70% of the favourable shale gas blocks are already under PetroChina and Sinopec. There is also long-term risk that the remaining acreage, which will go to independent companies through government auction, may have less favourable geological characteristics than the land held by these two companies.

iii. A mature pipeline infrastructure**:** In the US, pipeline infrastructure is very mature compared with the situation in China. This means that significantly more wells will be drilled in China and significantly more risk shouldered by operators, to prove up significant resource before pipeline investment is justified.

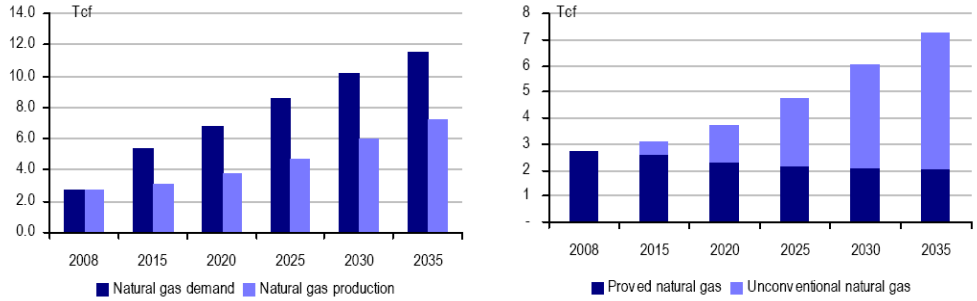
iv. Flat land**:** In the US, most of the large shale gas acreage is located in areas that are relatively flat and are easily accessed by existing road infrastructure. This is important considering the large amount of equipment needed to mobilise for fracking. In the case of China, much of the shale acreage is located in areas that are mountainous, for example in Sichuan, which will present logistical challenges when mobilising equipment.

v. Access to water**:** Each fracking job may require 2-5 million gallons of water per well. In certain parts of China, particularly in the Tarim basin (Xinjiang), water availability may be an issue.

vi. Depth**:** Shale resources in the US are typically at a depth of about 2,000 metres, while in China the depths can range from 4,000 to 6,000 metres. This means drilling can take longer, resulting in higher costs, and more challenges for horizontal drilling.

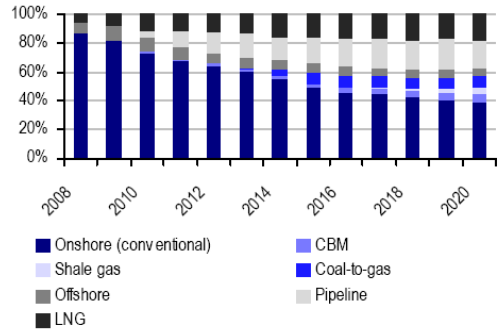
Although it is not clear to what extent production of nonconventional sources will grow, the Chinese government is clearly interested in exploring the possibilities.

Exhibit 6: Natural gas supply and demand in China (left) & Natural gas output outlook in China (right)



Source: IEA, IEA estimates

Exhibit 7: China natural gas supply



Source: CEIC, UBS estimates

Argentina has the third-largest technically recoverable reserves in the world, following China and the United States. Most of Argentina's resources are in the Neuquén Basin, in the south central part of the country. Both shale gas reserves and tight oil have been discovered, but infrastructure deployment and political risk are the key challenges. In the past, Argentine policy has kept natural gas prices low and the government has not been aggressive about exploration or development. However, the government became more interested in exploration and development around 2008 because of worsening gas shortages, and gas producers have been able to set natural gas prices at US$5MMBtu. In November 2012, the government vowed to increase consumer prices for natural gas, as state-controlled energy company YPF hopes to lure partners to invest in the Vaca Muerta shale site, which may hold enough resources to double Argentina's oil and natural gas output. YPF has mainly been responsible for evaluating potential reserves in Argentina, and some recoverable reserves have been discovered, including shale gas, tight oil and tight gas. These reserves and undiscovered reserves are together estimated at about 23bn barrels in oil-equivalent terms. BP, Petrobras, Apache, ExxonMobil, and others are involved in exploration and development.

West Africa is the region that is shouldering most of the reduction in US oil

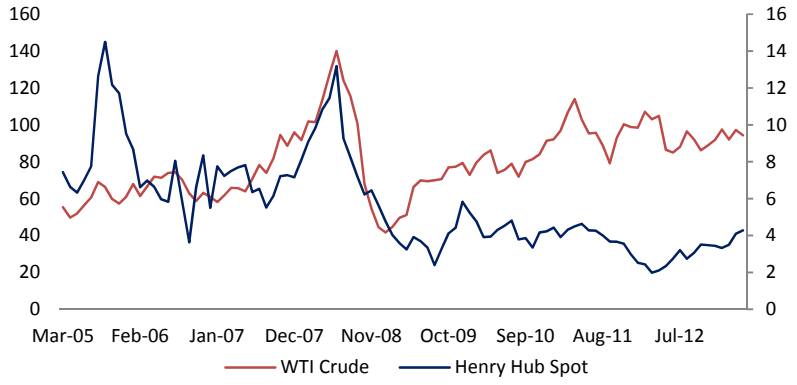
imports. Oil shipments from countries such as Nigeria and Angola have halved, as these countries produce the same kind of high quality, low sulphur crude oil as the US shale fields. Nigeria in particular suffered a 42 per cent drop in crude oil exports to the US to 0.4m b/d, the lowest since 1985. In the past, crude oil from the country was sought after by US east coast refiners as it is easy to refine into petrol. However, the boom in US domestic oil production is flooding the market with the same kind of oil, displacing the need for Nigerian crude.

Potential Impacts of the US Shale Gas Boom

In 2011, the US became the world's largest producer of natural gas, briefly overtaking Russia before settling back into second place. The aggressive advancement in the US shale gas industry over the past decade was a major reason for the increase in output, where the volume of shale gas rose from 2% of the total output in 2000 to 23% in 2010, growing to 27% in the past two years, and is projected by the EIA to reach 49% in 2035. If future trajectory roughly follows current estimates, it implies that there is still a long way to go before production rate peaks, which will attract many interested parties hoping to exploit this cheap and plentiful resource.

Since 2008 domestic gas price (Henry Hub) has fallen 62% to below US$2/MMBtu in March 2012, before recovering to $4.3/MMBtu this year: a direct result of supply-demand imbalance, as domestic output surged while global oil prices remained stubbornly high. The immediate effect of this is in reducing the dependence on foreign natural gas imports, which has experienced a dramatic decline. However, counter to popular belief, it will still be a long time before the US can achieve energy independence, if possible at all, since the majority of US energy imports is in crude oil and not natural gas. The potential transition to become a net energy exporter is therefore arguable, with the exception to succeed in becoming a small net exporter of liquefied natural gas (LNG).

Exhibit 8: Natural gas spot price versus WTI Crude price



Source: Bloomberg

The potential macroeconomic consequences of this boom are envisioned by many to be highly significant in shaping the future of the US economy with

ensuing effects on other nations. But others believe that the touted transformational effects are overstated. UBS analysts, for example, estimate a modest +0.5% per annum contribution to GDP growth, taking into consideration a combination of the factors below:

i) Increased domestic investment in energy industry
ii) Reduced dependency on foreign energy imports
iii) Higher purchasing power
iv) Benefits to the petrochemicals industry
v) Stronger dollar lowering US export, offsetting gains in other industries

In terms of analysing impact, we address the question in two parts:

i) How will it impact the wider US economy?
ii) What are the effects on industries?

We then follow on to discuss some of the stock-specific implications on a more micro level, of great interest from an investment perspective, by identifying of the major players as well as beneficiaries up and downstream along the production chain.

Impact on US Economy

To assess the broader economic implications, it is necessary to consider both the short and long-term consequences. Since the rapid expansion of the shale gas industry in the second half of the last decade, its impact has been mainly industry driven with a regional focus, thereby largely inconsequential to macroeconomics on a national level. The fact is that despite the expansion, oil & gas exploration still only account for less than 1% of the current dollar GDP today, suggesting that it would require a much larger annual growth rate to give a significant boost to US GDP growth.

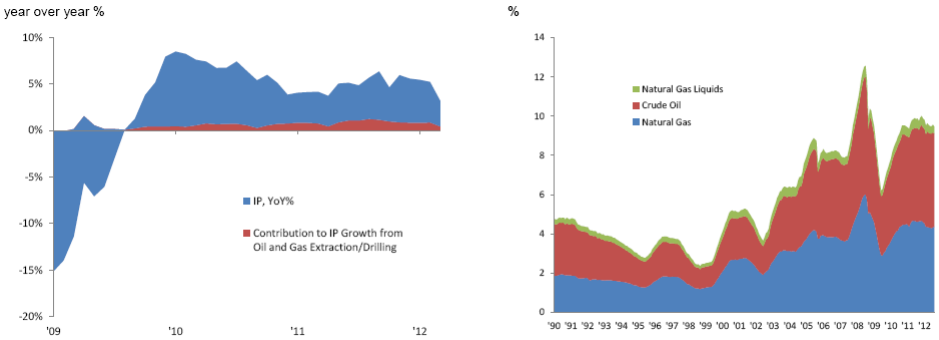
Exhibit 9: Oil & gas contribution to real US GDP growth

Source: US Bureau of Economic Analysis, Credit Suisse

The impression that oil and gas exploration has made on raising industrial production (IP) levels is more visible. As a share of industrial production (IP),

O&G exploration has almost tripled from a decade ago to around 9%, and during the peak production in January 2012 it contributed 28% to annual IP growth.

Exhibit 10: Oil & gas exploration as a share of industrial production



Source: US Bureau of Economic Analysis, Credit Suisse

The contribution to future GDP growth is likely to be spread out over a number of years, and will only really begin to gather momentum beyond the latter half of this decade, in part due to the time-consuming nature of making a wholesale transition from traditional oil and coal to natural gas, on a national scale. The necessary infrastructure to accommodate for the excess capacity is still in development: storage facilities, pipelines to transport gas to the relevant markets and various conversions units/new units to be built by different energy-intensive industries seeking to improve their cost efficiency.

Demand for natural gas will only pick up once these infrastructures are set in place, and will be predominantly driven by the following sectors:

i) Coal-to-gas substitution in power generation
ii) Utilities' demand from the residential and commercial sector
iii) Industrial demand from petrochemicals & fertilisers sector (feedstock/fuel)
iv) Transportation sector (natural gas vehicles NGVs)
v) LNG exports

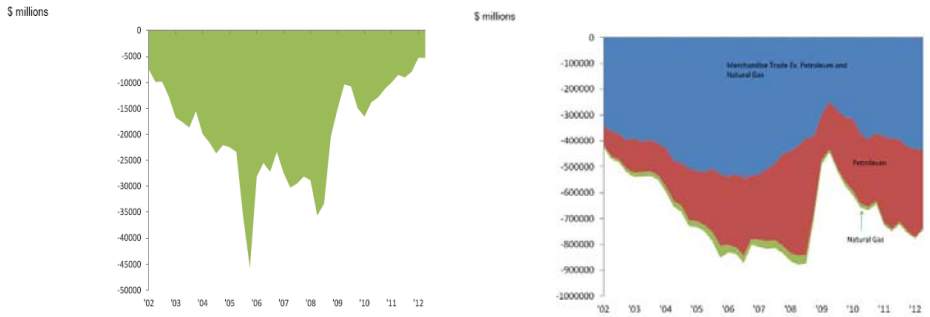
The effect can be more immediate (industrials) for some industries, whilst for others (transportation) the transition can take longer and the payoff will materialise at a much later stage. Throughout the implementation process a plethora of new economic activities, or multiplier effects, in terms of stimulating job creation, heighten manufacturing/industrial output, and increasing new orders for goods and services in the peripheral industries can be generated. The timeframe and the extent to which the economy can adopt the necessary changes across its sectors will be the key determinants in assessing when, and how significant the impact of shale gas on real GDP growth will be.

Foreign Energy Dependency

One of the direct effects of heightened natural gas output is reflected in the import volume, which has experienced a marked decline in recent years, as trade deficit in natural gas is rapidly creeping towards surplus territory. At current

paces, the ambition of becoming a net exporter of natural gas (mainly in LNG form) can be realised within the next year or two. The US has also achieved trade surplus in refined fuels in 2011, although a huge trade deficit still exists in total energy goods. Within the merchandise trade deficit, 41% is attributed to deficit in petroleum, and in aggregate crude oil imports represents approximately 2% of nominal GDP. Natural gas on the other hand forms a minuscule representation by comparison, inferring that the objective of achieving 'energy independence' becomes more relevant for oil rather than natural gas.

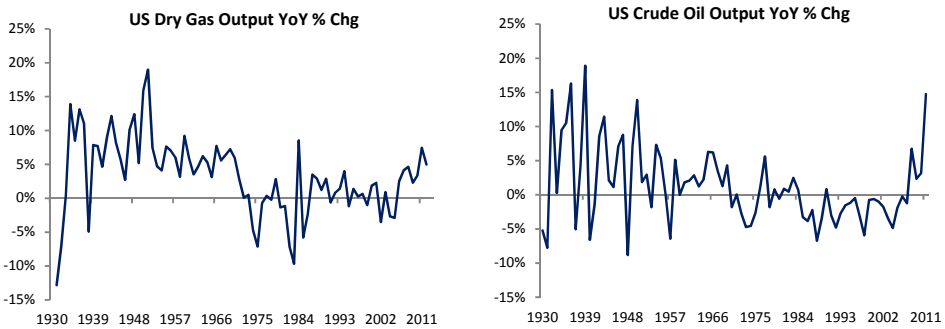
Exhibit 11: US natural gas trade balance (left); US trade deficit – energy & non energy (right)



Source: US Bureau of Economic Analysis, Credit Suisse

Whilst the expansion in shale gas exploration was primarily a result of technological advances, the collapse in natural gas prices since 2008 and the concurrent persistant high oil prices helped to drive an escalation in US domestic crude oil production over the past 3 years – the first time after 38 years of declining output. Gas exploration became so unprofitable that a number of rigs found themselves unable to break-even, propelling rig operators to drill for oil and liquids instead. Consequent to this, US had the largest growth in oil production of any nation outside the OPEC in 2011, where ¾ of the rigs in the US were drilling for oil. However, whether they are capable of maintaining this rate of production remains to be seen.

Exhibit 12: Historical US crude output & natural gas output 1930-2012



Source: Energy Information Association (EIA)

The US is the largest consumer of crude oil in the world, consuming around 18.9mb/d of liquid fuels in 2011. Domestic production on the other hand aggregated 8.5mbd (5.5mb/d crude, 2.1mb/d NGLs and 0.9mb/d biofuels) in the same year[10], leaving a 10.4mb/d gap that needs to be fulfilled by either imports or a combination of the following:

i) Higher domestic shale oil production
ii) Higher contribution from Gulf of Mexico
iii) Substitution from NGLs or GTLs, given the extra natural gas resource
iv) Energy efficiency/Lower demand

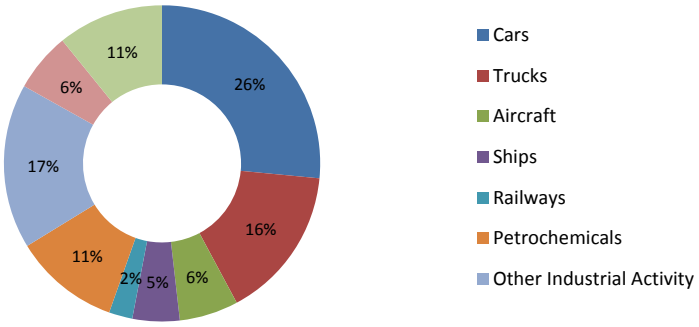
Projections of future production trajectory are subject to many uncertainties regarding the actual level of resources available, the difficulty in extraction, and the evolution of the technologies (and associated costs) used to recover them. The main risk this industry faces is the possibility that a plateau in growth will be reached sooner than expected, as on an energy content basis, drilling shale oil wells is much less efficient than drilling shale gas wells. The 'expected ultimate recovery' (EUR) of gas wells is five times higher than that of oil wells, meaning that possible high depletion rates will necessitate ever more investment and drilling to merely maintain output stability. Whilst production rate has been increasing over the past few years, it is by no means conclusive that this trend will continue, and it may well be the case that production will be hit by dramatic declines in the near future. Since shale oil exploration has a shorter history than shale gas, the science behind computation of well depletion rates is not as accurate, and therefore still subject to large margin for error.

From a logistics perspective, the challenge lies primarily in the upfront capex required to fund these programmes, which is difficult when the US economy is still recovering from the recession, especially for small players without deep pockets. To fund the US$150 billion of required annual industry capex, it would require oil prices to remain above $95/bbl at least for another two years, and in the longer term prices is calculated to hover around the $80/bbl mark[11]. In reality the price is likely to be higher, as outside North America non-OPEC production growth has been negative in 2012, constraining global supplies, potentially offsetting some of the negative concerns.

On a more positive note, with the constant development in new technologies, prospects could be improved in terms of bringing in plays that are not feasible using the current skill-set, thereby increasing the capacity of technically recoverable resources.

[10] Credit Suisse: The Oil production Outlook, *07 September 2012*
[11] Credit Suisse: The Shale Revolution, *13 December 2012*

Exhibit 13: Crude oil consumption in the US by sectors



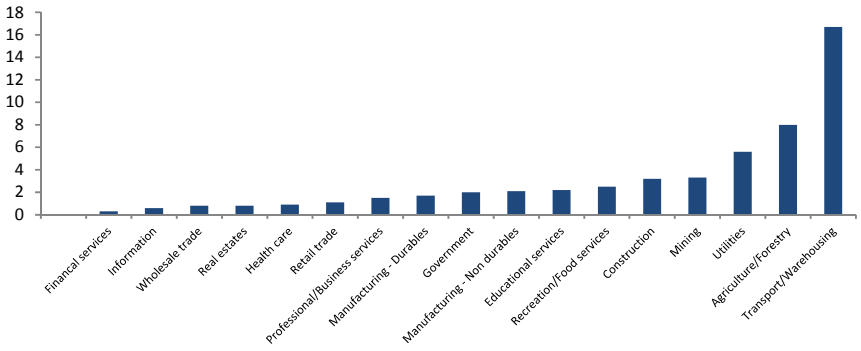
Source: Citigroup

Exhibit 13 illustrates the breakdown of that consumption in which we observe that over 55% comes from the transportation sector, making this the real game-changer in the goal to reduce the US dependence on crude oil. The way to resolve this issue is through an elevated utilisation of natural gas as a cheap alternative fuel via the promotion of natural gas vehicles (NGVs), and the engine of this transition has already began to turn. But, as mentioned above, the development is still in a very early stage and many companies remain cautious or outright sceptical about the economic ambiguity of making this transition; they are especially wary of taking big risks in the current economic environment. In this respect, there is still a long way to go before the US can achieve total 'energy independence'.

Domestic Purchasing Power

Lower natural gas prices in the US puts downward pressure in the near-term for some utility prices, in particular electricity and heating. In theory this is beneficial for the residential sector as it can enhance household purchasing power by reducing the domestic expenditure on utility bills, thereby creating excess wealth that can be distributed elsewhere in the economy. However in many areas the infrastructure is lacking to absorb the available natural gas capacity, but once the logistics issues are resolved, consumers stand to benefit in the long-term. As an example, a large-scale pipeline system is being built, extending from Southern Texas to New York City, which could supply the electricity-intensive city with 8.5Bcf of capacity per day system-wide. Consumers can also benefit via secondary impacts from reduced manufacturing costs in many industries feeding through to lower prices on end-products.

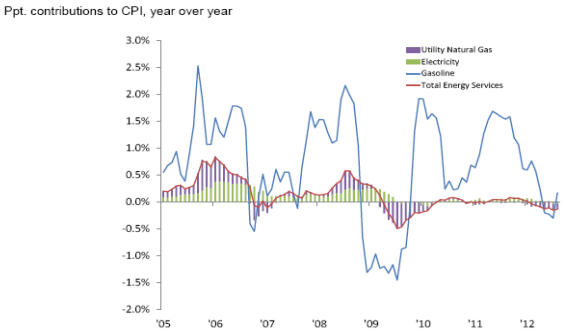
Exhibit 14: Energy input as a % of gross output by industry



Source: US Bureau of Economic Analysis

A minor consequence of lower utility bills is its adverse effect on headline CPI. But since its weight in the calculation of CPI is very small (0.9%), an 11% plunge in gas prices last year only resulted in a negligible -0.1% subtraction from headline CPI last year. However, one potential downside is that any decline in natural gas prices may be overshadowed by movements in gasoline prices, as it constitutes a much larger proportion of consumer spending with a much more volatile price movement, as illustrated by the Exhibit below. There is therefore an offsetting scenario where domestic income merely gets redistributed within the country.

Exhibit 15: Energy component contributions to inflation



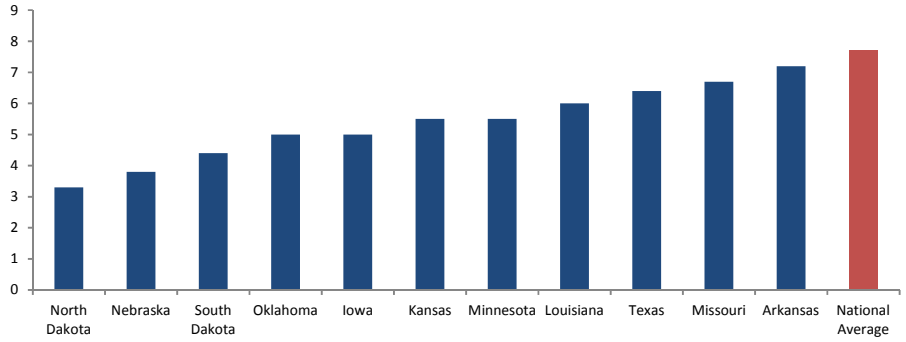
Source: US Bureau of Economic Analysis, Credit Suisse

Employment

At the end of March 2013, the number of workers (full and part time) in the oil and gas extraction industry constituted 0.14% of overall US non-farm payrolls, the 192,500 jobs is almost negligible when viewed against a 135 million total headcount. Even after including the supporting businesses in the peripheral industries it still aggregates to less than 1% of total payrolls. This is due partly to the nature of the industry, which is very capital intensive, thus giving rise to comparatively high real GDP per worker. The effect on the regional labour market is much more pronounced, with unemployment rates in the main deposit-rich

states all lower than the 7.7% national average. These states have also experienced sharp increases in headcounts over the past decade.

Exhibit 16: Regional unemployment rate (%) against national average, Feb 2013.



Source: US Bureau of Labour Statistics

Jobs in the oil & gas exploration industry grew by 4.2% since March 2012 (5.4% if inclusive of supporting industries), compared to a 1.4% growth rate for the total payrolls data over the same period. However, even if the industry (direct and indirect) doubles in size over the next five years, which is equivalent to 15% growth per annum, it would only contribute a meagre +0.1% estimated impact on the total US workforce, as calculated by UBS analysts[12]. Indirect effect on jobs data is also limited, as BLS Employment Requirement data implies that each job in the oil & gas exploration generates 2.3 jobs elsewhere.

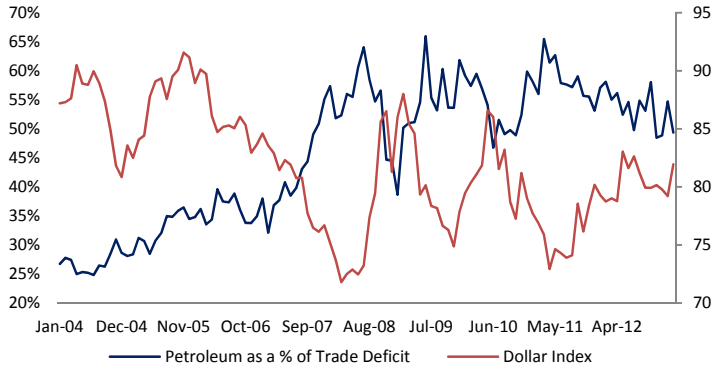
Dollar Strength

A stronger dollar will likely accompany an energy led decline in US trade deficit over the next decade as a consequence of the shale boom, which presents an offsetting factor for the non-petroleum part of US trade balance. Again, this will be a consequence of lower crude oil imports over the long term.

The US current account deficit has halved from 6% to 3% since 2007, and last year the US totalled a lower net oil import bill of £291bn or 2% of GDP, which accounted for two-thirds of the total estimated US account deficits as measured by the IMF. Historically the dollar has tended to fall during oil price rallies, and so there exists a clear long-term positive effect on the dollar if deficits continue to fall. UBS analysts predict that the dollar index will appreciate by 10% in the scenario that oil trade deficit will halve by another 1% of GDP over the next decade.

[12] UBS Q Series: Shale Boom & the Economy, *03 June 2012*

Exhibit 17: DXY vs. WTI or petroleum trade deficit.



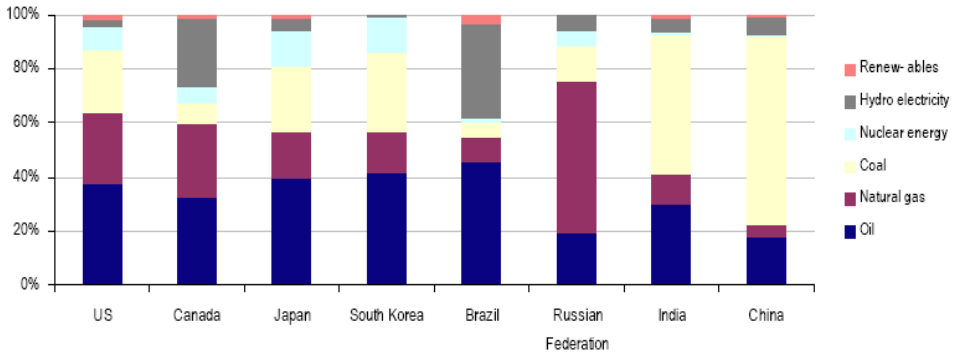
Source: Bloomberg

Furthermore the petro-balances in other major import regions including Europe, Japan and emerging Asia are set on a path of deterioration over the same period. The effect of dollar appreciation will have negative impacts on the relative competitiveness of US exports to some extent, thereby reducing real growth by 0.3% per annum, as calculated by the Asian Development Bank Institute (ADBI).

Impact on Industries

Fossil fuels represent over 80% of US fuel consumption, of which crude oil takes the biggest share; natural gas and coal each makes up around 20%-25% of the total. But in emerging economies such as China and India as shown in Exhibit below, coal is still by far the biggest driver of consumption, and demand for it remains strong.

Exhibit 18: World Energy consumption breakdown, 2011



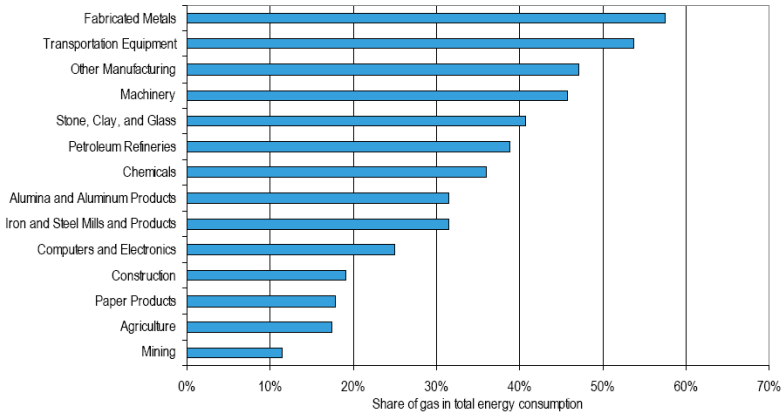
Source: UBS

The price of natural gas has recovered from the winter-2012 trough of US$1.9/MMBtu back up to over $4/MMBtu, but there is still a long way to go before closing in on the price of oil (75% discount to WTI) on an energy-equivalent basis. Even at $10/MMBtu (Europe) the discount is closer to 45% of

Brent, the only region that comes close is the landed LNG prices in Asia ($16/MMBtu)[13]. There are opposing views on the future of oil and coal. The majority view appears to be that even when US shale gas supply is fully ramped, it will not alter the price of crude oil and NGLs (natural gas liquids) meaningfully, as they are determined by international market supply and demand fundamentals. Even under this bullish outlook it will be years before noticeable effect can be observed. On the other hand, the effect on coal is more visible in the short-term.

Several manufacturing industries expect to see an increase in productions as they capitalise on the inexpensive and plentiful natural gas and its various liquefied form supplies. These industries include LNG, GTLs, CNGs, ammonia and ethylene/polyethylene and possibly NGVs over a longer horizon[14]. The impact varies from significant – petrochemicals – which do not require extensive modification to infrastructure, to modest – utilities & transport – where the upfront investment will be very costly, and demand is likely to stagnate or grow very slowly. Hence it would not be realistic to expect material changes to take place in the near-term (over the next 3-5 year horizon at least). The Exhibit below shows shares of natural gas in energy consumption in the most energy-intensive sectors. The share of NGLs/feedstock is not included, which would elevate usage to a much higher level for industries such as petrochemicals and fertilisers.

Exhibit 19: Natural Gas as a Share of Total Energy Consumption by Sector (dry only, does not include feedstock consumption)



Source: EIA, Citi Investment Research and Analysis

Power Generation & Utilities

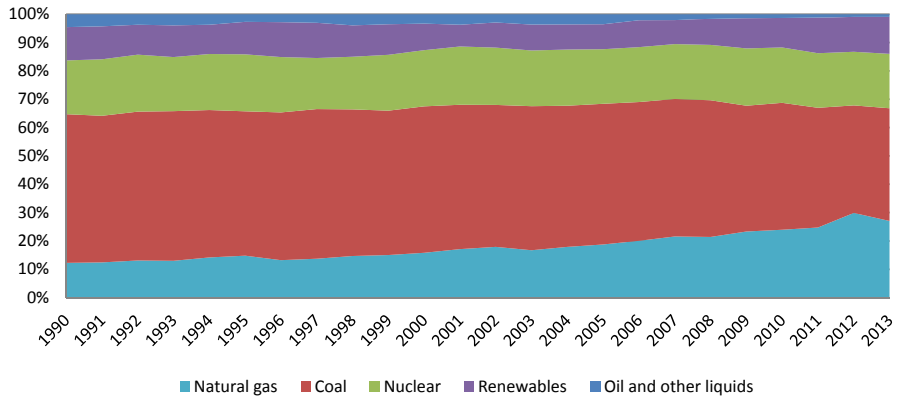
The development of shale gas has already witnessed concrete impacts on domestic demand for coal over the past 3-4 years. It is being displaced by natural

[13] Energy conversion factor: 1 barrel of crude oil = 5.8MMBtu = 5.7Mcf of natural gas

[14] See Appendix 1 for chemical constituent breakdown of the natural gas variants (CNG, LNG, NGL, GTL)

gas, where its share of power generation has fallen by a third in 2012, as electricity producers came to favour the cheaper gas alternative. On a longer horizon, natural gas has gained market share at the expense of coal, which has fallen from 45% to 35% since 2009, whilst natural gas rose from 22% to 30% during the same timeframe.

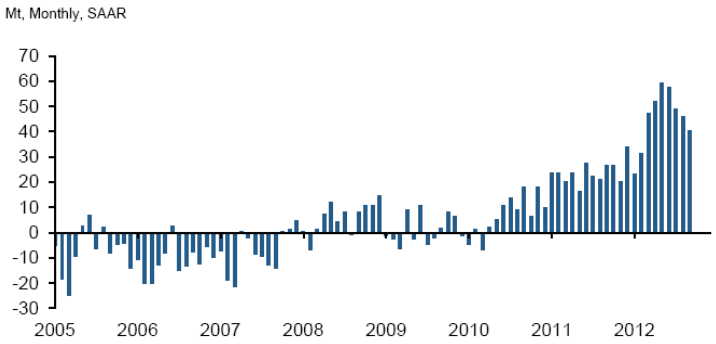
Exhibit 20: US power generation by fuel type



Source: EIA

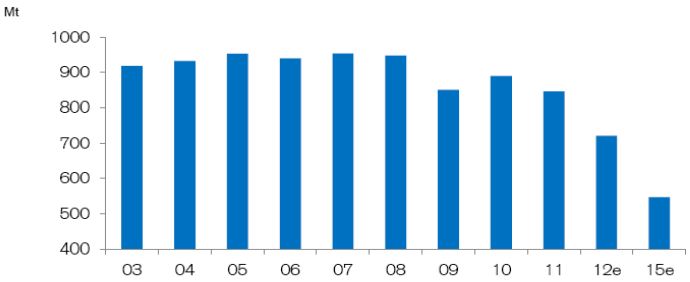
Recent recovery of the Henry Hub prices will reverse this trend to some extent in the short-term, but the longer-term trend seems to indicate a permanent structural decline in the US, as stringent emission rules will lead to numerous coal plant retirements in the future. This could result in an additional 3-4Bcf/d of gas demand by 2017, given the 45-50 Gigawatt of capacity void left by coal (a.k.a. 20% reduction in coal-fired capacity). Consequently, this will free up the excess capacity for export, as evidenced in the switching of US from being a net importer of coal to a net exporter over the last two years. The soft domestic market has driven coal producers to seek alternative markets overseas, mostly shipping to European countries (which has in fact led to an oversupply in the region), and subsequently helped to depress coal prices.

Exhibit 21: US trade balance in thermal coal



Source: Credit Suisse, Customs data

Exhibit 22: US domestic power plant coal consumption



Source: Credit Suisse, EIA

Outside the US, coal is likely to remain the core energy input for many nations. In particular, emerging countries such as China and India, the two largest coal importers in the world, will continue their consumption in huge quantities, relying on it as the main source of energy in industrial and commercial activities. Hence, on an environmental note, while shale gas leads to lower CO^2 emissions in the US, it will be compensated by a higher emission elsewhere in the world.

In Europe, coal consumption has increased over the past year, incentivised by the presence of falling coal prices and the inherent high natural gas prices prevailing across the continent. The potential to explore shale gas reserves is much lower due to geological difficulty and environmental concerns with hydraulic fracking. The Europeans are more likely to take the approach of exploiting other means of unconventional resources, such as renewable energy and nuclear energy, as well as importing LNG from the US, which a few countries, including the UK, have already struck deals to secure future supplies.

What will change the game for coal globally depends on how successfully these nations can tap their respective shale gas reserves. This is especially relevant for China as it has the largest proven shale gas reserve globally; its pressing environmental concerns and eagerness to consolidate energy security compels the government to take aggressive measures to develop this resource, which will become the key determinant driving future coal demands. Therefore, at least until the end of this decade, the capacity for substitution will be limited.

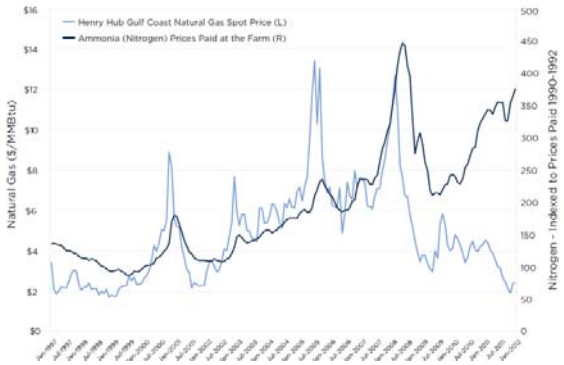
Agriculture – Fertilisers

On the manufacturing side, the North American nitrogen industry is benefitting immensely from the cheap natural gas; it constitutes almost 85% (including NGLs) of total production cost in the manufacturing of ammonia for fertilisers[15], where it is used as a feedstock as well as a process fuel. For each tonne of ammonia it requires 32.5MMBtu of natural gas input: the most gas-intensive within the industrial sector.

[15] Clean Skies: How innovation in oil and gas exploration is spurring the US economy, *October 2012*

In 2011, the US imported 55% of its ammonia from abroad, where prices remained at a premium due to continued high demand. As US farmers are expected to continue increasing acreage in response to rising commodity prices and demand for bio-fuel crops, the demand for ammonia will likely persist. The strong margins attracted a return to activities with investments for new capacity (Iowa Fertilizer - $1.3 billion facility), as well as planned expansions from the biggest nitrogen producers – including Agrium, CF and Koch – aggregating to 9m tonnes/year of additional production from 2016 onwards. The increase in domestic production will displace some of the more expensive imports, though it will have a negative impact on price premiums in the long-run as the US becomes self-sufficient in its nitrogen capacity.

Exhibit 23: Price differential between Henry Hub spot price and Ammonia prices



Source: American Clean Skies Foundation, USDA, EIA

Some corporations have taken the opportunity to restart previously idled operations, including:

i. **Orascom Construction** bought and reopened a large ammonia plant in Beaumont, TX.
ii. **CF Industries** restarted its large Donaldsonville, LA plant and has planned over $1 billion in investments to expand ammonia production capacity over the next four years.
iii. **Potash Corp** is investing in the restart of an ammonia plant shut in 2003.

Petrochemicals

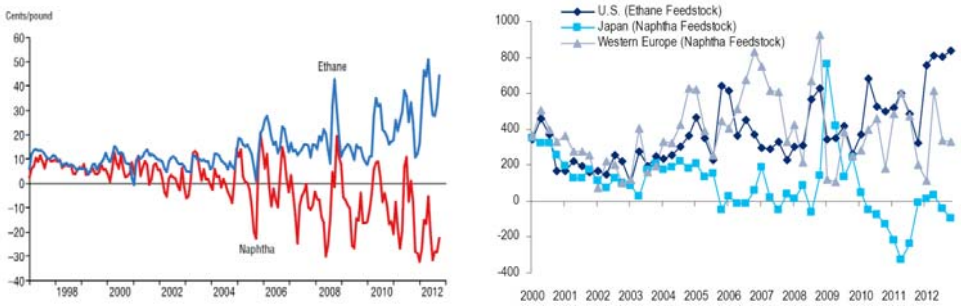
The biggest beneficiary of cheaper gas prices in the US to date has to be the petrochemical industry, re-emerging as producers can take advantage of the higher NGL content, or “wetness”, of many reserves to extract the required feedstock chemicals in the manufacturing of olefin products. This places them in an extremely competitive position, where the massive reduction in their input cost slides them towards the lower end of the global cost curve, to the extent that US producers will cripple competitions in Europe and Asia.

Ethane is the primary feedstock used in the US petrochemical industry for ethylene cracking in the production of various plastics, whilst their international

competitors rely heavily on expensive oil-based naphtha, and is observing increasing downward pressure on their profit margins. It cost 60 cents to produce a pound of ethylene with fewer than 12 cents of ethane in September 2012, whilst the naphtha equivalent requires an input cost of $1.37. In the US, the feedstock ratio is 2:1 of NGL to naphtha, constituting 90% of the capacity combined. An even higher ratio (75:21) can be found in the Middle East, whereas in Western Europe and Asia the ratio is reversed.

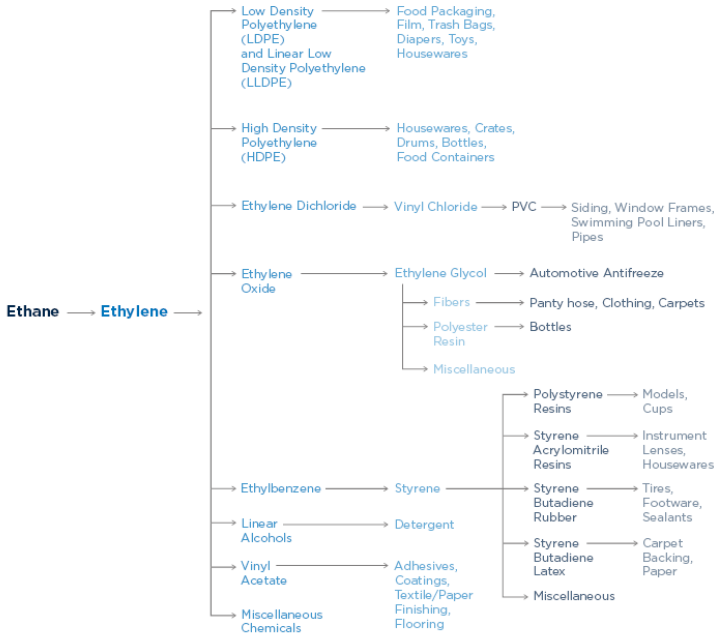
In this regard, the US has become a highly cost effective place to invest in new petrochemical refinery plants, with ethylene cracking capacities poised to increase by a third by 2016/2017, according the Federal Reserve Bank of Dallas.

Exhibit 24: Profit margins for one pound of of ethylene cracked, US (left) versus other regions (right).



Source: Federal Reseve Bank of Dallas (left), Citi Research (right)

Exhibit 25: Flow chart depicting the end uses for ethylene



Source: American Clean Skies Foundation, American Chemistry Council

Exhibit 26: Potential chemical plants in the pipeline

Company	Project	Capacity (tonnes)	Location	Cost	Start-up
ExxonMobil Chemical	New Cracker	1.5m	Baytown, TX	n.a.	2016
Chevron Phillips Chemical	New Cracker	1.5m	Cedar Bayou, TX	n.a.	1Q 2012
Dow Chemical	New Cracker	>800,000	U.S. Gulf Coast	n.a.	2016-17
Shell	New Cracker	>800,000	U.S. Northeat	n.a.	2016-17
Sasol	New cracker	1.2m	Lake Charles, LA	n.a.	2017
Formosa Plastics	New Cracker	800,000	Point Comfort, TX	$1.7bn	2016
Dow Chemical	Restart	390,000	St.Charles Parish, LA	n.a.	End 2012
LyondellBasell	Expansion	386,000	La Porte, TX	n.a.	2014
Williams	Expansion	272,158	Geismar, LA	$350m–$400m	3Q 2012
Westlake Chemical	Expansion	113,399	Lake Charles, LA	n.a.	2014
Westlake Chemical	Expansion	108,863	Lake Charles, LA	n.a.	Midyear 2012
INEOS	Debottleneck	115,000	Chocolate Bayou, TX	n.a.	End 2013

Source: UBS

Here we highlight the several important projects in progress:

i. **Westlake** plans expansion of ethylene cracker and is evaluating conversion from propane to ethane feedstock.
ii. **Chevron Phillips** is constructing a large-scale ethane cracker and ethylene derivatives at one of its facilities in the Gulf Coast region.
iii. **DOW Chemicals** made commitments to increase the ethylene and propylene production through the construction of a new cracker facility as well as re-starting an older cracker, with the objective of taking full geographical advantage of the Marcellus and Eagle Ford shale deposits.
iv. **Shell** is planning to build a large-scale ethylene cracking facility near Marcellus, with integrated derivative units in the Appalachian region of the US.

The other names mentioned in the table should also benefit from cost advantages at least until 2015-6, when domestic capacity goes into wholesale operation.

However the role of naphtha as an important raw material should not be dismissed. Naphtha cracking can yield valuable heavy hydrocarbons, including propylene (16%) and butadiene (19%), whereas ethylene cracking produces a much lower proportion of these products (5%). This has placed upward pressure on the prices for these products over the past 3 years as a result of poorer production. In response, Dow Chemical and Lyondell Basell are mobilised to address this problem and take advantage of the short propylene market in the US. The former plans to build 2 targeted (propane-to-propylene) plants on the Gulf Coast, and the latter is in the process of expanding propylene capacity in its existing ethylene crackers.

European chemical companies whose operations are not concentrated in ethylene chemistry will still be able to maintain some level of profitability in the medium term as they retain their propylene / butadiene production levels. Arkema, for example, has the greatest European exposure to propylene chemistry, whilst Solvay becomes increasingly disadvantaged as it has the highest exposure to ethylene chemistry. In the long-run, there is no foreseeable improvement in the European chemical industry, particularly in the ethylene sector, where facilities face a choice between wholesale closure and strategic

migration to the US (currently 15-20% of operations have already been established in North America) to sustain profitability and competitiveness.

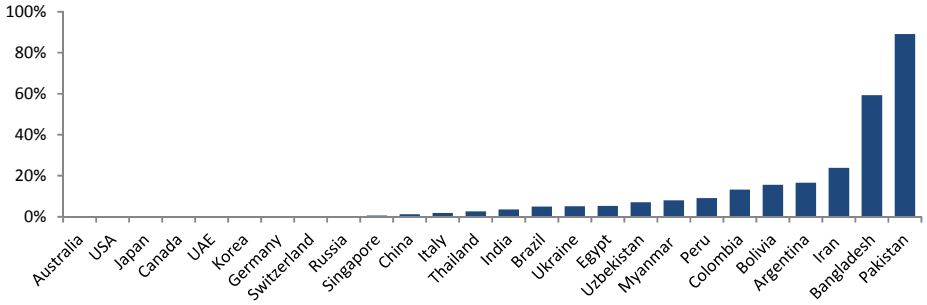
Asian petrochemicals on the other hand are much more seriously affected. This continent consumes almost half the global ethylene while sourcing a third of total capacity, with much of its production naphtha-based. In the long-term, most cracker operations in the region (especially Japan and Taiwan) will eventually face up to the problem of a permanent impairment of profitability, implying either restructuring or wholesale closure.

Transportation

In the transport sector natural gas still plays a niche role, while its diesel and gasoline counterparts remain the dominant fuel of choice, where they account for over 90% of total energy consumption combined. The sector itself is by far the most energy intensive, requiring the highest energy input as a share of gross output among all the US industries, and has gained a reputation as the 'wildcard' in defining future natural gas demand. If inexpensive natural gas fuels could be utilised on a large scale, particularly across heavy-duty fleets that accumulate high annual mileage, it could have far-reaching implications on the economy in terms of reducing oil imports, cutting costs for the transport sector and stimulating opportunities for the intermediary engineering and manufacturing companies (e.g. engine technology providers & fuelling infrastructure companies).

Based on data from NGVA Europe, the number of NGV fleets globally currently stands at approximately 16.2 million units, including 700,000 buses and 362,000 medium and heavy duty trucks. The numbers are growing fast at a compound annual rate of 15% since 2008, albeit from a small base where the NGV share of global fleets is still only 1.5%. Growth has been driven primarily by the emerging markets where NGV penetration reached around 3.5%, whereas its share of the developed markets falls considerably below the global average at 0.2%. For emerging countries many governments have strong incentives in place to promote NGVs by way of reducing dependency on oil and/or controlling pollution (a.k.a. China & India). In principle, there is substantial growth potential for developed markets, especially in the US where it has abundant and well established natural gas resources with prices at a large discount to oil.

Exhibit 27: Share of NGVs in a country's total vehicle market

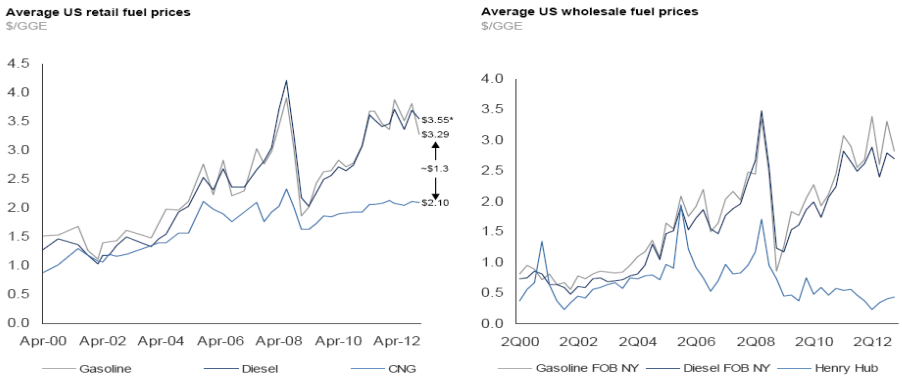


Source: NGVA Europe

Existing NGV models run predominantly on compressed natural gas (CNG) for passenger cars and LNG for medium to heavy-duty vehicles, due to its superior energy intensity (and the fact that it will vaporise after 1-2 weeks means it is more suitable for vehicles in constant use). This type of vehicle is offered by a plethora of European to Asian auto manufacturers. The selection in the US is more concentrated, although all four major US auto-makers have taken initiatives, offering a number of CNG cars as well as making retrofit engine conversions readily available for a range of regular engine models.

Morgan Stanley calculated that the payback period for adopting 'Class 8' LNG trucks can be relatively short (3-4 years), under the assumption that annual mileage exceeds 100,000 miles at an LNG price of $2.5-3.0/dge (diesel gallon equivalent)[16]. The economics of CNG and low-mileage cars in general are less attractive in comparison given the high incremental engine/equipment costs and the shorter travel range, putting it at a premium of $4000 per vehicle currently.

Exhibit 28: Average price of retail and wholesale CNG price in the US today



Source: US Department of Energy, Morgan Stanley

Currently the biggest hurdle is the lack of refuelling infrastructure; lower fuel cost from natural gas is actual the smaller part of the equation. In the US there are 1,074 CNG stations and only 28 LNG stations. Growing these numbers commands huge upfront capital investments, and in a somewhat circular argument, requires a critical number of NGVs on the road to justify the investment. The cost of adding a CNG facility to an existing fuelling station is estimated to be around $0.4 million, whilst building a new CNG station requires a budget of $1.6 million. The cost of LNG stations stands even higher at $1.4-2.2 million per station (which also needs to be located within a 150-300 miles radius of a LNG liquefaction plant by necessity). Both corporates and governments globally have announced or implemented a wide range of initiatives designed to increase the adoption of natural gas as a fuel in transportation. Some of the key projects in progress are listed below[17]:

[16] Morgan Stanley: Natural gas as a transportation fuel – Energy market wild card, *16 April 2013*

[17] A more comprehensive list of activities can be found on US DoE's Alternative Fuels Data Centre webpage: http://www.afdc.energy.gov/case

Conversion projects:

i. **Westport** & **Cummins** are both introducing new natural gas engines to incorporate into existing car models.
ii. **Navistar** is in a joint venture with **Clean Energy Fuels** (CLNE) to roll out NG-powered trucks with CLNE supplying the refuelling infrastructure.
iii. **UPS** announced its plan in April 2013 to purchase 700 LNG vehicles and to build 4 refuelling stations by the end of 2014, the most extensive conversion project in the US to date.
iv. **GM & Chrysler** announced their roll-out of natural gas powered pickup trucks in mid-2012.
v. **Volvo** & **Shell** are collaborating to use LNG in heavy duty trucks in North America and Europe.
vi. **FedEx** plans to convert the majority of its 90,000 US ground vehicles to CNG/LNG in the next few years.
vii. **MAN Diesel & Turbo** has received first orders for its dual fuel MEGI gas powered engine.
viii. **Volkswagen** announced the launch of a new CNG-powered Golf called the "TGI BlueMotion" in summer 2012.
ix. **The Beijing Public Transport Group** in China recently announced ~3,200 new LNG buses for its fleet in 2013.

Refuelling infrastructure projects:

i. **Shell** is building two small-scale liquefaction units in North American to establish two new LNG trucking corridors.
ii. **Chesapeake** and **GE** have launched a 'CNG in a box' system to allow easier adoption of CNG refuelling.
iii. **Clean Energy** is currently targeting to reach 150 LNG fuel stations along every major interstate trucking corridor in the US in 2013.
iv. **ENI, NGVA and European Union are collaborating** on the LNG 'Blue Corridors' project to develop LNG refuelling infrastructure across four pan-European long-distance truck routes.
v. **ENN Energy Holdings** aims to add 30-40 CNG stations each year and over 100 LNG stations in China in 2013.
vi. **Kunlun Energy** of China is working on a railway corridor for LNG transportation between Golmud, Qinghai and Lhasa with subsidies from the government.

There are also compelling arguments for switching to LNG fuel for ships, where the payback period can be as short as two years. But since current ship designs are incompatible with LNG engines and conversions can be logistically problematic, LNG-powered engines can only be installed on new vessels for the time being. Recently in the US rail industry there have also been intense debates over the viability of making the transition from diesel fuel to LNG or GTL, which could potentially slash substantial costs for US rail networks, since this is the second most diesel-intensive user after the US Navy.

Aside from CNG and LNG, there have also been numerous efforts to develop gas substitutes for oil with gas-to-liquid (GTL) – a hybrid natural gas and diesel fuel – that can be used to fuel heavy-duty trucks, trains and aircrafts. Qatar's Pearl GTL plant is currently the biggest producer of this fuel, holding on to the tight market. Pearl GTL is expecting to produce around one million tonnes of GTL per annum from 2012, enough to power a typical commercial airliner for half a billion

kilometres (equivalent to carrying 250 passengers around the world 4,000 times).[18] The US and Canada are set to follow this trend with Sasol and Shell contemplating ventures in these regions, although we are not likely to observe any tangible outcome until at least early next decade.

UPS is in the process of converting its fleets to natural gas, but has also indicated an interest in the GTL sphere. However, most advanced progress in GTL has come from the aviation sector. Boeing has designed a concept aircraft that runs on GTL, and Qatar Airways has advanced further in this field. The company partnered up with Qatar Petroleum and Shell and unveiled the result of Qatar's largest energy project - a new aviation jet fuel using a 50-50 semi-synthetic formulation of GTL jet fuel and synthetic paraffinic kerosene (SKP) - which can be used without any modification to the existing aircraft and engines. It claims to be the first new aviation fuel approved globally in two decades, and the first commercial flight running on this fuel has been already made, in October 2009 from Doha to Heathrow. GTL jet fuel has a higher energy density per unit volume, weighing less than conventional fuel, and offers improved thermal stability to withstand higher temperatures. This means better fuel economy, reduced aircraft weight, enhanced range performance, as well as lower particulate emissions beneficial to the environment.

Ship, Rail & Aviation:

i. **Shell** has contracted two new LNG-powered barges to operate on the Rhine from 2013.
ii. **BNSF** announced the plan to test a small number of locomotives in the US using LNG this year. **GE** and **EMD** (a unit of Caterpillar) will be helping to develop the natural gas engine technology to be used in the pilot.
iii. **Canadian National Railway** is experimenting with natural gas (using a combination of diesel and CNG) as a train fuel.

Export Potential: LNG markets

There have been keen proposals for the US to become a major exportation hub for natural gas in the shape of LNGs (Liquefied Natural Gas), which is simply natural gas cooled down to its liquid state at very low temperatures, under a process known as liquefaction. In liquid state, it takes up only 1/600th of the volume at its gaseous state and can achieve 60% of energy density as diesel fuel, which is more than its compressed natural gas (CNG) counterpart. Hence it is more cost efficient in terms of storage and for transporting over long distances, where it can be re-gassified and distributed to the relevant markets.

The high price differential between US natural gas prices relative to the rest of the world is prompting US producers to exploit the LNG market, where high global demand is constrained by available capacity. LNG prices in Asia and

18 Gas to Liquids Jet Fuel research: http://www.shell.com.qa/en/products-services/qatartechnology/jet-fuel.html

Europe have traded well above crude oil equivalents this past winter as a result of tight supplies. Exporters in Egypt, Algeria and Indonesia have faced steep declines in production in the past year, in conjunction with Japan and South Africa's escalating demand in the aversion of a future nuclear and hydro-power crisis. China, India and ASEAN countries will also become increasingly important at the receiving end of the LNG trade, with long-term incentives to progressively shift away from coal and oil in the interest of energy security and environmental needs for cleaner fuels. The supply situation will only begin to loosen beyond 2015-17, when new volumes are injected into the market as projects currently under construction (mainly Australia, US and African nations) mature, and go into operation. The question is to what extent is the US willing, or capable, of participating in this market?

The economic benefits supporting LNG exports appear to be mounting. A Department of Energy (DoE) study in Q4 2012 defended the notion that the net economic benefits would increase as the level of LNG exports increases. However, the possibility of the US becoming a major exporter appears to be thin at least in the near-term, as political oppositions inhibit large-scale energy exports. Protectionists fear the erosion of domestic competitiveness where prices would become more aligned with the global average in the onset of a surge in exports. Manufacturers of chemicals, fertilisers among others, who benefit from cheap domestic natural gas would also share this view, inducing pressure on Washington to cap export volume for some years.

Presently in the US, applications to obtain export permits must be authorised case by case by the DoE, where it awards new licences only to countries that have a free-trade agreement with the US, despite conclusions from its study (policy on oil exports is even more stringent, banned everywhere except to Canada). So far only Cheniere's Sabine Pass along California shores has received approval, becoming the first US LNG export terminal (originally intended as an import terminal). Eager subscribers from overseas, including companies like Centrica and BG Group from UK, KOGAS of Korea, Gas Natural Fenosa of Spain, Gail of India and Total of France, have already signed up with Cheniere to secure long-term LNG supplies for the next decade.

The DoE has received 26 applications, which, if all approved (a wildly impossible scenario), could total up to 35Bcf/d of new capacity. The reality would see less than 10 being approved, the list below shows some of the candidates whose projects are under consideration, and which are more likely to materialise out of the group.

Exhibit 29: Market-ready & speculative US LNG export terminals targeting APAC

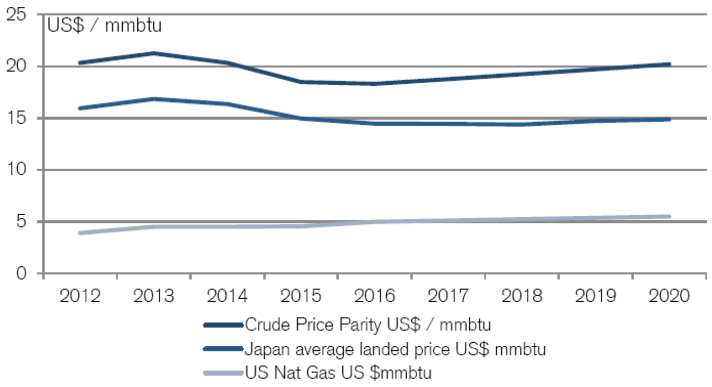
Project	Companies	Location	Capacity (Bcf/d)	Year	Status
Market Ready/Near Market Ready					
Kenai LNG	ConocoPhillips	Kenai, AK	0.2	1969	Operating
Sabine Pass	Cheniere	Cameron, LA	2.2	2016	Approved
BG Sabine Pass Sourced	BG Group	Cameron, LA	0.2	2015	Approved
Lake Charles Export	BG/Southern Union	Lake Charles, LA	2.0	2018	Applied
Freeport LNG	Freeport/Macquarie	Freeport, TC	1.4	2016	Applied
Cove Point Export	Dominion	Lusby, MD	1.0	2017	Applied
Cameron LNG Export	Sempra	Hackberry, LA	1.7	2017	Applied
Lavaca Bay LNG (floating)	Exelerate	Port Lavaca, TX	1.4	2017	Applied

Speculative					
Sabine Pass expansion	Cheniere	Cameron, LA		2017	-
Corpus Crhisti Export	Cheniere	Corpus Christi, TX	2.1	2018	Applied

Source: Credit Suisse, Citi, EIA

Further, the high capital costs associated with developing LNG projects by nature limits the development to major players, and the EIA warns that the ultimate size of recoverable reserves is still uncertain, citing that production could vary from 26Tcf/y (staying at current levels) to 34Tcf/y in 2035. Credit Suisse hypothesised a total export volume of 8.4Bcf/d by 2020 (or 18Tcf/y). Either way, US export volume is not expected to reach the same scale as production, implying that it would not be significant enough to erase the arbitrage opportunities or even disrupt overseas pricing. Landed LNG prices in Asia Pacific are still forecasted to be in the mid-teens by 2020, whilst the price parity with the US would decrease only marginally ($12/MMBtu in 2013 falling to $9.4/MMBtu in 2020). The scenario of a rise in US gas prices above $7/MMBtu would be self-sufficient in pricing out US exports as it becomes uncompetitive overseas, reducing the appeal to Asian importers as delivery cost could rise above $14/MMBtu[19], pushing landed price above this figure to the high-teens, making Henry Hub-indexed gas one the most expensive on the market.

Exhibit 30: Japan LNG landed price forecast 2012-2020



Source: Credit Suisse

What are the environmental risks associated with Hydraulic Fracturing?

As the use of fracking has increased, so have concerns about the possibility of water and air contamination, both above and below ground.

Water contamination:

The potential for contamination of water supplies is a key risk associated with shale gas extraction. Although there is limited evidence, it appears that the fluid used in hydraulic fracturing contains numerous chemical additives, many of

19 Credit Suisse: The Shale Revolution, *December 2012*

which are toxic to humans and/or fauna. Water supplies can be contaminated from four main sources:

- Accidental spills of fluids or solids (drilling fluids, fracturing fluids, water and produced water, hydrocarbons and solid waste) at the surface.

- Leakage of fracturing fluids, saline water from deeper zones, or hydrocarbons into a shallow aquifer through imperfect sealing of the cement column around the casing.

- Leakage of hydrocarbons or chemicals from the producing zone to shallow aquifers through the rock between the two.

- Discharge of insufficiently treated waste water into groundwater or, even, deep underground.

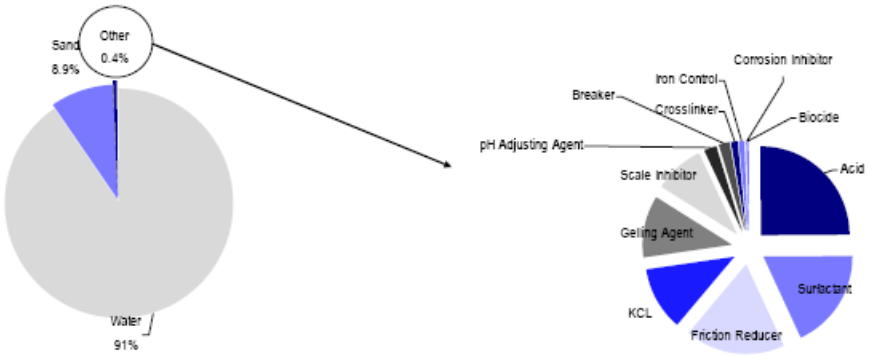
Water use:

Water is a critical issue for shale operations, as each well may require 3-5 million gallons of water for fracking. If mismanaged, fracking fluid which may contain potentially hazardous chemicals can be released by spills, leaks, faulty well construction, or other exposure pathways. Any such releases can contaminate surrounding areas. Fracking also produces large amounts of wastewater, which may contain dissolved chemicals and other contaminants that could require treatment before disposal or reuse. In addition, in areas of water-scarcity, the extraction of water for drilling and hydraulic fracturing can have broad and serious environmental effects. It can lower the water table, affect biodiversity and harm the local ecosystem.

Recent technology developed by Canadian energy company Gasfrac, shows that it may be possible to frack shale gas without requiring water and chemicals using a method called “waterless fracking”[20]. This waterless method involves pumping propane gel instead of water into shale formations, creating pressure that cracks the rocks and releases the trapped natural gas. Unlike water, the gel reverts into vapour due to pressure and heat and returns to the surface along with natural gas for collection, without carrying chemicals back to the surface. The technology is still in its infancy and may cost more than conventional hydraulic fracturing, however if adopted, could provide a solution to the issue of extensive water use necessary for shale gas exploration.

[20] Waterless Fracking Technology research: http://www.gasfrac.com/

Exhibit 31: Example of fracking fluid contents



Source: JOGMEC

Seismic activity:

Of greater concern is the link between fracking and seismic activity. The EIA found fracking to be the cause of earthquakes in Arkansas and Ohio, although many dispute the link to hydraulic fracturing as tenuous. The registered earthquakes were small, of a magnitude of around two on the Richter scale, meaning they were discernible by humans but did not create any surface damage. In the UK, the government has recently lifted its moratorium on fracking on the basis of introducing new regulatory requirements to ensure that seismic risks are effectively mitigated. What is essential for unconventional gas development is to carefully survey the geology of the area to assess whether deep faults or other geological features present an enhanced risk of seismic activity, and to avoid such areas for fracturing.

Methane and other air emissions:

One of its major components, methane, is a highly potent greenhouse gas. Methane leaks resulting from the natural gas extraction process pose significant environmental and health problems, including air and water pollution, as well as long-term risks such as cancer and respiratory illnesses.

Are there any advantages?

Analysts cite the main advantages of shale gas and oil discoveries as follows:

I. There should be a significant knock on effect on other industries including agriculture, power generation, transport, steel and the manufacturing sector.
II. On an energy-equivalent basis, shale gas produces almost no sulphur dioxide during combustion, and is 30% lower in CO2 emissions than fossil fuels, therefore switching from oil-based fuel to natural gas would materially reduce emissions generated during combustion. [21]

[21] Morgan Stanley: Natural Gas as a Transportation Fuel, *April 16 2013*

III. The need for significant spending on energy infrastructure, such as pipelines and storage facilities to cope with the surge in US oil production will also create further employment.
IV. By reducing dependency on imports of oil from the Middle East, the benefits to the balance of payments for the US could be extensive.

Investment Ideas

From an equity investor's perspective, there are several ways to access the shale theme and the stock implications are wide ranging. Whilst the obvious approach is investing directly in the oil & gas companies involved, the profit margins of these companies are tied to the price of the underlying commodity, which is currently trading at near-historic lows as growing supplies put downward pressure on the price. This dynamic incentivises investors to look for investment opportunities in companies providing services along the production chain, both upstream and downstream, including provision of consultation, technology, infrastructure & equipment, processing, storage, and transportation of natural gas.

The development of shale oil and gas reserves around the world will generally be much slower than in North America. Large companies such as Exxon Mobil and Chevron have both reported slow progress with starting up shale production outside the US, with Exxon pulling out of exploration in Poland and Chevron suggesting that commercial production from shale in Europe is unlikely to start this decade. Shell has shale projects around the world, in countries including China, Turkey, South Africa and Ukraine, and recently signed a landmark deal with Gazprom to develop shale oil in Russia.[22] In North America, shale production is supported by companies such as Halliburton, Schlumberger and Baker Hughes, which are experienced in the techniques of horizontal drilling and hydraulic fracturing needed to unlock shale reserves. Elsewhere in the world, the capabilities of the service industry are much less developed.

Two Major Energy Services Companies in the US:

Halliburton is currently one of the world's largest North American oilfield services companies with a strong global franchise. The company's major business segment is the Energy Services Group (ESG). ESG provides technical products and services for petroleum and natural gas exploration and production. UBS analysts believe that the company continues to trade at an unreasonable discount to its peer group (2013 and 2014 forward P/E of 19%/13%).[23] The analysts are also bullish on the short term outlook for the company, and specifically expect "international and deepwater activity to be the main driver of revenues and margins for the company and its peers over the next 2-3 years."[24] Importantly, the company has operated in China for almost 30 years, and has

[22] Gazprom research: http://www.gazprom.com/press/news/2013/april/article159865/
[23] UBS: Halliburton Co: Impressive Performance in International, *25 January 2013*
[24] UBS: Halliburton Co: Update from the Oilfield, *27 March 2013*

provided integrated drilling and completion fluids for Sinopec's shale gas wells in Chongqing. If China's shale gas ambitions are successful in the long-term, Halliburton is well positioned to grow its business considerably.

Schlumberger is the world's largest provider of oilfield services and equipment. The company has the number one market share across most of its product lines and earnings almost double its closest competitor. UBS analysts estimate that Schlumberger accounts for approximately 2.2% of the total onshore oilfield services (OFS) revenue in China making it the largest foreign OFS player. The company has been in China for over 10 years and has fracked the majority of the roughly 60 shale oil and gas wells drilled so far in the country. Last July, the company announced that it had acquired a 20% stake in Anton Oilfield.[25] Anton Oilfield is an onshore oil & gas service provider listed in Hong Kong. It has four business segments: downhole operations, well completion, drilling technology, and tubular services. In China, the company focuses on high end natural gas field services for PetroChina, Sinopec and Yanchang Petroleum. Overseas, the company adopts a 'follow-up' strategy to provide services for oil majors. Goldman Sachs analysts consider the company's superior execution, technological leadership and unmatched international footprint as critical advantages as the international drilling cycle unfolds. Similar to Halliburton, Schlumberger has positioned itself to capture the opportunity in China, if shale gas exploration reaches critical mass.

Supporting infrastructure companies

In the supporting infrastructure and services sector, many of the companies have exposure to multiple segments of operation that facilitates the growth of the natural gas industry. The four main segments are:

Planning & Consulting

This occurs at the very early stage of a project, where consultants provide advice and assistance to the drilling companies in land acquisitions, permitting, as well as evaluating environmental due diligence.

Extraction & Processing

This segment of the production chain involves the design and construction of extraction, gas processing and fractionation facilities, which remove impurities (non-hydrocarbons: water, hydrogen sulphide, carbon dioxide) and recover the more useful natural gas liquids (i.e. methane, ethane, propane, butane, pentane) from a stream of natural gas.

Storage

Natural gas inventory can be held above ground or underground. There are three types of underground facilities, including on-site depleted reservoirs, aquifers, and salt cavern formations. Above ground storage is more complex, and is

[25] UBS Q-Series: China Oil and Gas Sector, *21 September 2012*

typically found in association with regasification terminals and/or peak shaving facilities (liquefy gas during low demand seasons), which are very costly to build (can become 30-50% of capex).

Transport & Pipelines

Two types of pipeline are required to transport gas over different distances. Small diameter pipelines are typically used for gathering, which transports the gas to local processing facilities and connect directly to commercial, industrial and residential users of natural gas end products, and large diameter mainline pipelines are for long-haul cross-state transmission. INGAA forecasted incremental $232 billion additional investments in this infrastructure over the next two decades, with a further $60 billion for NGL and oil pipelines.

Sector-specific demands

Many E&C companies are also involved in consulting, engineering, construction and maintenance of industrial plants, providing sector-specific expertise in power generation, petrochemicals, and alternative fuels. They make their revenues from contracts commissioned by the major players in each field, often over a very long term. Since most industries are at the initial stage of transition that requires huge infrastructure investments, there will potentially be a wealth of opportunities for these E&C companies.

Some of the companies involved:

Exhibit 33: US E&C companies positioned for the shale gas theme

	Consultation	Technology	Processing	Storage	Pipelines	Power Gen.	Petrochemical	LNG	GTL
CB&I	v		v	v		v	v	v	
Fluor		v	v			v	v	v	v
Jacobs	v		v	v			v		
KBR		v	v			v	v	v	
Foster Wheeler					v		v	v	v
URS Corp	v		v						
Wilbros					v				
Quanta									
AECOM	v								
Shaw Group		v				v	v		

Source: UBS, Credit Suisse

i. **AECOM** provides planning and environmental consulting services to upstream players.
ii. **URS Corp.** is mostly involved in providing environmental planning, due diligence and permitting services, with some expertise in gas process (fractionisation).
iii. **CB&I** have numerous relevant exposures to shale gas, including processing (currently on two major EPC contracts - 15%), storage (above ground LNG facilities – 30%), chemicals (13%), and technology licensing (Lummus Division – processing & chemicals).

iv. **Fluor** mainly operates in the processing and chemicals sphere, licensing gas treating and NGL recovery technologies, and executes major global chemicals projects. It also has opportunities in GTL and power markets.

v. **Jacobs Engineering** provides design, construction, engineering, consultation and maintenance services to upstream oil & gas players, with experiences in gas treating, gathering and storage. Currently working on an EPC contract for ExxonMobil in a gas recovery project.

vi. **KBR** licenses proprietary technology for gas and chemicals applications, and also provides E&C services for processing, LNG liquefaction, and chemicals facilities. Its US construction business is involved in the building of gas fired power plants.

vii. **Foster Wheeler** provides design, E&C and management services in relation to gas processing, pipelines, chemicals, LNG and GTL.

viii. **Wilbros** specialises in construction and maintenance of small and large diameter pipelines and the associated gas compressor/pump stations.

ix. **Quanta** have capabilities in the realm of planning, design, installation, maintenance and repair of gas pipelines.

x. **Shaw Group** majors in technology licensing (chemicals) and construction of chemicals and gas-fired power generation facilities.

Conclusions

I. Advances in key technology mean that the US is on a path to greater energy independence, and production of shale gas may even exceed Saudi Arabia's by 2020. Longer term, US external accounts and GDP will improve, however the shale gas revolution may not have a big macro impact within the next 5 years. Other countries are still in the early stages of tapping into this unconventional resource.

II. The outlook for unconventional gas production globally depends critically on how the environmental issues described earlier are addressed. Society needs to be adequately convinced that the environmental and social risks will be well enough managed to warrant consent to unconventional gas production, in the interests of the broader economic, social and environmental benefits that the development of unconventional resources can bring.

III. Shale's impact on crude oil and coal will be gradual and by no means devastating. Demand in the US may see a structural decline over the decades, certainly a slow process, but they will continue to play an important role on the global energy market.

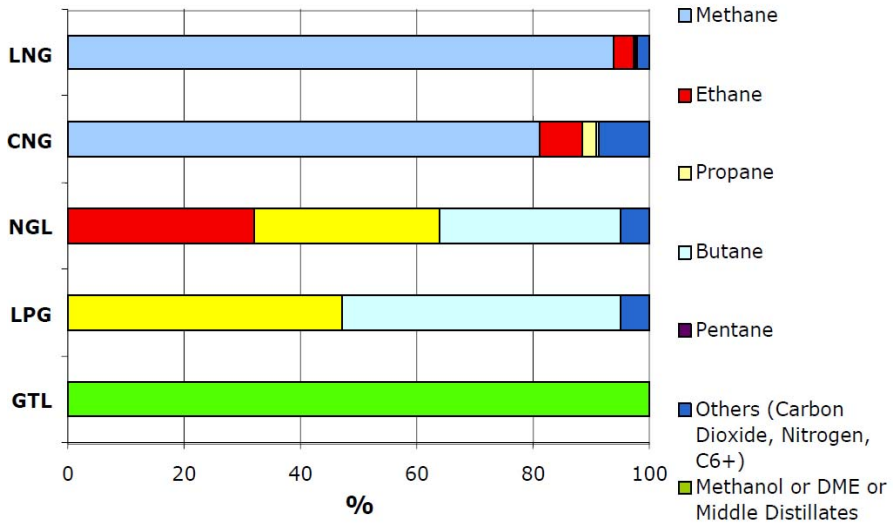
IV. Governments everywhere have a central role in ensuring a sound, scientific, credible, knowledge base is publicly available prior to widespread development. Policy-makers and regulators themselves need access to the necessary expertise in order to understand and mitigate the environmental risks.

V. For the US economy, development will likely mean a stronger dollar, new job creation, as well as a decrease in energy costs.

VI. Overwhelmingly, the short to medium term beneficiaries of the growth of shale gas will be the established petrochemical and drilling companies who are consolidating acreage and already well positioned to take advantage of the new resources. E&C companies will also benefit from taking on the new projects in building the necessary infrastructures to support mass adoption for natural gas in the economy.

VII. Finally, the future is most unpredictable for the transport sector, which would be the most disruptive factor in dictating natural gas demand in the long-term, *if* it can be realised on a large scale.

Appendix 1: Chemical components of various natural gas form



Source: American Clean Skies Foundation