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CONSEIL MONDIAL DE L'ÉNERGIE  
*For sustainable energy.*

# World Energy Resources

## Unconventional gas, a global phenomenon

Project Partner: Accenture Strategy

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**World Energy Resources****Unconventional gas, a global phenomenon**

World Energy Council

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# Executive summary

Natural gas is currently the number three fossil fuel in terms of share of the global primary energy mix and for years the world has debated the potential for natural gas to play a critical part in building a more resilient and sustainable energy future. While the demand outlook is currently uncertain, advances in supply side technologies for unconventional resource development, led by advances in US shale gas operations, have changed the supply landscape and created new prospects for affordable and secure supplies of natural gas.

The '2012 World Energy Council Survey of Energy Resources: Shale Gas – What's New' predicted that shale gas development would have a "significant impact on the dynamics and prices" of future natural gas markets. This latest study explores the implications of the rapid growth in unconventional gas supplies on global markets and concludes that, unconventional gas has become a global phenomenon and will continue to have global implications for some time to come. The weight of these changes on the global supply landscape is an important consideration for energy professionals seeking to understand the future of the industry.

## Key findings and implications

The bearing of unconventional gas on changing market dynamics should not be under-estimated. Now that Australian coal bed methane (CBM) and US shale gas are emerging on the global market as liquefied natural gas (LNG), the impact will no longer be contained to regional markets. In particular, three trends emerge as the most meaningful in the global context:

- ▶ **Interconnected markets:** With excess supplies in the market, there has been price normalisation and other structural shifts towards a more global and transparent market across the three main regional hubs: Asia, Europe, and North America.
- ▶ **International growth of unconventional gas:** Exploration and production (E&P) operators in Australia, China, and Argentina have made progress in growing unconventional gas supplies outside of North America.
- ▶ **Shifting portfolio allocations:** In this time of uncertainty, US unconventional gas emerged as a cost competitive asset type that continues to shift industry capital towards flexible, shorter-cycle investments in North America shale assets.

The key uncertainty, outside of North America, is whether gas can be made available at prices affordable to consumers while offering suppliers incentives for continued infrastructure investments. Unconventional gas reduces concerns about security of supply by providing a new cast of gas suppliers who will bring competition, liquidity, consumer bargaining power and a clear price signal to the market.

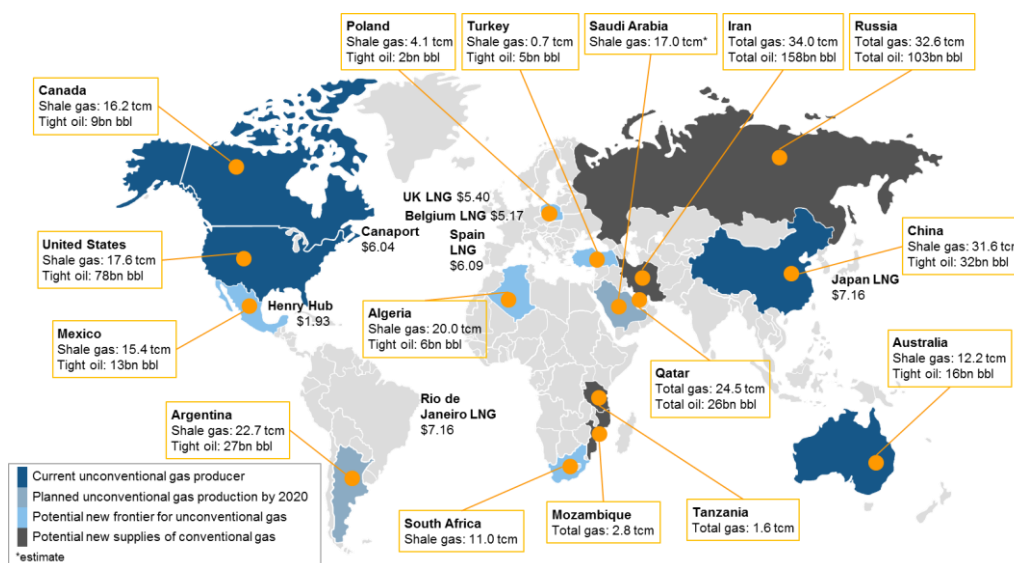
National Oil Companies (NOCs), driven by the desire to bring affordable natural gas supplies online, are making progress in developing unconventional resources outside of North America. The evolution of this trend will create competing investments for

some conventional assets and influence how trade flows evolve across regional markets.

US shale gas LNG is entering markets in a challenging period and it has disrupted the global supply structure with economics that are competitive with many conventional assets. Technology innovation drove productivity, efficiency, and operational flexibility in E&P and a new set of investors enabled the fast tracking of LNG export projects. As the market slack is absorbed through 2020 and prices move closer to the cost of supply, the US is well positioned to respond quickly and emerge as a marginal LNG supplier.

### Figure 1: New supply landscape (technically recoverable reserves)

Sources: BP Statistical Review of World Energy, EIA, FERC, and Reuters<sup>1</sup>



## Recommendations

The World Energy Council's Resources 2013 chapter on natural gas predicted natural gas could reach 25% of the global energy mix by 2030. Unconventional gas supplies have the potential to reflect a substantial portion of that share and will continue to change the supply landscape for natural gas. The US shale gas revolution serves as a unique case study that demonstrates how suppliers can use technology innovation to drive to more affordable and secure supplies of natural gas. However, the reality remains that current market dynamics place the future of natural gas at risk. Swift intervention is needed by key market actors to protect long-term conventional and unconventional supplies.

In the process of developing the 2016 World Energy Scenarios to 2060, the World Energy Council interviewed industry leaders in a broad variety of roles and geographies, and asked them to express their views on the future of energy. The group converged on their view that natural gas has the potential to play a critical role in the grand transition to an affordable and environmentally sustainable energy future.

<sup>1</sup> BP, 2015: BP Statistical Review of World Energy 2015. Accessed Nov 2015.

EIA, 2016: Henry Hub Natural Gas Spot Price. Accessed Jan 2016.

EIA, 2015: World Shale Resource Assessments. Accessed Jan 2016.

FERC, 2015: World LNG Estimated December 2015 Landed Prices. Accessed Jan 2016.

Reuters, 2015: Saudi Aramco extends bidding for unconventional gas work -sources. Accessed Jan 2016.

However, in order to meet these ambitions, certain decisive interventions were identified as necessary for market actors to alleviate uncertainty in the market:

- ▶ **Industry:** Bring a higher degree of focus to portfolio allocation, risk management, and efficiency and continue to seek new and innovative investment partnerships to deliver projects.
- ▶ **Policymakers:** Establish policies that promote a liquid market and competition needed for security of supply and the formation of clear price signals.
- ▶ **Consumers:** Evaluate the economic and environmental benefits of diversifying energy assets with natural gas in power, industry, transportation, and chemicals and consider innovative investment partnerships to secure supplies.

In shifting the supply structure of the global market, unconventional gas may compliment the actions of key actors by increasing transparency, competition, and reshaping the economics of natural gas. This will enable the confidence for investors to develop the infrastructure required for the reliable and safe use of natural gas as a fuel source for the long-run.

# Introduction

In 2016, the role of natural gas in the global energy mix appears uncertain. The so called "Golden Age of Gas" is no longer in sight. Economic, geopolitical, and policy constraints have slowed demand growth in Asia and led to a decline in demand in Europe. On the other hand, suppliers in Australia, the Middle East, Africa, and North America who bet on old forecasts for Asian demand growth are bringing plenty of new supplies to the market.

With the influx of added supplies outpacing demand growth, the world is faced with a global supply glut and depressed natural gas prices, and suppliers with large inflexible investments in natural gas assets are scrambling to stay afloat. More than one year into a down market, the resilience of unconventional gas, such as shale gas and coal bed methane (CBM), continues to reshape the international energy supply landscape. Just a few years ago, unconventional gas was considered a high-cost asset that required \$100 per barrel (bbl) oil to survive. However, in North America, operational efficiencies and technology innovation drove cost reductions, improved productivity, and enabled an unconventional gas supply revolution more quickly than many policymakers and industry stakeholders could have imagined.

In the US, a domestic supply glut drove investments that turned import terminals to export terminals, power stations from coal to gas, and drove substantial E&P activity. By 2014, gas production from the top seven shale basins in the US, represented 47% of total US natural gas production and more than 10% of global natural gas production.<sup>2</sup> In 2016, the influence of shale gas is stronger than ever, as it enters European and Asian markets in the form of LNG.

This perspective paper explores how the onset of unconventional gas supplies, led by the US Shale Revolution, contributed to the structural shifts currently underway in global natural gas markets. The '2012 World Energy Council Survey of Energy Resources: Shale Gas – What's New' predicted that shale gas development would "have a significant impact on the dynamics and prices" of future natural gas markets. In this latest study, the World Energy Council explores three significant implications of growing unconventional gas supplies on global markets:

- ▶ **Interconnected markets:** With excess supplies in the market, there has been price normalisation and other structural shifts towards a more global and transparent market across the three main regional hubs: Asia, Europe, and North America.
- ▶ **International growth of unconventional gas:** E&P operators in Australia, China, and Argentina have made progress in growing unconventional gas supplies outside of North America.

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<sup>2</sup> EIA, 2015: Monthly Natural Gas Gross Withdrawals, Average of Monthly Production. Accessed Dec 2015.  
EIA, 2016: Drilling Productivity Report, January 2016. Accessed Jan 2016.  
BP, 2015: BP Statistical Review of World Energy 2015. Accessed Nov 2015.

- ▶ **Shifting portfolio allocations:** In this time of uncertainty, US unconventional gas emerged as a cost competitive asset type that continues to shift industry capital towards flexible, shorter-cycle investments in North America shale assets.

The impact of these trends should not be under-estimated. Just 12 months ago Japanese spot LNG prices were \$10.00 per million British thermal units (MMBTU) higher than they are today and market dynamics remain highly uncertain. Outside of North America, there are valid concerns about whether gas can be made available at prices that are affordable to consumers while offering suppliers incentives for continued infrastructure investments. The evolution of this trend will create competing investments for some conventional assets and influence how trade flows evolve across regional markets.

The paper dives into each of the three trends and draws out the implications for the future of natural gas globally. It concludes by addressing the gloomy outlook that faces the market today. With global oil prices below \$30/bbl, the long-term role of natural gas in the global energy mix remains highly uncertain. Lower prices and new impetus for decarbonisation created by the outcome of the 21st Conference of the Parties have the potential to lead to increased demand in the short to medium-term. However, with the market in severe turmoil, decisive intervention from consumers, industry, and policymakers will be required to establish the future role of natural gas in the global energy mix.



# 1. Interconnected markets

The speed at which unconventional natural gas has disrupted markets is best evidenced in North America, led by the US, where a regional supply glut drove investments that turned import terminals to export terminals, power stations from coal to gas, and drove substantial E&P activity. In 2014, US shale gas production represented 47% of total US natural gas production and more than 10% of global natural gas production. In 2016, the influence of shale gas is stronger than ever, as it enters European and Asian markets in the form of LNG.

The US Energy Information Administration (EIA) expects the US to become a net exporter of natural gas by 2017.<sup>3</sup> According to company announcements and the Federal Energy Regulatory Commission (FERC), there are five US LNG export projects under construction, reflecting 62.7 million tonnes per annum (mtpa) of new US LNG export capacity coming online through 2019.<sup>4</sup>

When these projects are completed, North America will become the fourth-largest LNG export region, behind Asia Pacific, the Middle East, and Africa as evidenced in Figure 2. The US alone will account for almost one-fifth of global liquefaction capacity and will become the third-largest LNG export capacity holder in the world, after Qatar (77.0 mtpa) and Australia (86.5 mtpa).<sup>5</sup> Significant impact to natural gas hubs globally will accompany this rapid change in the North America landscape.

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<sup>3</sup> EIA, 2015: Annual Energy Outlook 2015. Accessed Nov 2015.

<sup>4</sup> FERC, 2015: North America LNG Import/Export Terminals Approved. Accessed Nov 2015.

<sup>5</sup> Australia Pacific LNG, 2015: About the Project. Accessed Jan 2016.

Santos GLNG, 2015: The Project. Accessed Jan 2016.

Chevron, 2015: Gorgon Project. Accessed Jan 2016.

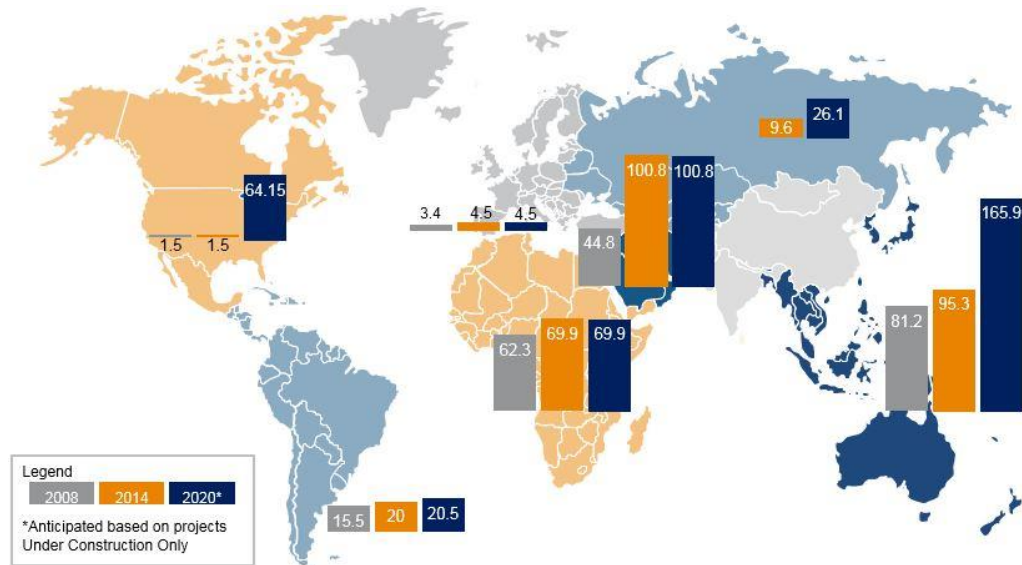
Chevron, 2015: Wheatstone Project. Accessed Jan 2016.

Total, 2015: Ichthys: Three Mega Projects Rolled Into One. Accessed Jan 2016.

Shell, 2015: Prelude FLNG - Overview. Accessed Dec 2015.

**Figure 2: LNG capacity (mtpa) 2008, 2014, and expected 2020**

Sources: International Gas Union (IGU) World LNG Report 2015 and company announcements



## From regional to global implications

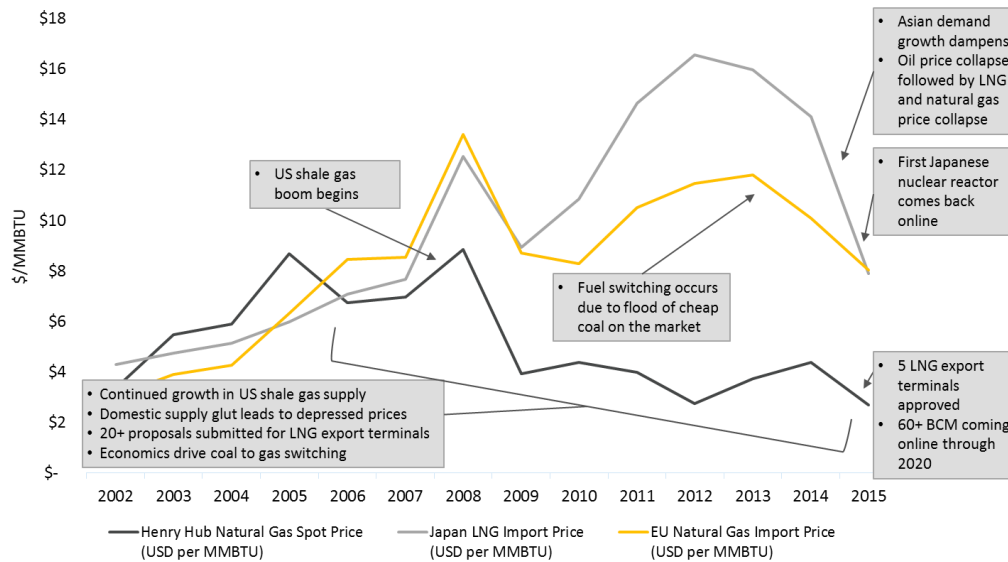
Natural gas markets have historically operated as three distinct regional markets: North America, Asia, and Europe. In North America, the build-up of shale gas supplies in the period since 2008 led to a domestic supply glut that created downward pressure on prices and reversed trade flows significantly. US natural gas imports peaked in 2007 at 129 billion cubic metres (bcm) of pipeline gas and 21.6 bcm of LNG imports.<sup>6</sup> A supply glut and reduced trade contributed to regional market dislocation and record spreads between the US Henry Hub price and major hubs in Europe and Asia from 2008 to 2015.

In 2016, with lower oil prices and weakened Asian demand, the spread between Japanese LNG and United Kingdom (UK) natural gas prices has virtually disappeared. US prices, however, remain significantly depressed due to the continued build-up of domestic supplies.

<sup>6</sup> EIA, 2015: US Natural Gas Imports by Country. Dec 31 2015. Accessed Jan 2016.

**Figure 3: Regional natural gas price benchmarks used in North America, Europe, and Asian natural gas trade**

Sources: EIA, the World Bank, and Japan Ministry of Economy, Trade and Industry (METI)



However, first cargoes of US LNG exports of shale gas set sail in 2016 and by 2017, the US is set to become a net exporter of natural gas. LNG exports are expected to serve as a release valve for the supply glut keeping North America prices dislocated from other regional markets. LNG exports also create the possibility of increased interconnectedness and reduced premiums across regional markets. Specifically, US LNG is set to contribute to interconnectedness across regional markets through its contribution to gas-on-gas competition, increased liquidity, and increased consumer bargaining power globally.

### Gas-on-gas competition

Natural gas pricing structures vary significantly across regions. While almost half of natural gas traded in Europe is priced based on natural gas hub pricing, in Asia, natural gas prices have historically been based on oil indexed pricing calculations.

Oil indexation has persisted in Asia in part due to a lack of gas-on-gas competition in the region. New US LNG contracts are largely priced via tolling arrangements based on a Henry Hub linked formula. The appetite for a move away from oil indexed pricing models is already evident in Asia. US LNG contracts now reflect the equivalent of 20% of Japanese LNG imports.<sup>7</sup> Industry reports also indicate that in 2015, there was a pronounced move away from traditional oil indexation to hub-linked pricing and hybrid indexation more broadly in Asia.<sup>8</sup>

Although current US Henry Hub prices plus liquefaction and transport costs do not compete on an economic basis with oil indexed prices when the oil price is below \$50/bbl, US LNG is still quite economic (~\$9.00/MMBTU) and helps to create the competition needed for Asian natural gas consumers to gain more influence in the global market. Major LNG importing nations, such as Japan and the Republic of

<sup>7</sup> Ministry of Economy, Trade and Industry, 2015: FY 2014 Annual Report on Energy (Energy White Paper 2015) Outline. Updated November 18, 2015. Accessed Jan 2016.

<sup>8</sup> Wood Mackenzie, 2015: The stakes are high as LNG players plan their next move. Accessed Dec 2015.

Korea, have expressed their views repeatedly of US LNG trade as a strategic driver in establishing Asian regional pricing hubs that better reflect regional supply and demand dynamics.<sup>9</sup>

In Europe, where gas-to-gas pricing is more prevalent than Asia, the presence of gas indexed US LNG and growing volumes of spot cargoes only serves to strengthen the trend of hub-based pricing and gas-on-gas competition. It also provides a flexible alternative to oil indexed supplies from the Middle East and Russia.

## Liquidity

Liquidity boosted by growing supply, new market participants, and increasing shipping availability has the potential to boost short-term trade in global LNG markets. Short-term trade more closely reflects international natural gas supply and demand balances and is a critical element in creating price transparency, eliminating premiums, and creating vehicles to hedge investments. Conversely, long-term contracts (LTCs) protect consumers from sudden price spikes and provide security of supply for large importers. LTCs also reduce uncertainty for suppliers making long-term investment decisions.

With the dynamics of today, where there is growing liquidity, short-term trade becomes less risky and a more attractive option for consumers who are unhappy with their current LTCs. Short-term LNG trade has already grown rapidly since 2010 driven mostly by Asia Pacific, where spot LNG trade almost tripled between 2010 and 2014 and represented 21% of all global LNG trade and 7% of total global natural gas trade in 2014.<sup>10</sup> The trend was spurred by a number of factors including supply slack due to a persistent decline in imports from the US and EU. Additionally, the growth of contracts with destination flexibility, growing demand for spot cargoes in the period after the Japanese nuclear crisis, and opportunities for price arbitrage between regions contributed to the growth in volumes of short-term trade.

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<sup>9</sup> Ministry of Economy, Trade and Industry, 2015: FY 2014 Annual Report on Energy (Energy White Paper 2015) Outline. Updated November 18, 2015. Accessed Jan 2016.

The Korea Herald, 2015: KOGAS to import 2.8 mln tons of LNG from the United States. Accessed Jan 2016.

<sup>10</sup> EIA, 2015: Natural gas prices in Asia mainly linked to crude oil, but use of spot indexes increases. Accessed Dec 2015.

**Figure 4: Growth in short-term trade in Asian LNG markets**Source: EIA<sup>11</sup>

In the current market, growing supply, new market participants, and increasing shipping availability will only serve to boost liquidity and could amplify the trend of growing short-term trade. This in turn could serve to create transparency, a critical element of a more interconnected market. It also empowers Asian consumers and sends a clear investment signal to suppliers, a requirement for reviving activity in the sector in the long-term.

### Growing bargaining power of consumers

In a buyer's market, large consumers are considering whether to renew LTCs or increase their exposure to the spot market. Gas-on-gas competition and a more liquid market create the bargaining power for consumers to push back on current market structures and negotiate more flexible contract terms. In 2015, two of the largest utilities in Japan, the number one importer of LNG, said they will no longer sign contracts that restrict reselling cargoes by limiting the destination of shipments they buy.<sup>12</sup> China Petroleum and Chemical Corporation (Sinopec) was believed to be pursuing changes to contract terms for cargoes from APLNG, its joint venture with ConocoPhillips and Origin Energy in Queensland Australia.<sup>13</sup> India also sought to renegotiate LNG prices with its biggest supplier, Qatar.<sup>14</sup>

In Asia, the arrival of US LNG could create the necessary liquidity and competition to establish regional natural gas pricing hubs. China, Japan, and Singapore are all taking steps to launch benchmarks against which both spot and LTCs can be priced. Singapore is expected to launch its first futures and swaps contracts in early 2016 that will be priced against a new benchmark, the Singapore SLInG (after the city's famous cocktail).<sup>15</sup> As Asian hubs evolve, pricing will grow to reflect the supply and demand

<sup>11</sup> EIA, 2015: Natural gas prices in Asia mainly linked to crude oil, but use of spot indexes increases. Accessed Dec 2015.

<sup>12</sup> Stapczynski, S, Inajima, T, and Urabe, E, Oct 2015: Buyers Market for LNG Turns Tables on Producers Amid Supply Glut, BloombergBusiness. Accessed Oct 2015.

<sup>13</sup> Petroleum Economist, June 2015: Sinopec rattles Origin and ConocoPhillips. Accessed Oct 2015.

<sup>14</sup> The Economist Intelligence Unit, April 2015: India seeks to renegotiate major LNG contract with Qatar. Accessed Oct 2015.

<sup>15</sup> Energy Market Company, 2015: SLInG. Accessed Dec 2015.

dynamics of the region more closely and consumers could begin to view natural gas as a more secure, stable, and potentially affordable source of energy in the region.

### **Clear price signal**

Currently, there is a lot of uncertainty around future demand for imported gas. New supplies are emerging all over the world and the cost structures of supplies are adjusting to a new era. As the market settles and supplies are absorbed, other factors such as geopolitics, economics, and the potential growth of international supplies of unconventional gas, could lead to further trade flow disruptions.

With plentiful supplies and a more diverse supplier base, unconventional LNG could serve to drive the liquidity and competition to create a more interconnected market and this transition could go a long way in alleviating uncertainty and establishing a leading position for natural gas in the global energy mix. From the consumer perspective, the key challenges for natural gas are affordability and security of supply. The evolution of a global market addresses these concerns through competition and liquidity. From the supplier perspective, a transparent price signal and the hedging opportunities created by a liquid market make long-term investments less risky.

## 2. International growth in unconventional gas

In the world's drive to access affordable and secure supplies of natural gas, the pursuit of unconventional gas has become inevitable. The International Energy Agency (IEA) estimated in their 2014 New Policies Scenario, that by 2040, unconventional gas could amount to 60% of all added supplies of natural gas in the period and 30% of total natural gas consumption.<sup>16</sup>

Significant progress has been made in Australia where CBM is fuelling several export projects on the East Coast. In China, 2014 targets from the Ministry of Land and Resources (MLR) indicate shale gas and CBM could grow to reflect at least 50% of domestic natural gas production by 2030.<sup>17</sup> Saudi Arabia has also made notable progress and is likely to become a commercial shale gas producer before 2020. Argentina's ventures into tight oil are also advancing at a notable pace. In addition, many other NOCs around the world are exploring the potential of their shale gas resources.

**Table 1: International shale gas reserves**

Source: EIA World Shale Resource Assessments

No.	Country	Trillion Cubic Feet (tcf)	Trillion Cubic Metre (tcm)
1	China	1115	31.6
2	Argentina	802	22.7
3	Algeria	707	20.0
4	US	623	17.6
5	Canada	573	16.2
6	Mexico	545	15.4
7	Australia	429	12.2
8	South Africa	390	11.0
9	Russia	285	8.1

<sup>16</sup> IEA, 2014: World Energy Outlook 2014. Accessed Nov 2015.

<sup>17</sup> Platts, 2014: China Could Double Oil, Gas Production By 2030 To 700 Mil Mtoe. Accessed Aug 2015.

No.	Country	Trillion Cubic Feet (tcf)	Trillion Cubic Metre (tcm)
10	Brazil	245	6.9
11	United Arab Emirates	205	5.8
12	Venezuela	167	4.7
	World	7577	214.5

While none of these nations have all of the unique characteristics that enabled the shale gas boom seen in the US, learnings from existing operations and the rapid pace of innovation and efficiency gains in the industry mean unconventional gas outside of North America could cause unexpected disruption to natural gas markets in the next decade.

This section argues that unconventional gas development has the potential to become a global phenomenon, in part due to the active nature of NOCs where resources are available. It attempts to put into perspective the magnitude and speed of the changes seen in the US since the onset of the Shale Revolution and provides a brief update on the status of unconventional gas production in the most mature regions outside of North America, Australia and China. Development efforts in these regions have been successful and emerging supplies have the potential to disrupt trade flows significantly as production grows.

Additionally, a section on frontier geographies for shale gas development gives a brief overview of developments in Argentina, Mexico, Saudi Arabia, South Africa, Poland, Algeria, and Turkey. The section ends with a discussion of potential competition from large conventional projects with economics that may dampen the growth of unconventional projects in the long-run.

The discussion will provide a brief overview of each region, considering eight critical factors for unconventional gas development. These factors are derived from Accenture's report, 'International Development of Unconventional Resources: If, where and how fast?'

## Eight critical factors for unconventional gas development:

1. **Size of potential resources**
2. **Enabling fiscal regime**
3. **Geology**
4. **Land access and operability**
5. **Unconventional services sector**
6. **Oil and gas distribution network**
7. **Conventional and other competition**
8. **Skilled workforce**



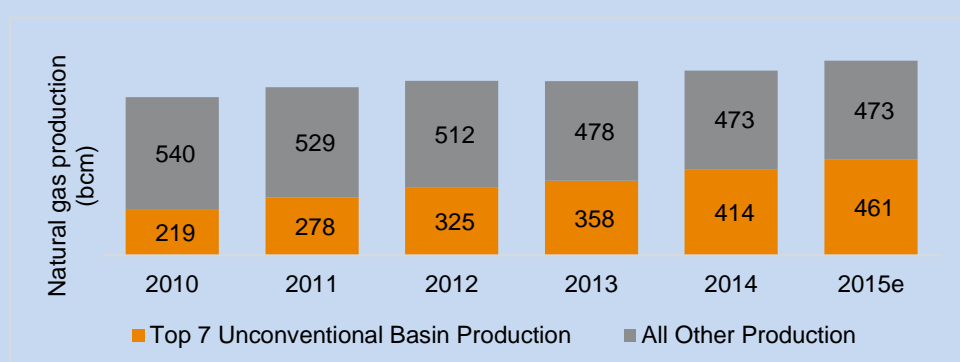
## US shale gas snapshot

Since 2011, shale gas and associated gas from tight oil production drove virtually all natural gas production growth. In 2015, US production remained surprisingly resilient in the down market. As of November 2015:

- ▶ US natural gas production was up 5% over 2014 production, reaching ~935 bcm (annualised).
- ▶ Natural gas production from the top seven unconventional basins accounted for 49% of total US natural gas production.<sup>18</sup>

**Figure 5: Natural gas production 2011– 2015 (bcm)**

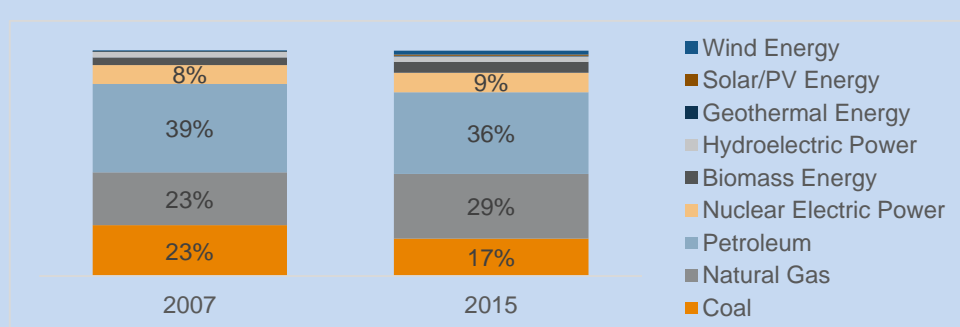
Sources: EIA Drilling Productivity Report Jan 2016 and EIA Gross Gas Withdrawals Jan 2016



The benefits of shale gas on the US economy have been substantial. The International Monetary Fund (IMF) claims that low domestic natural gas prices led to a 6% increase in US manufactured product exports from the start of the shale boom to October 2014.<sup>19</sup> Additionally, with the abundant and relatively cheap supplies of natural gas available in the US, the share of natural gas in the primary energy mix grew from 23% to 29% from 2007 to 2015.

**Figure 6: US % share of primary energy mix by fuel type 2007 vs. 2015**

Source: EIA<sup>20</sup>



Later sections of this paper explore the unique factors that led to the resilient production growth seen in US shale gas supplies in recent years.

<sup>18</sup> EIA, 2015: Monthly Natural Gas Gross Withdrawals, Average of Monthly Production. Accessed Dec 2015.

<sup>19</sup> IMF, 2014: World Economic Outlook, October 2014. Accessed Nov 2015.

<sup>20</sup> EIA, 2015: Total Energy Annual Energy Review. Accessed Jan 2016.

## Australia

While Australia's shale reserves are estimated at 12.2 tcm, shale gas development takes a back seat to Australia's world leading CBM projects. In eastern Australia, Queensland accomplished a world first in late 2014, using CBM as feedstock to produce LNG. CBM development represents about 40%<sup>21</sup> of Eastern Australian domestic gas production, or 9.2 bcm of production, as of 2014.<sup>22</sup> As part of Australia's natural gas strategy to position itself as a major LNG supplier to Asia, CBM will grow substantially to support domestic consumption and LNG exports from the East Coast.

In 2014 and 2015, three CBM to LNG projects came online or were in the final stages of construction, reflecting 21.4 mtpa of export capacity. This will increase to 25.3 mtpa as expansions come online in 2016. In total, Australia will grow LNG export capacity from 36.6 to 86.5 mtpa by 2020 and CBM LNG will account for nearly 40% of LNG export capacity.<sup>23</sup>

**Table 2: Added LNG capacity through 2020**

Source: IGU World LNG Report 2015, company announcements, and press releases<sup>24</sup>

Project	Owner	Capacity (mtpa)	CAPEX (\$bn)	Commercial Operating Date
<b>QCLNG</b> <b>(CBM to LNG)</b>	Train 1: BG Group 50%, CNOOC 50%  Train 2: BG Group 97.5%, Tokyo Gas 2.5%	Train 1 and 2: 8.5  Train 3: 4.25	\$20.4	8.5 mtpa online in 2014-15
<b>APLNG</b> <b>(CBM to LNG)</b>	Origin Energy 37.5% ConocoPhillips 37.5% Sinopec 25%	9-18	\$35	2015
<b>Gladstone LNG</b> <b>(CBM to LNG)</b>	Santos 30% Petronas 27.5% Total 27.5% KOGAS 15%	3.9-7.8	\$18.5	First cargoes in Oct 2015

<sup>21</sup> Queensland Australia, 2015: Queensland's petroleum and coal seam gas 2013-2014, Australia. Accessed Nov 2015.

<sup>22</sup> Queensland Australia, 2015: Coal Seam Gas Production. Accessed Nov 2015.

<sup>23</sup> BG Group, 2009: BG Group - QCLNG Fact Sheet. Accessed Dec 2015.

BG Group, 2015: BG Group starts commercial operations from QCLNG Train 2 in Australia, Nov 25 2015. Accessed Dec 2015.

Santos GLNG, 2014: First Cargo Shipped From GLNG. Accessed Sept 2015.

Chevron, 2015: Chevron and SK LNG Trading Sign Gorgon LNG Supply Agreement. Accessed Dec 2015.

<sup>24</sup> BG Group, 2009: BG Group - QCLNG Fact Sheet. Accessed Dec 2015.

BG Group, 2015: BG Group starts commercial operations from QCLNG Train 2 in Australia, Nov 25 2015. Accessed Dec 2015.

Santos GLNG, 2014: First Cargo Shipped From GLNG. Accessed Sept 2015.

Chevron, 2015: Chevron and SK LNG Trading Sign Gorgon LNG Supply Agreement. Accessed Dec 2015.

Project	Owner	Capacity (mtpa)	CAPEX (\$bn)	Commercial Operating Date
<b>Gorgon</b>	Chevron 47.3% ExxonMobil 25%	15.6	\$54	Test loads Jan 2016
<b>Offshore LNG</b>	Shell 25% Osaka Gas 1.25% Tokyo Gas 1% Chubu Electric Power 0.417%			First cargoes April 2016
<b>Ichthys</b>	INPEX 62.245% Total 30% CPC 2.625% Tokyo Gas 1.575% Osaka Gas 1.2% Kansai Electric Power 1.2% Chubu Electric Power 0.735% Toho Gas 0.42%	8.9	\$37.4	Q3 2017
<b>Wheatstone</b>	Chevron 64.14% Kuwait Foreign Petroleum Exploration Company 13.4% Woodside Petroleum Limited 13% Kyushu Electric Power Company and PE Wheatstone Pty Ltd 1.46% TEPCO 8%	8.9	\$29	Year-end 2016
<b>Prelude FLNG</b>	Shell 67.5% INPEX 17.5% KOGAS 10% CPC 5%	3.6	\$10	2017

However, Australia's CBM and massive offshore Greenfield LNG projects have faced delays and cost overruns. Projects are estimated to breakeven at more than double the \$6/MMBTU to \$7/MMBTU prices seen today at major Asian hubs. Financial storms are already surging; Origin Energy (APLNG) is selling assets to maintain its investment grade,<sup>25</sup> Santos (GLNG) has fired its chief executive,<sup>26</sup> and Chevron had to impair assets by more than \$2bn in 2015.<sup>27</sup>

Additionally, there are some risks regarding project valuations and the long-run commercial viability of Australian CBM assets because exploration and appraisal

<sup>25</sup> Macdonald-Smith, A, 2015: Origin Energy to rise \$2.5b equity to ease pressure on balance sheet, Sydney Morning Herald. Accessed Nov 2015.

<sup>26</sup> Paton, J, 2015: Oil's Slump Claims Another Casualty as Santos CEO Steps Down, BloombergBusiness. Accessed Nov 2015.

<sup>27</sup> Chevron, 2015: Chevron Reports Second Quarter Net Income of \$571 Million. Accessed Nov 2015.

continues after project commitment. Still, the projects under construction are too far along to turn back and will continue to come online to global markets making Australia the number one LNG exporter in the world by 2017.

## China

Since 2005, CBM production has been slow to make progress in China, but in 2014 production grew more than 20%, reaching 11.6 bcm from mines and 3.6 bcm from seam operations.<sup>28</sup> Research and development (R&D), industry partnerships, and the entry of several companies such as Jincheng Coal and China Petro in coal mine operations all contributed to the ramp-up seen in 2014 and 2015. CBM drilling operations in coal seams are led by one of China's leading NOCs, China National Petroleum Corporation (CNPC), and Shell in Changbei<sup>29</sup> and are expected to reflect 14 bcm of production by 2020.<sup>30</sup>

Shale gas production reached 1.3 bcm in 2014.<sup>31</sup> While the number is small today, China's quest for affordable and secure supplies of natural gas means the nation has ambitious plans in place to develop their shale resources. China's 2012 Five Year Plan outlined a US-inspired shale revolution; however in 2014, the MLR was forced to revise its 2020 shale gas production target down from 60 bcm to 30 bcm.<sup>32</sup> The Sichuan basin, where China's substantial shale gas reserves are located, is highly populated and a mountainous area with water scarcity concerns. This created challenges and slowed down the ramping-up of shale operations.

Still, the nation's NOCs have made significant progress. Fuling field in the Sichuan basin reached 4.4 bcm of production on an annualised basis in the first half of 2015.<sup>33</sup> Production rates of 60,000<sup>34</sup>- 200,000<sup>35</sup> cubic metres per day per well are comparable to wells in the US Marcellus basin, one of the most prolific unconventional basins in North America. The Marcellus and neighbouring Utica basin have accounted for 85% of all new natural gas production in the US since 2012.<sup>36</sup> This exemplifies the potential impact of a ramp-up of shale gas wells with these levels of production in China.

Falling demand and a 12% cut in Sinopec's capital budget in 2015 did not dampen the domestic outlook on shale gas production. Costs continue to fall partly due to efficiency and technological advances, but also because the initial spending on infrastructure such as roads has been sunk. Therefore, subsequent wells face

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<sup>28</sup> Xinhua Finance, Dec 2014: China to generate 15.2 bcm CBM in 2014 up 10 pct. Accessed Jan 2016.

<sup>29</sup> Shell, 2015: Shell Operations in China. Accessed Jan 2016.

<sup>30</sup> Platts, 2015: China's 2014 Unconventional Gas Output Soars 42% on Year to 4.9 BCM, Singapore. Accessed Nov 2015.

<sup>31</sup> Platts, 2015: China's 2014 Unconventional Gas Output Soars 42% on Year to 4.9 BCM, Singapore. Accessed Nov 2015.

<sup>32</sup> Platts, 2014: China Cuts 2020 Shale Gas Output Target as Challenges Persist, Singapore. Accessed Nov 2015.

<sup>33</sup> Shale Gas International, 2015: Sinopec produced 970 mcm of gas from Fuling field in first half 2015. Accessed Nov 2015.

<sup>34</sup> Sinopec, 2014: China's First Large-scale Shale Gas Field Enters into Commercial Production Ahead of Schedule. Accessed Dec 2015.

<sup>35</sup> Sinopec, 2015: China Petrochemical Fuling coke page 6-2HF well cumulative production over 150 million cubic meters of gas. Accessed Jan 2016.

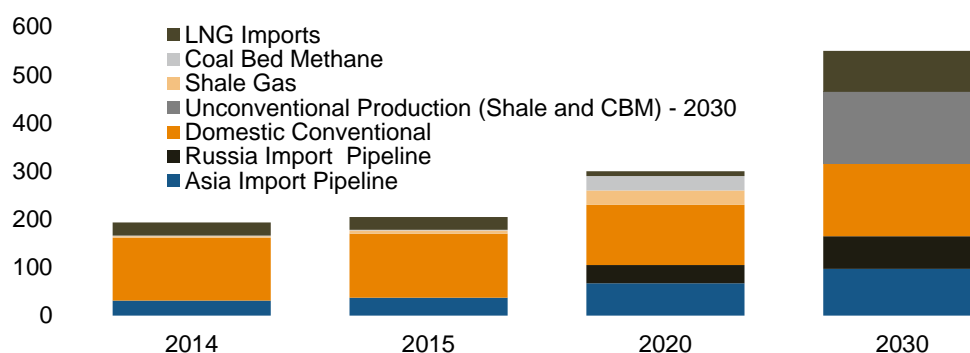
<sup>36</sup> EIA, 2015: Marcellus, Utica provide 85% of U.S. shale gas production growth since start of 2012. Accessed Jan 2016.

reduced cost structures.<sup>37</sup> Sinopec's production in Fuling is still expected to reach 10 bcm by the end of 2017 and 15 bcm by 2020.<sup>38</sup>

The MLR expects shale and CBM gas production to reach 60 bcm by 2020 and 150 bcm by 2030;<sup>39</sup> however, China will have to overcome significant challenges with land access and operability, infrastructure development, and technical capability in order to meet these ambitious targets and fully capitalise on domestic shale gas and CBM resources.

### Figure 7: China's natural gas supply forecast (bcm)

Sources: Energy Development Strategy Action Plan (2014 to 2020), MLR 2014–15 Statistics, and 2030 Targets via Platts



As demonstrated in Figure 7, the development of China's shale gas and CBM deposits has the potential to displace substantial amounts of LNG imports; however, in an oversupplied market, demand is also waning for some Russian import projects. Construction began in 2015 on the East Line of the Power of Siberia Pipeline. However, the current glut is blamed for delays seen in the development of the West Line.<sup>40</sup> The latest announcements indicate that the deal will be signed in 2016.<sup>41</sup>

### Table 3: China natural gas import pipelines

Source: Gazprom and CNPC<sup>42</sup>

Pipeline	Capacity (bcm/year)	Imports (bcm/year)	Production Year
Central Asia – Line A/B	30	28.3	2011

<sup>37</sup> Platts, Mar 2015: Sinopec, Petrochina Persevere With Shale Gas As Drilling Costs Fall. Accessed June 2015.

<sup>38</sup> Sinopec, 2014: China's First Large-scale Shale Gas Field Enters into Commercial Production Ahead of Schedule. Accessed Dec 2015.

<sup>39</sup> Platts, 2014: China Could Double Oil, Gas Production By 2030 To 700 Mil Mtoe. Accessed Aug 2015.

<sup>40</sup> RT, Jul 2015: Russia-China deal on 2nd gas route postponed - media. Accessed Jan 2016.

<sup>41</sup> Sputnik News, 2015: Russia, China Expect to Sign Power of Siberia-2 Deal in Spring 2016. Accessed Jan 2016.

<sup>42</sup> Power of Siberia Eastern (38 BCM) and Western Line (30 BCM) (Total 68 BCM)

Gazprom, 2015: 2014 Annual Report. Accessed Jan 2016.

Central Asia - Line A/B (30 BCM), Line C (25 BCM), Line D (30 BCM) (Total 85 BCM)

CNPC, 2015: Flow of Natural Gas from Central Asia. Accessed Jan 2016.

China-Myanmar Pipeline

CNPC, 2013: CNPC in Myanmar, Major Events. Accessed Jan 2016.

Pipeline	Capacity (bcm/year)	Imports (bcm/year)	Production Year
<b>China – Burma Pipeline (Sino-Myanmar pipelines)</b>	12	3	2013
<b>Central Asia – Line C</b>	25	Beginning of production	2014
<b>Russia – East Line ("Power of Siberia")</b>	38	Under construction	2018
<b>Russia – West Line ("Power of Siberia-2")</b>	30	Delayed	N/A
<b>Central Asia – Line D</b>	30	Under construction	2020

## New frontiers

### Argentina

While Argentina's unconventional operations are not as mature as China's and Australia's, developments in tight oil have been impressive in recent years and there is potential for shale gas to become the next big market. The Vaca Muerta formation, in the Neuquén basin, bears a resemblance to the early-stage Eagle Ford basin in the US. This makes the development process more straightforward and creates potential for production efforts to yield significant returns quickly as US operators such as Chevron and ExxonMobil have been able to capitalise on their US shale gas expertise. Vaca Muerta is also a well-established oil and gas production basin in Argentina with good road infrastructure, a developed services sector, and a substantial pipeline network.<sup>43</sup>

In October of 2015, Argentina's NOC, Yacimientos Petroliferos Fiscales (YPF), announced the drilling and completion of what they called a "super well" with an initial production of 1,600 barrels per day (Bpd), which is impressive even for conventional wells in Vaca Muerta.<sup>44</sup> While the industry still has a long way to go in developing the technical capabilities to bring the production of wells of this magnitude to scale, the achievement is a solid demonstration of the potential for Argentina to quickly build up its shale and tight resource production in the coming years.

### Saudi Arabia

Saudi Arabia is set to become a shale gas producer by 2020<sup>45</sup> and the nation's NOC, Saudi Aramco, recently announced it is investing another \$7bn to develop shale gas resources.<sup>46</sup> Saudi ambitions in shale gas are led by the nation's desire to boost its gas supply, support efforts to displace the use of liquid hydrocarbons for power

<sup>43</sup> Stark, M, 2014: International Development of Unconventional Resources: If, where and how fast?, Accenture. Accessed Nov 2015.

<sup>44</sup> Asociacion Petroquimica y Quimica Latino America, YPF Super Pozo y Super Produccion, Oct. 8 2015. Accessed Jan 2016.

<sup>45</sup> Oil and Gas News: Saudi Arabia Review: Aramco deploys rigs for shale. Accessed Jan 2016.

<sup>46</sup> Business Insider, Jan 2015: Saudi Arabia Is Putting Aside Billions For Its Own Gas-Fracking Revolution. Accessed Jan 2016.

generation, and increase available feedstock for the growing electric power and chemical industries.<sup>47</sup> Currently, when it lacks gas for power plants, Saudi Arabia burns liquids fuels and crude oil for the electric power sector, which, without an intervention, could exceed four million Bpd by 2020.<sup>48</sup>

In northern Saudi Arabia, where activity is the most mature, shale gas was originally expected to be delivered to Ma'aden facilities at Wa'ad Al Shamaal by 2016. By 2018, additional gas was to be made available for local power generation.<sup>49</sup> However, Saudi Aramco faces some challenges in the development of its unconventional resources. For example, the depth of the related reservoirs and likelihood of very low permeability make hydraulic fracturing (fracking) very difficult.<sup>50</sup>

Additionally, water scarcity issues will require technology advancements in the stimulation process. Saudi Aramco is exploring the use of carbon dioxide (CO<sub>2</sub>), saline aquifers, wastewater, propane, and other hydrocarbons to replace hydraulic fracturing. In particular, Saudi Aramco's CO<sub>2</sub> development initiatives could enable the reduction of stimulation water and acid volumes by 30%.<sup>51</sup>

Another consideration for Saudi Arabia will be developing the nation's technical expertise in unconventional resource development. Currently, Saudi Aramco is depending on the expertise of North America and Europe based companies such as Schlumberger, Halliburton, and Baker Hughes in its search for unconventional gas.<sup>52</sup> The development of a strong services sector and a skilled workforce will be key in meeting the nation's targets. Additionally, an enabling oil and gas distribution network, land access, and operability could become hurdles for Saudi Aramco in their drive to becoming a shale gas producer.<sup>53</sup>

## Mexico

Energy reform in December 2013 allows Pemex to have profit share contracts and to form partnerships with foreign developers, which improved the fiscal attractiveness of the market. From an implementation standpoint, the Burgos basin in Mexico is a direct extension of the Texas Eagle Ford basin, which gives the basin some geological promise; however, at present well data is limited and results are modest. Further exploration of the region will be required to pique the interest of investors.<sup>54</sup>

In terms of infrastructure, the Burgos basin represents 20% of Mexico's hydrocarbon outputs and therefore has existing roads. However, there is a security issue around the border. Additionally, the availability of abundant, cheap US shale gas in the region may serve to derail investments in Mexican assets.<sup>55</sup>

## Poland

Poland is the most mature shale market in Europe; however, until recently the policy framework limited the attractiveness of the market. A recent bill attempts to address

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<sup>47</sup> Saudi Aramco, 2015: Annual Review 2014. Accessed Jan 2016.

<sup>48</sup> Oil and Gas News: Saudi Arabia Review: Aramco deploys rigs for shale. Accessed Jan 2016.

<sup>49</sup> Saudi Aramco, 2015: Annual Review 2014. Accessed Jan 2016.

<sup>50</sup> Oil and Gas News: Saudi Arabia Review: Aramco deploys rigs for shale. Accessed Jan 2016.

<sup>51</sup> Saudi Aramco, 2015: Annual Review 2014. Accessed Jan 2016.

<sup>52</sup> Oil and Gas News: Saudi Arabia Review: Aramco deploys rigs for shale. Accessed Jan 2016.

<sup>53</sup> Stark, M, 2014: International Development of Unconventional Resources: If, where and how fast?, Accenture. Accessed Nov 2015.

<sup>54</sup> Stark, M, 2014: International Development of Unconventional Resources: If, where and how fast?, Accenture. Accessed Nov 2015.

<sup>55</sup> Stark, M, 2014: International Development of Unconventional Resources: If, where and how fast?, Accenture. Accessed Nov 2015.

policy chokepoints by abandoning state-controlled production partnerships and improving licensing.

In the Baltic basin, the most prospective region, there is an estimated technically recoverable reserve base of 105 tcf shale gas and 1.2bn bbl of shale oil. Approximately 60 wells have been drilled and there is good data availability. Test results from the basin are modest.<sup>56</sup>

Poland's Baltic basin has several favourable above ground characteristics such as low population density relative to other European states, good surface conditions, and favourable infrastructure. The basin is also already connected by the existing natural gas transmission pipeline. Additionally, Poland has access to the European services sector and labour force, which makes the development of technical expertise and access to a skilled workforce easier.<sup>57</sup>

Poland also faces several obstacles in its quest to develop shale resources and is still some time away from becoming a substantial shale gas producer. For example, further infrastructure development is required, including infrastructure for water treatment and disposal.<sup>58</sup> The nation's recent entry into the growing list of LNG importing nations in a buyer's market will create competition for shale gas investments. However, additional policy reforms to improve the fiscal attractiveness of Polish shale gas investments could accelerate the pace of development.<sup>59</sup>

## Algeria

Algeria's ambitions in shale gas are driven by the nation's declining conventional production and growing domestic demand. In 2013, Algerian authorities substantially revised the existing legislative framework to incentivise shale gas extraction further, providing for relatively low service taxes as well as attractive royalties schemes.<sup>60</sup> However, shale gas developments are still very new and production is not likely before 2020.

Algeria's potential to become a large producer of shale gas after 2020 is quite promising. It has a significant resource base and is well placed geographically to reach strategic markets in Europe and Asia. The nation is already a leading source of natural gas in Europe and has access to international markets via 26.9 mtpa of liquefaction capacity, although it should be noted that utilisation rates for Algerian LNG terminals were less than 50% in 2014.<sup>61</sup>

Algeria has a well-established natural gas industry and its NOC, Sonatrach, has strong conventional gas development skills and business partnerships that could enable the transfer of knowledge for shale gas development. In terms of oil and gas infrastructure, Algeria has a substantial network of pipelines and a well-developed local service industry with extensive pipeline systems and dozens of drilling rigs

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<sup>56</sup> Stark, M, 2014: International Development of Unconventional Resources: If, where and how fast?, Accenture. Accessed Nov 2015.

<sup>57</sup> Stark, M, 2014: International Development of Unconventional Resources: If, where and how fast?, Accenture. Accessed Nov 2015.

<sup>58</sup> Stark, M, 2014: International Development of Unconventional Resources: If, where and how fast?, Accenture. Accessed Nov 2015.

<sup>59</sup> Strzelecki, M, 2015: Poland Opens LNG Terminal, Pledges to End Russian Dependence, BloombergBusiness. Accessed Jan 2016.

<sup>60</sup> Boersma, T, Mar 2015: Algeria field report: Developing shale gas in North Africa, Brookings Institute. Accessed Jan 2016.

<sup>61</sup> IGU, 2015: World LNG Report - 2015 Edition. Accessed Nov 2015.



available. However, serious concerns over water scarcity, security, ageing infrastructure, community protests, and growing competition for market share in an already flooded market could all delay the development of shale gas in Algeria.<sup>62</sup>

### South Africa

In South Africa, an overreliance on coal and recurrent power shortages gave a new impetus to gas exploration in the nation. According to South Africa's Department of Energy's Integrated Resource Plan 2010-2030, South Africa needs more than 50GW of new electricity generation, but has committed itself to reduce greenhouse gas emissions by 34% by 2020. As a result, the South African government began exploring the potential to develop CBM and shale gas resources.<sup>63</sup>

The Karoo shale basin is considered a good prospect due to the presence of mature black shales. Eskom officials also estimate that shale gas from the Karoo could be produced and directly absorbed by existing electricity networks up to 1 to 2 GW, with no need for pipelines, which enables progress even in the low price environment.

Despite the potential and local need for new energy supplies, exploration and development have not yet made significant progress. Certain focal areas have the potential to accelerate the future of South African shale gas development. First, building local expertise will be important. Currently, the local workforce has limited access to oil and gas technical skills. The nation's service sector has some conventional resource development experience and there is some presence of maintenance and oil field services skills. However, the development of shale will require stronger technical expertise in shale gas development. Sasol, the nation's NOC has working interest in shale assets in Canada and has the potential to apply its learnings domestically.<sup>64</sup>

To improve market attractiveness, a new Infrastructure Development Bill was implemented to address the risks of expropriation. However, a clearer stance on tax incentives and subsidies, and ownership of mineral rights should be taken and formalised to further attract potential partners and foreign investment.<sup>65</sup> Shell as well as Chevron in partnership with Falcon Oil and Gas are currently exploring in Karoo.<sup>66</sup>

The largest hurdles for Karoo will be infrastructure development and water availability (Karoo means "thirsty land"). Currently, Sasol and Transnet own all significant pipeline infrastructure and there is no coverage in the Karoo basin. While it appears some development will occur without major infrastructure investments, eventually infrastructure will be required to realise the potential of the basin in a sustainable manner. This will be exceptionally true for water management. There is opportunity for shale gas to drive the development of road, pipeline, water management, and municipal infrastructure that could improve the services available to communities and build goodwill with the industry. The basin currently has poor road infrastructure.

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<sup>62</sup> Boersma, T, Mar 2015: Algeria field report: Developing shale gas in North Africa, Brookings Institute. Accessed Jan 2016.

<sup>63</sup> South Africa Electricity Regulation Act No.4 of 2006, Electricity Regulations on the Integrated Resource Plan 2010-2030, May 2011. Accessed Jan 2016.

<sup>64</sup> Sasol Canada, 2015: Natural Gas Assets. Accessed Jan 2016.

<sup>65</sup> Stark, M, 2014: International Development of Unconventional Resources: If, where and how fast?, Accenture. Accessed Nov 2015.

<sup>66</sup> Shell, 2015: The Karoo. Accessed Jan 2016.

Falcon Oil and Gas, 2012: Karoo Basin, South Africa. Accessed Jan 2016.

Additionally, there are significant local public concerns regarding potential environmental impact from shale operations.<sup>67</sup>

### **Turkey**

Turkey was one of the fastest growing economies in the world over the last decade and depended heavily on natural gas to meet runaway energy demand growth. Natural gas consumption more than doubled from 22.1 bcm in 2004 to 48.6 bcm in 2014. As a result, Turkey has grown to rely heavily on Russian natural gas imports, which reflected approximately 56% of total natural gas consumption in 2014.<sup>68</sup>

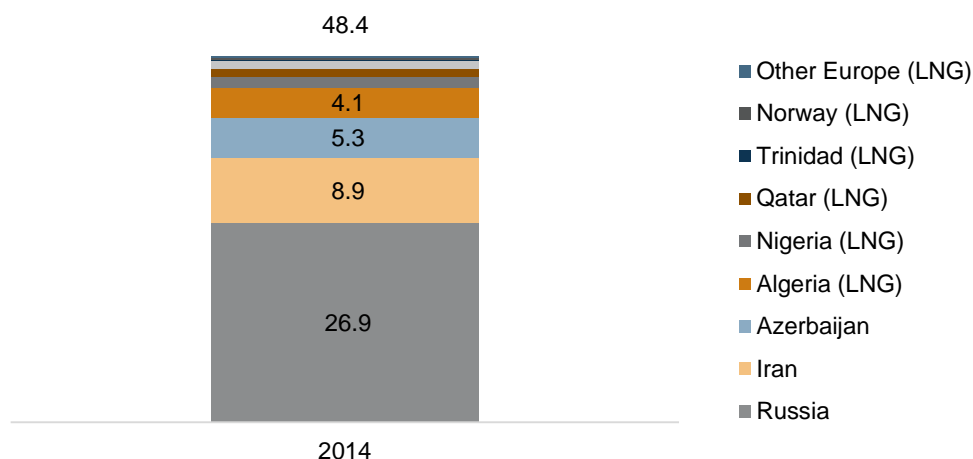
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<sup>67</sup> Stark, M, 2014: International Development of Unconventional Resources: If, where and how fast?, Accenture. Accessed Nov 2015.

<sup>68</sup> BP, 2015: BP Statistical Review of World Energy 2015. Accessed Nov 2015.

**Figure 8: Turkish natural gas supplies 2014 (bcm)**

Source: BP Statistical Review 2015



The EIA estimates that the Dadas Shale in the South East Anatolian basin and the Hamitabat Shale in the Thrace basin contain 163 tcf of risked shale gas in-place, with 24 tcf as the risked, technically recoverable shale gas resource.<sup>69</sup> Shell's Turkish subsidiary along with joint venture partner Turkish NOC, Turkish Petroleum Corporation, have carried out early stage exploration activities targeting a liquids-rich shale resource in the Dadas Shale.<sup>70</sup> Canadian company TransAtlantic Petroleum is also active in the region<sup>71</sup> and there are rumblings of ExxonMobil joining the fray.<sup>72</sup>

While Turkish shale gas developments are still in their infancy, Turkish reserves provide many incentives for the nation to push forward in bringing supplies online and establishing itself as a natural gas hub in the region. As a major consumer facing continued demand growth, Turkey is actively pursuing an energy security strategy with a diversified supplier base.<sup>73</sup> Additionally, Turkey is geographically positioned along trade routes to the EU and the Middle East and Mediterranean gas fields in Cyprus, Greece, and Israel.

However, Turkish shale gas reserves face many challenges. First, there is not enough known about the resource potential. Once that is assessed, concerns about additional policy, infrastructure, and technical challenges will have to be addressed to capitalise on Turkey's shale gas resources.

### Competition from conventional projects

The rapid growth in unconventional gas has already significantly disrupted trade flows globally. With concerns about affordability and security driving exploration into unconventional resources outside of North America, unconventional gas will continue to be a driving factor in how the market evolves. In particular, continued growth in the US, Australia, and China will significantly influence the balance of supply and demand out to 2020. Argentina and Saudi Arabia may also emerge as unconventional resource

<sup>69</sup> EIA, 2015: Technically Recoverable Shale Oil and Shale Gas Resources: Turkey. Accessed Jan 2016.

<sup>70</sup> Shell, 2015: Shell Upstream Turkey. Accessed Jan 2016.

<sup>71</sup> EIA, 2015: Technically Recoverable Shale Oil and Shale Gas Resources: Turkey. Accessed Jan 2016.

<sup>72</sup> Coskun, O, Jun 2015: UPDATE 1-ExxonMobil in talks with Turkey over shale gas exploration, Reuters. Accessed Jan 2016.

<sup>73</sup> Republic of Turkey Ministry of Foreign Affairs: Turkey's Energy Strategy. Accessed Jan 2016.

suppliers before 2020. However, a few very large conventional projects will create competition for future unconventional gas investments in the long-term.

### Sub-Saharan Africa

While there is potential for the development of unconventional gas in Algeria and South Africa, offshore projects in East Africa may win in the race for funding in the region. Natural gas discoveries in recent years in Mozambique and Tanzania appear very promising to the industry. Empresa Nacional de Hidrocarbonetos estimates indicate finds offshore Mozambique alone could reflect ~7.1 tcm of recoverable natural gas.<sup>74</sup> Tanzania's Energy and Minerals Ministry estimates that the country has ~1.6 tcm of natural gas reserves.<sup>75</sup>

The global supply glut and current economic climate means projects may be slowing down;<sup>76</sup> however, the weighty potential in East Africa makes the development of major natural gas projects practically inevitable. As excess supplies are absorbed on global markets, and the "right price" emerges, East African projects will begin construction. This is most likely to occur after 2020, given the prospects of continued supplies from projects already under construction globally.

In this period, the African continent has the opportunity to build a foundation that establishes the development of its vast resource on two pillars for economic growth: 1) exports to boost national coffers and 2) domestic gas to support local and regional development. If policymakers in the region are successful at regional cooperation and energy system integration, sub-Saharan Africa could emerge as an important new hub for natural gas that serves as an intermediary, connecting North America and Asian markets, and feeds growing demand for energy within Africa. This enables the development of strategic infrastructure, limits the need for fossil fuel imports in the region, and provides some protection for the continent against commodity price volatility.

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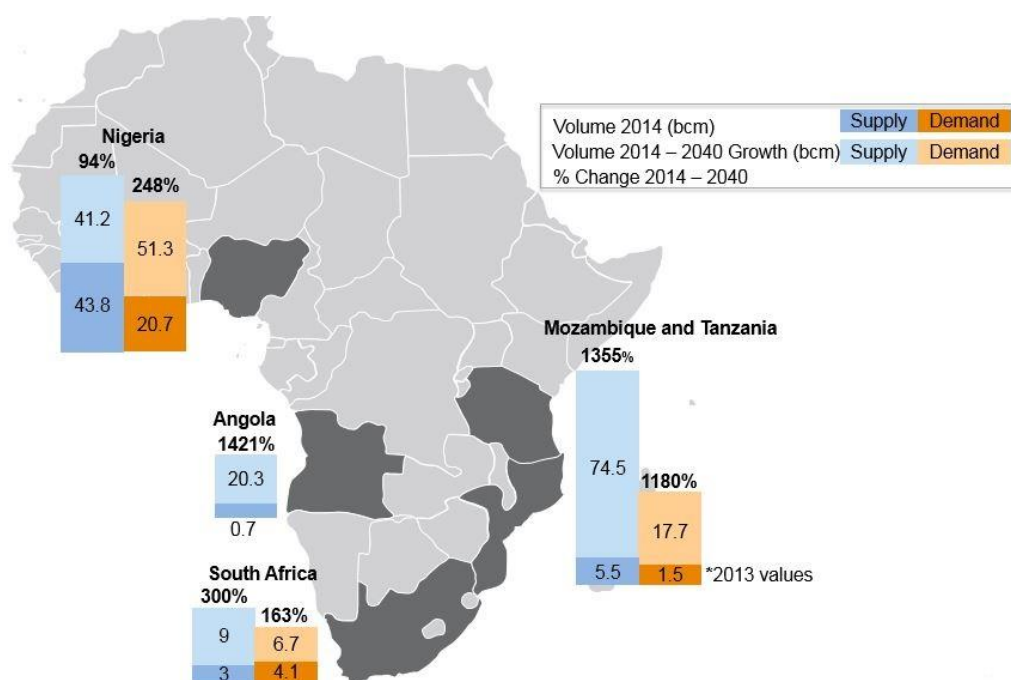
<sup>74</sup> Gismatullin, E, 2012: Eni-Anadarko African LNG Plant to Be World's Second-Largest, BloombergBusiness. Accessed Nov 2015.

<sup>75</sup> Bariyo, N, 2015: Tanzania Says Gas Reserves Rise 18% to Reach 55 Trillion Cubic Feet, The Wall Street Journal. Accessed Nov 2015.

<sup>76</sup> Reuters, 2015: Mitsui delays final decision on Mozambique LNG project to end-March. Accessed Jan 2016.

### Figure 9: Sub-Saharan Africa supply and demand for natural gas

Sources: BP Statistical Review of World Energy 2015, EIA International Energy Statistics, IEA World Energy Outlook 2014, National Petroleum Institute of Mozambique, Nigerian National Petroleum Corporation, OPEC Statistical Bulletin 2015, and Accenture Analysis



### Russia

While Russia has been a long standing supplier in the natural gas industry, security concerns in recent years drove big trade partners in Europe and Turkey to take active steps to diversify away from Russian natural gas imports. However, the current economics of Russia's oil indexed contracts imports make the resource more competitive than LNG imports. This has been a persistent trend since 2011. Even as Europe's natural gas imports have declined in recent years, the concentration of Russian pipeline gas has grown. In 2015, Europe increased shipments from Russia as contract prices declined.<sup>77</sup> Additionally, the cost of getting Russian supplies to European borders is significantly lower than US or Australian LNG, which could erode the chances of US and Australian LNG taking significant market share in the region.

### The Middle East

The Middle East remains the world's dominant reserve holder of natural gas and the region with the most potential to bring vast amounts of conventional gas onto the market quickly. In particular, Iran and Qatar have the potential to displace significant volumes of unconventional gas.

#### Iran

New supplies from the world's largest natural gas reserve holder, Iran, could swiftly derail unconventional gas investments. The Iran Nuclear Deal lifted international oil and gas sanctions and opened the door for Iran to capitalise on its substantial base of proved natural gas reserves, estimated at 34.0 tcm as of 2014.<sup>78</sup>

<sup>77</sup> Shiryayevskaya, A, Sept 2015: Cheap Russian Gas Tempts EU Buyers as LNG Import Growth Stalls, BloombergBusiness. Accessed Jan 2016.

<sup>78</sup> BP, 2015: BP Statistical Review of World Energy 2015. Accessed Nov 2015.

Iran moved quickly after Western sanctions were lifted to access global markets via LNG facilities. National Iranian Gas Export Company is said to be in talks to develop a project that could have Iranian LNG landing in Europe within two years. The European Commission (EC) estimates that Iranian LNG could grow to supply 25-35 bcm of natural gas to the EU by 2030.<sup>79</sup> Several other projects including a bi-lateral subterranean pipeline deal that would allow Iranian gas to be piped to Oman's LNG terminals and a floating LNG facility are also in play. There has also been talk of restarting work on the \$3.3bn project, Iran LNG, which was delayed due to sanctions and is about three to four years away from completion. The project could add another 14.5 bcm/year to global LNG supplies when it comes online.<sup>80</sup>

However, Iran still has a very large infrastructure hurdle to overcome, which will increase the costs and complexity of projects. Still, the nation has strong economic and geopolitical reasons to develop its gas resources and is well positioned to supply Europe and feed growing demand in the Middle East. Policy intervention and economics could drive an accelerated development process that sees new Iranian supplies on the market before 2020.

### *Qatar*

Qatar has been the world's leading LNG exporter since 2006, with 77 mtpa, or a third, of global export capacity and one third of global market share in 2014. By 2017, Australia is set to surpass Qatar as the number one LNG capacity holder with 86.5 mtpa;<sup>81</sup> however, there is still significant room for Qatar to disrupt global LNG developments.

As an established trade partner, Qatar is already well positioned to supply both Europe and Asia. In 2014, Qatar supplied 45% of all LNG imported to the Eurasia region and 31% of LNG imports to Asia.<sup>82</sup> With the world's largest LNG Trains, Qatar has the ability to produce and process large quantities of gas and can keep its costs far below Australian or US projects. IHS estimates that it costs about \$2/MMBTU to produce and liquefy gas in Qatar.<sup>83</sup> Additionally, at oil prices below \$50/bbl, Qatar's oil indexed contracts are still cheaper than US Henry Hub indexed contracts and provide QatarGas, the Qatari NOC, with a substantial margin to continue investing in export capacity. Increased competition from a lower cost resource for new market share could lead to a long-term shifting of investment flows away from unconventional resource development.

## Looking forward

The rapid growth in unconventional gas has already significantly disrupted trade flows globally. With concerns about affordability and security driving exploration into unconventional resources outside of North America, unconventional gas will continue to be a driving factor in how the market evolves. In particular, continued growth in the US, Australia, and China will significantly influence the balance of supply and demand out to 2020. Argentina and Saudi Arabia may also emerge as commercial unconventional resource suppliers before 2020. Most other frontier markets are at

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<sup>79</sup> Steinhauser, G, 2015: Iran Could Become Major Supplier of Natural Gas to EU, The Wall Street Journal. Accessed Jan 2016.

<sup>80</sup> Azernews, 2016: Iran in talk with Golar to export LNG to EU. Accessed Jan 2016.

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<sup>81</sup> IGU, 2015: World LNG Report - 2015 Edition. Accessed Nov 2015.

<sup>82</sup> BP, 2015: BP Statistical Review of World Energy 2015. Accessed Nov 2015.

<sup>83</sup> Reed, S, Aug 2015: Liquefied Natural Gas Makes Qatar an Energy Giant, The New York Times. Accessed Jan 2016.

least five to ten years away and will face competition from large conventional projects in sub-Saharan Africa and the Middle East.

Effective and sustainable development of unconventional resources will require several elements to come together in a given market. For one, it will require long-term strategies and investments and the financial resources to explore and develop basins as well as to develop infrastructure and a local supplier network. It will also require relationships with the local communities to garner support for the development, minimise surface disruption, and ensure that the local communities share in the benefits. It will also require collaboration with government and policymakers to ensure fit for purpose and environmentally sound regulations.

NOCs will have many advantages in meeting these requirements over an international or foreign oil company. Therefore, the fact that NOCs are leading unconventional developments in countries like Argentina, China and Saudi Arabia is not surprising and sets the stage for a new model that may be stronger in addressing societal and environmental concerns associated with unconventional gas operations.

Many nations with shale gas resources also face water stress and their NOCs have many incentives to deploy new technologies that overcome water related operational risks and constraints. For example, Saudi Aramco's breakthroughs in reducing water usage through the use of CO<sub>2</sub> for stimulation in the shale gas fracturing process would create significant advantages for the future energy mix. It would reduce water needs, a crucial target in countries facing water scarcity and competition for water between energy and food (refer to the World Energy Council report, Financing Resilient Energy Infrastructure). It would also create a potential new use for CO<sub>2</sub>, which creates economic incentives to capture more emissions.

## 3. Shifting portfolio allocations

In the current downturn, the future of many natural gas assets is at risk. With the realisation that oil and gas prices may stay at their current lower level for longer than initially anticipated, companies are reducing capital expenditures and cutting back on virtually all projects that have not been sanctioned. Among companies postponing big projects are BP, Shell, Chevron, Statoil, and Australia's Woodside Petroleum. Recent reports indicate more than half of reserves put on hold are deepwater projects. Canada is the biggest single region affected, with the development of some 5.6bn bbls of reserves deferred, most of which are in the oil sands.<sup>84</sup>

In the US, significant cuts were also made, but an interesting trend demonstrated the resilience created by the economic improvements seen in shale gas operations in recent years. In 2015, many E&P operators with US land assets reshuffled their portfolios towards North America land shale gas at a time when overall capital expenditure was declining. ConocoPhillips announced plans to up capital spending in US and Canada unconventional assets from ~\$2.5bn in 2015 to ~\$4.5bn by 2017.<sup>85</sup> Anadarko allocated 60% of its estimated \$5.6bn budget for onshore shale wells, even while reducing spending 33% overall.<sup>86</sup> ExxonMobil announced it will double the amount of oil it pumps from its US shale fields during the next three years, even as it moves more cautiously on investments in big projects elsewhere.<sup>87</sup>

In an uncertain price environment, shale gas assets surprisingly emerged as a source of high-return, short-cycle cash flows for E&P companies with North America land operations.

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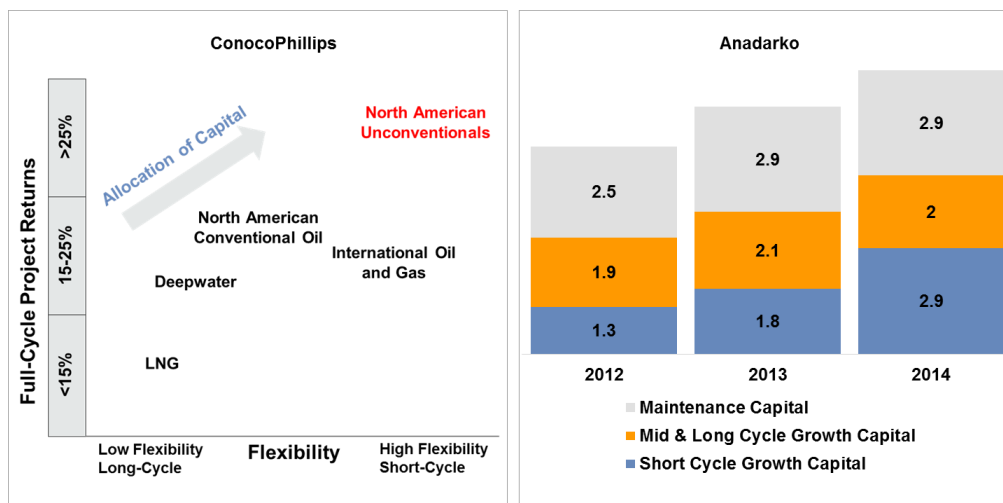
<sup>84</sup> The Financial Times, 2015: Oil groups have shelved \$200bn in new projects as low prices bite. Accessed Jan 2016.

<sup>85</sup> Lance, R, 2015: Barclays CEO Energy Conference: Sept. 9, 2015, United States, ConocoPhillips. Accessed Nov 2015.

<sup>86</sup> Reuters, 2015: Anadarko Petroleum cuts '15 capital expenditures by a third. Accessed Nov 2015.

<sup>87</sup> Carroll, J, 2015: Exxon Looks to U.S. Shale Fields to Drive Global Growth, BloombergBusiness. Accessed Nov 2015.



**Figure 10: Industry examples of increased desire for short-cycle flexible assets**Sources: ConocoPhillips and Anadarko<sup>88</sup>

Many operators who invested in driving technology advancements and operational efficiencies in their US shale operations were able to improve cycle time and reduce costs at an incredibly rapid pace throughout the development programme cycle.<sup>89</sup>

The technology and operational advances made by the industry strengthened the position of US shale gas within the upstream portfolio and in the case of a market rebound, capital will flow back to US shale assets at lower price points in North America.

The following section discusses some of the key drivers that enabled the rapid growth and demonstrated the resilience of the US shale gas industry. It explores how US shale gas emerged as a more flexible shorter-cycle investment option for E&P companies and provides a forward perspective on how the industry will evolve in 2016. Three main drivers led to the rapid economic improvements seen in the shale gas development process and enabled the fast-tracking of US LNG projects in the last five years:

- ▶ Operational flexibility
- ▶ Continued operational and technical innovation
- ▶ Favourable regulatory climate

### Operational flexibility

Despite the more than 50% decline in oil and natural gas prices in the last 12 months, upstream operators continued to drill wells in North America throughout 2015 and are waiting to complete them until price and cost structures are more favourable.

The EIA estimates there are between 2,000 and 4,000 uncompleted wells representing the potential to add 350,000 Bpd of production through October 2016.<sup>90</sup>

<sup>88</sup> ConocoPhillips, 2015: ConocoPhillips Investor Update: May 14, 2015. Accessed Nov 2015.

Anadarko, 2015: Anadarko Investor Book, October 2015. Accessed Nov 2015.

<sup>89</sup> Stark, M, 2015: Lower oil prices have strengthened the role of unconventional in upstream portfolios, Oil and Gas Journal. Accessed Sept 2015.

<sup>90</sup> Nülle, G, 2015: Tight Oil Production Trends in a Low Price Environment, EIA. Accessed Nov 2015.

Cost and cycle time improvements in drilling and completions mean production can be ramped up or down more quickly than ever before in response to market fluctuations.

The option to defer production allows US E&P companies to use the rigs they have under multi-year contracts and allows them to build an inventory of wells that can be completed in a matter of months. This flexibility makes shale gas assets more favourable and responsive in a volatile market and means that US LNG can respond first to a price rebound across regional gas markets.

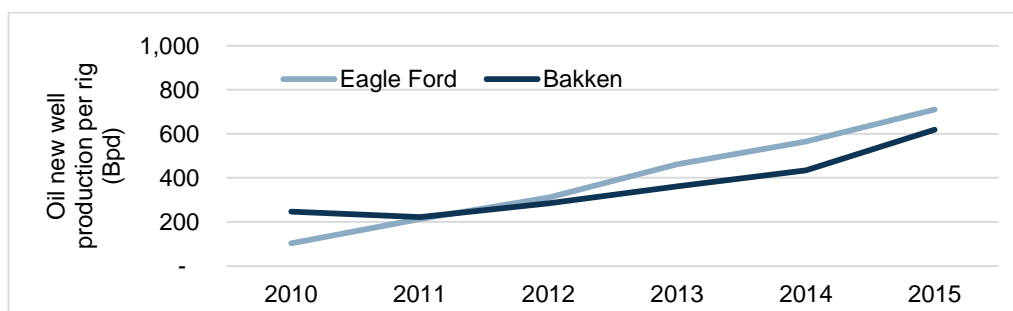
### Continued operational and technical innovation

There is still a lot of opportunity to improve well productivity in tight and shale operations, with an average of less than 10% recovery rates for tight oil and less than 25% for shale gas. Operators and service companies continue to invest in technical research and pilots to improve characterisation of the play, drilling, and completion techniques.

Still, well productivity in the US has seen rapid improvements since 2011. New well oil and gas production per rig has grown substantially in key basins such as the Eagle Ford, Bakken, Marcellus, and Utica as evidenced in Figures 11 and 12.

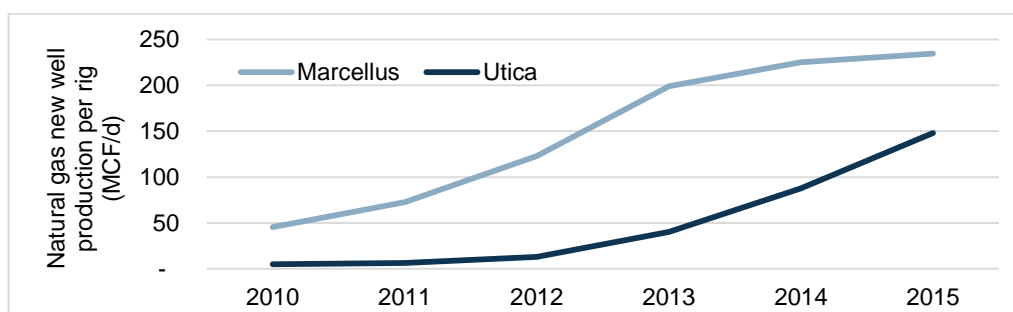
#### Figure 11: New well oil production in the Bakken and Eagle Ford basins per rig (Bpd) (2011–2015)

Sources: EIA Drilling Productivity December 2015 and BP Conversion Factors



#### Figure 12: New well natural gas production in the Marcellus and Utica basins per rig (MCF/d)

Sources: EIA Drilling Productivity December 2015 and BP Conversion Factors

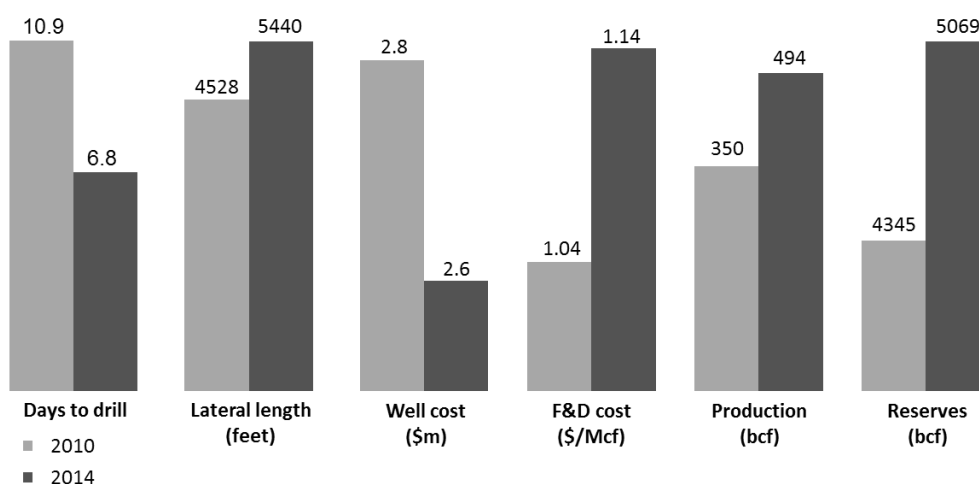


A strong continuous improvement and manufacturing mind set among the leading independents has driven significant time, and therefore cost, improvements in shale and tight operations. Examples of the value driven through efficiency gains and production optimisation abound. ConocoPhillips has achieved an impressive \$2.50/bbl lifting cost in their Eagle Ford operation through cost efficiency and production

optimisation initiatives.<sup>91</sup> Anadarko's US operations achieved 30% production growth, record oil sales volumes in the second quarter of 2015, highlighted by a 56% increase in wells drilled per rig in the Rockies year-over-year.<sup>92</sup> Figure 13 provides a visual example of the drastically improved well cost and efficiency in Southwestern Energy's Fayetteville Shale operations.

### Figure 13: Example of efficiency gains - Southwestern Energy's performance in the Fayetteville Shale

Source: Southwestern Energy July 2015 Update



Many operators such as EOG, Anadarko, and ConocoPhillips now have significant share of production that is able to break even in the \$40-\$50 range. In wet gas basins, operations are estimated to break even in the \$25-\$30 range.<sup>93</sup>

### Favourable regulatory regime

The fiscal, legal, and regulatory regimes in the US are uniquely favourable to the development of natural resources. A major driver is the ownership structure of mineral rights which allows landowners to reap the benefits of production on land they invest in. Additionally, a relatively fast permitting process for LNG export facilities enabled the US to enter the global LNG market as an exporter relatively quickly. The process, which involves the FERC and the US Department of Energy (DOE), facilitated the approval of six terminals through year end 2015, five of which are under construction.<sup>94</sup>

The learnings from US shale operations are also enabling a new set of policies to reduce safety and environmental risks. Shale gas operations are much more complex than conventional gas development and introduce additional risks around waste and water management, air pollution, congestion, dust, etc.

State and federal regulation has been for the most part catching up to the rapidly growing industry. This has created tension with some communities. However, as the industry evolves, new standards are being introduced. The US Environmental

<sup>91</sup> ConocoPhillips, 2015: 2015 Analyst and Investor Meeting – Final, 8 April 2015, CQ FD Disclosure. Accessed Oct 2015.

<sup>92</sup> Anadarko, 2015: Fourth Quarter 2014 Operations Report. Accessed Oct 2015.

<sup>93</sup> Reuters, 2015: FACTBOX-Breakeven oil prices for U.S. shale: analyst estimates. Accessed Jan 2015.

<sup>94</sup> FERC, 2016: LNG. Accessed Jan 2016.

Protection Agency (EPA) recently presented a new set of standards set to cut methane emissions by 25% over 2012.<sup>95</sup>

Industry best practices have also been established for water management based on experiences in more stringent state regulatory environments. These best practices make water treatment and reuse more economic and operationally feasible. Companies have also identified conveyance practices that reduce truck usage and new water storage designs that enable non-freshwater sourcing.<sup>96</sup>

While there is certainly room for growth in the development of policy frameworks for the safe and reliable development of US shale gas, the significant environmental risks raised in the early days of shale have not come to fruition in the US. Policymakers, communities, and industry are working relatively collaboratively to solve issues and regulatory frameworks are emerging to continuously reduce risks and improve community relations.

## Looking forward

In 2016, with the large inventory of uncompleted wells and reduced service prices, companies will be able to bring production on at reduced costs, having already sunk the drilling costs in 2015. This momentum will keep production stable through 2016. US market structures enable some operators who own midstream assets or who operate in wet gas basins to maintain favourable economics with current Henry Hub prices. Natural gas production continued to grow in the Utica, Permian, and Bakken basins in 2015 and production remained strong in the most prolific basin, the Marcellus.

**Figure 14: US natural gas production and net imports 2014–2017**

Source: EIA Short-Term Energy Outlook, January 2016



The trend to watch for in the next year will be bankruptcy and industry consolidation. Bankruptcies may occur for assets outside the core of the large unconventional basins. Although E&P consolidation has not come into full swing just yet, various industry dynamics have created the perfect storm for consolidation. In 2016, rising

<sup>95</sup> EPA, 2015: Oil and Natural Gas Air Pollution Standards. Accessed Jan 2016.

<sup>96</sup> Stark, M, 2012: Water and Shale Gas Development, Accenture. Accessed Jan 2016.

pressure on the industry will mean highly leveraged poor performers will start to get squeezed out. Many US E&P Independents are carrying hefty debt loads. Companies are auctioning assets to stay afloat. Canadian company Encana has made a series of asset sales totalling \$2.7bn in 2015. Occidental recently sold its Williston basin assets to Lime Rock for about \$500m.<sup>97</sup>

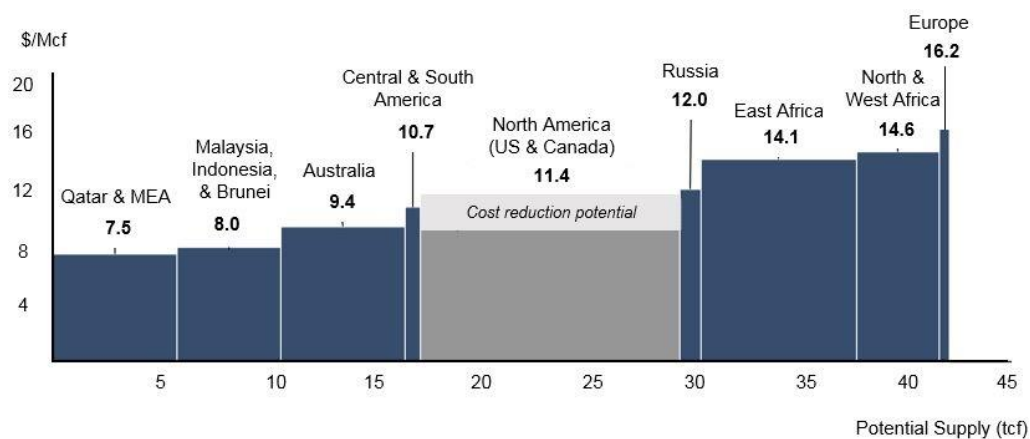
Noble Energy's \$2.1bn purchase of smaller rival Rosetta Resources in June 2015 was the year's first example of a larger US E&P Independent buyer taking advantage of the down market to acquire a smaller rival.<sup>98</sup> This deal was seen by some in the industry as paving the way for additional acquisitions in US E&P. As asset valuations continue to decline, more buyers will emerge to take advantage of discounted opportunities to build economies of scale in core areas of key basins.

Additionally, US LNG exports will start to come online in 2016 and the downward pressure on prices will become more apparent. US LNG export terminals currently under construction are more economic because they are retrofits of import terminals. Brownfield US construction costs per tonne of capacity are less than half the average cost of Greenfield projects expected to come online from 2015 to 2020.<sup>99</sup>

In US market structures, both the E&P and the LNG assets are owned by independent operators and tolling arrangements cover costs separately. This, combined with the economics and flexibility of shale gas and LNG operations, provides some protection to the US industry and positions US exporters relatively competitively in the market as evidenced by Figure 15. While current prices are bad for almost all LNG projects, the US economic model means that as the market absorbs excess supplies through 2020 and prices move closer to the cost of supply, the US is well positioned to respond quickly and emerge as a marginal LNG supplier.

**Figure 15: LNG cost in Japan vs. expected global capacity by country**

Source: Accenture Strategy Upstream



<sup>97</sup> Reuters, 2015: UPDATE 1-Encana to sell Denver Julesburg basin assets for \$900 mln. Accessed Jan 2016.

Scheyder, E and Stone, M, 2015: Exclusive: Oxy to exit North Dakota's oil fields in sale to private equity fund, Reuters. Accessed Jan 2016.

Olson, B and Polson, J, 2015: This \$2.1 Billion Shale Deal Will Be the First of Many, BloombergBusiness. Accessed Dec 2015.

<sup>98</sup>Olson, B and Polson, J, 2015: This \$2.1 Billion Shale Deal Will Be the First of Many, BloombergBusiness. Accessed Dec 2015.

<sup>99</sup> IGU, 2015: World LNG Report - 2015 Edition. Accessed Nov 2015.

## 4. Conclusion

Natural gas is currently the number three fossil fuel in terms of share of the global primary energy mix. For years the world has debated the potential for natural gas to play a critical role in creating a more resilient and sustainable energy future. On the supply side, technology advancements across the value chain are helping to improve the economics, safety, and reliability of this fuel source as exemplified by the US shale gas story.

Policymakers in the Middle East, Asia, North America, and Australia have all expressed commitment to natural gas as a cleaner source of energy for power, transportation, residential, and industry purposes. However, natural gas demand estimates have been revised down continuously in recent years due to reduced demand estimates for Asia.

US shale gas supplies are entering the market in a difficult period and will add downward pressure on prices across regional markets. US shale will also create greater liquidity in supplies, increased competition, and empower consumers; all of which indicate strong potential for the market to globalise. However, there is too much uncertainty around demand to determine how markets will evolve.

In the world's pursuit for secure and affordable natural gas, the rise of unconventional gas outside of North America is inevitable. Unconventional gas will continue to disrupt trade flows in unexpected ways. Australia and China have made significant progress and are already shifting dynamics in Asian markets. While still in the early stages, Argentina and Saudi Arabia have the potential to emerge as commercial unconventional oil and gas producers by 2020.

With the global supply glut growing in scale, the industry is in distress, virtually all projects that have not been sanctioned to date are delayed or cancelled, and companies are struggling to keep up with debt. In this challenging period, US shale gas has demonstrated that its economics are more competitive than many conventional assets, namely due to the short-cycle and flexible nature of shale gas operations. The surprising resilience of US shale gas and LNG projects creates optimism about the role of unconventional gas as a competitive resource in the global energy mix.

The World Energy Council's Resources 2013 chapter on natural gas predicted natural gas could reach 25% of the global energy mix by 2030. Unconventional gas supplies have the potential to reflect a substantial portion of that share and will continue to change the supply landscape for natural gas. The US shale gas revolution serves as a unique case study that demonstrates how suppliers can use technology innovation to drive to more affordable and secure supplies of natural gas. However, the reality remains that current market dynamics place the future of natural gas at risk. Swift intervention is needed by key market actors to protect long-term conventional and unconventional supplies.

In the process of developing the 2016 World Energy Scenarios to 2060, the World Energy Council listened to industry leaders, in a broad variety of roles and geographies, express their views on the future of energy. Amongst the participants surveyed, there was resounding consensus that natural gas has the potential to play a critical role in the grand transition to an affordable and environmentally sustainable energy future. However, in order to meet these ambitions, certain decisive interventions were identified as necessary for market actors to alleviate uncertainty in the market:

- ▶ **Industry:** Bring a higher degree of focus to portfolio allocation, risk management, and efficiency and continue to seek new and innovative investment partnerships to deliver projects.
- ▶ **Policymakers:** Establish policies that promote a liquid market and competition needed for security of supply and the formation of clear price signals.
- ▶ **Consumers:** Evaluate the economic and environmental benefits of diversifying energy assets with natural gas in power, industry, transportation, and chemicals and consider innovative investment partnerships to secure supplies.

In shifting the supply structure of the global market, unconventional gas may compliment the actions of key actors by increasing transparency, competition, and reshaping the economics of natural gas. This will enable the confidence for investors to develop the infrastructure required for the reliable and safe use of natural gas and contribute to the development of an affordable, secure, and environmentally sustainable energy future.

# Appendix 1: Major operator tables

This Appendix summarises some of the key statistics surrounding major oil and gas operators and also highlights improvements that have been made.

**Table 4: 2014 financials of various operators (\$bn)**

Sources: ExxonMobil, BP, Statoil, ConocoPhillips, Chesapeake Energy, Anadarko, EOG Resources, Marathon Oil, Pioneer Natural Resources, and EP Energy

Company	Revenue	Capital Expenditure	Interest Expense
<b>Mainly Conventional Operators</b>			
ExxonMobil (XTO)	411.94	38.54	0.29
BP	358.68	22.55	1.15
Statoil	80.90	15.13	0.22
<b>Large Independents</b>			
ConocoPhillips	55.52	17.14	0.65
Chesapeake Energy	20.95	5.31	0.09
Anadarko	18.47	9.26	0.77
EOG Resources	18.04	8.25	0.20
Marathon Oil	11.26	5.16	0.30
<b>Small Independents</b>			
Pioneer Natural Resources	5.06	3.58	0.18
EP Energy	3.08	2.20	0.32



**Table 5: 2014 production levels of various operators (MBOE/d)**

Sources: ExxonMobil, BP, Statoil, ConocoPhillips, Chesapeake Energy, Anadarko, EOG Resources, Marathon Oil, Pioneer Natural Resources, and EP Energy

Company	Total Production	Oil/Liquids Production	Gas Production	Gas Share
<b>Mainly Conventional Operators</b>				
ExxonMobil (XTO)	3969	2111	1858	47%
BP	3151	1927	1183	38%
Statoil	1740	978	715	41%
<b>Large Independents</b>				
ConocoPhillips	1540	883	657	43%
Chesapeake Energy	707	205	500	71%
Anadarko	733	299	434	59%
EOG Resources	595.2	369.2	226	38%
Marathon Oil	458	323	135	29%
<b>Small Independents</b>				
Pioneer Natural Resources	196	131	63	32%
EP Energy	98	66	32	33%

**Table 6: Key cost reductions and efficiency improvements of various operators**

Source: BP, ConocoPhillips, Chesapeake Energy, Anadarko, EOG Resources, Marathon Oil, Pioneer Natural Resources, EP Energy, the Bakken, and the New York Times

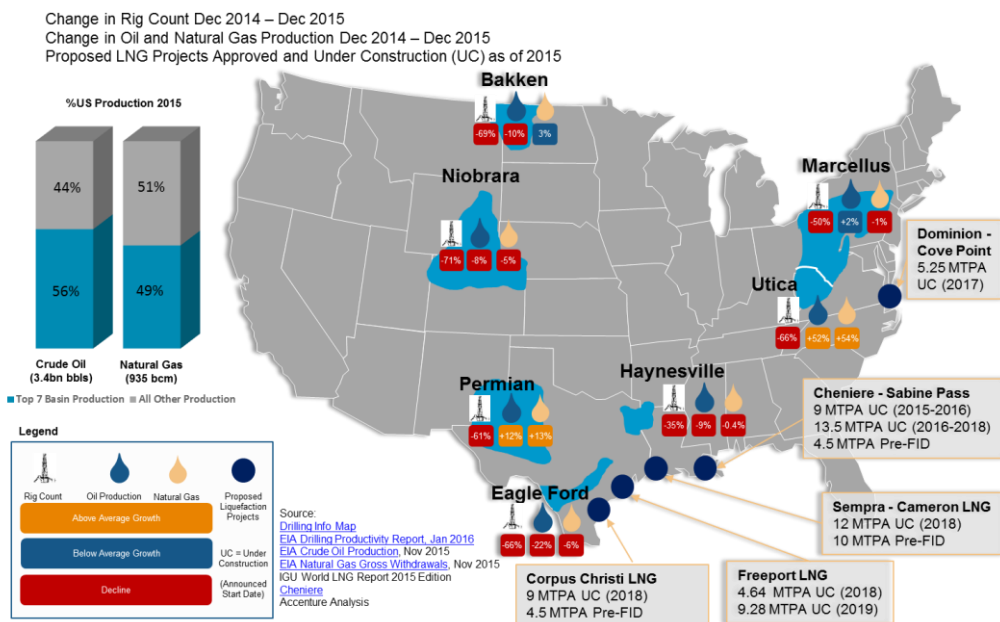
<b>Mainly Conventional Operators</b>	
ExxonMobil (XTO)	In the Bakken, XTO reduced drilling and completion costs by 25% from 2011 to 2014
BP	In 2015 as of Q3, unit cash costs were down 18% compared to the previous year in the Lower 48
Statoil	In Eagle Ford, they cut the average cost of drilling a well from \$4.5 to \$3.5 million and reduced average drill time from 21 to 17 days in 2015
ConocoPhillips	In Eagle Ford, they cut drilling and completion costs per well by 30% from 2013 to 2015
<b>Large Independents</b>	
Chesapeake Energy	In 2014 vs. 2013, they improved well cost per lateral foot by 11% in the Utica Shale and by 15% in Eagle Ford
Anadarko	In Eagle Ford, their well costs improved 14% in 1Q15 vs. 4Q14 and drilling-cycle times fell from 8.1 to 6.9 days in 1Q15 vs. 1Q14
EOG Resources	In the Parshall Core acreage of the Bakken, their average well costs were down 14% in 1Q15 vs. 2014 levels
Marathon Oil	In North America, their E&P production costs per BOE decreased by 27% in 3Q15 vs. 3Q14
<b>Small Independents</b>	
Pioneer Natural Resources	In the Spraberry/Wolfcamp, they reduced drilling and completion capital costs by 25% compared to 2014
EP Energy	In 2015 as of Q3, they reduced total well cost per foot by 19% in Eagle Ford and by 13% in Wolfcamp vs. 2014 levels

# Appendix 2: US production and LNG

This Appendix illustrates the transition occurring in major US basins and conveys the potential current LNG export terminals under construction.

**Figure 16: Major US basins and LNG export terminals**

Sources: Drilling Info Map, EIA Drilling Productivity Report, EIA Crude Oil Production, EIA Natural Gas Gross Withdrawals, IGU World LNG Report 2015, FERC, Company Announcements, Accenture Analysis



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# Appendix 4: Glossary

Bbl	Barrel
bcf/d	Billion cubic feet per day
Bcm	Billion cubic metres
Bn	Billion
Bpd	Barrels per day
CBM	Coal bed methane
CNPC	China National Petroleum Corporation
CO <sub>2</sub>	Carbon dioxide
DOE	US Department of Energy
E&P	Exploration and production
EC	European Commission
EIA	US Energy Information Administration
EPA	US Environmental Protection Agency
FERC	Federal Energy Regulatory Commission
IEA	International Energy Agency
IGU	International Gas Union
IMF	International Monetary Fund
LNG	Liquefied natural gas
LTC	Long-term contract
MBOE/d	Thousand barrels of oil equivalent per day
MCF/d	Thousand cubic feet per day
METI	Japan Ministry of Economy, Trade and Industry
MLR	China Ministry of Land and Resources
MMBTU	Million British thermal units

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mtpa	Million tonnes per annum
NOC	National Oil Company
R&D	Research and development
Sinopec	China Petroleum and Chemical Corporation
tcf	Trillion cubic feet
UK	United Kingdom
US	United States
YPF	Yacimientos Petroliferos Fiscales

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