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North America

The New American (Gas) Century II: Disruptive and Durable

Advances in production slash costs and prices, benefiting domestic industries, reinforcing the lasting durability in exports

- **Cost reductions and continued productivity gains mean North American production growth should be strong even in the face of low prices.** Since the gas price collapse post-2008, gas production rose by nearly 20-Bcf/d between 2009 and 2015, even as prices struggled to average above $4. Productivity gains are on-going at a rate of 10-20%pa as technology improves. Drilling, completion and production costs are falling as the shale oil/gas drilling boom eases, while supplies of equipment increase.
- **Citi now expects long-term (2017-2020) US Henry Hub natural gas prices to average $3.50/MMBtu in real terms, with a soft ceiling at the low-$4 range and soft floor at ~$3, giving North American gas a dominant, low-cost advantage**. In oil-equivalent terms, the average price would be ~$21/boe. These prices are down from the high-$4 to mid-$5 range forecasted previously. Citi's latest assessments on pricing reflect major structural shifts: (a) the size of gas well production and fields continued to expand (e.g. Marcellus/Utica), driving “half-cycle” costs down to the mid-$2 range or lower; (b) older shale plays (e.g. Haynesville) are experiencing a renaissance with ‘half-cycle’ costs down from the mid-$3 to $4 range to the mid-$2 to $3 neighborhood; (c) the decline in oil/liquids prices lowers the switching costs for producers to go from oil/liquids drilling to gas; (d) tightness seen in the services sector recently may not return for some years, lowering production costs.
- **Low upstream gas costs, an extensive pipeline network and much lower capital requirements for export facility construction should give the US a pre-dominant role in gas export markets for years to come**. High capital and per-unit costs and the long lead-time of developing many greenfield LNG projects elsewhere should make brownfield development in the US more attractive; building a new US liquefaction terminal should cost dramatically less than most other places. For now, the delivered US LNG cost could even fall to around $4.5 to $5 for Europe and $6 to $7 for East Asia, if capital costs of LNG terminals are considered sunk and shipping costs fall due to lower oil/gas prices. The growth of gas exports to Mexico should remain very robust as well.
- **All in all, much of the “demand” growth between now and 2020 could be driven by exports**. Domestic demand growth may only reach 2.5-Bcf/d between 2015 and 2020, as a supposed robust growth of industrial demand could be offset by **the likely flat or even decline of gas-fired generation in the power sector**.
- **With lower prices, sectoral impacts are increasingly differentiated.** Downstream users are major beneficiaries, including industrials, petchem, metals processing and utilities. North American renewables might turn out to be less competitive than previously thought, as low gas prices could keep power prices low.

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With thanks to
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Forget what you know about natural gas economics. The rules of the game have changed, and the impacts will be felt far and wide. North American gas is positioned to be two things in the coming decade: disruptive and durable.

The Golden Age of Gas so far has seen the greatest impact on production: production continues to surge, despite years of low prices, due to technological advances, productivity improvements and the growing size of reserves. Enhanced completion techniques that boosted tight oil production are now being reapplied to natural gas production, boosting output; the reserves size of the Marcellus and Utica shale plays in the Northeast has increased further; Mature plays, such as Haynesville, are benefiting from advances elsewhere that could make their production costs comparable to the low-cost US Northeast. The fierce competition among North American exploration and production companies could also drive prices down to the marginal, "half-cycle" costs of production. See the box "The microeconomics of shale are critical to understanding the sector" for details on how this works.

The shale revolution has been so disruptive to our understanding of production dynamics that conventional wisdom on production and pricing continue to be challenged by new thinking and concrete observations. Production growth continues even at locations where prices have fallen to the $1/MMBtu range. Although this price level does not appear to be sustainable long term as it may only cover variable costs in some locations, considerably lower price ranges due to cost reduction, productivity gains and exploitation of large gas fields seem likely and could have far-reaching consequences.

Citi now expects the long-term gas price to average $3.50/MMBtu in 2015 dollars, with a soft ceiling in the low-$4 range and soft floor around $3.

Figure 1. Average daily US Henry Hub price forecasts

Period	4Q'14	1Q'15	2Q'15	3Q'15	4Q'15	1Q'16	2Q'16	3Q'16	4Q'16	2015	2016	2017	2018	2019	2020
New (real)	**3.8**	**2.9**	**2.5**	**2.6**	**2.7**	**2.8**	**2.9**	**3.0**	**3.1**	**2.7**	**3.0**	**3.5**	**3.5**	**3.5**	**3.5**
Old	3.8	2.9	2.6	2.7	2.8	2.8	2.9	3.0	3.1	2.7	3.0	4.7	4.7	4.7	4.7

Source: Citi Research

With a low cost base, North America should be able to expand its gas export potential, with further acceleration possible if and when the global market demands it. More modest domestic consumption growth, efficiency gains in gas production and low services costs are all keeping a lid on production cost pressure.

The future of gas demand is no longer just about gas and coal. Patterns of gas demand growth are changing and slowing. More modest domestic consumption growth than we previously projected is resulting from flat to negative electricity demand growth and the rise of renewables generation. Although a low gas price environment should boost industrial demand for gas, industrials may only use as much gas as determined by the ultimate sales of goods produced. Efficiency gains in production continue with better drilling and completion (e.g. hydraulic fracturing) processes. Services costs should stay well below peaks seen in recent years: service margins, widened during a tight market, should fall sharply as rig counts, as proxies for drilling activities, are cut by nearly 50% vs. the peak in Oct'14, while the high costs of labor, equipment and materials should decline as the demand for services drops.

Figure 2. North American Natural Gas Supply-Demand Balance

NAM	2012	2013	2014	2015	2016	2017	2018	2019	2020	2020 vs. 2015
Supply	**84.6**	**85.8**	**90.8**	**94.8**	**95.4**	**95.2**	**96.4**	**98.1**	**99.7**	**4.9**
Production	83.3	84.8	89.2	93.2	95.6	97.4	101.1	105.0	107.6	14.4
US	64.9	66.2	70.5	74.9	76.4	79.4	82.8	86.4	88.7	13.9
CA	13.9	13.8	13.8	13.7	14.5	13.5	13.8	14.0	14.3	0.6
MX	4.6	4.8	4.9	4.7	4.6	4.5	4.5	4.6	4.6	(0.1)
Net LNG Imports	1.0	1.0	1.3	1.5	(0.0)	(2.2)	(4.6)	(6.9)	(7.9)	(9.4)
Demand	**84.3**	**87.5**	**90.3**	**94.0**	**93.7**	**95.1**	**96.3**	**98.0**	**99.6**	**5.6**
US	69.7	71.7	73.8	76.4	75.4	76.4	77.0	78.0	78.9	2.5
CA	7.9	8.3	8.5	8.8	9.0	9.2	9.5	9.7	10.0	1.1
MX	6.7	7.5	8.0	8.8	9.3	9.5	9.9	10.3	10.8	2.0
Electricity Generation	29.6	27.5	28.3	30.4	29.9	29.6	29.4	29.5	29.6	(0.8)
US	25.0	22.4	22.9	24.7	23.9	23.3	22.8	22.6	22.3	(2.4)
CA	1.5	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	(0.0)
MX	3.1	3.8	4.1	4.4	4.6	4.9	5.2	5.6	5.9	1.6
Non-Electricity Generation	54.7	60.0	62.0	63.6	63.8	65.5	67.0	68.5	70.0	6.4
US	44.6	49.3	51.0	51.7	51.5	53.0	54.2	55.4	56.5	4.9
CA	6.4	7.0	7.1	7.5	7.7	7.9	8.1	8.4	8.6	1.1
MX	3.6	3.7	3.9	4.4	4.6	4.6	4.7	4.8	4.8	0.4
US	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	
Total Supply	**69.2**	**70.1**	**74.3**	**77.4**	**76.5**	**76.4**	**77.0**	**78.0**	**78.9**	**1.4**
Production*	64.9	66.2	70.5	74.9	76.4	79.4	82.8	86.4	88.7	13.9
LNG Imports	0.4	0.2	0.2	0.2	0.1	0.1	0.1	0.0	0.0	(0.2)
Exports to Mexico	(1.6)	(1.9)	(1.9)	(2.8)	(3.7)	(4.6)	(5.1)	(5.5)	(6.1)	(3.3)
Imports from Canada	5.5	5.6	5.5	5.3	4.8	4.3	4.3	4.3	4.3	(1.0)
LNG Exports	-	-	-	(0.1)	(1.1)	(2.7)	(5.0)	(7.2)	(8.1)	(8.0)
Demand	**69.7**	**71.7**	**73.8**	**76.4**	**75.4**	**76.4**	**77.0**	**78.0**	**78.9**	**2.5**
Industrials	19.5	20.4	21.2	22.0	22.7	23.7	24.5	25.3	26.1	4.1
ResComm	19.3	22.9	23.7	23.4	22.5	22.7	22.9	23.1	23.2	(0.2)
Electricity Generation	25.0	22.4	22.9	24.7	23.9	23.3	22.8	22.6	22.3	(2.4)
Pipe Use	1.9	2.0	2.1	2.1	2.1	2.1	2.1	2.2	2.2	0.0
Lease and Plant Fuel	3.8	3.8	3.9	4.0	4.0	4.2	4.3	4.5	4.6	0.6
Transport	0.1	0.1	0.2	0.2	0.3	0.3	0.4	0.4	0.5	0.3
Growth										
Production*		1.3	4.3	4.3	1.6	2.9	3.4	3.6	2.3	
GDP	2.30%	1.90%	2.30%	3.25%	2.80%	2.50%	2.50%	2.50%	2.50%	
Canada	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	
Total Supply	**8.6**	**8.2**	**8.6**	**8.6**	**9.6**	**9.3**	**9.6**	**9.8**	**10.1**	**1.5**
Production	13.9	13.8	13.8	13.7	14.5	13.5	13.8	14.0	14.3	0.6
LNG imports	0.2	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	(0.1)
Pipe imports	(5.4)	(5.6)	(5.2)	(5.2)	(4.9)	(4.3)	(4.3)	(4.3)	(4.3)	0.9
Total Demand	**7.9**	**8.3**	**8.5**	**8.8**	**9.0**	**9.2**	**9.5**	**9.7**	**10.0**	**1.1**
Industrials	3.7	4.0	4.1	4.4	4.7	4.9	5.2	5.4	5.6	1.2
Electricity	1.5	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	(0.0)
Residential/Commercial	2.7	3.0	3.0	3.1	3.0	3.0	3.0	3.0	3.0	(0.1)
Transportation	-	-	-	-	-	-	-	-	-	-
Other	0.1	0.3	(0.1)	0.3	0.1	0.1	0.1	0.1	0.1	(0.2)
Mexico	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	
Total Supply	**6.8**	**7.5**	**8.0**	**8.8**	**9.3**	**9.5**	**9.9**	**10.3**	**10.8**	**2.0**
Production	4.6	4.8	4.9	4.7	4.6	4.5	4.5	4.6	4.6	(0.1)
Pipe imports	1.7	1.9	2.0	2.8	3.7	4.6	5.1	5.5	6.1	3.3
LNG imports	0.5	0.8	1.1	1.3	1.0	0.4	0.3	0.2	0.1	(1.2)
Total Demand	**6.7**	**7.5**	**8.0**	**8.8**	**9.3**	**9.5**	**9.9**	**10.3**	**10.8**	**2.0**
Petroleum	2.3	2.4	2.4	2.8	2.9	2.8	2.8	2.8	2.8	-
Industrial	1.2	1.2	1.4	1.5	1.6	1.7	1.7	1.8	1.9	0.4
Power	3.1	3.8	4.1	4.4	4.6	4.9	5.2	5.6	5.9	1.6
ResComm	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.1
Transport	-	-	-	-	-	-	-	-	-	-

Source: EIA, Citi Research

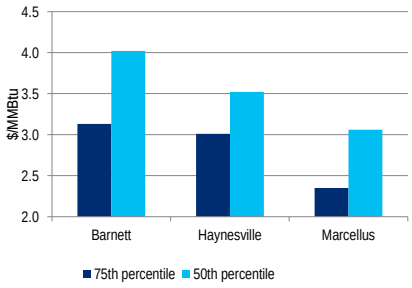
This report breaks down the analysis that leads to our long-term price into six segments: (1) new era of gas pricing; (2) Golden Age of Gas: a little too golden on production; (3) gas imports as swing supplies; (4) low cost base to make exports robust poised for further growth; (5) limited domestic demand growth possible due to structural headwinds; and (6) sectoral impacts: winners and losers in a low gas price environment.

(1) A new era of gas pricing

US natural gas prices (Henry Hub) look likely to be entering a prolonged period with a soft price ceiling and floor could be set between ~$3/MMBtu and a low-$4/MMBtu range.

We determine this range by analyzing (a) breakeven prices at key shale plays for both the 50th and 75th percentile levels of initial production, and (b) price ranges that would motivate producers to switch from liquids back to gas.

Figure 3. Breakeven gas prices at key shale plays by the 30-day initial production rate percentiles



Source: EIA, state data, Citi Research

At the 50th percentile of initial production rates (i.e. the median) for gas, the breakeven price could be around $3.50 at the Haynesville and around $3 back in the southwest Pennsylvania and Ohio part of the Marcellus and Utica. This assumes a 10% reduction in well costs and a likely gas pipeline transport cost of ~$0.4 to $0.6/MMBtu from the Northeast down to the Gulf Coast. This transport rate is applicable for producers who have signed up capacity on pipeline expansions early. **This assessment underpins our long-term price.** Continued productivity gains could lower this further, offsetting a potential rebound in cost.

A soft floor should be set by production costs from marginal resources, which could be the Haynesville and US Northeast, including the Marcellus and Utica. At the 75th percentile of initial production rates, a situation that could happen when demand growth disappoints and requires smaller production growth, the breakeven price would be around $3 at the Haynesville and around $2.4 at the Marcellus.

Further cost cuts in drilling, completion and production should lower total cost; excess takeaway pipeline capacity out of the Northeast should compress the traded basis differentials between the Northeast and Henry Hub, as the supply of pipe capacity would likely exceed demand, so that the price for pipe capacity should fall. However, the future pricing of natural gas also depends on the pace of natural production declines at other locations, the financial health of producers being able maintain production, and the pace of industry consolidation.

A soft ceiling would be set by the gas price needed for producers to switch from oil and liquids drilling back to gas at marginal plays. A producer would switch if the returns on gas drilling were larger than oil/liquids drilling. If long-term oil prices were to settle at around $90/bbl, as discussed in the first installment of "The New American (Gas) Century" report (Jan'14), then the switching price for gas would be in the mid-$5/MMBtu range. In other words, if natural gas prices were to rise above $5, then it would make sense for producers to drill for gas rather than liquids. In comparison, if long-term oil prices were to settle at around $70/bbl, then the switching price for gas should fall to the low-$4/MMBtu range. A stronger oil price recovery would push the gas price ceiling higher.

To illustrate, suppose a producer were to switch from oil/liquids to gas drilling. Assuming that the producer is leaving behind a median type oil/liquids well (50th percentile) for a median type gas well (also 50th percentile), then the switching gas price would be largely in the low-$4 range for the Haynesville at $70/bbl oil. This

level would be higher in the mid-$5 range if oil were at $90/bbl; this was the oil price used in the last version of the "New American (Gas) Century" report (Jan'14).

Figure 4. Gas "switching price" at $90/bbl oil (from a 50th percentile oil/liquids well to a 50th percentile gas well)

	Haynesville	Barnett	Marcellus
Niobrara	5.1	6.0	4.2
Permian	5.6	6.6	4.6
Eagle Ford	8.5	10.4	6.7
Bakken	6.0	7.0	5.0

Source: Citi Research

Figure 5. Gas "switching price" at $70/bbl oil (from a 50th percentile oil/liquids well to a 50th percentile gas well)

	Haynesville	Barnett	Marcellus
Niobrara	4.1	4.8	3.4
Permian	4.5	5.3	3.7
Eagle Ford	6.7	8.1	5.3
Bakken	4.6	5.3	3.9

Source: Citi Research

Figure 6. Gas "switching price" at $50/bbl oil (from a 50th percentile oil/liquids well to a 50th percentile gas well)

	Haynesville	Barnett	Marcellus
Niobrara	3.2	3.7	2.7
Permian	3.4	3.9	2.9
Eagle Ford	4.9	5.9	4.0
Bakken	3.2	3.6	2.7

Source: Citi Research

But suppose a producer were to leave a median quality oil/liquids well (50th percentile) and head for a better (~75th percentile) gas well, then the switching gas price would only be in the mid-$3/MMBtu range at $70/bbl oil. This could happen if gas consumption and export growth were disappointing, so that not much new gas production would be needed.

Figure 7. Gas "switching price" at $90/bbl oil (from a 50th percentile oil/liquids well to a 75th percentile gas well)

	Haynesville	Barnett	Marcellus
Niobrara	4.1	4.3	2.9
Permian	4.5	4.7	3.2
Eagle Ford	6.6	6.9	4.4
Bakken	4.9	5.1	3.5

Source: Citi Research

Figure 8. Gas "switching price" at $70/bbl oil (from a 50th percentile oil/liquids well to a 75th percentile gas well)

	Haynesville	Barnett	Marcellus
Niobrara	3.4	3.5	2.5
Permian	3.7	3.8	2.7
Eagle Ford	5.2	5.5	3.6
Bakken	3.8	3.9	2.8

Source: Citi Research

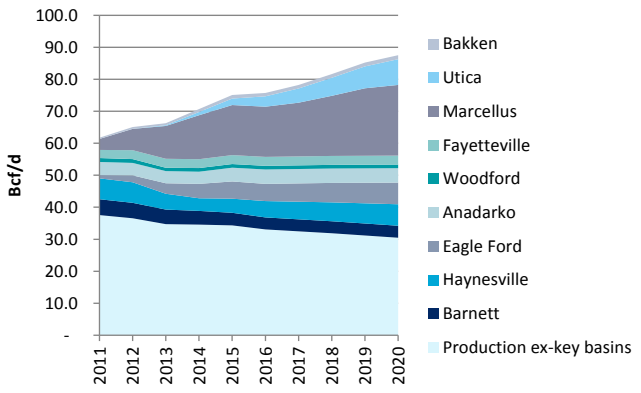
Figure 9. Gas "switching price" at $50/bbl oil (from a 50th percentile oil/liquids well to a 75th percentile gas well)

	Haynesville	Barnett	Marcellus
Niobrara	2.7	2.8	2.1
Permian	2.9	3.0	2.2
Eagle Ford	3.9	4.1	2.8
Bakken	2.7	2.8	2.1

Source: Citi Research

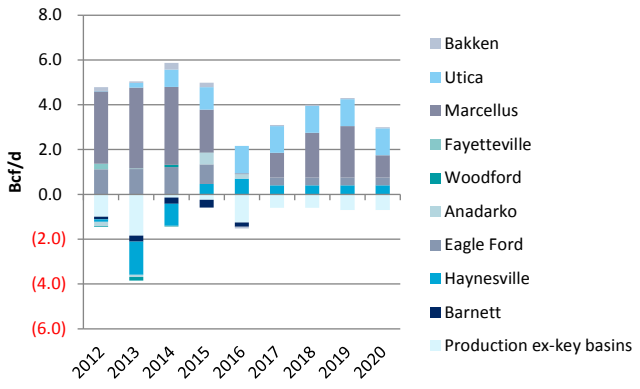
In all, based on the North American supply-demand balance derived above, the amount of production growth from US gas fields may only average around 3-Bcf/d between 2017 and 2020 due to only moderate demand growth later this decade. This eases the need for more expensive gas supply options and could keep gas prices around the middle of the $3 to $4 range.

Figure 10. Future US gas production growth driven by a few key shale plays...



Source: EIA, state data, Woodmac, Citi Research

Figure 11. ... with growth possibly averaging only ~3-Bcf/d between 2017 and 2020



Source: EIA, state data, Woodmac, Citi Research

The microeconomics of shale are critical to understanding the sector

To analyze the shale industry and its impact on the overall oil and gas sector, understanding the microeconomics becomes critical.

(a) Perfect competition: Simply put, it is prudent for almost all producers to maximize their production to maximize revenue, as they are too small for their individual actions to affect prices. They would do so as long as the selling price is above marginal production costs, subject to financing constraints. If there is ever a time when the sector has resembled a perfectly competitive market, it is now. But when almost everyone keeps production strong, the result would be too much production, driving prices lower.

(b) War of attrition: In general, by keeping their own production growth robust, each firm seeks to differentiate itself from the competition by demonstrating that it can operate in a low price environment. In fact, despite sharp cuts in capex, some producers are still insisting on growing production at this point. Some have even raised capex. By being able to outlast others, the promise is that better times are ahead for those who can stay beyond the "shake-out" period, where weak producers exit the market. Unless there are much deeper cuts to capex and actual declines in production, the market should remain oversupplied.

(c) Disruptive change from technological breakthroughs: As much as other sectors tout their technological advances, breakthroughs in the shale sector are having arguably bigger impacts by crushing gas and oil prices. The oil and gas sectors are large, mature industries, so that analysis of the sector based on historical trends and behavior leads to misjudgment about the impacts of shale on individual firm behavior. Hence, the macro view on the sector that gradual demand growth would absorb excess production was wrong because shale growth turned out to be more prolific and disruptive than anyone expected.

When might a recovery come? It is only after this period of "war of attrition" that the wrongly anticipated producer discipline could come back and the market could reach balance between supply and demand. This discipline might be partially achieved through consolidation because, in a nearly perfectly competitive market where there are lots of smaller producers, producers will repeat (1) and (2) until enough of them exit. With proved reserves and demonstrated productivity at various key shale plays, larger companies with strong balance sheets should come in to buy weaker ones later on. Those firms with high debt loads, limited hedging and constrained gas pipeline takeaway capacity should be candidates for acquisition.

Should such consolidation happen, gas prices could recover but subject to where oil prices would be because of the relative economics of drilling for oil/liquids vs. gas. Oil prices could place a soft cap on how high gas prices could rise. Citi has conducted a series of studies reviewing the impacts of the oil price fall on gas:

"Producer Odyssey: Could US oil and gas production be falling soon" (Mar'15)
"US Gas/Oil: With the sharp fall in oil prices, could producers switch from oil/liquids drilling back to gas" (Dec'14)
"US Gas/LNG: Collateral Impact of Oil's Fall" (Oct'14)

However, the entry barrier to oil and gas drilling in the US is low enough that only partial consolidation might take place. There is an abundance of land, geological knowledge and engineering expertise ready to be hired, as well as an abundance of capital to be marshalled such that generations of wildcatters and now more informed entrepreneurs are poised to enter the sector. As a result, prices should remain low for years as new entrants, with their ingenuity, continuing to improve productivity, driving costs lower and discovering new ways to exploit an extensive resource base.

This is similar to the computer hardware sector, where, through gains in productivity and computing power, the personal computer sector became commoditized.

(2) The Golden Age of Gas: a little too golden when it comes to production

In essence, two critical factors should determine the future price range of gas: (1) there is plenty of low-cost gas available and (2) the growth of domestic consumption and exports may only average around a modest 3-Bcf/d per year between 2016 and 2020. The production growth in recent years has been so strong that production has risen by nearly 50% since 2006. This is a

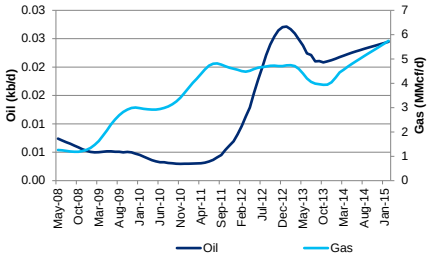
staggering number. Current US production is nearly equivalent to total production from the Middle East and Africa combined. Robust production growth should continue at this pace, helped by technological advances, better experience and the large size of reserves. Hence, without a strong need for more expensive gas production, prices should stay within the $3 to low-$4 range. How did we get here and where will the market be heading? Productivity gains, the "80/20" rule of production, strong contributions outside of the US Northeast, and the vast size of reserves are key.

Productivity gains: Demonstrating production growth and well-productivity have been the name of the game for many producers. At a time of tremendous productivity gains due to technological advances and learning-by-doing, shale gas and oil production have surged.

Based on the latest EIA data, productivity gains per year, as defined by the y/y percentage change in first month production per rig, are still in the low-20%pa for gas and high-20%pa for oil. Take Utica for example: its gas production per rig is generally still half of that of the Marcellus; recent well data on the Utica showing substantial gains in initial production should result in strong production in the months ahead.

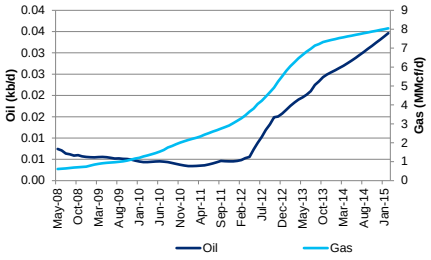
Services costs should stay well below peaks seen in recent years: service sector margins, high when the market was tight, should fall sharply as rig counts, as proxies for drilling activities, are cut by nearly 50% vs. the Oct'14 peak, while the high costs of labor, equipment and materials should decline as the demand for services drops.

Figure 12. Initial production per rig at the Haynesville: growth resuming on the gas side



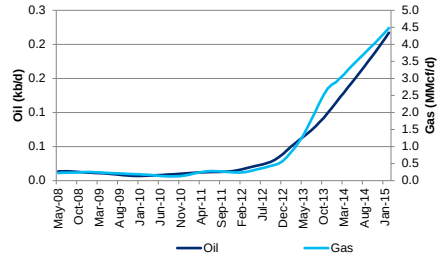
Source: EIA, Citi Research

Figure 13. Initial production per rig at the Marcellus: continued climb despite low prices



Source: EIA, Citi Research

Figure 14. Initial production per rig at the Utica: surge to continue

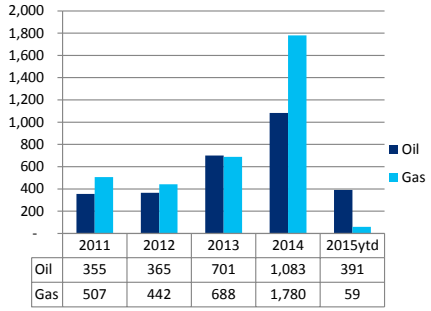


Source: EIA, Citi Research

The "80/20" rule of production: This simple rule crystalizes the impact of key shale plays on production growth. Since 2009, total dry US natural gas production has risen by nearly 20-Bcf/d, with around 16-Bcf/d coming from the US Northeast, including the Marcellus and Utica. Deep Utica, beneath the Marcellus, holds promise as the next big field. Production from other shale plays, such as Haynesville and Barnett, as well as associated gas production, offset declines from conventional and offshore fields. The continued production surge should be led by the Northeast, home of the Marcellus and Utica shales, and wet gas plays elsewhere, such as the Permian and Eagle Ford.

In the interim, the inventory of drilled-but-not-producing wells could also provide sufficient gas supply even at a low level of rig counts currently.

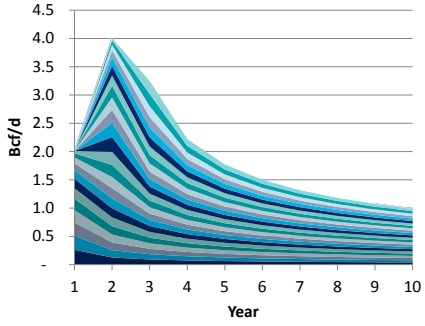
Figure 15. Number of inactive or "drilled-but-not-producing" oil and gas wells by year



	2011	2012	2013	2014	2015ytd
Oil	355	365	701	1,083	391
Gas	507	442	688	1,780	59

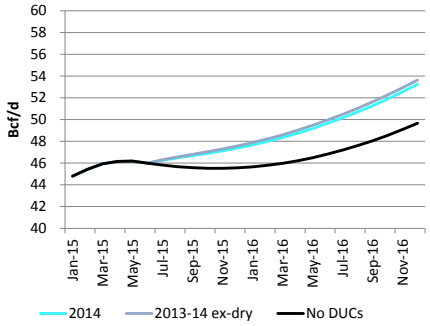
Source: EIA, state data, Citi Research

Figure 16. Annual gas production from well backlogs from wells drilled in 2013-2014, excluding possible "dry" holes



Source: EIA, state data, Citi Research

Figure 17. US gas production outlook with different levels of well backlogs in a rig count rebound scenario: production will still grow



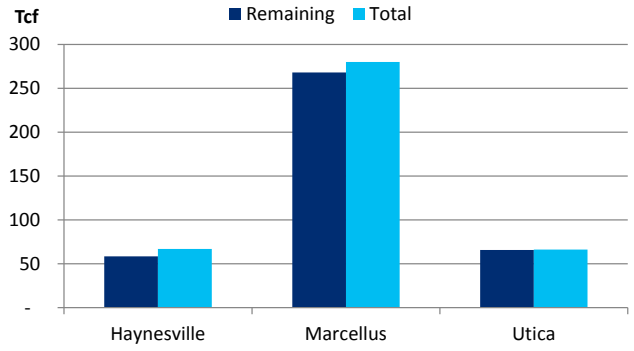
Source: EIA, state data, Citi Research

Strong contribution outside of the Northeast: Louisiana production, inclusive of Haynesville, should rise again, benefiting from enhanced completion techniques. Some producers are applying techniques and experience learned from tight oil completion, making some Haynesville wells economically competitive vs. good tight oil wells in the Bakken and Eagle Ford. This cross-pollination from shale gas to shale oil and vice versa is boosting the productivity of both sets of wells: geosteering is being used more widely; laterals are lengthened; volume of fracturing fluid and proppants used have increased; pad-drilling has become prevalent; fracturing stages in some cases have doubled from the last drilling boom in Haynesville pre-2012. Over a hundred wells drilled in the last couple of years in the Haynesville could have EURs (estimated ultimate recovery) of over 10-Bcf. Further improvements could make these Haynesville wells economic at $2.50/MMBtu. Haynesville has the advantage of being much closer to Henry Hub than the Northeast. A renaissance at the Haynesville could well be on the horizon.

Associated gas production should still grow as long as oil production growth, driven by the continued rise of tight/shale oil production, remains robust in the 0.5-mb/d to 1-mb/d range.

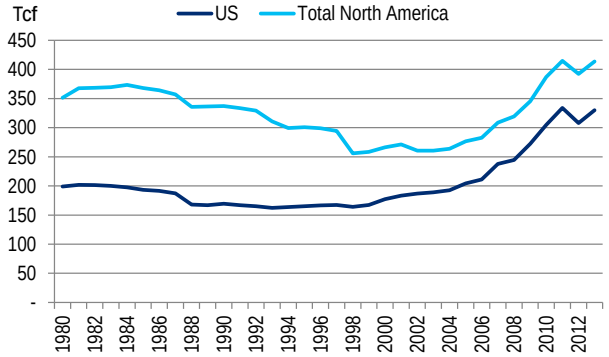
Vast reserve base: The available reserves at the major US gas plays are huge. In total, 2P reserves (proved and probable) of gas at Haynesville, Marcellus and Utica total 413-Tcf, of which 392-Tcf are still remaining. Not only that, but proved reserves have been on the rise since the beginning of the decade. With these resources available, there should be little pressure on gas prices from supply constraints for many years to come.

Figure 18. Most proved and probable reserves at Haynesville, Marcellus and Utica are yet to be drilled...



Source: Woodmac, Citi Research

Figure 19. ... and proved reserves in the US have been on the rise



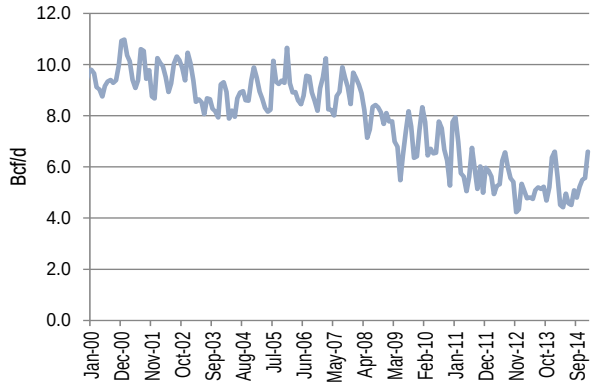
Source: BP, Citi Research

(3) Gas imports as swing supplies should cap prices

Gas imports from Canada, though expected to be limited, should serve as the new swing supply, while LNG imports may not disappear entirely.

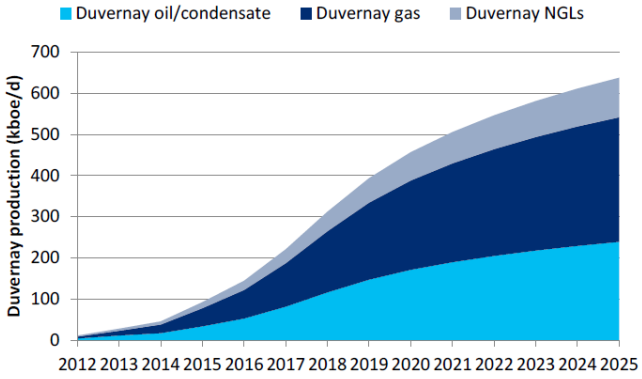
Canadian gas exports to the US look to stay low long-term out to 2020, as US gas production in the Northeast continues to grow, backing out Canadian gas targeted for the US Midwest and New England, while the structural demand decline in California reduces the need for Canadian gas, as stranded Rockies gas should also serve the US West Coast markets. A rebound in oil prices, thereby boosting Bakken production again after a steep fall in rig counts, should raise associated gas production as well. US gas exports to Mexico and rising industrial US demand could help raise gas demand, but that should draw on US gas first.

Figure 20. US net imports of Canadian gas have fallen, though surges happen in times of need



Source: EIA, Citi Research

Figure 21. Duvernay gas and liquids production could climb, providing ample resource if additional supply is demanded



Source: Wood Mackenzie, Citi Research

Canadian gas should also serve as the swing supply when US gas demand is very strong and if associated gas production from US oil production were to disappoint. Canadian gas could readily supply the US, as a well-established pipeline infrastructure across multiple points along the US-Canadian border enables

relatively smooth gas flow from Canada to the US. Very strong north-to-south flows during peak winter periods have consistently stressed-tested this capability. Some may say that the resource base in Canada is not as large as the US, but even a modest 1 to 2-Bcf/d increase in gas exports to the US (simply a return to export levels several years ago) could be sufficient to moderate prices.

For details on the long run outlook for Canadian gas and how flow patterns could change, please refer to the report "US/Canadian Gas: Too Much of a Good Thing?" (Mar'15).

LNG imports to New England should still continue at 0.1-Bcf/d or less – an insignificant amount for the country as a whole – as pipeline constraints in the region are unable to accommodate the increase in pipeline gas delivery needed when demand surges.

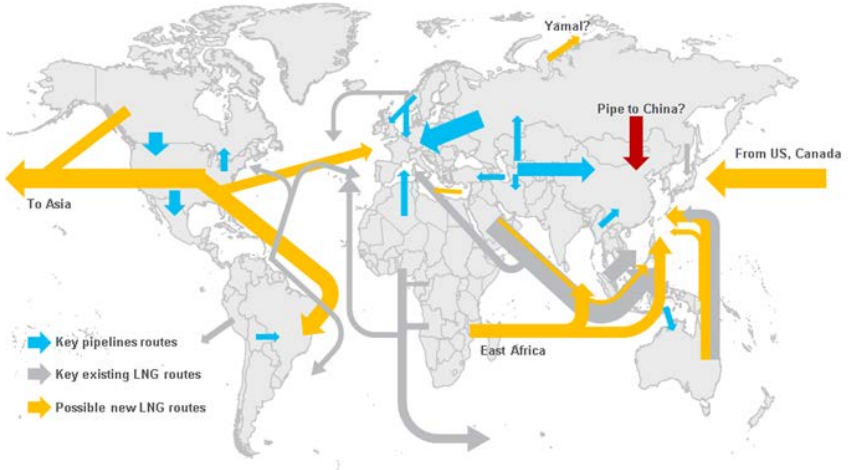
(4) Cheap gas for world: Low cost base to support strong export growth

US LNG exports and gas exports to Mexico should remain robust due to North America's low cost advantage. However, note that the growth of exports is dwarfed by the size of production growth (or the potential to ramp up production at a low cost) to that exports growth should have limited impact on US prices.

(4.1) LNG

A low cost base looks likely to be US gas' enduring competitive advantage in the future growth and influence of gas exports. High capital and per-unit costs of developing many greenfield LNG projects, along with the long lead-time, should make brownfield development in the US more attractive when new LNG supplies are needed. In contrast, US gas fields are mostly developed in an environment of well-established infrastructure, so that the incremental cost of building new liquefaction terminals at brownfield sites could stay less than 5 billion dollars, compared with more than 10 to 15 billion dollars elsewhere, almost all of them greenfield sites, and the political environment is relatively facilitative of exports.

Figure 22. Map of future global gas flow



Source: Wood Mackenzie, Citi Research

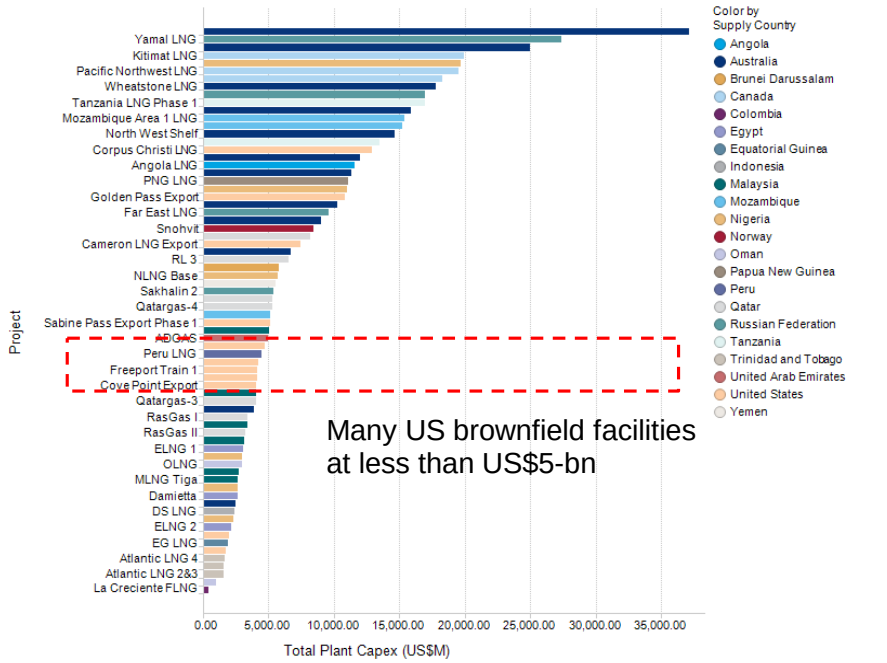
Over the next half-decade when new US LNG terminals come online, the delivered US LNG cost could even fall to around $4.5 to $5 for Europe and $6 to $7 for East Asia, if the capital cost of LNG terminals are considered sunk. Lower oil and gas prices have been driving shipping costs lower, reinforced by a likely oversupply of LNG tankers:

- **The US-Asia arb:** With US Henry Hub gas at below $4/MMBtu out to 2020 and nearby prices in the $3/MMBtu range, new LNG liquefaction projects that have not started construction are unlikely to go ahead, as the transportation cost, factoring in the "fixed" capacity charge of ~$3/MMBtu for the terminal as well as shipping/liquefaction fuel cost in the ~$3/MMBtu range, would put delivered LNG costs from the US to Asia in the $9 to $10/MMBtu range. Taking away the ~$3 fixed capacity charge would put US LNG competitive in Asia, but only if Asian LNG prices stay in the high $6 range while US Henry Hub prices remain below the mid-$3 level.

- **The US-Europe arb:** Similar to the US-Asia arb, making US LNG competitive in Europe requires considering the capacity charge as sunk. This also means that US LNG terminals not already under construction would likely not go ahead. But with low freight cost in the $0.70/MMBtu range for now, the delivered cost into Europe, ex-capacity charge, could be in the $4 to $5/MMBtu at current US Henry Hub prices. This still makes US LNG competitive for terminals under construction.

- **The Europe-Asia arb:** To round-out the global trade flow analysis, the 2014-15 winter points to the potential that a colder winter in Europe and an oversupplied Asia could once again put European prices above Asian prices. With freight costs between Western Europe and East Asia between $1.5 to $2/MMBtu, the re-export arb from Europe to Asia is now out of the money by ~$2.5 to $3/MMBtu. This upends the notion that Asia would always be the premium market.

Figure 23. Capex of new LNG liquefaction facilities globally



Source: Wood Mackenzie, Citi Research

A major question going forward is whether capacity charges of US liquefaction terminals could be renegotiated. We believe the possibility of such renegotiations down the road could affect the profitability of existing liquefaction terminals in the future. Long-term, new terminals, especially additions to existing liquefaction facilities, could see lower capacity charges, making US exports more competitive.

For an analysis on the future of global LNG supply, please see the report "LNG Landscape: Buyers' market, risk of project delays and lower prices" (Mar'15) by Citi's Australian oil and gas analyst Dale Koenders et. al. For details on the impact of lower oil prices on US LNG exports, please refer to the report "US Gas/LNG: Collateral Impact of Oil's Fall" (Oct'14).

(4.2) Mexico

US natural gas exports to Mexico should continue to rise significantly given rapid pipeline capacity build-out from the US into the central region of Mexico and along the Pacific Coast, as well as growing demand for natural gas in Mexico both for the power and industrial sectors. While it seems obvious that cheap, abundant US natural gas would flow increasingly to satisfy growing Mexican natural gas demand driven by robust industrial and power generation needs, the ramp-up in US flows to Mexico could be faster than expected. This is in the context of the opening up of Mexico's energy sector – which is introducing competition to state-owned Pemex and CFE – and an explicit strategy by the country's energy watchdog agencies to grow imports of low-priced US natural gas. While the energy reforms also open up Mexico's upstream sector, which could bolster oil and gas production from onshore/offshore, conventional/shale resources, the near term is likely to see increased consumption of low-cost energy from the US as pipeline infrastructure improves (see "Mexico Energy Reforms").

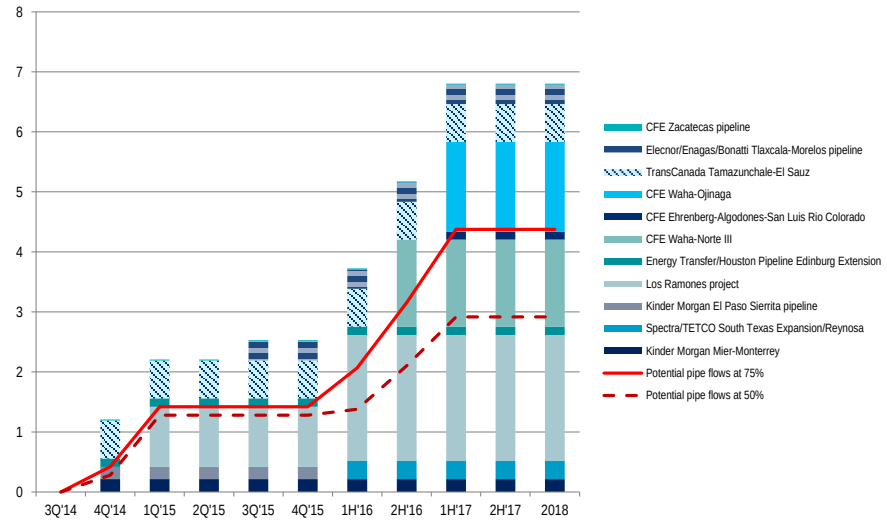
Three major factors should drive Mexico's demand for US gas higher: (a) the switch from fuel oil to natural gas in power generation; (b) robust electricity demand growth to be met by natural gas; and (c) a reduction and potential eventual elimination of higher-cost LNG imports.

The first wave of gas demand increase comes from the reduction of the share of fuel oil in power generation. By reducing fuel oil's share from 20% to 5%, gas demand could rise by 0.8-Bcf/d, as coal consumption in Mexico is minimal and nuclear is limited.

The second wave of gas demand increase should come from new power plant builds and the growth of electricity consumption. Historically, electricity demand growth was highly correlated with economic growth. Gas-fired power plants would be ones that satisfy growing power demand. Electricity demand growth could accelerate further as electricity prices fall due to the availability of low cost natural gas driving down the marginal cost of generation in Mexico.

Meanwhile, improved pipeline infrastructure and the energy reform should allow for the delivery of low cost US-sourced natural gas to reach areas that have been importing higher cost, oil-price-indexed LNG. Backing out ~1-Bcf/d of LNG imports should lead to an equivalent increase in US gas exports to Mexico.

Figure 24. Potential incremental gas pipeline flows from US into Mexico (Bcf/d) capacity



Source: Bentek, SENER, company reports, Citi Research

To facilitate the consumption of US gas inside Mexico, there is substantial gas pipeline infrastructure that already exists, and much more being built. But this is constrained by Mexico's domestic pipeline system. At mid-2014, there was perhaps as much as 5.5-Bcf/d of cross-border pipeline capacity sending gas from the US to Mexico (and not from Mexico to the US), but under 2.3-Bcf/d of US-to-Mexico flows. Going forward, we expect the domestic infrastructure build-out to be fast. Major pipeline projects target four broad zones into Mexico: (1) the Northwest region of Mexico, to reach west coast power plants; (2) the Northeast region of Mexico and onwards to the Central region of Mexico; (3) the Central region of Mexico, (4) and the Southeast region of Mexico.

For details on US gas exports to Mexico, please refer to the report "Mexico set to pipe in more US natural gas" (Aug'14).

(5) Structural headwinds limit domestic demand growth

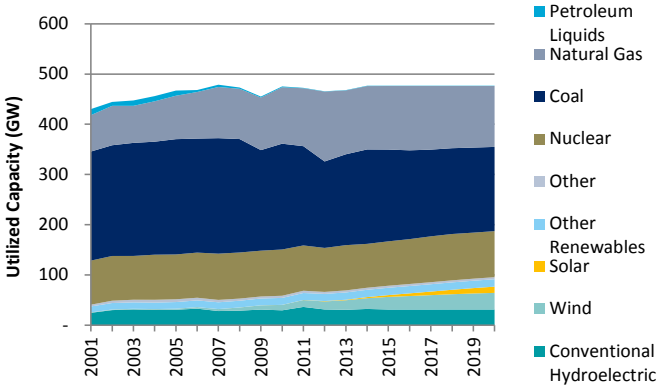
A low cost base is what most industries hope for to profit in their markets; low-cost US gas could sustain its competitive advantage for many domestic industries. For industrial gas consumers, North American gas still holds substantial cost advantages over European gas or Asian LNG: global gas prices have fallen to the $7/MMBtu range recently but with a bias toward higher prices as oil prices recover, a factor in some gas pricing formulas outside of North America. However, North American prices in the $3 to $4 range would still be half or lower as opposed to other gas prices around the world. **However, gas demand for power generation, another key source of potential gas demand growth, should be limited by weak power demand growth and the rise of renewables.**

(5.1) Power generation

The growth in gas demand for power generation looks likely to be less significant than is commonly believed. Gas is commonly thought of as the substitute fuel for coal in power generation once coal plants retire. At first glance, emission rules, by inducing coal-fired generation retirements, and low natural gas

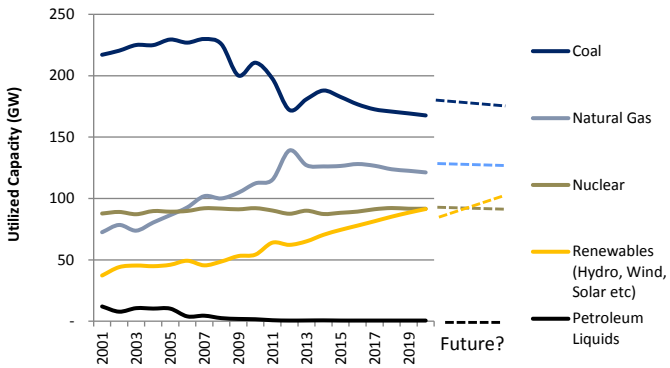
prices, should drive out coal and boost gas demand. But flat to negative growth in electricity demand, rising renewables generation and the longevity of nuclear generation could offset the loss of coal-fired generation.

Figure 25. Generation demand to grow slowly or remain flat



Source: EIA, Citi Research

Figure 26. Rapid rise of renewables limit the potential for much stronger gains in gas demand

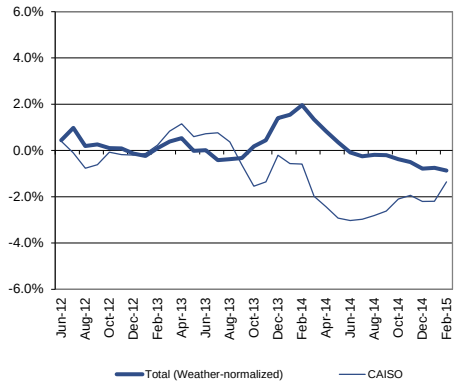


Source: EIA, Citi Research

(I) **Electricity demand growth**: Gas demand should initially benefit more from electricity demand growth than other fuels, as gas-fired power plants populate both the baseload and peaking parts of the electricity generation stack. However, power demand growth now looks likely to be much slower than expected and could even be negative in some regions due to demand-side management programs, efficiency gains, behavioral changes and the rise of distributed generation.

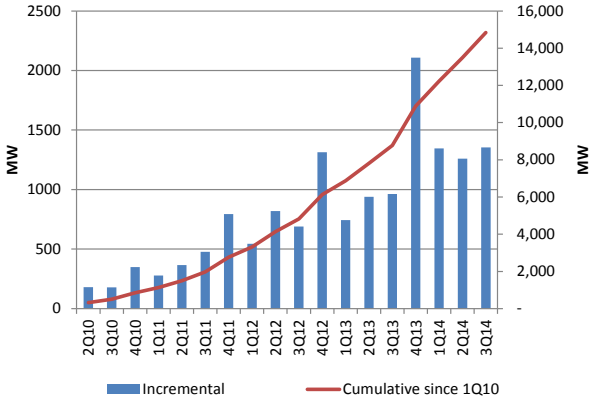
(II) **The rise of renewables and distributed generation**: New sources should bring about a sea-change in the power generation mix, especially with falling costs. *For probably the first time ever*, gas may no longer be the obvious choice as a replacement fuel, as illustrated by the possible decline in gas demand for power generation despite a drought on the U.S. West Coast. The combination of lackluster electricity demand and the rise of wind and solar generation on the West Coast could be enough to offset the sharp reduction in hydroelectric generation. See the report "US Gas/Renewables: a not-so-happy couple this spring" (Feb'15) for details. Nonetheless, a stable grid operation (i.e., grid reliability) becomes critically important as variable generation increasingly constitutes a larger share of the generation mix and substitutes retiring baseload power plants.

Figure 27. Weather-adjusted electricity demand growth has been flat to negative in recent years



Source: ISOs, Citi Research

Figure 28. Although the effective solar PV generation capacity is only ~15 to 20% of nameplate shown below, the growth has been impressive and should continue to surge



Source: SEIA, Citi Research

(III) **Nuclear generation remaining resilient:** Additional nuclear plants could retire due to the high cost of operation and maintenance, with four already taken offline in the last two years. Nuclear retirements could be a greater long-term driver of gas demand growth because of their high capacity utilization rates. Nonetheless, new plants and uprates (i.e., incremental expansions of existing capacity), made even more economic by higher expected gas prices towards the end of the decade and beyond, could more than offset the impact of retirements, reducing the need for gas plants to act as baseload generation. In addition, there are state-level legislative actions that mandate the use of clean generation sources, keeping nuclear units on.

For details on the slowdown in gas demand growth for power generation, please refer to the report "A Short Gas Bridge to Renewables" (May'14).

(5.2) Other areas of gas demand

With lower gas prices, the increased use of gas as a feedstock and energy source, partly through fuel substitutions from both oil and coal to gas, could add conservatively speaking 6-Bcf/d between 2013 and 2020. This could include retrofits or conversions adding to baseload demand. Four sectors are key:

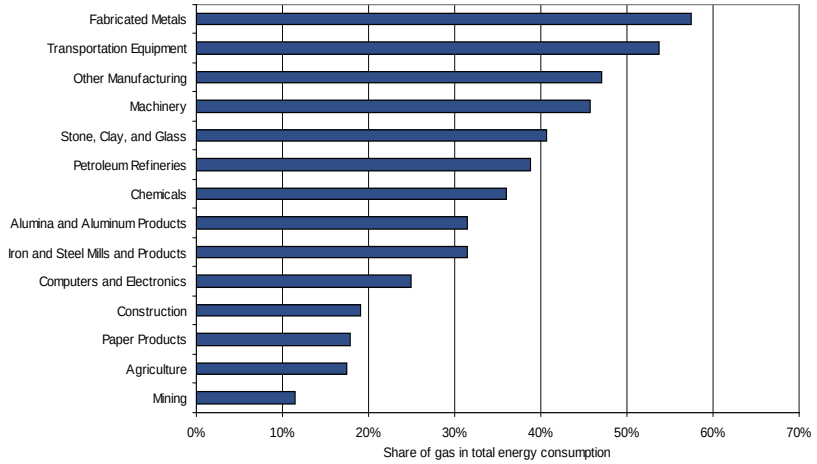
(a) Although the petrochemical sector mainly uses natural gas liquids as a feedstock, natural gas is also used for co-generation and as a heat source for making steam. Low crude oil prices and the surge in light oil/condensate production should lower the input costs for international petrochemical facilities, while those ethane-based petrochemical facilities already under construction in the US should still go ahead.

(b) Low gas prices are driving a resurgence in the manufacturing of nitrogen fertilizer.

(c) Refineries are major users of natural gas, nearly 4-Bcf/d, or a fifth of total industrial gas demand, according to the EIA. Using low cost natural gas as a fuel for energy can translate into substantial savings. The cost advantage enjoyed by US refiners should help to expand this sector, thereby raising gas demand.

(d) Gas-for-oil substitution in transportation, particularly trucking, should slow due to the sharp decline in crude oil and diesel prices. However, locations with access to cheap natural gas, combined with the lower-cost CNG conversion process vs. LNG, could still encourage some operators to switch from diesel to gas, albeit at a lower pace than we had expected earlier. This is particularly true for those with policies or mandates to reduce emissions or diversify fuel sources.

Figure 29. Natural gas as a share of total energy consumption by sector



Source: EIA, Citi Research

Summary

All in all, much of the demand growth between now and 2020 could be driven by exports. Domestic demand growth may only reach 2.5-Bcf/d between 2015 and 2020, as a supposed robust growth of industrial demand could be offset by the probable flatten or even decline of gas-fired generation in the power sector.

(6) Sectoral impacts: winners and losers in a low gas price environment

Producers and services companies should see the most positive impacts, as both prices and volume should be falling.

The midstream space, with the possibility of smaller and isolated production growth, could see slower-than-expected volume growth.

Downstream users are major beneficiaries, including industrials, petchem, metals processing and even utilities. Why utilities? Electricity prices are set by the marginal source and fuel of generation. Relatively stable but higher coal prices compared with gas could pin power prices at higher levels. Gas-fired power plants, with lower fuel costs, could benefit from having higher coal prices setting prices.

However, if very low gas prices were to persist and keep power prices low, renewables might turn out to be less competitive than previously thought, thereby reducing its adoption rates and sales.

Appendix A-1

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