The Shifting Sands of Natural Gas Abundance

June 22, 2016

American Gas Association
Natural Gas Records in 2015

- **Domestic Annual Production** – 27.1 Tcf
- **Proved Reserves** – 368 Tcf (dry)
- **Undiscovered Gas Resources** – more than 2,500 Tcf
- **Domestic Natural Gas Consumption** – 27.4 Tcf
- **Natural Gas Consumed for Power Gen** – 9.4 Tcf
- **Working Gas in Underground Storage** – 4,009 Bcf

Sources: Bentek Energy, Energy Information Administration, Potential Gas Committee
Natural Gas Energy Policy Future

• Social License to Consume “Fossil” Natural Gas
• “Winning” the Energy Sweepstakes with Customer Savings, Reliability and Affordability
• Success of Energy Efficiency Investments
• Federal (and State) Climate Change Policy
• Selecting a Glide Path to Lower Carbon
• Developing and Renewing Pipeline Infrastructure
• Customizing the Energy Experience for End-Users
• Geopolitics and World Oil Prices
• Pricing Carbon in the US Economy
MARKET BALANCE OR IMBALANCE?
Natural Gas Delivered to Consumers

EIA Natural Gas Delivered to Consumers in the U.S. (MMcf)
Natural Gas Sector Consumption 2015
PowerGen/Industrial/Res-Com

Bcf per day

Jan 13 25 6 18 2 25
Mar 14 26 7 19 3
May 13 25 6 18 2
Jun 12 24 5 17 2
Jul 11 23 4 16 2
Aug 10 22 3 15 2
Sep 9 21 2 14 1
Oct 8 20 1 13 0
Nov 7 19 0 12 6
Dec 6 18 0 11 2
Jan 5 17 0 10 7
Feb 4 16 0 9 12
Mar 3 15 0 8 17
Apr 2 14 0 7 22
May 1 13 0 6 27
June 0 12 0 5 32
July 0 11 0 4 37
August 0 10 0 3 42
September 0 9 0 2 47
October 0 8 0 1 52
November 0 7 0 0 57
December 0 6 0 0 62

- Pwr Gen
- Industrial
- Res/Com
Despite falling rig counts, natural gas production continues to grow.

US dry gas production record: February 19, 2016 – 73.8 Bcfd (Bentek)
Relatively Low and Stable Natural Gas Prices

Dollars per Million BTU

Natural Gas Prices
Prompt-Month Futures at Henry Hub

Price Range
2006-2010

2014
2013
2016

Source: Energy Information Administration
NATURAL GAS PRODUCTION
Record annual production in 2015
New daily records already in 2016

Daily Dry Natural Gas Production
US Lower-48

Four-Year Range 2007-2010

Source: Bentek Energy.
Change in upstream capital budget (2015 to 2016)

Average = 26%

Source: Wood Mackenzie, company reports
Domestic Drilling and Completion Costs Have Been Falling

Source: Energy Information Administration
UNDERGROUND STORAGE
New storage classifications

U.S. underground natural gas storage facilities by type (July 2015)

- Working gas capacity: billion cubic feet
  - 100 and above
  - 75 to 100
  - 50 to 75
  - less than 50

- Reservoir type:
  - Aquifer
  - Depleted field
  - Salt dome

Map colors indicate the working gas capacity and reservoir type distribution across the United States.
US Natural Gas Underground Storage

Working gas in underground storage compared with the 5-year maximum and minimum

Source: U.S. Energy Information Administration
NEW NATURAL GAS DEMAND
Natural Gas Delivered to Consumers

EIA Natural Gas Delivered to Consumers in the U.S. (MMcf)
Peak Day Natural Gas Consumption 2007-2016 (Bcf/d)

Source: Bentek Energy
Natural Gas May Exceed Coal as Fuel for Power Generation in 2016
One view shows LNG export growth to 7 Bcfd by 2020
Delays and market issues could slow potential

Source: Bloomberg New Energy Finance
How much US LNG can the global market absorb?
Maybe not much ...

Global LNG Supply and Demand Balance (MMTPA)

Source: Bloomberg New Energy Finance, Poten & Partners
US Gas Exports to Mexico

Mexico’s natural gas pipeline expansions key to accessing U.S. exports

Source: EIA and industry sources
EMISSIONS
The Environmental Protection Agency (EPA) made substantial updates to its estimates of methane emissions in the Inventory of U.S. Greenhouse Gases and Sinks: 1990–2014 that it released in April 2016. The Inventory now incorporates new data available from studies on emissions as well as its Greenhouse Gas Reporting Program (GHGRP).
Key Findings

- Annual methane emissions from natural gas distribution systems declined 74 percent from 1990 to 2014.

- The natural gas emissions rate of production from distribution systems is now less than 0.1 percent.

- Industry wide the natural gas emissions as a rate of production (the “leakage rate”) increased to 1.4 percent—a level still well below even the most stringent thresholds for immediate climate benefits.

- Updates to the distribution stage methodology resulted in a 65 percent downward revision for year-end 2013 methane emissions.

The EPA Inventory reveals once again that the natural gas distribution systems have a small emissions footprint shaped by a declining trend.
Key Findings continued

• Total methane emissions from all natural gas systems have declined 15 percent from 1990 to 2014.

• Despite upward revisions, field production emissions have been flat since 2005 even as production increased 34 percent.

• Transmission and storage methane emissions dropped 45 percent from 1990 to 2014.

• Methane from the processing stage has increased 13 percent from 1990 to 2014.

As companies and the country continue to modernize the natural gas infrastructure base and connect homes and businesses, there will be new opportunities to achieve low-cost carbon emissions reductions by leveraging this existing infrastructure and the nation’s natural gas resource.
Sources of methane emissions 2014

Natural Gas Systems: 11% Methane as a Portion of All Emissions
Enteric Fermentation
Landfills
Petroleum Systems
Coal Mining
Manure Management
Wastewater Treatment
Rice Cultivation
Stationary Combustion
Abandoned Underground Coal Mines
Composting
Mobile Combustion
Field Burning of Agricultural Residues
International Bunker Fuels
Petrochemical Production
Incineration of Waste
Iron and Steel Production & Metallurgical...
Silicon Carbide Production and...

Environmental Protection Agency
Pipeline Replacement Lowers Emissions

Miles of installed main has increased 34% since 1990.

Even with this tremendous growth, estimated methane emissions from pipeline leaks declined 74%.

A consequence of increased removal of unprotected steel & cast iron pipe replaced with plastic & protected steel.

Environmental Protection Agency
US GHG emissions are down 7% since 2005 with natural gas playing a key role in the decline.
INFRASTRUCTURE
Rockies Express Becomes Bi-directional

Source: EIA based on company report
Accelerated Infrastructure Replacement Programs

- The overall trend is positive
- States address this issue differently
- The basis for these decisions is always just and reasonable rates for consumers
Near-Term Cost of Supply
We estimate the current marginal supply cost at Henry Hub is ~$2.69/MMBtu, including producer margin. Our models point to a similar range to that stated by major E&P companies in earnings calls over the past two quarters. They estimate that their current supply cost sits between $2.50-$2.80/MMBtu.

Near-term commodity prices have an inverse relationship with inventory. Natural gas is no exception. A linear regression model using seasonally adjusted inventory levels vs. price will yield an R-square greater than 0.75, indicating that inventory is the largest explanatory variable behind near-term prices.

Keeping track of power burn. Power burn (as opposed to heating demand) will determine market balance between now and end-Oct. Bloomberg’s ALLX GSDM feature will allow subscribers to track regional gas demand.
The statistical approach: we analyze the impact of inventories (adjusted for seasonality) on price and how it changed over time:

\[ y = \alpha + \beta x_1 + \varepsilon \]

where:
- \( y \) = estimated gas price
- \( \alpha \) = y-intercept
- \( x_1 \) = inventory vs. 5 Year average
- \( \varepsilon \) = error

In this context, the y-intercept (\( \alpha \)) represents what prices would be if inventory is the same as the 5 Year average inventory, or when: \( \beta x_1 = 0 \).

We believe the y-intercept is a reasonable proxy for marginal supply costs. Our theory is that the y-intercept represents the point where the market is neither in surplus or deficit.

**BNEF Modeling The Relationship Between Price and EIA Weekly Storage Inventory**

Average gas prices vs. EIA weekly inventory less 5 Year average

$/MMBtu (weekly average Henry Hub spot gas prices)

\[ y = -0.0012x + 2.6907 \]

\( R^2 = 0.7581 \)

$2.69/MMBtu

deviation of weekly natural gas inventory vs. 5 Year average

BNEF Evolution of Marginal Cost of Supply

We examined how the model’s y-intercept evolved over time:

The y-intercept (α) is a proxy for marginal supply costs plus producer margin for the data set’s time period.

By running our inventory vs. price model over various time periods, we see the y-intercept decline over time.

2011-2012: Gas prices vs. month-end inventory less 5 Year average
$/MMBtu (weekly average Henry Hub spot gas prices)

2012-2013: Gas prices vs. month-end inventory less 5 Year average
$/MMBtu (weekly average Henry Hub spot gas prices)

2013-2014: Gas prices vs. month-end inventory less 5 Year average
$/MMBtu (weekly average Henry Hub spot gas prices)

2014-2015: Gas prices vs. month-end inventory less 5 Year average
$/MMBtu (weekly average Henry Hub spot gas prices)

Source: EIA, Bloomberg

*Removing the outlier improves model R-square to 0.79.

* Removing the outlier improves model R-square to 0.90.
BNEF Long-Range Henry Hub Gas Price
(real 2015$/MMBtu)

2016/H1 2017:
Glut eases as ex-Northeast supply drops/demand rises slightly

H2 2017/H1 2019:
Rapidly growing demand forces producers back into Haynesville, MidCon and Canada

2019-23:
Demand continues to grow, but at a calmer pace

2024+:
More Canadian LNG exports, permanent declines in the Haynesville and the Marcellus plateauing push prices to a higher steady-state

Source: Bloomberg New Energy Finance.
Natural Gas Energy Policy Future

• Social License to Consume “Fossil” Natural Gas
• “Winning” of the Energy Sweepstakes with Customer Savings, Reliability and Affordability
• Success of Energy Efficiency Investments
• Federal Climate Change Policy
• Selecting the Glide Path to Lower Carbon
• Developing and Renewing Pipeline Infrastructure
• Customizing the Energy Experience for End-Users
• Geopolitics and World Oil Prices
• Pricing Carbon in the US Economy
What’s next for 2016?
Aliso Canyon - Cementing the Well
Typical Well Construction

Graphic by Al Granberg
Huge shale gas production begins to level

US Shale Gas Production

- Antrim (MI, IN, & OH)
- Bakken (ND)
- Woodford (OK)
- Barnett (TX)
- Fayetteville (AR)
- Eagle Ford (TX)
- Haynesville (LA & TX)
- Marcellus (PA & WV)
- Utica (OH, PA & WV)
- Rest of US 'shale'

LNG Export Facility Progress

Sabine Pass
Train 1 operating with train 2 expected in May 2016. 4.16 Bcf/d

Freeport LNG
1.80 Bcf/d

Dominion Cove Point
Dominion reports 64% completed in early May 2016. 0.82 Bcf/d

Sempra-Cameron LNG Hackberry
Trains 1-3 reported 43 percent complete in early May 2016. 1.70 Bcf/d

Cheniere Corpus Christi
Construction on trains 1 and 2 33% completed as of March 31, 2016. 2.14 Bcf/d

Lake Charles (Not Under Construction)
Energy Transfer Group expects final investment decision by fourth quarter 2016. 2.20 Bcf/d

Jordan Cove (DOE Approved Non-FTA)
FERC denied certificate authority. Appeal by Jordan Cove filed in April 2016. 0.80 Bcf/d
Natural gas distribution emissions dropped 74% since 1990

Methane emissions from natural gas distribution (Million Metric Tons CO2e)

Environmental Protection Agency
Breakdown of distribution emissions

Share of Methane Emissions from the Natural Gas Distribution Stage

- Pipeline leaks: 49%
- Customer Meters: 28%
- Meter/Regulator (City Gates): 9%
- Upsets: 13%
- Routine Maintenance: 1%

Environmental Protection Agency
Methane emissions from natural gas systems have declined 15% from 1990 levels

Environmental Protection Agency