ADDITIONAL MATERIALS

Natural Gas: From Shortages to Abundance in the U.S.

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SUMMARY

- Tortured history of natural gas wellhead price and interstate gas pipeline regulation, deregulation and regulatory reform 1938- 1993: creating and responding to natural gas shortages and then contract surpluses 1970-1990
- Deregulation of wellhead prices, unbundling, and pipeline regulatory reform ultimately created a platform conducive to efficient static and dynamic performance on the supply and demand sides of the natural gas market
- Shale gas resources became economical to exploit due to technological innovations in drilling technologies that could easily be exploited without the burdens of inefficient economic regulation
- The magnitude of shale gas production was a “surprise”. Early 2000’s expectation was that U.S. would become a large importer of natural gas from Canada, Alaska, LNG from Middle East and North Africa.
- Expected North American production of shale gas keeps increasing year after year, gas prices have fallen significantly, but are probably below long run equilibrium levels, and the U.S. is now expected to be a gas exporter by about 2020.
- Natural gas consumers will benefit from lower gas prices, the trajectory of CO2 emissions will be lower, and there are national security benefits from going from an expected gas importer to an expected gas exporter
- Unresolved environmental concerns, along with misleading information and a lack of transparency, have led to public opposition in some areas. These issues can be and must be resolved if shale gas is to reach its full potential

U.S. Natural Gas Wellhead Price

Dollars per Thousand Cubic Feet

Source: U.S. Energy Information Administration

Source: U.S. EIA <http://www.eia.gov/dnav/ng/hist/n9190us3m.htm> 12/26/12

Natural Gas Regulation, Deregulation and Regulatory Reform

- 1938 --- FPC pipeline regulation of bundled gas and pipeline services
- 1954 --- *Phillips Decision*: FPC Regulation of wellhead prices begins
- 1954 – 1979 --- Various approaches to cost of service regulation applied to set maximum wellhead prices.
- Blending and bundling of gas contracts by pipelines key to implementation
- 1970 – 1981 --- Shortages and rationing
- 1978: Natural Gas Policy Act: old gas, new gas, high cost gas ; category by category ceiling prices.
- Pipelines rush to sign long term contracts for “new gas” with high ceiling prices and “blend” diverse contract prices together to create average cost-based sale prices
- 1981: Oil prices peak and then fall 2/3 by 1986. “Take or pay” contract surpluses.

Natural Gas Regulation, Deregulation and Regulatory Reform

- 1981- 85: SMPs for customers with fuel switching capabilities and the start of unbundling. Clear price discrimination leads to rejection by the courts
- 1985: FERC Order 436 voluntary unbundling available to all customers
- 1987: FERC Order 500 and take or pay contract renegotiation
- 1989: Natural Gas Wellhead Decontrol Act
- 1992: FERC Order 636 makes unbundling mandatory
- 1993: Regulation of wellhead prices formally ends
- 1990s: Competitive natural gas markets and light handed regulation of pipeline services mature --- prices low and stable
- 2000: (ex post) “Gas bubble” ends, gas prices rise and become volatile.
- 2001-2006: Large increase in pipeline imports from Alaska, Canada and LNG imports from other countries and higher prices expected to balance U.S. supply and demand in the future
- 2007: Shale gas slowly begins to be recognized as important future supply source
- 2009: Shale gas production starts to have significant effect on domestic gas supplies leading to much lower gas prices
- 2011: LNG exports begin to get serious attention in the U.S. and Canada

Figure 20. Major sources of incremental natural gas supply, 2002-2025 (trillion cubic feet)

Figure 38. U.S. and Canadian Natural Gas Supply

Figure 14. Lower 48 natural gas production by resource type, 1990-2025 (trillion cubic feet)

Figure 17. Major sources of incremental natural gas supply, 2002-2025 (trillion cubic feet)

Figure 21. Projected LNG imports by terminal and region in the reference case, 2025 (billion cubic feet)

Table 12. North American LNG regasification proposals as of December 1, 2003 (million cubic feet per day)

<i>Project</i>	<i>Owners</i>	<i>Location</i>	<i>Start year</i>	<i>Capacity added</i>
West Coast				
Terminal GNL Mar Adentro de B.C.	ChevronTexaco	Baja California, Mexico (offshore)	2007	750
Tijuana Regional Energy Center	Marathon/Golar LNG/Grupo GGS	Baja California, Mexico	2006	750
Sound Energy Solutions	Mitsubishi	Long Beach, California	2007	700
Terminal LNG de Baja California	Shell	Baja California, Mexico	2007	1,000
Energia Costa Azul LNG	Sempra Energy	Baja California, Mexico	2007	1,000
Crystal	Crystal Energy	Oxnard, California (offshore)	2006	600
Tractebel Mexico	Tractebel	Lazaro Cardenas, Mexico	2007	500
Cabrillo Port LNG	BHP Billiton	Oxnard, California (offshore)	2008	1,500
Florida/Bahamas				
Ocean Express LNG	AES	Ocean Cay, Bahamas	2006	850
Freeport	El Paso	Freeport Grand Island, Bahamas	2007	500
Calypso	Tractebel Bahamas LNG	Freeport Grand Cayman, Bahamas	2007	832
Gulf Coast				
ExxonMobil LNG	ExxonMobil	Quintana Island, Texas	2007	1,000
Sabine Pass/Cheniere	Cheniere	Sabine Pass, Texas	2008	2,000
Port Pelican	ChevronTexaco	Louisiana (offshore)	2007	1,600
Cameron LNG	Sempra Energy	Hackberry, Louisiana	2007	1,500
Altamira	Shell	Altamira, Mexico	2004	500
Corpus Christi LNG	Cheniere Energy	Corpus Christi, Texas	2008	2,000
ExxonMobil/Sabine Pass LNG	ExxonMobil	Sabine Pass, Texas	2008	1,000
Liberty	HNG Storage/Conversion Gas	Cameron, Louisiana	2007	3,000
Main Pass Energy Hub	Freeport-McMoRan Sulphur	Gulf of Mexico (offshore)	2006	1,500
Gulf Landing	Shell	West Cameron, Louisiana (offshore)	2008-2009	1,000
Vermilion 179	Conversion Gas Imports	Louisiana	2008	1,000
Mobile Bay LNG	ExxonMobil	Mobile Bay, Alabama	2008	1,000
Freeport LNG	Freeport, Cheniere, Contango	Freeport, Texas	2006	1,500
Energy Bridge	El Paso	Floating Dock (offshore)	2005	500
East Coast				
Canaport	Irving Oil/Chevron Texaco	Canaport, New Brunswick, Canada	2006	500
Weaver's Cove	Poten	Fall River, Massachusetts	2007	400
Access Northeast Energy	Access Northeast Energy	Bearhead, Nova Scotia, Canada	2008	500
Fairwinds LNG	TransCanada, ConocoPhillips	Harpwell, Maine	2009	500
Providence LNG	Keyspan, BG LNG Services	Providence, Rhode Island	2005	500
Crown Landing	BP	Logan Township, New Jersey	2008	1,200
Somerset LNG	Somerset LNG	Somerset, Massachusetts	2007	430

Figure 20. U.S. net imports of LNG and Canadian natural gas, 1990-2025 (trillion cubic feet)

EIA AEO 2004

North American shale plays

Source: U.S. Energy Information Administration based on data from various published studies. Canada and Mexico plays from ARI.

Underground sources of natural gas

Source: modified from U.S. Geological Survey Fact Sheet 0113-01

Diagram of a typical hydraulic fracturing operation

Source: ProPublica, <http://www.propublica.org/special/hydraulic-fracturing-national>

Figure 3. U.S. dry natural gas production by source, 1990-2040 (trillion cubic feet)

EIA AEO 2013 Early Release (December 2012)

**Figure 12. Electricity generation by fuel, 1990-2040
(trillion kilowatthours per year)**

Figure 6. Delivered energy consumption by sector, 1980-2040 (quadrillion Btu)

Figure 4. Total U.S. natural gas production, consumption, and net imports, 1990-2035 (trillion cubic feet)

Source: EIA AEO 2012

The U.S. becomes a net natural gas exporter

Figure 109. U.S. net imports of natural gas by source, 1990-2035 (trillion cubic feet)

Source: EIA AEO 2012

U.S. crude oil production increases, led by lower 48 onshore production

Figure 112. Domestic crude oil production by source, 1990-2035 (million barrels per day)

Source: EIA AEO 2012

Figure 7. U.S. primary energy consumption by fuel, 1980-2040 (quadrillion Btu per year)

**Figure 10. U.S. energy production by fuel, 1980-2040
(quadrillion Btu)**

**Figure 11. U.S. liquid fuels supply, 1970-2040
(million barrels per day)**

Figure 115. Carbon dioxide emissions by sector and fuel, 1990-2025 (million metric tons)

Projected energy-related carbon dioxide emissions remain below their 2005 level

Figure 122. U.S. energy-related carbon dioxide emissions by sector and fuel, 2005 and 2035 (million metric tons)

Source: EIA AEO 2012

Figure 13. U.S. energy-related carbon dioxide emissions in recent *AEO* Reference cases (percent change from 2005)

2013 AEO Early Release (December 2013)

Figure 10: 2010 LNG Trade (Tcf)

From\To	Africa	Canada	China/ India	C&S America	Europe	FSU	Korea/ Japan	Middle East	Oceania	Sakhalin	Southeast Asia	U.S.	Total Exports
Africa		0.03	0.05	0.31	1.33		0.24	0.21			0.07	0.31	2.54
Canada													0.00
China/India													0.00
C&S America		0.00		0.01	0.02		0.00					0.01	0.05
Europe				0.01	0.11		0.05	0.01			0.00		0.18
FSU													0.00
Korea/Japan													0.00
Middle East		0.01	0.44	0.08	1.15		1.28	0.10			0.15	0.08	3.29
Oceania			0.17				0.62				0.04		0.83
Sakhalin			0.02				0.39	0.00			0.02		0.43
Southeast Asia			0.14	0.06			1.92	0.01			0.21		2.34
U.S.							0.03						0.03
Total Imports	0.00	0.04	0.81	0.47	2.61	0.00	4.53	0.34	0.00	0.00	0.49	0.40	9.70

Source: "The LNG Industry 2010," GIIGNL.

Global Production ~ 120 Tcf

NERA Economic Consulting (2012)

Figure 16: Projected Wellhead Prices (2010\$/MMBtu)

	2010	2015	2020	2025	2030	2035
Africa	\$1.75	\$1.89	\$2.09	\$2.31	\$2.55	\$2.81
Canada	\$3.39	\$3.72	\$4.25	\$5.20	\$5.64	\$6.68
China/India	\$12.29	\$12.86	\$13.00	\$13.25	\$13.57	\$13.51
C&S America	\$2.00	\$2.16	\$2.39	\$2.64	\$2.91	\$3.22
Europe	\$9.04	\$9.97	\$10.80	\$11.95	\$12.39	\$13.23
FSU	\$4.25	\$4.60	\$5.08	\$5.61	\$6.19	\$6.84
Korea/Japan	\$14.59	\$15.30	\$15.47	\$15.79	\$16.19	\$16.11
Middle East	\$1.25	\$1.35	\$1.49	\$1.65	\$1.82	\$2.01
Oceania	\$1.75	\$1.89	\$2.09	\$2.31	\$2.55	\$2.81
Sakhalin	\$1.25	\$1.35	\$1.49	\$1.65	\$1.82	\$2.01
Southeast Asia	\$2.00	\$2.16	\$2.39	\$2.64	\$2.91	\$3.22
U.S.	\$3.72	\$3.83	\$4.28	\$5.10	\$5.48	\$6.36

NERA Economic Consulting (2012)

Figure 4.3 ▶ Indicative economics of LNG exports from the United States

* Includes cost of pipeline transport to export terminal. ** Widening of the Panama Canal, due to be completed in 2014, will allow for more LNG tanker traffic.

Notes: LNG costs are levelised assuming asset life of 30 years and a 10% discount rate. The Japanese import price is for liquefied gas, so it does not include regasification.

Figure 7: Comparison of EIA and NERA Maximum Wellhead Price Increases

Environmental Issues

- Does “fracking” lead to contamination of drinking water aquifers with methane?
 - Hydraulic fracturing has been used in the oil and gas industry since at least 1947 and probably earlier
 - Fracking in shale deposits per se is unlikely to lead directly to drinking water contamination because it takes place thousands of feet below water aquifers
 - If there is contamination of drinking water it is much more likely due to failures in the vertical well casing, stray gas releases from conventional pools during vertical drilling, or surface spills of fracking fluids and drilling mud
 - The connection between shale gas production and groundwater contamination is weak and the studies that claim to document a connection are deficient --- little if any “before and after” analysis

Environmental Issues

- There are more important pathways leading to potential environmental impacts that are probably of more concern
 - Vertical well failures
 - Above ground spills of toxic fracking fluids and drilling mud and inadequate long-term disposal methods
 - Air emissions from drilling and support equipment
 - Increased truck traffic delivering equipment and disposing of wastes
 - Fresh water use
 - Earth tremors from below-ground disposal of fluids
 - Methane emissions
- Regulatory frameworks and capabilities vary widely from state to state and between states and federal government
- Best practices for regulatory frameworks have not been developed
- Lack of transparency by the industry has created suspicions that environmental impacts are not being taken into account adequately