Introduction to U.S. LNG Supply Chain and Infrastructure

GREat Seminar
LNG 17

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Presentation Segments

1. U.S. LNG Supply and Supply Chain
2. Current, Planned, and Developing LNG Infrastructure
3. Conclusion

Appendix

A. Source and End Use Major Components
U.S. Gas Supply Summary

- 23.5 TCF/Y Non-linear Use
- 20 TCF is produced domestically (The oil market is almost 2X the NG market; equivalent to approximately 40 TCFY of NG)
- 3 TCF Imported from Canada and declining.
- Approximately 100 LNG Facilities in US; 37 located in Northeast.
- 8 Marine Import Terminal in the US.
- Approximately 100 BCF of LNG Storage in US.
- Approximately 3.5 TCF of Underground Storage in US.
- Approximately 400 gas storage fields in US.
- Gas costs per MMBTU: approximately $3.33 (Henry Hub: February 2013)
EIA Projected Energy Spread
Measured in Price Per MMBtu

Conclusion: the projected spreads will sustain a growing off pipeline LNG/CNG marketplace
Big Picture Potential

2012 U.S. Liquid Fuels Consumption by Sector
(quadrillion Btus)
U.S. Natural Gas Supply Chain: Pre Shale

LNG Import

Production

Interstate Pipeline

LDC Satellite Peakshaving

Local Distribution Company Tap

Local Distribution Company
U.S. Natural Gas Supply Chain: Post Shale
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A. Source and End Use Major Components
Approx. 100 LNG Facilities; Mostly LDC Peaking Plants

Marine Terminal - Export (1)
Marine Terminal - Import (4)
Storage (with liquefaction) (57)
Storage (without liquefaction) (39)
Stranded Utility (5)
Vehicular Fuel (2)
Nitrogen rejection unit or other special processing (5)

Stranded Utility: A stranded local utility system is typically very small and too far from the pipeline grid to be economically connected.

Nitrogen Rejection Unit: At NRU facilities, the entire gas stream is liquefied to remove impurities then regasified and sent on as pipeline-quality gas.
North American LNG Import/Export Terminals

Proposed/Potential

**Import Terminal**

**PROPOSED TO FERC**
1. Robbinston, ME: 0.5 Bcf/d (Kestrel Energy - Downeast LNG)
2. Astoria, OR: 1.5 Bcf/d (Oregon LNG)
3. Corpus Christi, TX: 0.4 Bcf/d (Cheniere - Corpus Christi LNG)

**POTENTIAL U.S. SITES IDENTIFIED BY PROJECT SPONSORS**
4. Offshore New York: 0.4 Bcf/d (Liberty Natural Gas)

**Export Terminal**

**PROPOSED TO FERC**
5. Freeport, TX: 1.8 Bcf/d (Freeport LNG Dev/Freeport LNG Expansion/FLNG Liquefaction)
6. Corpus Christi, TX: 2.1 Bcf/d (Cheniere - Corpus Christi LNG)
7. Coos Bay, OR: 0.9 Bcf/d (Jordan Cove Energy Project)
8. Lake Charles, LA: 2.4 Bcf/d (Southern Union - Trunkline LNG)
9. Hackberry, LA: 1.7 Bcf/d (Sempra – Cameron LNG)
10. Cove Point, MD: 0.75 Bcf/d (Dominion – Cove Point LNG)
11. Astoria, OR: 1.30 Bcf/d (Oregon LNG)
12. Lavaca Bay, TX: 1.38 Bcf/d (Exelon Liquefaction)
13. Elba Island, GA: 0.5 Bcf/d (Southern LNG Company)
14. Sabine Pass, LA: 1.3 Bcf/d (Sabine Pass Liquefaction)
15. Lake Charles, LA: 1.07 Bcf/d (Magnolia LNG)

**PROPOSED CANADIAN SITES IDENTIFIED BY PROJECT SPONSORS**
16. Kitimat, BC: 0.7 Bcf/d (Apache Canada Ltd.)
17. Douglas Island, BC: 0.25 Bcf/d (BC LNG Export Cooperative)

**POTENTIAL U.S. SITES IDENTIFIED BY PROJECT SPONSORS**
18. Brownsville, TX: 2.8 Bcf/d (Gulf Coast LNG Export)
19. Pascagoula, MS: 1.5 Bcf/d (Gulf LNG Liquefaction)
20. Sabine Pass, TX: 2.6 Bcf/d (ExxonMobil – Golden Pass)
21. Plaquemines Parish, LA: 1.07 Bcf/d (CE FLNG)
22. Cameron Parish, LA: 0.16 Bcf/d (Waller LNG Services)
23. Ingleside, TX: 1.09 Bcf/d (Pangea LNG (North America))
24. Cameron Parish, LA: 0.20 Bcf/d (Gasfin Development)

**U.S. – MARAD/COAST GUARD**
25. Gulf of Mexico: 3.22 Bcf/d (Main Pass - Freeport-McMoRan)

**POTENTIAL CANADIAN SITES IDENTIFIED BY PROJECT SPONSORS**
26. Prince Rupert Island, BC: 1.0 Bcf/d (Shell Canada)
27. Goldboro, NS: 0.67 Bcf/d (Fluoride Energy Canada)
28. Kitimat, BC: 2.0 Bcf/d (LNG Canada)

As of March 20, 2013

Office of Energy Projects
Off Pipeline LNG Model

**Project Components:**
- Source Location Siting
- Permitting
- Design
- Pipeline Interconnect
- Gas Marketing
- Prefab Components & Construction
- Liquefaction
- Truck Loading
- End User Facilities Permitting & EPC
- Logistics
- Billing
- O&M
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A. Source and End Use Major Components
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A. Source and End Use Major Components
LNG Source Site Major Components

Liquefaction & Storage

Truck Loading
Three Major Types of LNG Facilities

1. Marine Terminals (Import or Export)
   - Ship Loading or Unloading
   - On-Site Storage
   - Liquefaction or Vaporization
   - Truck Loading

2. Peak-Shaving
   - Liquefaction or Truck Unloading
   - On-Site Storage
   - Vaporization
   - Truck Loading

3. Base-Load
   - Liquefaction or Truck Unloading
   - On-Site Storage
   - Vaporization
   - Truck Loading
Other Types of LNG Facilities

1. Vehicular Fueling
   - Truck Unloading or Liquefaction
   - On-Site Storage
   - Vehicle Fueling

2. Stranded Gas Reserves
   - Liquefaction
   - On-Site Storage
   - Truck Loading

3. Land Fill Gas
   - Liquefaction
   - On-Site Storage
   - Truck Loading
Types of Liquefaction Systems

- Natural Gas Expander
- Cascade Refrigeration
- Mixed Refrigerant
- Nitrogen Recycle
Two Main Types of LNG Storage Tanks

1. Field Erected (API-620 Appendix Q):
   - 1,000,000 to 42,000,000 Gallons (3,800 to 160,000 Cubic Meters)
   - 0.5 to 2 psig Design Pressure
   - Pre-Stressed Concrete
   - Single Containment (9% Nickel Steel Inner Tank & Carbon Steel Outer Tank)
   - Full Containment (9% Nickel Steel Inner Tank & Concrete Outer Tank)
   - External or Internal Sendout Pumps

2. Shop Fabricated (ASME):
   - 30,000 to 70,000 Gallons (113.5 to 265 Cubic Meters)
   - 70 to 250 psig Design Pressure
   - 9% Nickel Steel Inner Tank & Carbon Steel Outer Tank
   - Horizontal or Vertical Configuration
   - Above Ground or Buried
   - Differential Pressure Sendout or External Sendout Pumps
LNG End Use Site Major Components

Storage

Truck Unloading

Odorant

Remote Heat or Ambient Vaporizers
Types of Vaporizers

- Direct Fired
- Indirect Fired Water Bath
- Indirect Fired Submerged Combustion
- Ambient Heat
- Remote Heated Shell and Tube
- Remote Heated Falling Film
- Open Rack Seawater