Liquefied Natural Gas and Regasification

Harvard Energy Journal Club
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Talk outline

• Natural Gas Market Overview
• What is LNG?
• Market Outlook
Global Natural Gas Demand
3,427 BCM

Europe: 15%
Americas: 26%
Asia: 8%
Oceania: 7%
Africa: 3%
FSU/non-OECD Europe: 20%
Latin America: 5%
China: 4%
Middle East: 12%
Natural Gas Sector Use

- Residential and Commercial: 30%
- Industry: 22%
- Power Generation: 38%
- Energy Industry Use: 8%
- Other: 2%
Natural Gas Timeline

- Gas Street Lamps
- Petroleum Transported by Tankers
- First Metal Pipeline
- Material Advances that Withstand Cold Temperatures
- Pipeline Technology Improvements
- LNG Peakshaving Plant
- LNG Maritime Shipment

Tusiani, MD and Shearer, G (2007)
Natural Gas Pricing

Figure 54 Gas price developments in the three main regional markets, Jan 2003-Jan 2013

USD/MBtu

Jan 03, Jan 04, Jan 05, Jan 06, Jan 07, Jan 08, Jan 09, Jan 10, Jan 11, Jan 12, Jan 13

HH, NBP, Asian LNG (average), German border price

IEA (2013)
LNG

- Reduce volume via cooling the gas to a liquid
  - Boiling Point: -163°C
  - Volume reduction > 600 fold
- Auto-refrigeration sustains liquid form
- Either use as LNG, or reheat to return to gas state

When liquefied, natural gas that would fill a beach ball... ...becomes LNG that can fit inside a ping-pong ball.

DOE (2005)
LNG Value Chain

Gas production → Liquefaction → Shipping → Regasification → Delivery by pipeline
LNG Value Chain – Gas Production

- Expands viability of various gas production sites
- 15-20% of capital cost
LNG Value Chain – Liquefaction

- Essentially just a giant refrigerator
- (Plus some pretreatment for impurities)
- 30-45% of capital cost
Liquefaction Process

Tusiani, MD and Shearer, G (2007)
Simple Refrigeration Schematic

Heat Source

Evaporator

Compressor

Condenser

Expansion Valve

Heat Distribution
Storage Tanks

DOE (2005)
LNG Value Chain – Shipping

- 10-30% of capital cost
- Substantial component of operational costs
- Tanker must be cooled before loading
LNG Shipping

An LNG ship's hull and containment system, more than six feet thick, as shown in cross-section.
LNG Value Chain – Regasification

- 15-25% of capital cost
- Unloading arms, storage tanks, and vaporization equipment
LNG Value Chain – End Use

1. Gas production
2. Liquefaction
3. Shipping
4. Regasification
5. Delivery by pipeline
Project Timeline

Two-Train LNG Project

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Tusiani, MD and Shearer, G (2007)
Current State of LNG

[Chart showing the growth of Bcm from 2000 to 2012 with CAGR from 2000-2012 indicating 7.5%, 4.0%, and 1.8% for different categories.]

IGU (2014)
Current State of LNG

Exports

- Qatar, 77.2, -0.2
- Malaysia, 24.7, +1.6
- Australia, 22.2, +1.4
- Indonesia, 17.0, -1.1
- Nigeria, 16.9, -3.1
- Trinidad, 14.6, +0.2
- Algeria, 10.9, -0.1
- Russia, 10.8, -0.2
- Oman, 8.6, +0.6
- Yemen, 7.2, +2.1
- Brunei, 7.0, +0.2
- UAE, 5.4, -0.2
- Peru, 4.3, +0.4
- Eq. Guinea, 3.9, +0.1
- Norway, 3.0, -0.4
- Egypt, 2.8, -2.3
- Angola, 0.3, +0.3

Imports

- Japan, 87.8, +0.5
- South Korea, 40.9, +4.1
- China, 18.6, +3.8
- India, 12.9, -1.1
- Taiwan, 12.8, +0.1
- Spain, 9.4, -4.9
- UK, 6.8, -3.6
- Mexico, 6, +2.4
- France, 5.8, -1.7
- Argentina, 4.9, +1.1
- Brazil, 4.4, +1.9
- Turkey, 4.2, -1.5
- Italy, 4.2, -1
- Chile, 2.9, -0.2
- US, 1.8, -1.4
- Kuwait, 1.6, -0.5
- Malaysia, 1.6, +1.6
- Other, 10.1, -0.5

IGU (2014)
Current State of LNG

IGU (2014)
LNG Flows

IEA (2013)
LNG – A Tight Market

Liquefaction Capacity

Import Capacity

IGU (2014)
Future Trends in Europe

Figure 12 Monthly quantity of power produced by coal and gas in Germany, Spain, United Kingdom, Jan 2004-Jan 2013

IEA (2013)
Natural Gas Interregional Trade

Map 9 Interregional trade in 2018 (bcm)

IEA (2013)
LNG Exports

Figure 48 Evolution of LNG exports, 2012-18

IEA (2013)
LNG Imports

Figure 49 Evolution of LNG imports, 2012-18

IEA (2013)
LNG plants under construction

IGU (2014)
Natural Gas for Transportation

Figure 28 Evolution of gas demand in the transport sector, 2000-18

IEA (2013)