LNG supply chain

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Describing gas industry we can distinguish two main areas:

- **Up-stream sector**
  - exploration
  - mining

- **Down-stream sector**
  - Processing / production
  - Liquefaction
  - Transportation
  - Distribution of natural gas
Up-Stream LNG Supply Chain
The global production of natural gas increased by 1.6% in 2014.

- U.S. produced 728.3 billion cubic meters - increase by 6.1%
- North America - increase 5.3%
- Russia produced 578.7 billion cubic meters - decrease 4.3%
- Europe and Eurasia - decrease 3.1%
Consumption of LNG

• The global consumption of natural gas increased slightly by 0.4%

• The highest increase
  o China (8.6%)
  o Saudi Arabia (8.2%)
  o Iran (6.8%)

• The European Union decline 4.8%
Production-Consumption of LNG

Production by region
Billion cubic metres

Consumption by region
Billion cubic metres

- Rest of World
- Asia Pacific
- Europe & Eurasia
- North America

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Main Trade Routes of LNG

Source: Includes data from Cerdigaz, CIESin, FGII, MEA-Nafgas service, GESNI, IHS Waterborne, PIRA Energy Group, Wood Mackenzie

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LNG import terminals

- LNG import terminals are located throughout Europe
- In Norway there are 40 terminal LNG small scale facilities (storage capacity < 1,000 m³)
- The total storage capacity of LNG in the region was app. 2 million m³
LNG import terminals

- Supply with LNG fuel for ships is quite difficult and time consuming

- LNG fuel supply in the port of Grangemouth requires a route at least **150 nautical miles by boat**
Locations of existing LNG terminals

**EXISTING**
- 23 LNG Terminals (201 bcm/a)

**UNDER CONSTRUCTION / COMMITTED**
- 5 LNG Terminals (28 bcm/a)

**UNDER STUDY / PLANNED**
- 24 LNG Terminals (> 146 bcm/a)
LNG Storage Capacity Development

LNG Terminals' Storage Capacity in Europe
in mcm LNG

- Total LNG capacity incl. proposed projects
- LNG capacity existing and under construction

Source: GLE LNG Investment Database, September 2014

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Down-Stream LNG Supply Chain
The various options for supply ships
Characteristics of the three size scales

LNG supply structure will differentiate for small, medium and large solutions

<table>
<thead>
<tr>
<th>Activity/Aspect</th>
<th>Large-scale</th>
<th>Medium-scale</th>
<th>Small-scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>On shore storage capacity</td>
<td>Import terminal ≥ 100.000 m³</td>
<td>Intermediary terminal 10.000-100.000 m³</td>
<td>Intermediary terminal &lt; 10.000 m³</td>
</tr>
<tr>
<td>Ship size, LNG capacity</td>
<td>LNG carriers 100.000-270.000 m³</td>
<td>LNG feeder vessels 10.000 -100.000 m³</td>
<td>LNG bunker vessels 1.000-10.000 m³ LNG bunker vessels/barges 200-1.000 m³</td>
</tr>
<tr>
<td>Tank trucks</td>
<td></td>
<td></td>
<td>40-80 m³</td>
</tr>
</tbody>
</table>
Small and Medium-sized LNG carriers for refueling

Three categories:

• LNG Bunker Vessels
• LNG Feeder Vessels
• Barges with or without self propulsion
Small and Medium-sized LNG carriers for refueling

LNG Bunker Vessels

- allow for smaller and flexible movements within the port
- propulsion is possible with two azimuth thrusters to ensure a unique maneuverability
- their capacity ranges from 1.000 to 10.000 m$^3$
- transfer both LNG and fuel oil
- use LNG as fuel making it environmentally friendly
Small and Medium-sized LNG carriers for refueling

LNG Feeder Vessels

- Their basic aim is the regional distribution of marine fuel LNG by large import terminals to points along the coastline
- The size and dimensions vary according to
  - market demands
  - depths
  - other physical features of the port
- Typical capacity ranges from 7,000 to 20,000 m³
- It should have "bow thrusters" and high performance rudder
- It would be preferable to have dual fuel engine to increase backup propulsion
Small and Medium-sized LNG carriers for refueling

Barges

- With or without self propulsion
- Environmentally friendly
- Low fuel oil consumption, able to operate on boil-off from cargo
- Efficient-Quick turn-around at loading / discharging ports
Small and Medium-sized LNG carriers for refueling

Dry Disconnect Couplings

- designed for **quick** and **spill free** connection and disconnection of hoses and pipelines
Small and Medium-sized LNG carriers for refueling

Safety Break-away Coupling (SBC)

- prevent pull away accidents
- protect terminal and loading/unloading equipment
- eliminated unwanted product release
Special Tankers for Regional LNG Distribution

- Truck capacity 50-80 m³
- Typical refueling can last up to two hours
- Pumping transfer rate 60 m³/h
- 350,000-500,000 € for a typical 55 m³ tanker
Old threaded coupling at tank truck
LNG transport via pipelines

- Difficult and expensive technique
- The use of pipelines is limited
- Necessary infrastructure
- It cannot be used for long distances
LNG Solutions for LNG Bunkering

The infrastructure for refueling LNG in Europe is still at an early stage. There are 3 ways of refueling:

- Ship-to-Ship, STS
- Truck-to-Ship, TTS
- LNG Terminal-to-Ship via pipeline, TPS
LNG Solutions for LNG Bunkering

1. Terminal Tank to Vessel
2. Truck to Vessel
3. Vessel to Vessel
4. Portable ISO-Tank Transfer

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Ship-to-ship (STS) Bunkering

- Supply made STS can be performed:
  - ship is in dock at anchorage
  - the vessel is in operation at sea
- Necessary
  - Suitable buffers
  - Appropriate quality and quantity of the mooring lines
- Feasible for volumes more than 100 m³
- The average bunkering is 150-200 m³/h
Ship-to-ship (STS) Bunkering

• A typical scenario of supply
  • Ro-Pax vessel for short distances
  • Refueling near urban areas

• Basic Requirements:
  • High levels of safety
  • Short refueling time

• The amount of fuel is set at $130 \text{ m}^3 \approx 65 \text{ ton}$

• The maximum time refueling including mooring is set to 50 minutes
Ship-to-ship (STS) Bunkering

LNG BUNKERING TIMELINE
TOTAL AVAILABLE BUNKER TIME
50 Min.

BEFORE BUNKERING
15 Min.

DURING BUNKERING
25 Min.

AFTER BUNKERING
10 Min.

INERTING
TANK SYSTEM CHECK
EQUIPMENT CHECK
CALL
ARRIVAL
MOORING
CHECKLIST TO RECEIVING SHIP
CONNECTION LINK / EARTHING
CONNECTION HOSE
RETURN OF SIGNED CHECKLIST
OPEN MANUAL VALVES
READY SIGNAL BOTH SHIPS
PUMP START SEQUENCE
TRANSFER SEQUENCE
PUMP STOP SEQUENCE
PURGING OF CARGO LINES (BOTH SHIPS)
SHUT MANUAL + REMOTE CONTROLLED VALVES
DISCONNECTION HOSES
INERTING OF CARGO LINES (RECEIVING SHIP)
DISCONNECTION LINK / EARTHING
DELIVERY CARGO DOCUMENT
UN-MOORING
DEPARTURE
INERTING OF CARGO LINES (BUNKER SHIP)

Transfer rate = 329 m³/h at 5 m²
24 min = 130 m³ = 65 tonnes

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Truck-to-Ship (TTS) Bunkering

- The most widespread form of ship supply
- Inexpensive compared to other alternatives
- This method is not fast enough (40 m$^3$/h)
- Suitable for small fuel volumes (up to 100-200 m$^3$)
- There should be special facilities to the port
LNG Terminal-to-Ship (TPS) via Pipeline

• Ideal Method for:
  o high rates (500m\(^3\)/h)
  o large fuel quantities

• Appropriate solution for:
  o ships operating voyages on short duration
  o high frequency ports

• Cover requirements from very small (20m\(^3\)) to very large (100,000m\(^3\)).

• Low flexibility (possible necessity of barges)
Advantages and disadvantages of the three supply modes

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<tr>
<th>Advantages</th>
<th>STS</th>
<th>TTS</th>
<th>TPS</th>
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<tr>
<td>Flexibility</td>
<td>Flexibility</td>
<td>Non-flexibility</td>
<td></td>
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<tr>
<td>High transfer rate</td>
<td>Small investment and operating costs</td>
<td>Ability supply large quantities of fuel</td>
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<tr>
<td>Refueling at sea</td>
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<td>Fast supply</td>
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<table>
<thead>
<tr>
<th>Disadvantages</th>
<th>STS</th>
<th>TTS</th>
<th>TPS</th>
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<tr>
<td>High investment and operating costs</td>
<td>Small fuel quantities</td>
<td>Fixed refueling point</td>
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<td></td>
<td>Low transfer rate</td>
<td>Takes up space in the terminal</td>
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THANK YOU!