The Growth and Opportunity for Small Scale LNG

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Small scale value chains

- Large = >1MTPA
- Mid = 0.2 to 1MTPA
- Small = 0.05 to 0.2MTPA
- Micro = < 0.05 MTPA

Gas/LNG users
LNG Transporters

Small Scale LNG Carrier/barge

Onshore Small Scale Regas / Storage

Small FSRU

Gas Pipeline

Small Scale Liquefaction/Storage

LNG Fuelled Ships

LNG Trucking/Rail

LNG Fuelled Vehicles

Onshore Small Scale Regas / Storage

Small -Scale Gas users
### Proposed FSRU Projects

<table>
<thead>
<tr>
<th>Project</th>
<th>Location</th>
<th>Possible Award Date</th>
<th>Possible Floater Solution</th>
</tr>
</thead>
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<tr>
<td>Woodfibre LNG</td>
<td>Canada</td>
<td>2016-2017</td>
<td>FSO (LNG)</td>
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<tr>
<td>Hawaii Gas</td>
<td>Hawaii</td>
<td>2017-2018</td>
<td>FSRU</td>
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<tr>
<td>Aegean LNG</td>
<td>Greece</td>
<td>2016-2017</td>
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<tr>
<td>Port Meridian Regas Terminal</td>
<td>UK</td>
<td>2016-2017</td>
<td>FSRU</td>
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<tr>
<td>Falconara</td>
<td>Italy</td>
<td>2017-2019</td>
<td>FSRU</td>
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<tr>
<td>DR LNG</td>
<td>Dominican Republic</td>
<td>2017-2019</td>
<td>FSO (LNG)</td>
</tr>
<tr>
<td>Brazil Gas to Power</td>
<td>Brazil</td>
<td>2016-2017</td>
<td>FSRU</td>
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<tr>
<td>Grupo Bontegni Powerplants</td>
<td>Brazil</td>
<td>2017-2018</td>
<td>FSRU</td>
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<td>Bay of Mejillones</td>
<td>Chile</td>
<td>2017-2018</td>
<td>FSRU</td>
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<tr>
<td>Colburn LNG</td>
<td>Chile</td>
<td>2017-2019</td>
<td>FSRU</td>
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<td>Java LNG (West/ Central)</td>
<td>Indonesia</td>
<td>2016-2017</td>
<td>FSRU</td>
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<td>Luzon Gas-to-Power</td>
<td>Philippines</td>
<td>2016-2017</td>
<td>FSRU</td>
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<td>Tabangao LNG</td>
<td>Philippines</td>
<td>2016-2017</td>
<td>FSRU</td>
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<tr>
<td>Chittagong Gas-to-Power</td>
<td>Bangladesh</td>
<td>2017-2018</td>
<td>FSRU</td>
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<td>Haidia FSRU</td>
<td>India</td>
<td>2017-2018</td>
<td>FSRU</td>
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<tr>
<td>Jafrabad LNG (Pipavav)</td>
<td>India</td>
<td>2016</td>
<td>FSRU</td>
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<tr>
<td>Kakinda-Hadia LNG</td>
<td>India</td>
<td>2016-2017</td>
<td>FSRU</td>
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<tr>
<td>Mumbai Port LNG</td>
<td>India</td>
<td>2016</td>
<td>FSRU</td>
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<tr>
<td>Port Qasim Regas Terminal #2 &amp; 3</td>
<td>Pakistan</td>
<td>2016</td>
<td>FSRU</td>
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<tr>
<td>LNG Import Road Map</td>
<td>Indonesia</td>
<td>2017-2020</td>
<td>FSRU</td>
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<td>Myanmar FSRU</td>
<td>Myanmar</td>
<td>2017-2019</td>
<td>FSRU</td>
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<td>Montanao LNG</td>
<td>Philippines</td>
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<td>Chana LNG</td>
<td>Thailand</td>
<td>2016-2018</td>
<td>FSRU</td>
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<td>PV Regas Terminals – Thi Vai &amp; Son My</td>
<td>Vietnam</td>
<td>2017-2018</td>
<td>FSRU</td>
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<td>Yancheng Regas Terminal</td>
<td>China</td>
<td>2017-2019</td>
<td>FSRU</td>
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<tr>
<td>Gangavaram Regas Terminal</td>
<td>India</td>
<td>2017-2019</td>
<td>FSRU</td>
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<tr>
<td>Karnataka LNG</td>
<td>India</td>
<td>2018-2020</td>
<td>FSRU</td>
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<tr>
<td>Hanas LNG</td>
<td>China</td>
<td>2017-2019</td>
<td>FSRU or FSO (LNG)</td>
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Among other things, the Directive requires Member States to ensure that "an appropriate number" of refueling points for LNG are put in place at maritime ports throughout the TEN-T Core Network by 31 December 2025.

The Council today adopted a directive on building up minimum infrastructure for alternative fuels across the EU (PE-CONS 79/14; statements: 13267/14 ADD 1).

"With the formal adoption of the directive today, we are taking a decisive step to make the European economy more resource-efficient, less dependent on oil and more attentive to the quality of life of citizens," said Maurizio Lupi, Italian Minister of Infrastructure and Transport.

Today’s final adoption of the legislative act by the Council follows an agreement reached at first reading with the European Parliament earlier this year.

The directive will enter into force 20 days after its publication in the EU Official Journal, which is expected to take place within the next few days.

Coordinated roll-out

Under the directive, each member state has two years to draw up an alternative fuel deployment strategy and send it to the Commission. These strategies or "national policy frameworks" will set out the country’s national targets for putting in place new recharge and refueling points for the different types of "clean fuel", such as electricity, hydrogen and natural gas, as well as relevant supporting actions.
Shipping environmental regulations strengthening

**Adopted**

- US BW requirements
- EU Recycling Regulation
- EEDI phase 0
- EEDI phase 1
- EEDI phase 2
- EEDI phase 3
- NOx tier III for new builds in North America
- EU CO2 monitoring, reporting and verification (MRV)
- EU 0.5% sulphur cap
- 0.1% ECA sulphur limit
- EU 0.5% sulphur cap
- Ballast Water Convention - entry into force
- Operational requirements to CO2 emissions
- Additional ECAs established
- BC, noise, bio-fouling and VOC regulation
- Global CO2 monitoring, reporting and verification
- Carbon pricing?
- HK Recycling convention ratified?

**IMO set 2020 for Global Sulphur cap in October 2016.**
There are currently 188 confirmed LNG ship fuel projects

Additional orders beyond 2018 are confirmed

Updated 9 December 2016
Excluding LNG carriers and inland waterway vessels
Small Scale LNG – Complex distribution chain to end users

- LNG is a growing fuel in the transport sector, for heavy duty trucks and for the marine sector.
- LNG is considered a more environment friendly alternative to traditional fuels – 30% fewer emissions of CO2 than oil. Lower emissions of sulfur oxides (SOx), particulate matter (PM) and nitrogen oxides (NOx)

- From the large-scale import terminals, LNG can be transported by several modalities.
  - Small LNG carriers (feeder vessels);
  - LNG bunker vessels or bunker barges;
  - LNG trailer trucks;
  - LNG rail trailers;
  - ISO-tanks or containers.
DNV GL Initiated a Joint Industry Project
Smart Design of the small-scale LNG Distribution Value Chain.

- Optimisation of small scale value chains. The need for robust decision support tools.

Questions that arise are:
- What are the supply and demand scenarios to help to demonstrate the business case?
- What are the optimum port infrastructure requirements?
- What is the impact of changing LNG quality in the value chain?
- What is the optimum number of transshipment points and storage volumes?
- What are the opportunities for supplying LNG from different sources, or for blending LNG, for manipulating/maintaining LNG quality?
- Are there options for different ways of transporting LNG or the ability to use other tank types to maintain LNG quality?
- Determine best scenarios for the early stages of development of LNG distribution network
- Determination of best operational practices
LNGi provides all needed information to keep you on top of LNG bunkering for ships

- **Map** of LNG bunkering infrastructure with **detailed** project data
- Heat map and vessel positions of LNG fuelled fleet operating area using **AIS**
- Detailed **statistics** of LNG fuelled **fleet** development
- Scrubber + alternative fuels overview
- LNG related studies and publications

*The heat map and vessel positions are based on AIS data from 01.01.2016-11.01.2016*
Determination of methane number is critical to safeguard the ship’s safety

- The occurrence of engine knock leads to significant loss of performance (power reduction), engine shutdown and potential damage.
- The knock resistance of LNG is characterized by the methane number, which is similar to the octane number used in gasoline engines.
- The global variation in methane number is more than 32 points.
- Knowledge of the knock characteristics of LNG fuels is crucial for suppliers and traders to provide reliable and efficient products and for the end user to secure optimal engine operations.
- DNV GL developed a fundamentally correct method to characterize gaseous fuels (PKI Methane Number).

32 point variation in Methane number
Source: IGU
Guidelines and Standards

**TECHNICAL SPECIFICATION**

**ISO/TS 16901**

First edition
2015-03-01

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Guidance on performing risk assessment in the design of onshore LNG installations including the ship/shore interface

*Guide pour l'évaluation des risques dans la conception d'installations terrestres pour le GNL en incluant l'interface terre/navire*

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**TECHNICAL SPECIFICATION**

**ISO/TS 18683**

First edition
2015-01-15

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Guidelines for systems and installations for supply of LNG as fuel to ships

*Lignes directrices pour les systèmes et installations de distribution de gaz naturel liquide comme carburant pour navires*

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**RECOMMENDED PRACTICE**

DNVGL-RP-G105
Edition October 2015

Development and operation of liquefied natural gas bunkering facilities
Gazprom and Gasunie discuss infrastructure projects and cooperation in small-scale LNG sector

Gazprom and Fluxys sign Framework Agreement on small-scale LNG cooperation

DNV GL joins cross industry group to spur LNG uptake

Maersk, Qatargas and Shell Team Up on LNG as Marine Fuel

Qatargas, Shell and UASC Continue to Lead the Way in the Development of Liquefied Natural Gas as a Marine Fuel

Air Products and Kiewit Team-Up to Pursue Smaller-Sized LNG Projects in North America
Summary

- Small scale market developing in part off the back of the need for greater supply flexibility, e.g. growth in FSRU market, greater market fluidity
- Regulation and policies are maturing, especially for LNG as a transport fuel and in the EU for small scale LNG
- Collaborations are important to stimulate growth in market demand and infrastructure development
- Intelligence is important to share global knowledge of infrastructure, markets, etc to stimulate the market
Thank you

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