Global Small and Medium Scale LNG -
Baltic Sea and South East Asia to Lead the Industry Growth to 2020

LNR1010A - February 2012
1 Table of Contents

1 Table of Contents ................................................................. 2
   1.1 List of Tables................................................................. 5
   1.2 List of Figures ............................................................... 7
2 Global Small Scale LNG Industry Outlook to 2015 ................................................... 8
   2.1 Industry Overview ............................................................ 8
      2.1.1 Small Scale LNG Industry- Key Benefits ................................. 8
      2.1.2 Small Scale LNG Industry- Key Challenges .............................................. 9
      2.1.3 Industry Scope ........................................................................... 9
      2.1.4 Applications of Small LNG .......................................................... 11
   2.2 Global Small Scale LNG Capacity forecast to 2015 .................................................. 11
2.3 Production Forecasts ........................................................................... 12
3 Potential Investment Opportunities for Small LNG Terminals .......................................... 14
   3.1 Russian Federation looks to strengthen its position in Baltic and Black Seas .................. 14
   3.2 South East Asia- Gas Demand in Power Generation and Marine sector drive Small LNG Industry growth .......................................................... 14
      3.2.1 Indonesia ................................................................................. 15
      3.2.2 Singapore .................................................................................. 15
      3.2.3 Southern Philippines and Northern Vietnam ................................................... 15
   3.3 Baltic Sea- LNG Consumption as Marine Fuel ................................................... 16
   3.4 Trinidad and Tobago ........................................................................ 16
   3.5 Small European Gas markets- Finland, Poland, Latvia, Lithuania and Scotland .... 16
   3.6 Emerging Gas Sub markets- South Korea and Singapore .......................... 17
   3.7 Large Geographic Areas- China, Australia, Russia and Indonesia ............... 17
   3.8 Export Oriented Markets- Papua New Guinea and Nigeria .......................... 17
4 Latest Trends and Drivers in Small LNG Industry ................................................... 18
   4.1 Small Scale LNG Increasingly Viewed as Feasible Solution for Exploiting Stranded Reserves ........................................................................... 18
   4.2 Higher Fuel Efficiency and Lower Emissions pose LNG as Preferred Marine Fuel ...... 19
   4.3 Surging demand from Power Sector boosts Investments in Small LNG .................. 21
   4.4 Technical Advancements Prove Small LNG terminals to be Technically Viable and Economic Feasible ................................................... 21
   4.5 Small LNG Industry Continues to Grow despite Shipping, Trucking, Terminal and Infrastructure Challenges ................................................... 21
   4.6 Development of terminals capable of handling multiple feed gases .................... 22
4.7 Single Mixed Refrigerant technology, Nitrogen and Expander technologies being increasingly used. ................................................... 22
4.8 Increasing number of Road Trucks use LNG as fuel ................................................... 22
4.9 Small LNG Industry Likely to Compete with DME and LPG plants ............................................. 23
4.10 Small scale LNG fleet vessels of size over 10 thousand m3 continue to be developed. .... 24
5 Planned Small and Mid Scale LNG terminals ............................................................................. 25
5.1 Small and Mid Scale Terminals Scheduled for operation in 2012 ........................................... 25
5.2 Small and Mid Scale Terminals Scheduled for operation in 2013 ........................................... 25
5.3 Small and Mid Scale Terminals Scheduled for operation in 2014 ........................................... 26
5.4 Small and Mid Scale Terminals Scheduled for operation in 2015 ........................................... 26
6 Global Operational and Planned Mini LNG Terminal Details ................................................... 27
6.1 Asia Pacific- Small and Mid Scale LNG Plant Details ................................................... 27
6.1.1 China Small and Mid Scale LNG Industry ........................................................................... 27
6.1.2 Australia Small and Mid Scale LNG Industry ............................................................... 30
6.1.3 Thailand Small and Mid Scale LNG Industry ................................................................. 31
6.1.4 Japan Small and Mid Scale LNG Industry ................................................................. 31
6.2 Europe- Small and Mid Scale LNG Plant Details .............................................................. 33
6.2.1 Norway Small and Mid Scale LNG Industry ........................................................... 33
6.2.2 Scotland Small and Mid Scale LNG Industry ............................................................. 34
6.2.3 Germany Small and Mid Scale LNG Industry ............................................................ 34
6.2.4 Poland Small and Mid Scale LNG Industry ............................................................... 35
6.2.5 United Kingdom Small and Mid Scale LNG Industry .................................................. 35
6.2.6 Finland Small and Mid Scale LNG Industry ............................................................. 36
6.2.7 Russia Small and Mid Scale LNG Industry ............................................................... 36
6.2.8 Belgium Small and Mid Scale LNG Industry ............................................................. 37
6.2.9 Ecuador Small and Mid Scale LNG Industry .............................................................. 37
6.2.10 Sweden Small and Mid Scale LNG Industry ............................................................. 38
6.2.11 Netherlands Small and Mid Scale LNG Industry ....................................................... 38
6.2.12 Spain Small and Mid Scale LNG Industry ............................................................... 39
6.2.13 Greece Small and Mid Scale LNG Industry .............................................................. 39
6.3 Middle East and Africa- Small and Mid Scale LNG Plant Details ............................................ 40
6.3.1 South Africa Small and Mid Scale LNG Industry ....................................................... 40
6.3.2 Libya Small and Mid Scale LNG Industry ............................................................... 40
6.3.3 Iran Small and Mid Scale LNG Industry ....................................................................... 41
6.4 Americas- Small and Mid Scale LNG Plant Details .......................................................... 42
6.4.1 The US Small and Mid Scale LNG Industry ............................................................... 42
6.4.2 Canada Small and Mid Scale LNG Industry ..................................................... 49
7 Latest Developments in Global Small and Medium Scale Industry ............................ 50
  7.1 BOC Limited in Australia opens its $65 million Upgraded LNG plant – 8 Feb, 2012 .... 50
  7.2 Sumitomo and Sojitz to Compete in global spot LNG markets – 2 Feb, 2012 .. 51
  7.3 Gazprom Gazenergoset Plans to Develop Urals Small LNG Plant by 2013– 6 Dec, 2011 .. 52
  7.4 China Natural Gas Commences operations of its 1 mcm/d Guang’an small LNG plant – 2 Dec, 2011 ............................................................. 53
  7.5 OJSC Gazprom to Develop Khabarovsk Small LNG to supply six Boilers in the region – 25 Nov, 2011 ........................................................................... 54
  7.6 Kogas proposes to build three mini LNG plants and DME plant in Far East – 25 Oct, 2011 ................................................................. 55
  7.7 JSC Cryogenmash sign Equipment supply contract to Chongqing Endurance Industry Stock Co. for its LNG terminals – 9 March, 2011 ................................................... 57
8 Introduction to Small Scale LNG Industry ................................................................. 58
  8.1 Rising gas demand Encouraging Investments in Small and Mid Scale LNG Projects .... 58
  8.2 Supply Chain of Mini Scale LNG Projects .......................................................... 60
  8.3 Small Scale LNG vs. Large (Base Load) LNG ......................................................... 62
9 Small and Mid Scale Liquefaction and Regasification Technologies ............................ 63
  9.1 Analysis of Available Technologies ..................................................................... 63
  9.2 Linde Engineering- Technologies and Processes .................................................. 64
  9.3 APCI LNG- Technologies and Processes ............................................................. 66
  9.4 Black and Veatch- Technologies and Processes .................................................. 66
  9.5 Kryopak- Technologies and Processes ............................................................... 66
  9.6 Hamworthy (Nitrogen Cycle)- Technologies and Processes ............................... 68
  9.7 CH4 International- Technologies and Processes .................................................. 68
  9.8 Cryonorm- Technologies and Processes ............................................................. 68
  9.9 Cryostar- Technologies and Processes ............................................................... 68
10 Appendix .................................................................................................................. 70
  10.1 Abbreviations ...................................................................................................... 70
  10.2 LNG Conversions ............................................................................................... 70
  10.3 LNG Pricing ........................................................................................................ 70
  10.4 Sources and Methodology .................................................................................. 72
  10.5 About LNGReports ............................................................................................ 74
  10.6 Disclaimer ........................................................................................................... 74
1.1 List of Tables

Table 1: Existing and Emerging Small Scale LNG Markets, 2000-2015 ................................. 10
Table 2: Estimated Small and Midscale LNG Capacity Forecast, Thousand Tonnes per day, 2000-2015 ......................................................................................................................... 12
Table 3: Estimated Small and Midscale LNG Production Estimates, Tonnes, 2000-2015 .... 13
Table 4: Global Small and Medium Sized LNG Vessels, Capacities ........................................ 24
Table 5: Small and Midscale LNG Plants in China - I ................................................................. 27
Table 6: Small and Midscale LNG Plants in China - II ............................................................... 28
Table 7: Small and Midscale LNG Plants in China - III ............................................................ 29
Table 8: Small and Midscale LNG Plants in Australia .............................................................. 30
Table 9: Small and Midscale LNG Plants in Thailand ............................................................... 31
Table 10: Small and Midscale LNG Plants in Japan - I .............................................................. 31
Table 11: Small and Midscale LNG Plants in Japan - II ............................................................ 32
Table 12: Small and Midscale LNG Plants in Norway ............................................................. 33
Table 13: Small and Midscale LNG Plants in Finland ............................................................. 34
Table 14: Small and Midscale LNG Plants in Germany .......................................................... 34
Table 15: Small and Midscale LNG Plants in Poland .............................................................. 35
Table 16: Small and Midscale LNG Plants in the UK .............................................................. 35
Table 17: Small and Midscale LNG Plants in France .............................................................. 36
Table 18: Small and Midscale LNG Plants in Russia .............................................................. 36
Table 19: Small and Midscale LNG Plants in Belgium .......................................................... 37
Table 20: Small and Midscale LNG Plants in Ecuador ............................................................ 37
Table 21: Small and Midscale LNG Plants in Sweden ............................................................ 38
Table 22: Small and Midscale LNG Plants in Greece ............................................................ 39
Table 23: Small and Midscale LNG Plants in Spain ............................................................... 39
Table 24: Small and Midscale LNG Plants in South Africa ................................................... 40
Table 25: Small and Midscale LNG Plants in Libya ............................................................... 40
Table 26: Small and Midscale LNG Plants in Iran ................................................................. 41
Table 27: Small and Midscale LNG Plants in the US -- I ....................................................... 42
Table 28: Small and Midscale LNG Plants in the US -- II ..................................................... 43
Table 29: Small and Midscale LNG Plants in the US -- III .................................................... 44
Table 30: Small and Midscale LNG Plants in the US -- IV .................................................... 45
Table 31: Small and Midscale LNG Plants in the US -- V ..................................................... 46
Table 32: Small and Midscale LNG Plants in the US -- VI .................................................... 47
Table 34: Small and Mid Scale LNG Plants in the US -- VII......................................................... 48
Table 35: Small and Mid Scale LNG Plants in Canada ............................................................ 49
Table 36: World Natural Gas Demand Forecast, Bcm, 2000-2020 ........................................ 59
Table 37: Small Scale LNG Vs. Base Load Regasification Terminals...................................... 62
1.2 List of Figures

Figure 1: Global LNG Gas Reserves, Tcf, 2010 ................................................................. 19
Figure 2: World Natural Gas Demand Forecast, Bcm, 2000-2020 ................................. 60
Figure 3: Small Scale LNG- Typical Supply Chain ......................................................... 61
2 Global Small Scale LNG Industry Outlook to 2015

2.1 Industry Overview

The growing scope of small- mid scale LNG is opening up new markets for natural gas including maritime fuelling, fuel for trucks and off-grid customers in addition to traditional usage of natural gas. In particular, markets like China, the US and Indonesia have strong demand for gas from remote (limited pipeline connectivity) areas and have strong dependence on small and medium LNG plants. Countries in Baltic Sea, South East Asia and Americas are planning to invest in the infrastructure.

Small Scale LNG is increasingly emerging as an effective solution to transport natural gas where pipeline transportation is infeasible. Small terminals, with capacities less than 250 tonnes per day, provide strong solutions in countries with minimal transport infrastructure (road/railway/pipelines). Further, for long distance transport also, these terminals prove efficient alternatives.

On the liquefaction front, Small Scale LNG provides an innovative way of accessing stranded gas reserves. Fields with limited reserves and located far from onshore will be monetized using this technology.

2.1.1 Small Scale LNG Industry- Key Benefits

In addition to providing natural gas to remote regions, mini LNG terminals provide several benefits for operators. Some of the key advantages of the small scale LNG include:

- Small space required for construction
- Lower capital requirement
- Low Operational expenditure
- Simple technologies
Table 2: Estimated Small and Mid Scale LNG Capacity Forecast, Thousand Tonnes per day, 2000-2015

<table>
<thead>
<tr>
<th>Year</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td></td>
</tr>
</tbody>
</table>

Source: LNGReports

2.3 Production Forecasts

Economic development, increasing capacity and high prices are encouraging higher production from Small Scale LNG Terminals. The table below details global small and medium scale LNG production from 2000 to 2015 worldwide.
for meeting the total demand in the region. Companies that move early are likely to strengthen their position despite new entry barriers.

3.2.1 Indonesia

Among South East Asian markets, Indonesia is witnessing increased demand from islands in eastern region. As construction of pipelines to these scattered islands is economically infeasible, the country is looking for developing small terminals. Recently, it is planning to develop eight new Small LNG terminals by 2015.

By 2012, the state owned company PT Pertamina is planning to construct four terminals in East Kalimantan, Bali and Sulawesi. Lombok; Southern Kalimantan will witness new plants by 2013 and Sulawesi and Maluku islands by 2015. Gas source for these will come from marginal fields surround demand area in Western and Eastern region of Indonesia.

3.2.2 Singapore

Singapore is the preferred location for LNG bunkering. Amidst stringent marine regulations, LNG fuelled ships are expected to rise. These ships can fill fuel in Singapore due to calm seas, ongoing infrastructure activities and large shipping volumes in the country. Though no firm plans have been announced, new plants are expected by 2015.

3.2.3 Southern Philippines and Northern Vietnam

Strong demand for natural gas from power plants will drive the need for small scale LNG terminals. Both the countries are yet to announce new project proposals. Korea East-West Power Co., Ltd is considering realization of one project in Philippines but has not yet finalized its plans. Similarly, Vietnam and Thailand are also considering construction of Small LNG plants.
MARPOL Act-

IMO has drastically reduced the maximum SOx and NOx emission limits from ships. Accordingly, the limits include-

In Sulphur Emission Control Areas like Baltic Sea and North Sea, MARPOL has limited the control-

- From 2010- from 1.5% to 1.0%
- From 2015- from 1.0% to 0.1%

Globally, maximum sulphur content of the fuel is limited to-

- From 2012- from 4.5% to 3.5%
- From 2020- from 3.5% to 0.5%

Similarly, NOx limitations in Emission Control Areas-

- From 2011- 20% reduction over Tier I
- From 2016- 80% reduction over Tier I

Where as Tier 1 corresponds to-

- N< 130 rpm \( \Rightarrow 17.0 \text{ g/kWh} \)
- 130<= N < 2000 rpm \( \Rightarrow 450 + 0.2 \text{ g/kWh} \)
- \( n\geq 2000 \text{ rpm} \) \( \Rightarrow 9.8 \text{ g/kWh} \)

Such stringent emission norms will force all ship owners and operators to shift for cleaner fuels. As LNG is the most efficient and economic fuel for ships, small LNG fuelling stations, peak shaving terminals and bunkering terminals will witness significant growth.
### 4.10 Small scale LNG fleet vessels of size over 10 thousand m3 continue to be developed

<table>
<thead>
<tr>
<th>Vessel Name</th>
<th>Built Year</th>
<th>Capacity (Thousand m3)</th>
</tr>
</thead>
</table>

Source: LNGReports
6  Global Operational and Planned Mini LNG Terminal Details

6.1  Asia Pacific- Small and Mid Scale LNG Plant Details

Growing demand for natural gas in the region will boost the investments in Small Scale LNG projects. Amidst escalating costs of large terminals, mini LNG projects offer viable gas distribution solutions. Gas from these plants is likely to compete mainly with other fuels like gasoline, diesel and LPG.

6.1.1  China Small and Mid Scale LNG Industry

<table>
<thead>
<tr>
<th>Terminal</th>
<th>Type</th>
<th>Status</th>
<th>Location</th>
<th>Start Up Year</th>
<th>Company</th>
<th>Capacity (tpd)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ordos LNG 1</td>
<td>Liquefaction</td>
<td>Operational</td>
<td>Erdos-Xingxing</td>
<td>2008</td>
<td>Erdos-Xingxing Gas Co.</td>
<td>640</td>
</tr>
<tr>
<td>Zhuhai</td>
<td>Liquefaction</td>
<td>Operational</td>
<td>Zhuhai</td>
<td>2008</td>
<td>CNOOC</td>
<td>390</td>
</tr>
<tr>
<td>Dazhou</td>
<td>Liquefaction</td>
<td>Operational</td>
<td>Dazhou</td>
<td>2010</td>
<td>Dazhou Huixin Energy Source Co., Ltd</td>
<td>640</td>
</tr>
</tbody>
</table>

Source: LNGReports
8.2 Supply Chain of Mini Scale LNG Projects

Small Scale LNG is similar to other petroleum product distribution chain networks. LNG is sourced from peak shaving/liquefaction/ Base Load Regasification terminals. LNG storage terminals also supply LNG is then transported through pipelines or rail cars or semi-trailers to either end users or local storage plants.

LNG Supply Sources:
- Small liquefaction plants
- Peak Shavers
- Base Load Regasification plants
- LNG Storage terminals
- Satellite LNG plants
- Offshore LNG plants
8.3 **Small Scale LNG vs. Large (Base Load) LNG**

Small Scale LNG terminals require simple technology, lower construction periods and less capital investment as compared to large terminals. Further, these terminals also have wider access to end users and are likely to operate at higher utilization rates based on demand. Lower operational expenditure and construction space also increase the attractiveness of Small Scale LNG terminals.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Smaller Mid LNG</th>
<th>Large Regasification LNG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Capital Investment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Typical Construction Period</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Operational Expenditure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Construction Space</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: LNGReports
Some of the leading small/medium scale liquefaction processes include:

**Mini Size – Similar to Peak Shaving Plant, Satellite Fuel Center, and No-Flare**

- APCI, Costain (Nitrogen Expander)
- Kryopak (Nitrogen, SMR)
- Hamworthy (Nitrogen, LNG Tanker Re-Liquefaction)

**Small/Middle Size – 0.3 – 2.0 MMTPA**

- Black & Veatch (SMR(Prico))
- Linde (SMR, Nitrogen - China)
- Mustang (Nitrogen (NDX-1 Smart))
- Kanfa Aragon/Costain (Nitrogen - Flex)
- Hamworthy (Nitrogen)
- CBI Lummus (Nitrogen/Methane – Niche)
- LNG Limited (SMR with Ammonia Pre-Cool)
- APCI (Nitrogen Flex)

### 9.2 Linde Engineering - Technologies and Processes
10.5 About LNGReports

Providing comprehensive data and analysis on LNG industry trends, strategies, investments, competition, technologies, trading and prices.

LNGReports is the leading publisher of data and market intelligence reports on global LNG industry. We provide detailed analysis on entire LNG value chain including blocks, fields, liquefaction and regasification terminals, shipping fleet and distribution pipelines.

We also provide historical and forecasted information on LNG, natural gas supply, demand, trends, drivers, technologies, market structures and company strategies at all global, regional and country levels. Further, information on global LNG monthly trade, prices, contracts, capital expenditure are also provided.

For further information, please contact us at sales@lngreports.com or visit our website at www.lngreports.com

10.6 Disclaimer

The information and analysis provided by LNGReports are based on different primary and secondary sources and are believed to be correct at the time of publishing. In spite of the enormous efforts and rigorous quality checks, some errors might peep in here and there in the report. We accept no liability for whichever actions taken based on any information or analysis that may subsequently prove to be incorrect. However, if such things are brought to our notice, we shall rectify the same and produce it in the next reports.

This report is solely intended for the buyer and no part of it may be reproduced, stored or transmitted in any form by any means, electronic, mechanical, photocopying, recording, or otherwise without the prior written permission of LNGReports.

All rights reserved.