LNG REGASIFICATION — TECHNOLOGY EVALUATION AND COLD ENERGY UTILISATION

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ABSTRACT

The import of LNG by means of re gasification terminals is an important element needed to meet the current and the future energy demand, globally. Over the past decade, the global LNG industry has grown rapidly both in terms of liquefaction and re gasification capacity. Almost 70 LNG re gasification terminals are now operating in 21 countries worldwide, nearly 20 more are under construction, and approx 30 more have been proposed. The costs, supply reliability and process safety are the key issues for the gas supply in the future. The demand on gas supply costs requires continuous efforts at optimizing the LNG supply chain efficiency and enhanced utilization of the available energy. The current research is undertaken as part of an industry focused PhD program. The research is to study the current technology position on LNG re gasification and identify new opportunities for optimization and utilization of cold (cryogenic) energy. The proposed study is expected to be techno economic in nature. The purpose of this initial paper is to assess the currently operating LNG regasification terminals in terms of the technologies employed and challenges, locational parameters, LNG quality, efficiency and utilization of cold (cryogenic) energy.

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World primary energy demand is expected to grow by 1.6% per annum over the period 2010 to 2030, which will require 39% additional energy to meet this requirement. Natural Gas is a natural resource which has had a huge demand in recent years. While the share of oil in energy use decreases by 2030, Natural gas share increases and reaches 25.9% of world energy usage.

<table>
<thead>
<tr>
<th>Share of fuel 1990-2030 (% shares of world energy use)</th>
<th>1990</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renewables*</td>
<td>0.4</td>
<td>6.3</td>
</tr>
<tr>
<td>Nuclear</td>
<td>5.6</td>
<td>6.0</td>
</tr>
<tr>
<td>Hydroelectric</td>
<td>6.0</td>
<td>6.8</td>
</tr>
<tr>
<td>Coal</td>
<td>27.3</td>
<td>27.7</td>
</tr>
<tr>
<td>Natural gas</td>
<td>21.8</td>
<td>25.9</td>
</tr>
<tr>
<td>Oil</td>
<td>38.9</td>
<td>27.2</td>
</tr>
</tbody>
</table>
World primary energy demand is expected to grow by 1.6% per annum over the period 2010 to 2030, which will require 39% additional energy to meet this requirement. Natural gas is a natural resource which has had a huge demand in recent years. While the share of oil in energy use decreases by 2030, the natural gas share increases and reaches 25.9% of the world energy usage.


**World LNG production by Country (2011)**

- **Trinidad**, 6%
- **Australia**, 8%
- **Nigeria**, 8%
- **Indonesia**, 9%
- **Malaysia**, 10%
- **Qatar**, 31%
- **Algeria**, 5%
- **Russia**, 4%
- **Oman**, 3%
- **Brunei**, 3%
- **Yemen**, 3%
- **Egypt**, 3%
- **UAE**, 2%
- **Equatorial Guinea**, 2%
- **Peru**, 2%
- **Libya**, 0.03%
- **US**, 0.1%
World LNG demand by Country (2007-2016)

World LNG demand by Country (2011)

- Japan, 33%
- Korea, 15%
- UK, 8%
- Spain, 7%
- China, 5%
- India, 5%
- Taiwan, 5%
- France, 4%
- Italy, 3%
- US, 2%
- Turkey, 2%
- Belgium, 2%
- Argentina, 1%
- Mexico, 1%
- Chile, 1%
- Canada, 1%
- Kuwait, 1%
- Portugal, 1%
- Other Small Importers, 2.2%
The LNG chain can be divided into three main sections including production region, LNG tankers and consumption region. In the production region, natural gas is chilled to a liquid state where it takes up only 1/600 of its original space. Then LNG is transported by insulated cryogenic ships. In the consumption region, LNG is then changed into its normal gaseous form ("re-gasified") and delivered to customers by gas pipelines. During LNG production, approximately 500 kWh energy/t LNG is consumed for compression and refrigeration and a considerable portion of this invested energy is preserved in the LNG, which has a final temperature of about -163°C (110 K). Therefore, a considerable potential of energy recovery exists during the re-gasification process.

**Importing capacity in Asia & Europe in 2011 and 2015**

<table>
<thead>
<tr>
<th>Region</th>
<th>Importing Capacity (mmtpa)</th>
<th>2011</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>70</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>Korea</td>
<td>35</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>China</td>
<td>15</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>India</td>
<td>20</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Taiwan</td>
<td>15</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Thailand</td>
<td>10</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Singapore</td>
<td>6</td>
<td>3.5</td>
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</tr>
</tbody>
</table>

The total importing capacity in 2011 from Asia and Europe is 148.5 mmtpa and 77 mmtpa, respectively. It will increase to 216 mmtpa and 98 mmtpa for Asia and Europe by the year 2015.
Common LNG regasification technologies

Open rack vaporisers (ORV)

Submerged combustion vaporisers (SCV)
Shell & tube vaporisers (STV)

Intermediate fluid vaporisers (IFV)
Direct and indirect heat transfer processes using in LNG re gasification systems are dissipative and LNG cold energy is wasted. By using LNG cold energy in existing industrial facilities, the LNG re gasification can be changed to a productive process.

Some of the current and potential cold energy utilisation applications:

- Inlet air cooling (IAC) to gas turbines
- Cold power generation
- Air separation or other low temp fractionation
- Air conditioning, Cold storage & warehousing
- District cooling
- Cooling media for the adjacent refineries/petrochemical plants, Chilled water for industry
- Cryogenic crushing
- BOG (Boil off gas) re liquefaction
- Dry ice manufacturing
<table>
<thead>
<tr>
<th></th>
<th>Japan</th>
<th>Thailand</th>
<th>Singapore</th>
<th>Taiwan</th>
<th>China</th>
<th>India</th>
<th>Korea</th>
<th>UK</th>
<th>Spain</th>
<th>Italy</th>
<th>Belgium</th>
<th>France</th>
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</thead>
<tbody>
<tr>
<td>ORV</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
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<tr>
<td>SCV</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
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<td>x</td>
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<tr>
<td>STV</td>
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<td>x</td>
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<td>x</td>
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<td>AAV</td>
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<td>Air fin</td>
<td>x</td>
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<td>x</td>
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<tr>
<td>Air as heating medium</td>
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<tr>
<td>Cold utilization (%)</td>
<td>60%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>10%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Cold utilisation application</td>
<td>Air separation &amp; Cryogenic power generation</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>First Air separation unit commissioned during Q4,12</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
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</tbody>
</table>

As we can see in the table above, only in Japan and China has the cold utilisation capacity of LNG been implemented. Initial numbers suggest that around 80% of LNG cold energy of the total imported LNG, globally, as being wasted.

**PURPOSE OF THE STUDY**

To enhance energy efficiency of LNG re-gasification and improve utilisation of available cold energy from LNG. Consequently, to evaluate potential impact on the economics of gas supply and the gas based power generation.
RESEARCH METHODS

1. Establish current status i.e. Technologies, Cold utilisation and the economics.
2. Evaluation of the existing technologies without cold energy utilization. Efficiency and cost optimisation opportunities. (i.e. location factors, boil off gas options, LNG interchangeability etc)
3. Evaluation of cold energy utilisation applications. (energy efficiency and exergy analysis, develop thermo-economics model for selected cases i.e. Integrated power generation, retrofitting cold energy to the existing terminals that are currently without etc) Analyse an enhanced project economics due to Cold utilisation.
4. Develop a re-gasification technology selection process. A techno-economic model.
5. Identification and feasibility analysis of new applications for cold energy utilisation.

REFERENCES


SUPERVISORS

1. Associate Professor Richard Brown, QUT, Australia.
2. Professor Theodore Steinberg, QUT, Australia.