Natural Gas and LNG
E-Drive Technology
Natural gas and LNG E-drive technology
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Increasing interest in E-drive in LNG? Why?

• Potential for higher plant availability

• Reduced maintenance costs and down time for motors and VFDs

• Improved plant operational flexibility (speed variation)

• Reduced plant emissions
Historical trend LNG refrigerant compressors

<table>
<thead>
<tr>
<th>Year</th>
<th>Project</th>
<th>Location</th>
<th>Capacity</th>
<th>Trains</th>
</tr>
</thead>
<tbody>
<tr>
<td>1969</td>
<td>Kenai LNG, Alaska, USA</td>
<td></td>
<td>1.5 MTPY</td>
<td>One</td>
</tr>
<tr>
<td>1974</td>
<td>Brunei LNG, Nation of Brunei</td>
<td></td>
<td>1.44 MTPY</td>
<td>One</td>
</tr>
<tr>
<td>1983</td>
<td>MLNG Satu, Indonesia</td>
<td></td>
<td>8.4 MTPY</td>
<td>Three</td>
</tr>
<tr>
<td>2009</td>
<td>Qatargas II, Qatar, 2009</td>
<td></td>
<td>7.8 MTPY</td>
<td>One</td>
</tr>
</tbody>
</table>
Historical trend LNG refrigerant compressors

Gas Turbines have been the choice of compressor driver since the beginning.

In some projects in 70's and 80's steam turbines were used as well.

2008
First E-Drive for refrigerant compressor

2019

Hammerfest LNG, Norway
- Capacity: 65 MW

Gulf Coast LNG, USA
- Capacity: 75 MW
- Operational in 2019
## Historical trend liquefaction plant cost

<table>
<thead>
<tr>
<th>Average train size (MTPY)</th>
<th>Average Liquefaction Capex ($/TPY)</th>
</tr>
</thead>
<tbody>
<tr>
<td>60's to late 80's</td>
<td>1.5</td>
</tr>
<tr>
<td>90's to 2000</td>
<td>3</td>
</tr>
<tr>
<td>2000 to present</td>
<td>5</td>
</tr>
</tbody>
</table>

Liquefaction plant represents about 50% of the total plant cost.
**Plant availability, Plant efficiency**

\[
\text{Availability} = \frac{\text{MTBF}}{\text{MTBF} + \text{MDT}}
\]

- **MTBF**: Mean Time Between Failure
- **MDT**: Mean Down Time
  (The time system is not available due to delay on spare parts, manpower and repair time)

  - Large frame type Gas Turbine
    Availability: 95%
  - Equivalent size Variable Speed Drive System: MTBF: 7 years. Availability: ~ 99%

**PE**: Production Efficiency

\[
\text{PE} = \frac{\text{Predicted Achieved Production}}{\text{Potential Production}}
\]

- **Predicted Achieved Production**: Total field life production as predicted by the reliability, availability and maintainability (RAM) model
- **Potential Production**: Field life production as determined by deliverability profile for the system
Maintenance costs

8 MTPY plant in the Gulf Coast, USA

Gas Turbine Driver

- Maintenance cost per operating hours: $140/hour
- Gas turbine scheduled maintenance: 10-21 days after 2 years of operation

45 MW Electric Drive

- Maintenance cost per operating hours: $20/hour
- Motors require minimal maintenance. Can be operational for 6 years without scheduled maintenance

Motors require minimal maintenance. Can be operational for 2 years of operation.
Operational flexibility

• Electric drives allow compressor speed variation that in turn provides production flexibility to user

• Quick start up is possible with electric drives without depressurization

• Gas Turbines lose approximately 0.33% of their output for every one degree F increase in ambient temperature that limits the plant production in summer

• E-Drive systems can run at an optimized speed where compressor efficiency is maximized
Emissions

• Heavy duty single shaft gas turbine: 250 - 280 kg CO₂/tLNG

• Electric Drive: 6 - 190 kg CO₂/tLNG

• If CO₂ free energy supply is available the annual reduction in CO₂: 1.3 million tons

• E-Drive with external CO₂ free electricity supply is the greenest LNG Plant!
Large electric drives in other industries

• Air compressors in Oxygen Plants (Steel plants)
  - Mostly Electric Drive: 40-60 MW

• Air compressors in Air Separation
  (Oil & Gas Petrochemical)
  - Mostly Electric Drive: 40-60 MW

• Mega Air Compressor installed in South Africa
  in 2016: 64 MW electric motor
The differential net present value (Power solution – Gas Turbine solution) for a rate of return of 10% is $8 million (US).
When can E-LNG be used?

• All Electric motor driven LNG plant is a viable solution with today’s technology

• Motor and VFD manufacturers are confident that large motors and VFDs around 100 MW are feasible

• They are essentially the same technology as large two pole generators built to sizes exceeding 250 MW

• External grid power solution has low CAPEX and low operating cost

• Self generation plant requires much greater capital investment than gas turbine driven LNG Plant
Small to Mid-scale LNG Solutions

General

- A conservative estimate suggest that small to mid-scale LNG plants makes up 10% of all liquefaction capacity (mostly in China)
- Mid-scale LNG trains can range from 1.0-2.0 MTPA to 5.0-8.0 MTPA
- LNG units are building blocks that allow individual units to be built as offtake is sold
- Standard pre-engineered design is repeatable
- Reduced delivery time compared to large scale plants
Small to Mid-scale LNG Solutions

Financial

• Very competitive pricing
• Cost for each Liquefaction unit is very competitive on a cost per MTPA basis
• No big investment commitment upfront.
• Easier to finance

Projects

• Elba Island Project – Georgia, USA
  0.25 MTPY x 10 trains = 2.5 MTPY (under construction)
• Woodfibre Project – Canada
  1.05 MTPY x 2 trains = 2.1 MTPY (FEED)
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