Opportunities & Synergies for LNG in the port and cargo handling industry - Sweden

Go LNG, 25-26 April 2018, Malmö

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Blekinge Institute of Technology,
Karlshamn, Sweden
Learning Objectives for today:

• Opportunities for using LNG for other equipment and vehicles in a port
• Case for Terminal Tractors
• Case for yard cranes (Rubber Tired Gantry Cranes. RTGs)
• Case for other equipment, such as Automated Guided Vehicles and Straddle carriers
• Questions and Answers – don’t be shy – ASK!!
Aim of the project

GoLNG project will focus on developing LNG competence and value chain (in Baltic Sea Region) by:

- Providing strategic approach towards the LNG infrastructure deployment in BSR shaping BSR Blue Corridor strategy

- Consolidating integrated LNG value chain adding users to existing LNG infrastructure.

- Providing technology, skills and knowledge for LNG value chain, establishing BSR LNG competence center.

- Providing business opportunities for regions LNG industry, establishing BSR LNG business cluster.

- Establishing a sustainability factor for LNG infrastructure, providing LBG value chain, technological concepts and business models

WWW.GOLNG.EU
Blue Corridor Strategy

The aim of the Strategy is to establish strategic approach of LNG infrastructure development and mobilize the critical mass of technology, business partnerships, and regulative authorities to implement LNG powered transport networks in BSR.

We will provide a model on how LNG infrastructure should be deployed in order to establish LNG powered transport corridors for Maritime; Road; Rail; Port equipment.
Cargo Handling: Container Terminal case
Port Equipment in Container Terminals

1. **STS** | Ship to Shore Cranes
2. **RTG** | Rubber Tyred Gantry Crane
3. **RMG** | Rail Mounted Gantry Crane
4. Intermodal Cranes
5. Horizontal Transport | AGVs, Trucks, Straddle Carriers
6. Shore Power Supply (LNG Bunkering..)
Market and Customer Trends
Market size for Port Equipment & Container Handling
9 Billion €
Main drivers of the Market

**Trends**

- Increasing competition of terminals
- Globalization
- Bigger Vessels
- Increase in energy costs
- Increasing environmental demands

**Consequence**

- More efficient systems
- New investments in modern port facilities
- Bigger Cranes and faster logistics
- Energy Savings
- Automation of Container Yards
# Factors for developing Ecological Equipment

<table>
<thead>
<tr>
<th>Environmental</th>
<th>Economical</th>
<th>Technological</th>
</tr>
</thead>
<tbody>
<tr>
<td>reducing pollution</td>
<td>reducing operating costs (oil prices) and</td>
<td>optimizing productivity &amp;</td>
</tr>
<tr>
<td>(air and noise)</td>
<td>maintenance costs</td>
<td>performances</td>
</tr>
</tbody>
</table>

- Environmental: reducing pollution (air and noise)
- Economical: reducing operating costs (oil prices) and maintenance costs
- Technological: optimizing productivity & performances
If necessity is the mother of invention then vision is the father of innovation!
Lets Go GREEN!

= Ecological Equipment
Where can we apply Ecological Equipment?

How much energy is consumed?  
Where is the energy consumed?

Reference: GreenCranes Project
Which Machinery or Equipment to Consider?

- Rubber Tyred Gantry Crane (RTG)
- Terminal Tractor
- Reach Stacker
- Empty Forklift
How much DIESEL (FUEL) consumption?

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCTV Yard Machinery</td>
<td>6,986,564 L</td>
</tr>
<tr>
<td>RTGs</td>
<td>4,049,138 L</td>
</tr>
<tr>
<td>Yard Tractors</td>
<td>2,245,147 L</td>
</tr>
<tr>
<td>Reach Stackers</td>
<td>611,460 L</td>
</tr>
<tr>
<td>Empty Forklifts</td>
<td>80,819 L</td>
</tr>
</tbody>
</table>

90% of the total fuel consumption is:

- 4,049,138 L (58%)
- 2,245,147 L (32%)
- 611,460 L (9%)
- 80,819 L (1%)

X 4,000 (1,300 L / year)
• Terminal Tractors are the most used type of horizontal equipment found in Container Terminals worldwide.

• Terminal Tractors represent significant part of the total fuel consumption in a port – often the 2nd most consuming of fuel after yard cranes.
### Feasibility Evaluation: Terminal Tractors

#### Terminal Tractors

<table>
<thead>
<tr>
<th>Alternatives TT</th>
<th>2.4 Million L</th>
<th>1.8 Million € GoB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasoil TIER 4 / Stage IV (2014)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LNG</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dual Fuel</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### RTGs

<table>
<thead>
<tr>
<th>Alternatives RTG</th>
<th>4.6 Million L</th>
<th>3.4 Million € GoB</th>
</tr>
</thead>
<tbody>
<tr>
<td>RTG Engine Replacement TIER 4 (2014)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LNG / Dual Fuel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrification</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conductor Bar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cable Reel</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### STS + Other

<table>
<thead>
<tr>
<th>Supply Alternatives</th>
<th>17.8 GWh</th>
<th>2.2 Million € kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Electrical Tariff</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tariff 6.1 (Electrical Supplier)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tariff 6.3 (Electrical Supplier)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Current European LNG market

1,500 LNG Vehicles
Mainly UK, NL & Spain

- UK: 621 trucks
- Netherlands: 387 trucks
- Belgium: 33 trucks
- Spain: 306 trucks
- France: 10 trucks
- Portugal: 11 trucks
- Russia: 1 truck
- Sweden: 69 trucks
- Poland: 46 buses, 11 trucks
- Switzerland: 1 truck
- Finland: 1 truck
- Turkey: 2 trucks
- Italy: 56 trucks

Source: NGVA Europe, 01.12.2014
Terminal Tractor Market by supplier

- Kalmar: 51%
- Capacity: 24%
- Others: 8%
- Mafi: 3%
- MOL: 2%
- CVS: 2%
- Terberg: 10%

Kalmar
51%

Capacity
24%

Others
8%

Mafi
3%

MOL
2%

CVS
2%

Terberg
10%
LNG Facts for Terminal Tractors

- LNG in fuel tank is stored at less than 100 PSI but at temperatures of –259 F and lower. It has the ability to **contain more fuel in slightly less space** and much lower pressure than CNG.

- Fuel consumption in liters per hour is about **13.2 – 17 Liters per hour**. (Cummins C Gas + 250 HP/750lb/ft T).

- Based upon a 216 liter usable tank size this would **limit to about 12 – 16 Hours** on LNG vs. **about 24 – 30 hours on a standard 190 liter** tank of diesel.

- Clear, odorless, and non-corrosive.

Reference: Kalmar Industries
GoLNG

Hybrid Diesel/Electric

Full electric Battery

Future energy Full cell-hydrogen
  Under development

LNG Under development
Fuel Consumption per Liter in comparing Engine Alternatives

<table>
<thead>
<tr>
<th>Engine Types</th>
<th>Liter Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>6BTA5.9-173</td>
<td>5.68</td>
</tr>
<tr>
<td>BLPG-195 PLUS</td>
<td>14.20</td>
</tr>
<tr>
<td>BGAS-195 PLUS</td>
<td>16.09</td>
</tr>
<tr>
<td>CGAS-250 PLUS</td>
<td>17.60</td>
</tr>
</tbody>
</table>
Energy Comparison

- #2 Diesel
- Unl. Gas
- LPG
- LNG
- Methanol

BTU / Gal.
# Machinery or Equipment Deliveries 2008-2013

<table>
<thead>
<tr>
<th>Equipment type</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reach Stackers</td>
<td>1408</td>
<td>796</td>
<td>1227</td>
<td>1452</td>
<td>1504</td>
<td>1324</td>
</tr>
<tr>
<td>FLTs Laden</td>
<td>198</td>
<td>110</td>
<td>113</td>
<td>146</td>
<td>178</td>
<td>146</td>
</tr>
<tr>
<td>FLTs empty</td>
<td>613</td>
<td>318</td>
<td>467</td>
<td>549</td>
<td>709</td>
<td>671</td>
</tr>
<tr>
<td>Terminal Tractors 4x2</td>
<td>2843</td>
<td>1778</td>
<td>1343</td>
<td>1727</td>
<td>1625</td>
<td>1596</td>
</tr>
<tr>
<td>Terminal Tractors 4x4</td>
<td>692</td>
<td>404</td>
<td>320</td>
<td>375</td>
<td>414</td>
<td>404</td>
</tr>
</tbody>
</table>
What is the Pay Back?

\[ ICC = (\text{Initial Cost of Vehicle}) - \text{Purchase Incentives} + \text{PVFuel} - \text{PVResale} \]

Where:

- **Purchase Incentives** = Value of Grants, Tax Credits, etc. Applied to Vehicle Purchase
- **PVFuel** = Present Value of Fuel Expenses During Vehicle Service Life
- **PVResale** = Present Value of Resale Value of Vehicle at End of Service Life
- **PV** = \( \frac{\text{Ft}}{(1 + d)t} \)
- **Ft** = Future Cash Flow in Year \( t \)
- **d** = Discount Rate
<table>
<thead>
<tr>
<th>Factor</th>
<th>Diesel</th>
<th>LNG – No Incentives</th>
<th>LNG – LNG Incentives</th>
<th>LNG – SCAQMD (Max. 25 Vehicles)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Cost of Vehicle</td>
<td>$80,000</td>
<td>$120,000</td>
<td>$120,000</td>
<td>$120,000</td>
</tr>
<tr>
<td>Purchase Incentives</td>
<td>$0</td>
<td>$0</td>
<td>$32,000</td>
<td>$40,000</td>
</tr>
<tr>
<td>Fuel Cost/Gallon After Tax Credits</td>
<td>$2.60</td>
<td>$0.50</td>
<td>$0.50</td>
<td>$0.50</td>
</tr>
<tr>
<td>Gallons/Operating Hour</td>
<td>1.7</td>
<td>3.8</td>
<td>3.8</td>
<td>3.8</td>
</tr>
<tr>
<td>Annual Operating Hours</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Annual Fuel Costs</td>
<td>$8,840</td>
<td>$3,800</td>
<td>$3,800</td>
<td>$3,800</td>
</tr>
<tr>
<td>Service Life</td>
<td>10 Years</td>
<td>10 Years</td>
<td>10 Years</td>
<td>10 Years</td>
</tr>
<tr>
<td>Discount Rate</td>
<td>3%</td>
<td>3%</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td>Present Value Fuel</td>
<td>$77,669</td>
<td>$33,387</td>
<td>$33,387</td>
<td>$33,387</td>
</tr>
<tr>
<td>Resale Value</td>
<td>$5,000</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Present Value Resale ICC</td>
<td>$3,832</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>ICC</td>
<td>$153,837</td>
<td>$153,837</td>
<td>$121,387</td>
<td>$113,387</td>
</tr>
</tbody>
</table>
Comparison Hybrid, Electric, LNG

<table>
<thead>
<tr>
<th></th>
<th>LNG-Elec</th>
<th>CNG-Elec</th>
<th>Diesel-Elec</th>
<th>Full-Elec</th>
<th>H2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Pack™ Cost (Capex)</td>
<td>😊</td>
<td>😊</td>
<td>-</td>
<td>😊</td>
<td>-</td>
</tr>
<tr>
<td>Cost of Energy</td>
<td>😊</td>
<td>😊</td>
<td>-</td>
<td>😊</td>
<td>-</td>
</tr>
<tr>
<td>Efficiency</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
<td>😊</td>
</tr>
</tbody>
</table>

- Benchmark: Better
- Best:

Cost of Energy

<table>
<thead>
<tr>
<th></th>
<th>Natural Gas Hybrid</th>
<th>Diesel Hybrid</th>
<th>Hydrogen Hybrid 1</th>
<th>Hydrogen Hybrid 2</th>
<th>Full Electric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bar Graph</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Cost of Hydrogen in €/kWh (2002-2030)

- Electrolysis (conventional)
- Electrolysis (renewable)
- Steam reforming (conventional)
- Steam reforming (renewable)
- Other / non-classified

Total efficiency (source to wheels)

<table>
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<tr>
<th></th>
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</tbody>
</table>

8/10/2018
• RTG are the main solution for moving containers in terminal yards worldwide
• RTG represent significant part of the total fuel consumption in a port (more than 50%)
Feasibility Evaluation: RTG

Terminal Tractors RTGs STS + Other

2,4 Million L
1,8 Million € GoB
4,6 Million L
3,4 Million € GoB
17,8 GWh
2,2 Million € kWh

Alternatives TT

• Gasoil TIER 4 / Stage IV (2014)
• LNG
• Dual Fuel

Alternatives RTG

• RTG Engine Replacement TIER 4 (2014)
• LNG / Dual Fuel
• Electrification
  • Conductor Bar
  • Cable Reel

Supply Alternatives

• Current Electrical Tariff
• Tariff 6.1 (Electrical Supplier)
• Tariff 6.3 (Electrical Supplier)
Facts + Figures

- Diesel engines are the main source of RTGs
- Container handling increases
- At the same time diesel prices increased rapidly
- In some cases RTGs account for 50% of a container terminals’ diesel consumption

Effects

- High fuel consumption & costs
- High dependency on fossil fuels that have unpredictable prices
- High cost in larger size Genset service (- USD 20k / year)
- Environmental; carbon emissions, air and noise pollution
Kalmar is engineering a diesel-LNG powered reachstacker prototype as part of the GREENCRANES project.

"The LNG power is a very interesting future fuel alternative both for port equipment business as well as for the whole shipping industry. Natural gas extractions are increasing and this can clearly be seen as one of the future trends."

She’s no gas guzzler
• Port Container Terminals are huge energy consumers, especially on those energy sources based on fossil fuels.

• From the economic point of view, increase of energy prices means more cost which reduces Port competitiveness.

• In terms of environmental impact, with the current motivation in having LNG bunkering and ships being built with LNG engines, the additional effort to “bunker port equipment is a low barrier to entry (Cherry Picking).

• Concerning social impact, ports are usually located near populated cities affect nearby population as direct GHG emissions (derived from diesel oil) are locally deployed, not only CO₂ but also other pollutant and toxic gases like N₂O, Sulphur compounds and suspension particles.

• Efforts to reduce fuel consumption and GHG emissions produced by RTGs, yard tractors and reach stackers are strongly recommended.
Total and CMA CGM have signed an agreement covering the supply of around 300,000 tons of liquefied natural gas (LNG) a year for 10 years starting in 2020.

Questions ...

Is your Port Ready?

Will you be able to Compete or risk be left behind....?
LNG STAKEHOLDERS WILL MEET ONBOARD FJORD LINE’S LNG POWERED FERRY

The upcoming international conference “LNG – best fuel of the future!” will take place onboard Fjord Line’s LNG powered ferry M/S Stavangerfjord. Bringing together buyers and sellers from all Baltic Sea Region, the event will give an ideal platform to get the latest news on LNG technologies, legislation and funding possibilities, explore new markets and become a part of the current and future LNG supply chain.

On 10-12 April 2018, the ferry will host participants, representing business organisations from Denmark, Lithuania, Sweden, Norway, Germany and Poland. Professionals will meet to exchange ideas and opinions about LNG development, to review LNG regulatory landscape, deepen technical and scientific knowledge.

International conference is to be held within the framework of the Go LNG project that has brought together 18 partners from 7 countries.

The speakers list includes the delegates of the international companies Bureau Veritas Marine & Offshore, Kosan Crispian Nauticor GmbH&Co KG, DNV GL, Fjord Line A/S, SkanGas etc. Academic Institutions, such as World Maritime University, established by the International Maritime Organisation (IMO), and Maritime University of Szczecin will also send their delegates to share their presentations.

Formal sessions and discussions will be coupled with matchmaking meetings, possibility to experience the bunkering of M/S Stavangerfjord and guided tour “LNG from the Engine room to the Bridge” – the programme will ensure that attendees were given meaningful time and outstanding networking opportunities.

Organisers of the upcoming conference highlight that new investments are required worldwide to meet the growing LNG demand: “It is time for the Baltic Sea Region LNG Cluster companies and businesses to demonstrate their vast knowledge, cutting edge technologies and newest innovations to the world”.

The global demand for LNG is expected to increase 4-5% pr. year between 2015 and 2030. Most of the future LNG growth is anticipated to be created by further floating storage regasification units (FSRs), the declining domestic gas production, small scale LNG and the transport sector.
Thank You for your attention!

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“The best way to predict the future is to create it”

&

“Innovation can be systematically managed if one knows where and how to look.”

- Peter Drucker, professor of management

QUESTIONS?....