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

LNG Workshop and LNG Value Chain

Prof. Lawrence Henesey
Blekinge Institute of Technology,
Karlshamn, Sweden
Who is this guy?

- Scientist on the application of Distributed Artificial Intelligence in Container Ports and Terminals.
- Develop solutions for energy and data transmission by employing automation and electrification technologies such as AGVs, ASCs, Automated cranes, RTGs and RMGs.
- Possesses 27 years of industrial work experience such as: Evergreen, Sea Land, Bank of America, Deutsche Post GmbH, Sea Trade Reefer, TTS Port Equipment, Conductix-Wampfler AG and SIMPORT AB.
- Member of the following organisations: Port Equipment Manufacturers Association (PEMA), Swedish Artificial Intelligence Society (SAIS), and Association of Computer Machinery (ACM).
- PhD in Computer Science from Blekinge Institute of Technology at Karlshamn, Sweden. MSc (Cum-Laude) in Transport and Maritime Management from the University of Antwerp, Belgium and degrees from Old Dominion University, Virginia, USA.
Learning Objectives for today:

- Brief History Lesson
- 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!!
Developing LNG as a business opportunity using the “Value Chain” as a platform
Cargo Handling: Container Terminal case
A Very Brief History Lesson
Early days – For centuries, freight was handled manually
A truck driver who eventually built one of the largest trucking companies in America

Malcolm P. McLean

He realized that there had to be a better way
In 1956 Malcom changed the shipping world forever!

The ship carried 58 35-feet containers, along with a regular load of 15,000 tons of bulk petroleum from Newark to Houston in April 26, 1956.
Just 5 Years later, a Global Standard was set that improved production, safety and cut costs while improving the way that we move goods around the world.
As a result of Standardization...

Production went from a rate of 1.3 Tons/Hour to > 30 Tons/Hour

The Cost to move goods decreased from $5.86/Ton to $0.16/Ton

There are over 6,000 container vessels in service globally.

In 1966, only 1% of countries had container ports. By 1983, > 90% had container terminals.

A sweater made in China can travel 3,000 miles by sea for only pennies.

There are over 17 million containers which make over 200 million trips per year.
We find ourselves, once again, at the threshold of a new vision in terminal production, safety and cost savings
Pick up any Trade/Industry magazine and we see that Automation and Energy is here to stay
There have been a lot of major changes in the way we do business. Standardization will allow us to work effectively and utilize the best that technology has to offer.

Since the earliest days of containerization…
Standardize Port / Terminal LNG Bunkering and Distribution Services. . .?
Market size for Port Equipment & Container Handling
7 Billion €
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..)
Description and Segmentation

- Ports and terminals industry projected growth rate of 6% - till 2017
- Total global container throughput will be 830 million TEU (Twenty-foot Equivalent Units) by 2017. Growth rate of 40% between 2011-2017.
- Conservative growth rate of 5% will double current global container volumes by 2025
- Containerisation with strong port development in various regions.
- More Large ships ordered, 445 new ships with capacity of 3,27 million TEU
- Larger ships means more time at port - leading to more costs.
Main drivers of the Market

<table>
<thead>
<tr>
<th>Trends</th>
<th>Container Ports</th>
<th>Consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increasing competition of terminals</td>
<td>GTOs</td>
<td>More efficient systems</td>
</tr>
<tr>
<td>Globalization</td>
<td>Carriers/Liners</td>
<td>New investments in modern port facilities</td>
</tr>
<tr>
<td>Bigger Vessels</td>
<td>Port Authorities</td>
<td>Bigger Cranes and faster logistics</td>
</tr>
<tr>
<td>Increase in energy costs</td>
<td></td>
<td>Energy Savings</td>
</tr>
<tr>
<td>Increasing environmental demands</td>
<td></td>
<td>Automation of Container Yards</td>
</tr>
</tbody>
</table>
Factors for developing Ecological Equipment

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!
Let's 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?

**NCTV Yard Machinery. Total Fuel Consumption 2012**

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

**Livorno TDT Yard Machinery. Total Fuel Consumption 2012**

- 6,986,564 L

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 2\textsuperscript{nd} most consuming of fuel after yard cranes.
Feasibility Evaluation: Terminal Tractors

Terminal Tractors
- 2.4 Million L
- 1.8 Million € GoB

Alternatives TT
- Gasoil TIER 4 / Stage IV (2014)
- LNG
- Dual Fuel

RTGs
- 4.6 Million L
- 3.4 Million € GoB

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

STS + Other
- 17.8 GWh
- 2.2 Million € kWh

Supply Alternatives
- Current Electrical Tariff
- Tariff 6.1 (Electrical Supplier)
- Tariff 6.3 (Electrical Supplier)
Current European LNG market

1,500 LNG Vehicles
Mainly UK, NL & Spain

Source: NGVA Europe, 01.12.2014
Terminal Tractor Market?

- Terminal Tractor market accounted for 5900 units (2700 delivered to ports and 3200 to other facilities for warehousing and distribution)

### Market Potential by Product Group 2005

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Europe</td>
<td>200</td>
</tr>
<tr>
<td>North/South America</td>
<td>770</td>
</tr>
<tr>
<td>North East Asia</td>
<td>570</td>
</tr>
<tr>
<td>South East Asia</td>
<td>150</td>
</tr>
<tr>
<td>Middle East/India/Africa</td>
<td>450</td>
</tr>
<tr>
<td>Ports Operations (RoRo &amp; LoLo)</td>
<td>2630</td>
</tr>
</tbody>
</table>

### Market Potential by Region

- Europe: 28%
- North/South America: 21%
- North East Asia: 23%
- South East Asia: 17%
- Middle East/India/Africa: 11%

Terminal Tractor Market by supplier

- Kalmar: 51%
- Capacity: 24%
- Others: 8%
- Termberg: 10%
- Mafi: 3%
- MOL: 2%
- CVS: 2%
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
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>Liters</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>
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</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>
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<tbody>
<tr>
<td>Reach Stackers</td>
<td>1408</td>
<td>796</td>
<td>1227</td>
<td>1452</td>
<td>1504</td>
<td>1324</td>
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<tr>
<td>FLT's Laden</td>
<td>198</td>
<td>110</td>
<td>113</td>
<td>146</td>
<td>178</td>
<td>146</td>
</tr>
<tr>
<td>FLT's 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** = (Initial Cost of Vehicle) – Purchase Incentives + PVFuel – 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** = \( Ft / (1 + d)t \)
- **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>
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<tr>
<td>Purchase Incentives</td>
<td>$0</td>
<td>$0</td>
<td>$32,000</td>
<td>$40,000</td>
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<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>
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<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</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>

### Cost of Energy

<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Cost of Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Gas Hybrid</td>
<td>🟩</td>
</tr>
<tr>
<td>Diesel Hybrid</td>
<td>🟩</td>
</tr>
<tr>
<td>Hydrogen Hybrid 1</td>
<td>🟩</td>
</tr>
<tr>
<td>Hydrogen Hybrid 2</td>
<td>🟩</td>
</tr>
<tr>
<td>Full Electric</td>
<td>🟩</td>
</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)

- Natural Gas Hybrid
- Diesel Hybrid
- Hydrogen Hybrid 1
- Hydrogen Hybrid 2
- Full Electric
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

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- 2.4 Million L
- 1.8 Million € GoB

Alternatives TT
- Gasoil TIER 4 / Stage IV (2014)
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Supply Alternatives
- Current Electrical Tariff
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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
Other equipment to be « LNG-nized »

AGV – Automated Guided Vehicles

Straddle Carriers
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.”
What have we learned in 20+ minutes. ?...

- 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 to Supply LNG for CMA CGM’s New 22,000 TEU Ships

Questions …

Is your Port Ready?

Will you be able to Compete or risk be left behind….?

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.
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, Kossan Crispplant, 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 (FSRUs), the declining domestic gas production, small scale LNG and the transport sector.

More information found at: www.GoLNG.eu

April 10-12, Bergen Norway
Thank You for your attention!

Asst. Prof. Dr. Lawrence Henesey
Blekinge Institute of Technology
Dept. of Computer Science and Engineering
Biblioteksgatan 4
Karlshamn, Sweden
www.bth.se

+46 (0) 706009809
QUESTIONS?....