LNG in the Baltic Sea
Experiences and future outlook

Ulrika Roupé, Project Manager
SSPA Sweden AB
Trelleborg, 3 December, 2015
SSPA Sweden AB.

• Providing maritime consultancy services on a worldwide basis since 1940

• Independent consulting company, fully owned by the Foundation Chalmers University of Technology.

• Main clients; Maritime operators and shipyard industry, energy companies, industry, ports, authorities, European Commission, IMO, EMSA

• 20% internationally funded research

• 115 employees, 14 Million Euros

Bridge between theory and practice....
Business areas

Research

Maritime Operations

Ship Design
Maritime Operations

- **Infrastructure Development** – Port design, bunkering facilities, fairways, multimodal transport systems, DD

- **Sustainable development** – decision support, multidisciplinary approaches

- **Energy/alternative fuels** – LNG, Methanol, FEEDs, Hazid/QRA, energy logistics, operations

- **Research and Development**
Risk awareness

Risks in all operations must be

Identified
Quantified
Handled
Avoided
Minimized

Tolerated?
Formal Safety Assessment

• **identification of hazards** (a list of all relevant accident scenarios with potential causes and outcomes);

• **assessment of risks** (evaluation of risk factors);

• **risk control options** (devising regulatory measures to control and reduce the identified risks);

• **cost benefit assessment** (determining cost effectiveness of each risk control option); and

• **recommendations for decision-making** (information about the hazards, their associated risks and the cost effectiveness of alternative risk control options is provided).
LNG bunkering in Stockholm
Urban infrastructure

• New bridge downtown Gothenburg 2020

• Safe ship traffic during construction and operation,
• Guidelines for design
• Permission process
• Simulations and risk analyses
• Visualisation of winning design concepts
Arctic operations development

- Oil in Ice Management – development of response strategies
- Ice breaker performance criteria for ice management in drill operations
- Operational Risk analysis in Arctic – ”number of drill days”
- Ice management in ports
Small scale LNG and LNG bunkering
### Introduction – IMO MARPOL Annex VI

*Depending on the outcome of a review of fuel oil availability, to be completed 2018, the 2020 date could be deferred to 2025*

<table>
<thead>
<tr>
<th>Current and confirmed Emission Control Areas (ECAs)</th>
<th>Entry into force</th>
<th>Effective from</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baltic Sea SECA (SOₓ)</td>
<td>19 May 2005</td>
<td>19 May 2006</td>
</tr>
<tr>
<td>North Sea SECA (SOₓ)</td>
<td>22 November 2006</td>
<td>22 November 2007</td>
</tr>
<tr>
<td>North America ECA, up to 200 nautical miles (SOₓ, NOₓ and PM)</td>
<td>1 August 2011</td>
<td>1 August 2012</td>
</tr>
<tr>
<td>US Caribbean Sea ECA, Puerto Rico/US Virgin islands (SOₓ, NOₓ and PM)</td>
<td>1 January 2013</td>
<td>1 January 2014</td>
</tr>
</tbody>
</table>
Some LNG references

- Location criteria for LNG in Swedish ports for *Energigas*
- North European LNG Infrastructure Project for *European Commission and DMA*
- Bunkering of LNG fuelled ships in South Korea for *KOGAS*
- Terminal locations and safety/*LNGGOT*, Gothenburg, *VOPAK*, *KLASCO*, Klaipeda, etc
- Maritime LNG Strategies for Gas providers in Europe, Korea and Caribbean *IMO*
- AGA – Viking Line LNG bunkering in Stockholm/AGA
Recent projects for

Petroleum Geo-Services
Midway Alignment of the Bothnian Corridor

- Identify and establish a sustainable transport concept – facilitate and strengthen development in two peripheral regions
- Intermodality in transport solutions
- The concept includes:
  - New innovative ferry, running on LNG
  - All necessary land infrastructure; port and rail connections
  - Fuel distribution for ferry (LNG terminal/supply)
- Focus on environmental profile of transport concept, reduce emissions, reduce weight, reduce road transport
- Arctic knowhow
Zero Vision Tool.

- Pilot LNG
  Six pilot LNG projects in small scale distribution infrastructure, bunkering systems and ship building
- Pilot Scrubber
  Introduction and investment in a new generation of lightweight scrubbers in two vessels
- Pilot Methanol
  Conversion of the Stena Germanica travelling between Kiel and Gothenburg to methanol.

SSPA is the co-funder and owner of the ZVT platform together with the Swedish Shipowners Association.
LNG in Kenya

- Electricity from LNG, not diesel
- Regional/national energy plan
- Decision support
- Investment plans
- Import to Port of Mombasa
- FSRU in the port
- Distribution systems
- Power plants, industrial and maritime use
Methanol as ship fuel

- SPIRETH – Methanol as marine fuel – an SSPA project with STENA
  - The main goal of the SPIRETH (“Alcohol (spirits) and ethers as marine fuel”) project is to test methanol-based fuels in a full scale pilot project, to contribute to finding the best environmental and economic alternative for a sustainable and successful maritime transport industry.

- A study on ships fuel and its infrastructure – EMSA 2015, SSPA with LR

\[ CH_3OH \]
LNG in Baltic Sea Ports I and II

• The first project was focused on Feasibility, Risk assessment, early stages in the planning process
• SSPA assisted in Stockholm, Aarhus, Copenhagen-Malmö, and the Handbook
• The second project was more focused on design and the permit process
• SSPA assisted in Trelleborg, Sundsvall and the Handbook
<table>
<thead>
<tr>
<th>Terminal</th>
<th>Type</th>
<th>Capacity</th>
<th>Operator</th>
<th>Status</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fredriksstad/Øra, Norway</td>
<td>Closed</td>
<td>6 400</td>
<td>Skangas</td>
<td>In operation</td>
<td>Local gas grid and redistribution by truck</td>
</tr>
<tr>
<td>Nynäshamn, Sweden</td>
<td>Closed</td>
<td>20 000</td>
<td>AGA</td>
<td>In operation</td>
<td>Redistribution by truck and pipeline</td>
</tr>
<tr>
<td>Lysekil/Brofjorden, Sweden</td>
<td>Closed</td>
<td>30 000</td>
<td>Skangas</td>
<td>In operation</td>
<td>Local gas delivery to refinery and redistribution by truck. Maritime redistribution by bunker barge. In operation since 2014.</td>
</tr>
<tr>
<td>Świnoujście, Poland</td>
<td>Open</td>
<td>320 000</td>
<td>Polskie LNG</td>
<td>Under construction</td>
<td>European gas grid and redistribution by truck. Maritime and rail based redistribution and bunkering is under discussion. Planned operational start was December 2014 but has been delayed.</td>
</tr>
<tr>
<td>Klaipeda, Lithuania</td>
<td>TBD</td>
<td>170 000</td>
<td>Klaipeda’s Nafta</td>
<td>In operation</td>
<td>FSRU unit designed to connect to the local gas grid. In operational since December 2014.</td>
</tr>
<tr>
<td>Regional terminal, Gulf of Finland</td>
<td>TBD</td>
<td>180 000</td>
<td>Gasum</td>
<td>Under discussion</td>
<td>Regional terminal for the Baltic energy market area located in either Finland (Inkoo) or Estonia (Paldiski). Planned operation by 2021.</td>
</tr>
<tr>
<td>Tallin Muuga, Estonia</td>
<td>Open</td>
<td>180 000</td>
<td>Vopak /Elering</td>
<td>Under discussion</td>
<td>Terminal with loading and unloading of LNG to vessels as well as to LNG trucks is discussed. For the future, train unloading is discussed. Planned operation by 2017.</td>
</tr>
<tr>
<td>Pori, Finland</td>
<td>TBD</td>
<td>30 000</td>
<td>Skangas</td>
<td>Under production</td>
<td>Terminal with pipeline distribution in the Turku area, truck loading facilities and loading/unloading via existing jetty. Planned to be in operation by 2017.</td>
</tr>
<tr>
<td>Turku, Pansio Port, Finland</td>
<td>TBD</td>
<td>30 000</td>
<td>Gasum/ Skangas</td>
<td>Under discussion</td>
<td>Terminal with loading and unloading of LNG to vessels as well as to LNG trucks is discussed. For the future, train unloading is discussed. Planned operation by 2017.</td>
</tr>
<tr>
<td>Tornio, Finland</td>
<td>Closed</td>
<td>50 000</td>
<td>ManGa LNG</td>
<td>Under production</td>
<td>Terminal mainly for industrial use. Unloading to trucks and vessels is under discussion. Planned operation by 2018.</td>
</tr>
<tr>
<td>Gävle, Sweden</td>
<td>TBD</td>
<td>30 000</td>
<td>Skangas</td>
<td>Under discussion</td>
<td>Terminal with loading and unloading of LNG to vessels as well as to LNG trucks is discussed. For the future, train unloading is discussed. Planned operation by 2017.</td>
</tr>
<tr>
<td>Sundsvall, Sweden</td>
<td>TBD</td>
<td>5 000</td>
<td>TBD</td>
<td>Under discussion</td>
<td>Terminal dedicated to industrial purposes and transportation. Planned loading to trucks and rail distribution. Planned operation by 2020.</td>
</tr>
<tr>
<td>Gothenburg, Sweden</td>
<td>Open</td>
<td>30 000</td>
<td>Swedegas</td>
<td>Under discussion</td>
<td>Redistribution by truck and through a connection to Swe/Dan gas grid as well as bunkering. Planned construction starting 2016.</td>
</tr>
<tr>
<td>Malmö/ Copenhagen, Sweden/Denmark</td>
<td>TBD</td>
<td>10 000</td>
<td>TBD</td>
<td>Under discussion</td>
<td>Redistribution by truck and train and through the Swe/Dan gas grid as well as bunkering is under discussion.</td>
</tr>
<tr>
<td>Aarhus, Denmark</td>
<td>TBD</td>
<td>&lt;10 000</td>
<td>TBD</td>
<td>Under discussion</td>
<td>Terminal for marine purposes. Possible loading of trucks.</td>
</tr>
<tr>
<td>Helsingborg, Sweden</td>
<td>TBD</td>
<td>&lt;15 000</td>
<td>TBD</td>
<td>Under discussion</td>
<td>Redistribution by truck, train, maritime and through local gas grid as well as bunkering is under discussion.</td>
</tr>
<tr>
<td>Trelleborg, Sweden</td>
<td>TBD</td>
<td>&lt;5 000</td>
<td>TBD</td>
<td>Under discussion</td>
<td>LNG supply for maritime purposes, possible loading of trucks</td>
</tr>
<tr>
<td>Hirtshals, Denmark</td>
<td>TBD</td>
<td>500</td>
<td>HMN Naturgas</td>
<td>In operation</td>
<td>Small LNG tank for bunkering of ferries, in operation since 2015.</td>
</tr>
<tr>
<td>Rauma, Finland</td>
<td>TBD</td>
<td>10 000</td>
<td>AGA</td>
<td>Under discussion</td>
<td>Bunkering of ships from trucks and land. Planned operation by 2017.</td>
</tr>
<tr>
<td>HaminaKotka, Finland</td>
<td>TBD</td>
<td>30 000</td>
<td>Haminnan Energia</td>
<td>Under discussion</td>
<td>Terminal with distribution to industries, shipping and trucks. Planned operation by 2018.</td>
</tr>
<tr>
<td>Fjusö/Ingå Helsinki, Finland</td>
<td>TBD</td>
<td>TBD</td>
<td>Gasum</td>
<td>Under discussion</td>
<td>Floating storage facility is planned for maritime use. Planned operation by 2021.</td>
</tr>
<tr>
<td>Riga, Latvia</td>
<td>TBD</td>
<td>180 000</td>
<td>Latvenenergy</td>
<td>Under discussion</td>
<td>Large scale terminal. Planned operation by 2016.</td>
</tr>
<tr>
<td>Vaasa, Finland</td>
<td>TBD</td>
<td>360 000</td>
<td>Gazprom</td>
<td>Under discussion</td>
<td>Planned operation not yet decided.</td>
</tr>
<tr>
<td>Vysotsk</td>
<td>Closed</td>
<td>1 500 000</td>
<td>Gazprom-bank</td>
<td>Under discussion</td>
<td>Terminal for industrial and maritime use. Planned operation not yet decided.</td>
</tr>
</tbody>
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*CCPA* - European Commission for the Protection of the Atmosphere (CCPA)
The LNG Supply chain

Pipe line

- Natural Gas source
  - One or several concession owners
- Liquification plant
  - Usually owned and operated by one local entity co-owned by the concession owners.
- Shipping
  - Vessels usually controlled by concession owners (Downstream)
  - Operation and/or ownership of assets may be made in house or by tonnage providers
- Storage and regasification
  - Usually owned and operated by:
  - Service providers
  - Private or public utilities
  - Limited or no LNG redistribution capability
- Pipeline distribution
  - National or international multi source gas grids
  - Usually owned and operated by private or public utilities
- End users
  - Power plants
  - Other industrial clients
  - Domestic clients
Main issues in the second project

• Choices and decision to be made during the design process:
  – Location of the terminal, and deciding on proper preparations of the land area
  – Size of the terminal or supply
  – Type of tank/supply
  – Volumes of the tank
  – Distribution system for LNG supply; bunkering, truck filling stations, pipelines etc.
  – Financial aspects and investment costs
  – Safety measures and security aspects
Deciding on location

- Optimal location for customers
- Operational efficiency
- Maximize benefits
- Minimize risks
- Safety zones
- Training and education
- Information to the public
LNG Location Criteria

- Dimensions and terminal design
- Location of land based users
- Safety and security aspects
- Exiting jetties or location of possible new jetties
- Safety zones
- Distribution systems for gas – grid, road, rail
- Market potential and possible demand expansion
- Costs
- Environment

The requirements for an optimal location of an LNG terminal for marine purposes is to find suitable onshore terminal areas that:
- are located remote from any existing commercial marine operations
- are on a safe distance from centres of population
- provide safe marine access to berth(s)
- are located in sheltered water
Choosing type of supply and terminal

- Import of LNG
- Storage system
- Distribution system
LNG Storage

Some general storage possibilities are listed below

• No terminal but a truck, supplying LNG directly to the ship
• No terminal but a bunkering vessel, supplying LNG to the ship
• Small storage tank, with pipelines or truck supplying the ship
• Larger storage tank, with pipelines or truck supplying the ship
• Floating storage, large or small size, supplying LNG directly to ships by truck or by pipeline
Floating Storage (FSRU)

- Floating Storage and Regasification Unit
- Volumes around 150 – 250,000 m³
- Supply for both land and maritime use
Risk and safety

- Cryogenic damage – metal embrittlement, cracking, structural failure;
- Cryogenic injuries – frost burns;
- Asphyxiation – if the air oxygen is replaced methane asphyxiation may occur;
- Reduced visibility due to un-ignited vapor clouds;
- Thermal radiation from various fire scenarios;
  - delayed or immediate ignition of vapor clouds (flash fire),
  - slow fire front
  - delayed or immediate ignition of vapor-air mixture (fire ball),
  - rapid burn
  - LNG pool fires or
  - flame jets from leaks in pipes, hoses, tanks or pressure vessels
- Rapid phase transition, RPT;
- Vapor cloud explosion (in confined spaces and enriched with other hydrocarbons);
- Boiling liquid expanding explosions (BLEVE);
- Rollover in LNG storage tanks;
- Sloshing on board LNG tankers
Conclusions

For ports that are about to start the process of establishing LNG bunkering operations, or planning for LNG supply in their port, the following steps are recommended:

- **Technical feasibility study**: First, a thorough feasibility study regarding the market potential for LNG supply in a port and its hinterlands should be made to determine needed volumes and from that different set-ups for LNG storage and sourcing can be suggested. As there is a significant scale of economy in handling of cryogenic gases such as LNG, it is valuable to determine the optimal storage types and suitable bunkering techniques.
- Secondly, a financial overview is suggested to establish the maturity of the project.
- Also important is a thorough inventory of all relevant stakeholders and applicable regulations.
- Thereafter a Design Process can be initiated to determine the needed installations.
- Identify the relevant laws and regulations that apply for the permit process, and in parallel to this a permit process should be initiated to accommodate for any needed alterations and ensure a smooth process.
- Commence a dialogue with the relevant authorities at an early stage. This could be both on local and on national level.
- During the design phase, involve stakeholders and possible financers of the terminal.
Thank you!
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