LNG value chain optimization

Case study: Philippines

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WARTSILA’S INVOLVEMENT IN LNG

Wartsila in Brief
This is Wärtsilä

Marine/Offshore

Power Generation

SOLUTIONS FOR

Net sales by business 2015
Listed in Helsinki
5.0 billion € turnover
Solid financial standing

Marine Solutions 34%
Energy Solutions 22%
Services 43%

18,900 Professionals

EFFICIENCY
GAS AND DUAL-FUEL SOLUTIONS
ENVIRONMENTAL SOLUTIONS

LEADER IN

GAS AND DUAL-FUEL SOLUTIONS

ENVIRONMENTAL SOLUTIONS

LEADER IN
A leader in the global energy industry

ENERGY EFFICIENT SOLUTIONS
Smart Power Generation combining energy efficiency, fuel and operational flexibility
Most complete offering of marine products and integrated solutions, including a broad portfolio of environmental products
Optimised asset performance over the lifecycle

GAS BASED TECHNOLOGY
A forerunner in gas and multi-fuel engines, fuel systems, technology and services
Offering that covers gas value chain from exploration to end consumers
Wide LNG offering in small-scale LNG

INNOVATIVE SOLUTIONS
Making use of digital technology in lifecycle solutions to optimise the operations of our customers
Building on E&A, engineering competence and digitalisation to offer hybrid solutions and new business models
Strong and global track record in distributed energy project management
YOUR SHORTER ROUTE TO THE GAS AGE

Let the leader in LNG enable your smooth transition to gas. We have the expertise, experience and offering you need. Our offering covers integrated solutions*, EPC turnkey delivery**, services and products for all phases of the LNG lifecycle.
Wärtsilä LNG solutions

**ONSHORE**
- Small LNG liquefaction plants
- Mini LNG liquefaction plants
- Medium-scale LNG terminals
- Small satellite LNG terminals
- LNG storage & regasification barge

**OFFSHORE**
- LNG regasification
- BOG reliquefaction
- Cargo handling system
  - Gas and LNG carriers
- Fuel gas handling system
- Ship and cargo tank design

**LIFECYCLE**
- Lifecycle services
- Start-up support
- Product and technical support
- Spares
- Tank control systems
Mini and small-scale liquefaction plants

**INPUT**

Gas sources
- Pipeline gas
- Biogas
- Landfill gas
- Associated gas
- Coal seam gas
- Tight gas
- Shale gas

**PLANT**

2000-300,000 TPA (3400-510,000 GPD)

Gas pre-treatment

Liquefaction
  - Mixed Refrigerant: 2000-30,000 TPA (3400-51,000 GPD)
  - Reversed Brayton: 20,000-300,000 TPA (34,000-510,000 GPD)

Storage tanks
Jetty & marine facilities
Export systems

**OUTPUT**

LNG transport
- Carriers
- Tanker trucks
- Containers
- Rail cars

Peak shaving gas send-out

Ship bunkering
**Small- and medium-scale terminals**

**INPUT**
- LNG transport
  - Carriers
  - Tanker trucks
  - Containers
  - Rail cars

**TERMINAL**
- **Tank capacity**
  - 100-160,000 m³ (26,400-42 million gallons)
- Jetty & marine facilities
- Unloading systems
- Storage tanks
- Boil-off gas handling
- Regasification
  - Up to 1000 TPH (1000 MMSCFD)
- Export systems

**OUTPUT**
- LNG transport
  - Carriers
  - Tanker trucks
  - Containers
  - Rail cars
- Gas send-out
- Ship bunkering

**LNG transport**
- Carriers
- Tanker trucks
- Containers
- Rail cars

**Gas send-out**
- Satellite terminals for gas power plants
- Small satellite terminals
- Storage & regasification barges
- Medium-scale terminals
How does Wärtsilä create value?

Reduce risk by guaranteed price, delivery and performance

We turn project ideas into reality

Increase revenues by shortening project development and EPC lead time

Reduce costs by adequate & standardized solutions
BEFORE: CONVENTIONAL LNG VALUE CHAIN
AFTER: CONVENTIONAL + SMALL-SCALE VALUE CHAIN
VALUE CHAIN OPTIMIZATION
Value chain optimization

• When developing an LNG project, it is important to consider the setup and reliability of the whole LNG value chain in order to achieve an affordable and well-functioning system.
• Wartsila has the experience and tools that already at an early stage allow us to simulate an LNG value chain to preliminarily determine:
  • LNG storage tank sizes
  • LNG carrier fleet
  • Routing of fleet
  • Price of LNG delivered at site
Tank dimensioning philosophy

<table>
<thead>
<tr>
<th>Function</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage Capacity</td>
<td>Send-out Rate</td>
</tr>
<tr>
<td></td>
<td>Reserve requirement</td>
</tr>
<tr>
<td></td>
<td>Heel Requirement</td>
</tr>
</tbody>
</table>

• Optimization of the logistic chain might show that choosing a higher investment in CAPEX leads to lower costs of delivered LNG
• Is the most optimal solution available to you?
• Do you trust the logistical chain to perform as planned?
Risks in the logistical chain

• Times at port and congestion delays are normally under-calculated
  • Unloading a part cargo takes almost the same time as unloading a full cargo
• Availability of suitable LNG carriers
  • Few LNG carriers available immediately
• LNG supplier’s ship requirements
• Draft restrictions
• Port costs
• Probability of delays: Do we need to build in large reserve tank capacity?

One-to-one

Milk run
Case: Philippines

<table>
<thead>
<tr>
<th>Site</th>
<th>MW</th>
<th>LNG consumption m³/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Puerto Princesa</td>
<td>30</td>
<td>289.5</td>
</tr>
<tr>
<td>Iloilo</td>
<td>50</td>
<td>482.5</td>
</tr>
<tr>
<td>Toledo</td>
<td>30</td>
<td>289.5</td>
</tr>
<tr>
<td>Nasipit</td>
<td>100</td>
<td>965</td>
</tr>
</tbody>
</table>

FOB LNG price has been set to 8 USD / mmBtu
Case: Philippines

**Inputs**
- Locations of supply and receiving ports
- Distances between all ports
- Demands at receiving ports
- Ship sizes, charter costs, etc.
- Loading/unloading rates, berthing times
- Investment costs for terminals
- Time horizon for study
- Possible constraints

The following LNG carrier sizes were allowed for this case study:
- 5,000 m³
- 7,500 m³
- 10,000 m³
- 15,000 m³
- 30,000 m³
- 40,000 m³

Rest of the input data is based on assumptions and experiences from elsewhere in the world. No restrictions regarding draught have been considered.
LNG CONSUMPTION IN A POWER PLANT

200 MW plant (baseload 8000 h/year)
620,000 m³/year (=280,000 tonnes/year)

100 MW plant (baseload 8000 h/year)
310,000 m³/year (=140,000 tonnes/year)

50 MW plant (baseload 8000 h/year); OR
100 MW (flexible baseload = 4000 h/year); OR
200 MW (peak load = 2000 h/year)
155,000 m³/year (=70,000 tonnes/year)
Optimization shows that a system price of 10.2 USD/mmBtu for LNG delivered at site is achievable

- Point where cost of delivered LNG is minimized
- 8 days of storage gives an optimal system

Cost of delivered LNG (excl. FOB price)
Terminal investment costs
Logistical costs
## Tank storage – Analysis of 5 periods of 8 days

<table>
<thead>
<tr>
<th>Site</th>
<th>MW</th>
<th>LNG consumption m³ / day</th>
<th>Tank size m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Puerto Princesa</td>
<td>30</td>
<td>289.5</td>
<td>3,088</td>
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<tr>
<td>Iloilo</td>
<td>50</td>
<td>482.5</td>
<td>5,147</td>
</tr>
<tr>
<td>Toledo</td>
<td>30</td>
<td>289.5</td>
<td>3,088</td>
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<tr>
<td>Nasipit</td>
<td>100</td>
<td>965</td>
<td>10,293</td>
</tr>
</tbody>
</table>

Example of what a 5,000 m³ terminal could look like
Recommended fleet

One 30,000 m³ LNG carrier
Utilization of capacity ≈ 68 %

Approximate dimensions:
- Length overall: 185 m
- Breadth: 28 m
- Design draught: 8.5 m
- Design speed: 15.5 knots

If there are draught limitations, these can be set in the input data, whereby the simulation will yield a different result.
Routing – 8 days time periods & 30,000 m³ LNGC

Batangas → Toledo → Nasipit → Iloilo → Puerto Princesa → Batangas
If terminal investment costs don’t need to be considered, logistical costs can be lowered.

**Tank storage – Analysis of 5 periods of 17 days**

<table>
<thead>
<tr>
<th>Site</th>
<th>MW</th>
<th>LNG consumption m³ / day</th>
<th>Tank size m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Puerto Princesa</td>
<td>30</td>
<td>289.5</td>
<td>8,810</td>
</tr>
<tr>
<td>Iloilo</td>
<td>50</td>
<td>482.5</td>
<td>11,686</td>
</tr>
<tr>
<td>Toledo</td>
<td>30</td>
<td>289.5</td>
<td>6,562</td>
</tr>
<tr>
<td>Nasipit</td>
<td>100</td>
<td>965</td>
<td>22,683</td>
</tr>
</tbody>
</table>

Storage level at beginning of period:

- Iloilo
- Nasipit
- Puerto Princesa
- Toledo

Tanks would be considerably larger.
Routing – 17 days time periods & 15,000 m³ LNGC

If terminal investment costs don’t need to be considered, logistical costs can be lowered.

Periods 1, 3 & 5

Batangas → Toledo → Nasipit → Batangas
Batangas → Nasipit → Batangas
Batangas → Iloilo → Puerto Princesa → Batangas

Periods 2 & 4

Batangas → Iloilo → Nasipit → Batangas
Batangas → Nasipit → Batangas
Batangas → Toledo → Puerto Princesa → Batangas
Common hurdles in small-scale LNG projects

- Supply of LNG in small quantities might be difficult to arrange
- LNG is new to authorities, so it takes time to identify requirements for FEED study & tender
- Limitations and requirements (e.g. marine infrastructure) dictated by the site increase costs
- Failure to consider the whole LNG value chain, which may have a greater impact on the price of delivered LNG than the CAPEX of the terminal.
- Difficulty of signing up customers due to project uncertainties, such as difficulty to estimate what the small-scale LNG price will be
- Financing
More than equipment

In addition to a safe, well-functioning and complete LNG facility, Wärtsilä creates value by ensuring:

- Expertise and contacts in the shipping industry
- Optimization of the LNG value chain
- Constructability of the facility
THANK YOU
KIITOS
SALAMAT