Liquefied-to-Compressed Natural Gas Opportunities & Strategies
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**What is LNG?**

- LNG is natural gas that has been cooled downed and condensed to liquid state

- **1 liter of LNG = 600 liters of Natural Gas at 1 bar**

- LNG temperature at 1 bar is \(-163^\circ C\)

- LNG contains in average 93 to 98 % of methane (CH4)

- **1 m3 of LNG = 580 liters of diesel in terms of energy content (=25,2 Gigajoule)**

- **1 m3 of LNG = 460 Kg**

- LNG is available at large import terminals or small scale liquefaction plants (biogas)
Where to get LNG from?

- Landfill Gas
- Biogas (Agricultural wastes and Sewage)
- Associated Gas from oil wells
- Non-Associated Gas (Gas wells without pipeline access)
- Coalbed Methane/Coal Seam Methane
- Coal Mine Methane (Recovery for safety or GHG reduction)
- Transmission and distribution lines

Fleet Refuelling
- LNG
- LCNG

Off-grid Customers
- Industries
- Communities

Peak Shaving and Infrastructure Reinforcement
**LNG and LCNG Vehicles Refueling**

**LNG + LCNG Refueling Station**

- From LNG it is possible to fuel both LNG and CNG into vehicles (Trucks, buses, trains, ships, …)
- LNG and LCNG station usually require LNG delivered by trailer from terminal or small scale production plant
- Colder the LNG is, higher its density is, and longer its storage can be
- The composition of LNG will **not** change from the production source downstream to the vehicles
Liquefied-to-Compressed Natural Gas Opportunities & Strategies

★ LNG and CNG Vehicles Refueling

★ LCNG stations (Liquid to Gas)

- LCNG station allows refuelling of CNG vehicles with a **0.05 KW/kg** specific power requirement
- LCNG station usually require LNG storage at a minimum of **3 bar/-153°C**
- Colder the LNG is, higher its density is, and longer its storage can be
- LCNG stations are not that sensible to heat entries as the LNG is transformed to gas

MRP pump
AGA, SWEDEN
### 800 Nm³/h typical LCNG stations characteristics

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<tbody>
<tr>
<td>Maximum fuelling pressure:</td>
<td>250 bar @ 15°C</td>
<td></td>
<td></td>
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<tr>
<td>Intermediate storage:</td>
<td>300 bar</td>
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<tr>
<td>Flow regulation:</td>
<td>with VFD for flow regulation</td>
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<tr>
<td>Average refueling time:</td>
<td>2 minutes for a 80 litres tank</td>
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<tr>
<td>Number of vehicles/h:</td>
<td>12 vehicles/dispenser</td>
<td></td>
<td></td>
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<tr>
<td>Fuelling flow at nozzle:</td>
<td>9.5 KG/min (800 Nm³/h)</td>
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</tr>
<tr>
<td>Measurement accuracy:</td>
<td>99.9% (Coriolis)</td>
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<tr>
<td>Station power requirement:</td>
<td>Approximately 30KW (0.05 KW/kg)</td>
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</tbody>
</table>
**LNG and CNG Vehicles Refueling**

**LNG stations (Liquid to Liquid)**

- LNG station allows refuelling of LNG vehicles with LNG with a **0.005 KW/kg** specific power requirement
- LNG station usually requires LNG storage from **3 bar/-153°C to 10 bar/-125°C**
- LNG at 3 bar and -153°C is called **« cold LNG »** when 8 bar and -130°C LNG is called **« saturated LNG »**
- LNG stations are quite sensible to heat entries as the LNG can boil off quite rapidly
**Typical LNG station characteristics**

- **Fuelling temperature:** -150°C (cold) to -130°C (saturated)
- **Fuelling pressure:** 3 to 10 bar
- **LNG pump skid flow:** 320 l/min @ 12 bar diff. pressure
- **Fueling flow at nozzle:** 160 l/min
- **Average refueling time:** 3 minutes for 450l tank
- **Number of vehicles/h:** 10 vehicles/dispenser
- **Measurement accuracy:** 99.5% (W&M MID approved)
- **Power requirements:** Approximately 20 KW (0.005 KW/kg)
Advantages of LCNG stations

- The best and most efficient solution for mother daughter station system
- Possibility to distribute CNG when no grid is available nearby
- High purity CH4 source, indeed LNG is already purified at liquefaction stage
- Operational cost reduction compared to a compressor solution (Power)
- Lower investment than a compressor solution (in case of low pressure grid)
- LNG for transportation takes 600 times less space than CNG at 1 bar
- Great solution to start with LNG fueling and small trial fleets
Advantages of LNG stations

- Independent refueling stations allowing for alternative gas sourcing

- The unique solution to distribute LNG to heavy duty vehicles

- Huge operational cost reduction compared to CNG or LCNG stations (power)

- Can be installed anywhere on public or private areas

- Much lower investment cost than LCNG or CNG stations (in €/kg.min capacity)

- Possibility to have mobile stations for easy trials
Basic requirements for LCNG and LNG stations

- There is no CNG grid where I want to install my station!

- I need to fuel LNG vehicles...

- I want to set-up a mother daughter stations concept

- I need to fuel large amounts of CNG into vehicles

- I want to be able to chose my gas provider

- I need both CNG and LNG fueling capability on my station

- I have an available LNG source available

- Piggy back on industrial power supply through LNG
**Economics of LCNG and LNG stations**

**Typical investment cost:**

- Investment for a typical LCNG station of 800 Nm3/h flow (1 disp.): 550'000 €
- Investment for an LNG station with 1 LNG dispenser: 600’000 €
- Investment for a moveable LNG station: 450’000 €
- Investment for an LNG + LCNG station (above performances): 900’000 €
### Economics of LCNG and LNG stations

**Typical operational costs:**

- Electrical consumption for a typical LCNG station of 800 Nm3/h flow: **0,05 Kwh/Kg**
- Maintenance cost for a typical LCNG station with 1 dispenser: **0,005 €/Kg**

- Electrical consumption for a typical LNG station with 1 dispenser: **0,005 Kwh/Kg**
- Maintenance cost for a typical LNG station with 1 dispenser: **0,001 €/Kg**

*If combined LNG + LCNG station, these costs can be cumulated*
**Economics of LCNG and LNG stations**

Data:
- Consumption: 1700 T/year
- Equivalent to 800 Nm³/h
- Electricity price: 0.1 €/kwh
- Gas price: Equivalent
- ROI: 3 years

Gas prices articulation

Operational costs
Capital expenditures
Transportation costs
Gas cost
**Economics of LCNG and LNG stations**

**Gas prices matrix**

**Data:**
- Consumption: 1700 T/year
- Equivalent to 800Nm³/h
- Electricity price: 0,1 €/kwh
- Gas price: Equivalent
- ROI: 3 years

*Note: for the same capital expenditure the LNG station can provide up to 4000 Tons per year*
**Decision matrix**

**Environmental factors:**
- I have no possibility to access the grid
- I want to set-up a mother/daughter station concept
- I want to get gas from different sources
- I need to fuel high volumes of CNG

**Customers:**
- My customer is using LNG vehicles, or has plans to do so
- My customer is using, or wants to use LNG for industrial purpose
- My customer wants to use Bio LNG

**LNG supply:**
- Is LNG available?
- Is Bio LNG available?
- What is my back-up solution?
- What is the cost for LNG delivered on site?

**Business plan:**
- May I integrate the benefits of running LNG vehicles into my business plan?
- LNG fueling will allow for much higher consumption
- What is the cost difference per Kg with CNG?
- Who’s investing into the station, and at which point will the gas been sold?
Reference Project – LCNG station Brazil
Reference Project – Public LCNG station Sweden
**Reference Project – LNG and LCNG station POLB (CA)**
Reference Project – LCNG station for HDV’s Sweden
Reference Project – LNG station Australia (Tasmania)
Reference Project – LNG and LCNG station Sweden (Göteborg)
Reference Project – LCNG and LNG station Los Angeles (CA)
Conclusion

- LNG and LCNG stations are ideal in some specific cases

- They allow for an alternative to CNG stations allowing for different business model

- With increasing number of LNG trucks, LCNG becomes a serious option

- ISO Standards are being discussed for LNG and LCNG stations construction

- The increasing LNG trade worldwide will provide for more on-shore LNG

- LCNG and LNG stations are ideal when using liquefied biogas or landfill gas
Thank you for your attention

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