



LNG AS A FUEL FOR VEHICLES





★ Different refueling technologies

★ CNG: Compressed Natural Gas refueling

- Gas coming from a gaseous source (pipeline)
- Refueling in gas

★ LNG: Liquefied Natural Gas refueling

- Gas coming from a liquid source at -163°C
- Refueling in liquid

★ LCNG: Liquid to Compressed Natural Gas refueling

- Gas coming from a liquid source at -163°C
- Refueling in gas



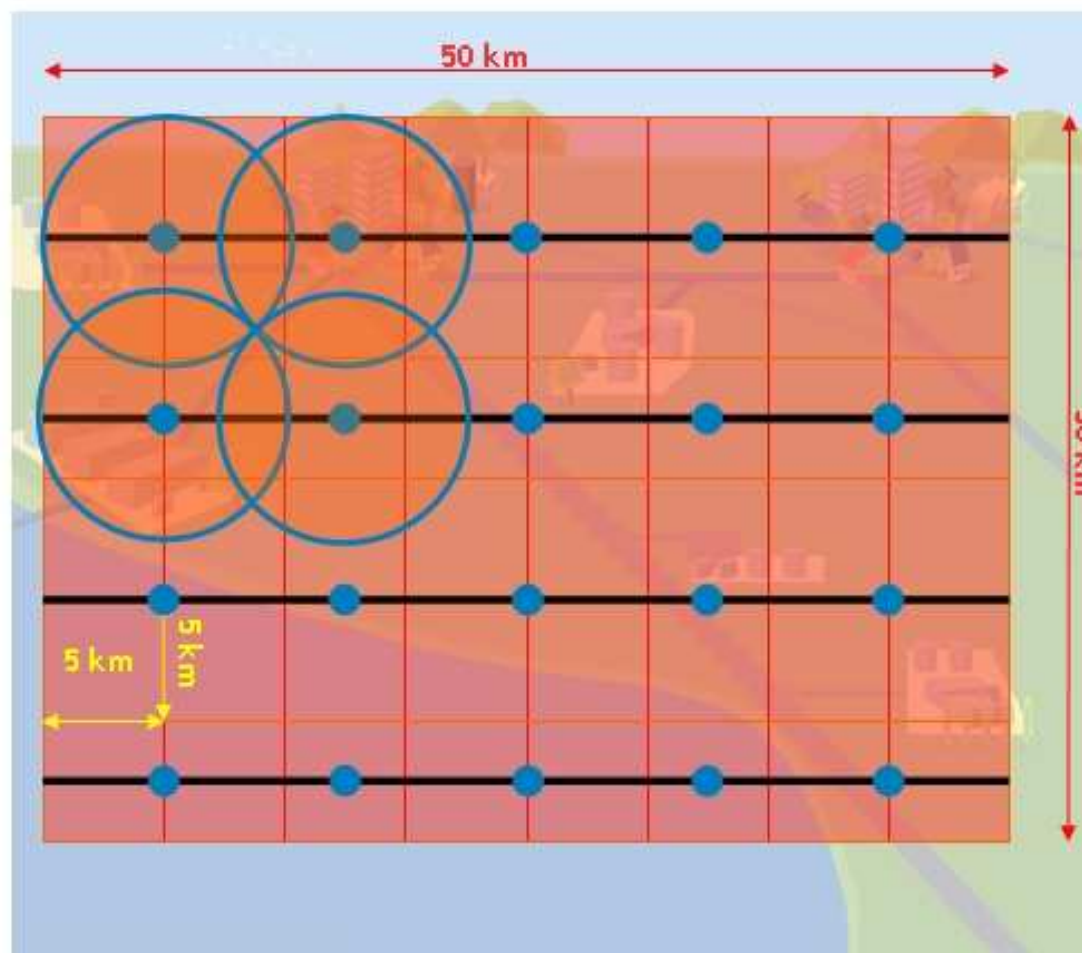


★ Compressed Natural Gas (CNG) - Local supply for Natural Gas Vehicles

Infrastructure WITH EXISTING natural gas grid

On 50x50 km area:

- ✓ CNG station every 7.5 km
- ✓ 300 km of pipeline
- ✓ approx 36 CNG filling stations



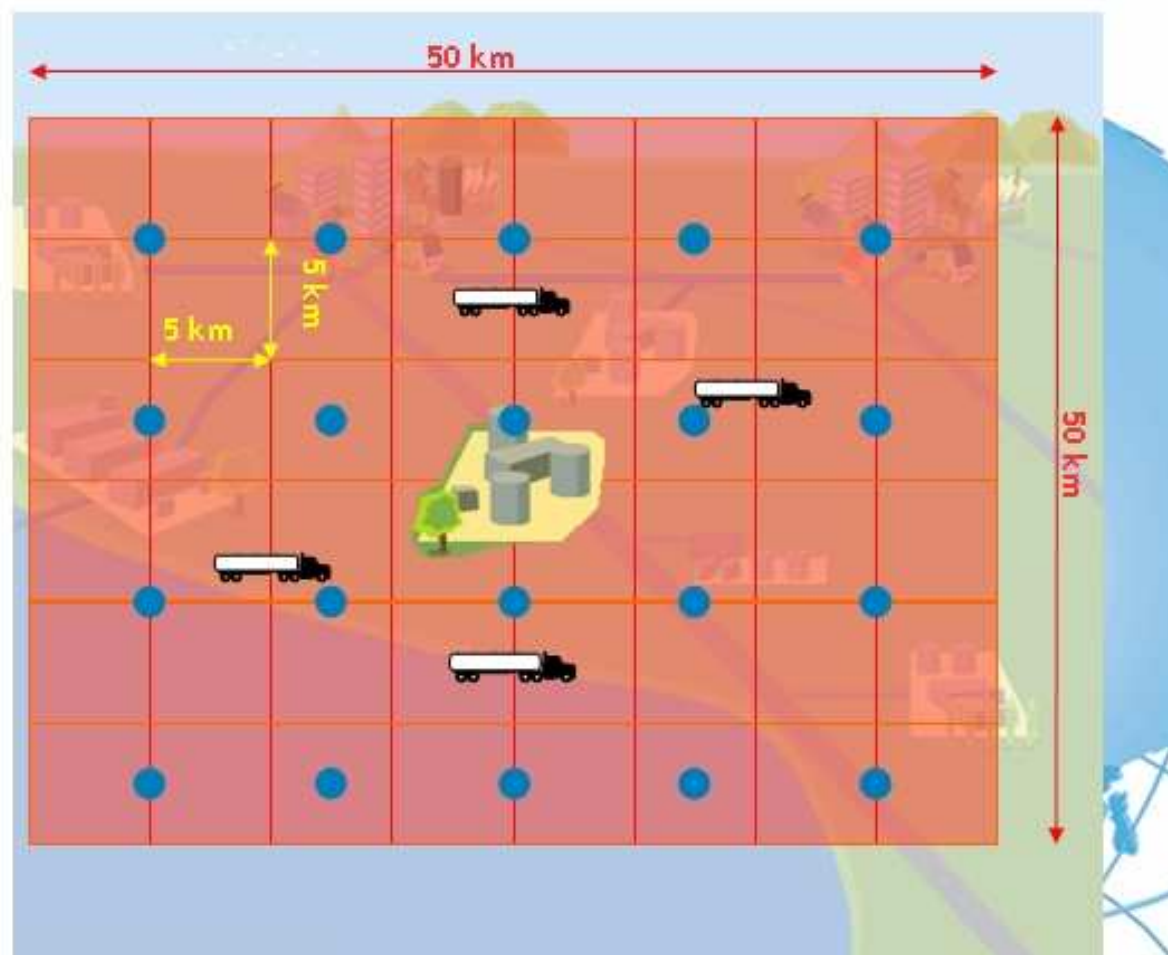


★ Liquid Natural Gas (LNG) - Local supply for Natural Gas Vehicles

Infrastructure WITHOUT natural gas grid

On 50x50 km area:

- ✓ LCNG station every 7.5 km
- ✓ 1 liquefaction plant or
- ✓ 1 LNG terminal, or 1 biogas
- ✓ Liquefaction plant
- ✓ 5-6 semi trailers for delivery
- ✓ 36 LCNG filling stations





★ LCNG vs CNG

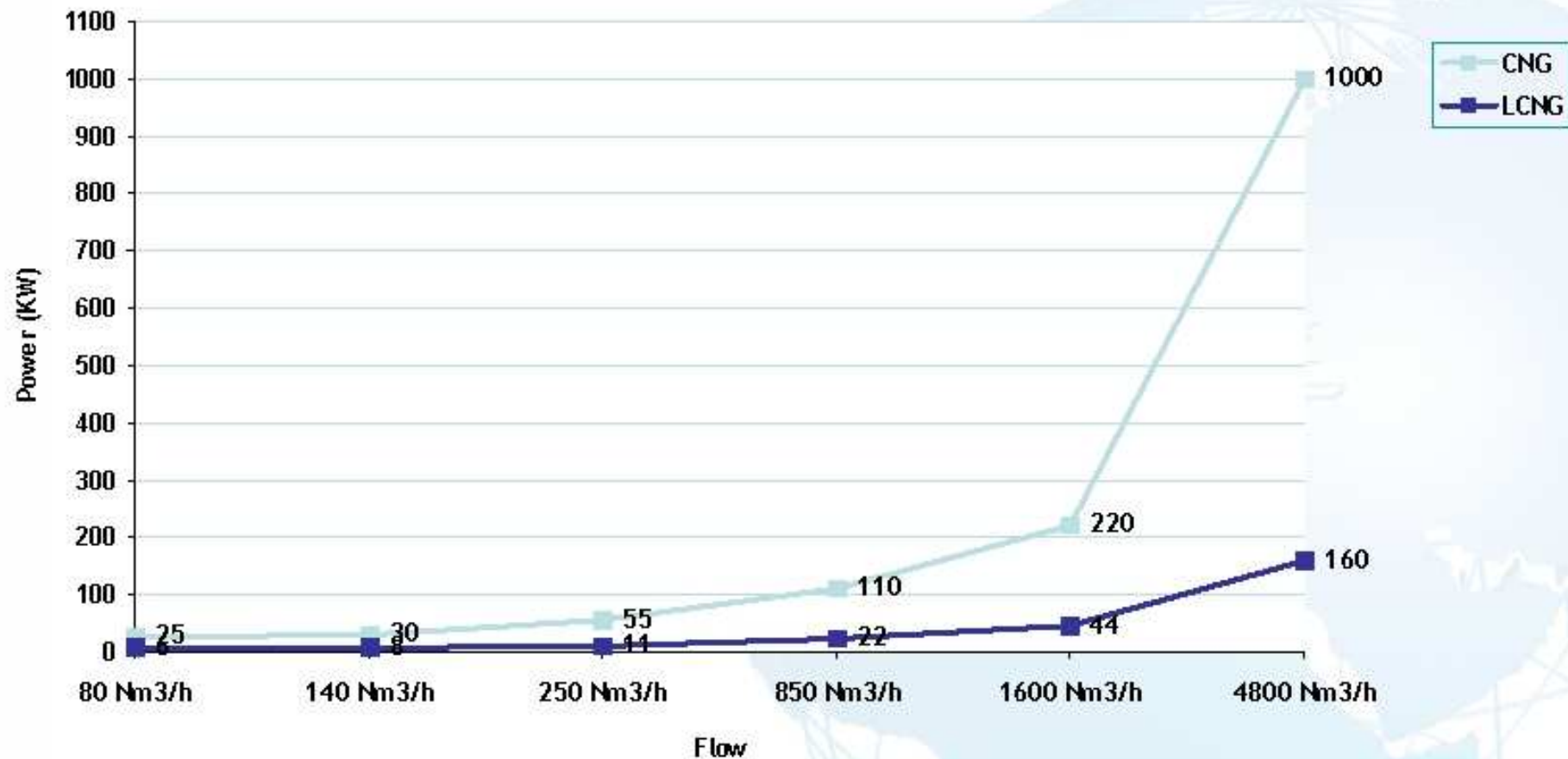
- **High purity** CH₄ source, indeed LNG is already purified at liquefaction stage
- **Energy cost reduction** compared to a compressor solution (Approx. 4 times less)
- **Lower maintenance costs** than a compressor solution (Approx. 3 times less)
- **Flexibility** => possibility to fill both in LNG and in CNG from the same source of gas
- **Independent** refueling stations using a dedicated LNG storage

➤ *30 to 40 years ago, most of the industrial gases were filled into bottles by compressors. Today 90% of the cylinders are filled by cryogenic pumps connected to liquid storage tanks*



★ LCNG vs CNG - Power consumption

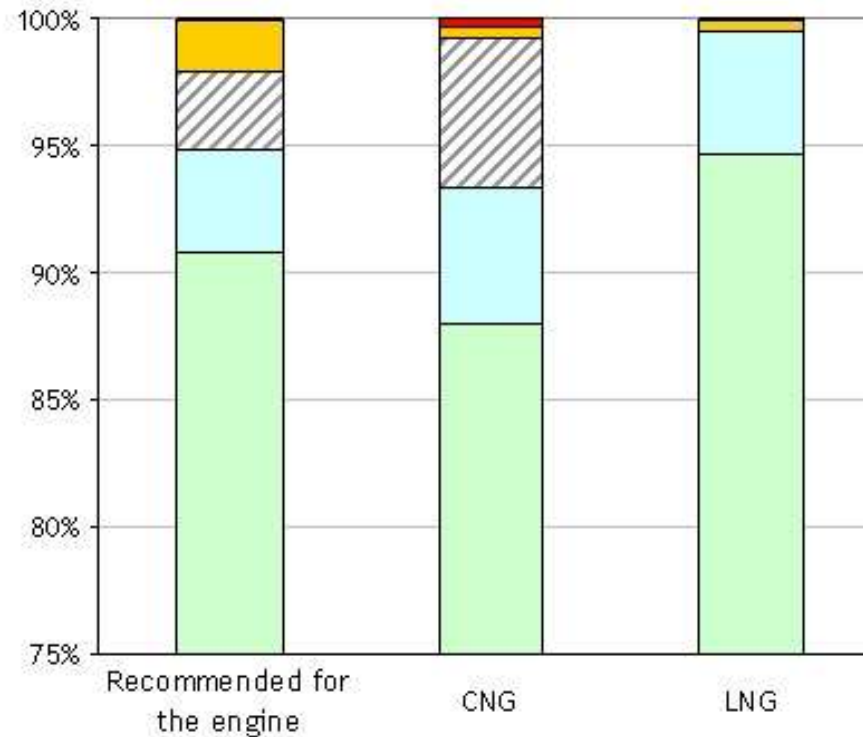
LNG requires less power to be pressurized than CNG as it takes **630 times** less space at 1 bar and 15°





★ LNG vs CNG - Gas purity

- LNG is already purified at liquefaction stage ensuring a high quality off delivered gas

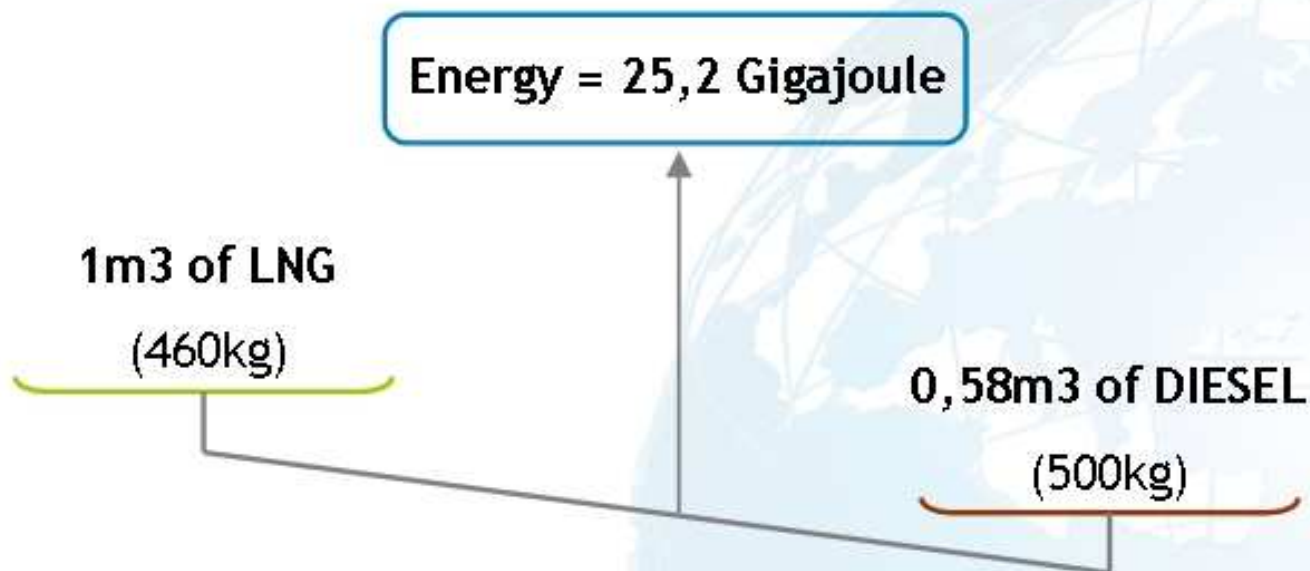


Component	Recommended for the engine	CNG	LNG
Other (O2, H2, CO, He etc...)	0,1	0,3	0,08
Propane	2	0,46	0,4
Co2 and Nitrogen	3	6	0,02
Ethane	4	5,34	4,8
Methane	90	88,9	94,7





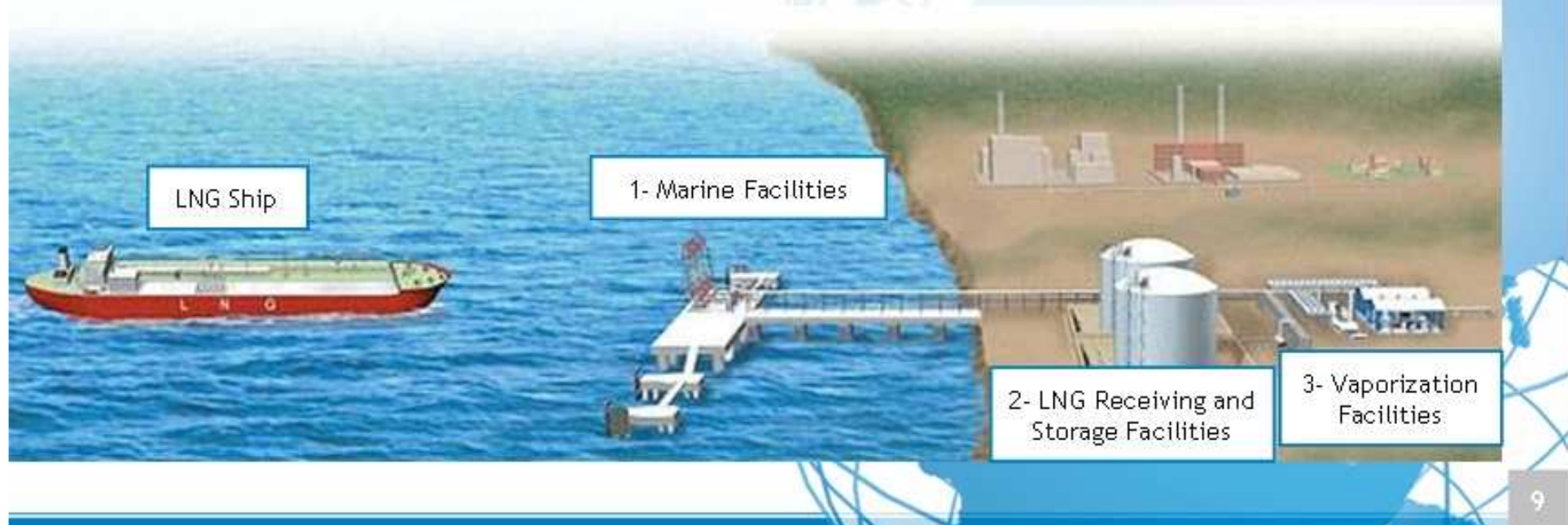
★ LNG vs Diesel





Liquid Natural Gas (LNG) - LNG Terminal

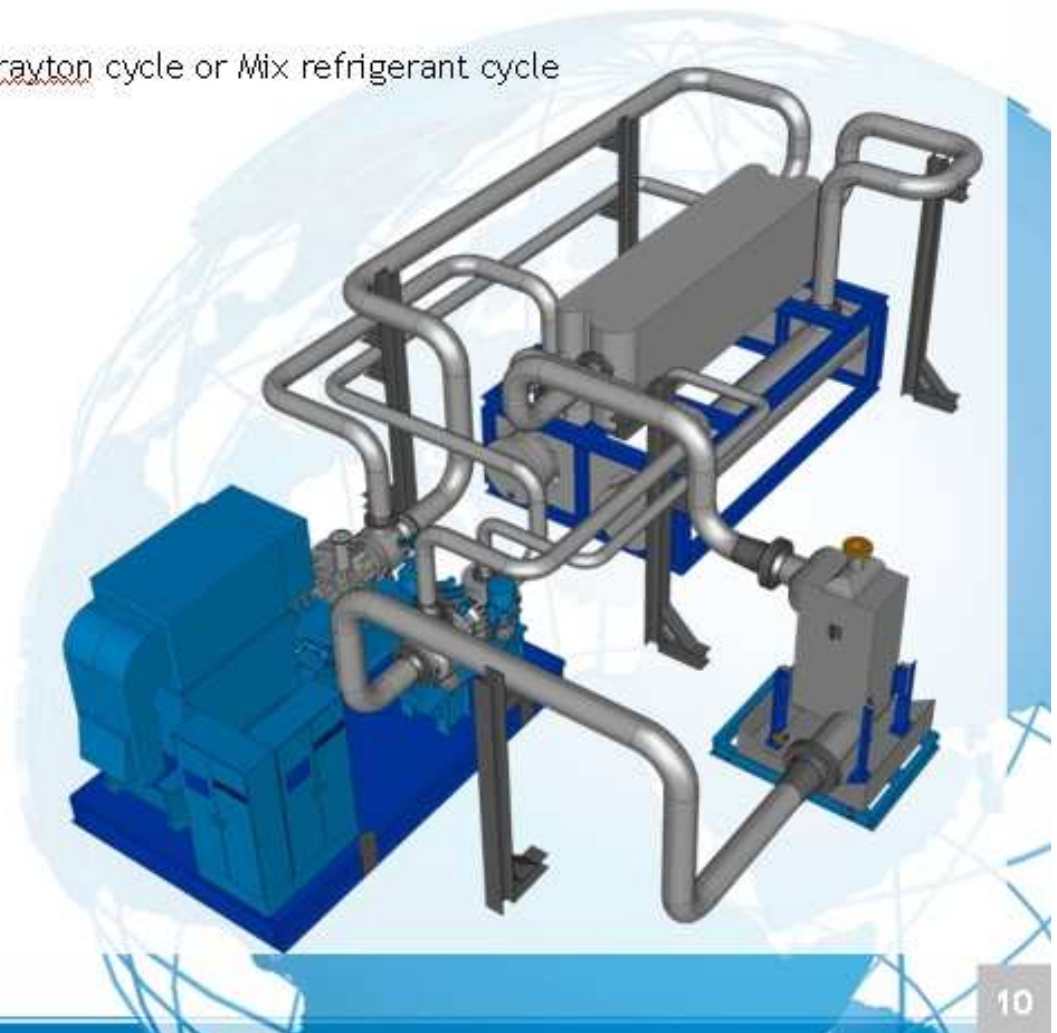
- LNG can be transported by water, road, and train
- LNG is kept in its liquid form and has not to be vaporized on site
- The storage capacities are enormous allowing supply of gas for peak shaving (mostly during winter time)
- Ship with 100'000 M3 of LNG is enough to supply gas for a 1 million people city during 1 year





★ Liquid Natural Gas (LNG) - Small scale liquefaction plants

- ★ Main liquefaction methods: Nitrogen Brayton cycle or Mix refrigerant cycle
- ★ Liquefaction from 10 to 300 TPD
- ★ Pipeline gas liquefaction
- ★ Biogas liquefaction





★ Liquid Natural Gas (LNG) - Bulk Logistic





★ Liquid Natural Gas (LNG) - Local transportation

Nowadays LNG is mostly transported by diesel powered trailers
Knowing that LNG is much cleaner than diesel why not carrying clean fuel with clean trailers?



LNG semi trailer using WESTPORT HPDI technology with CRYOSTAR pump increasing the cleanliness of the overall LNG supply chain

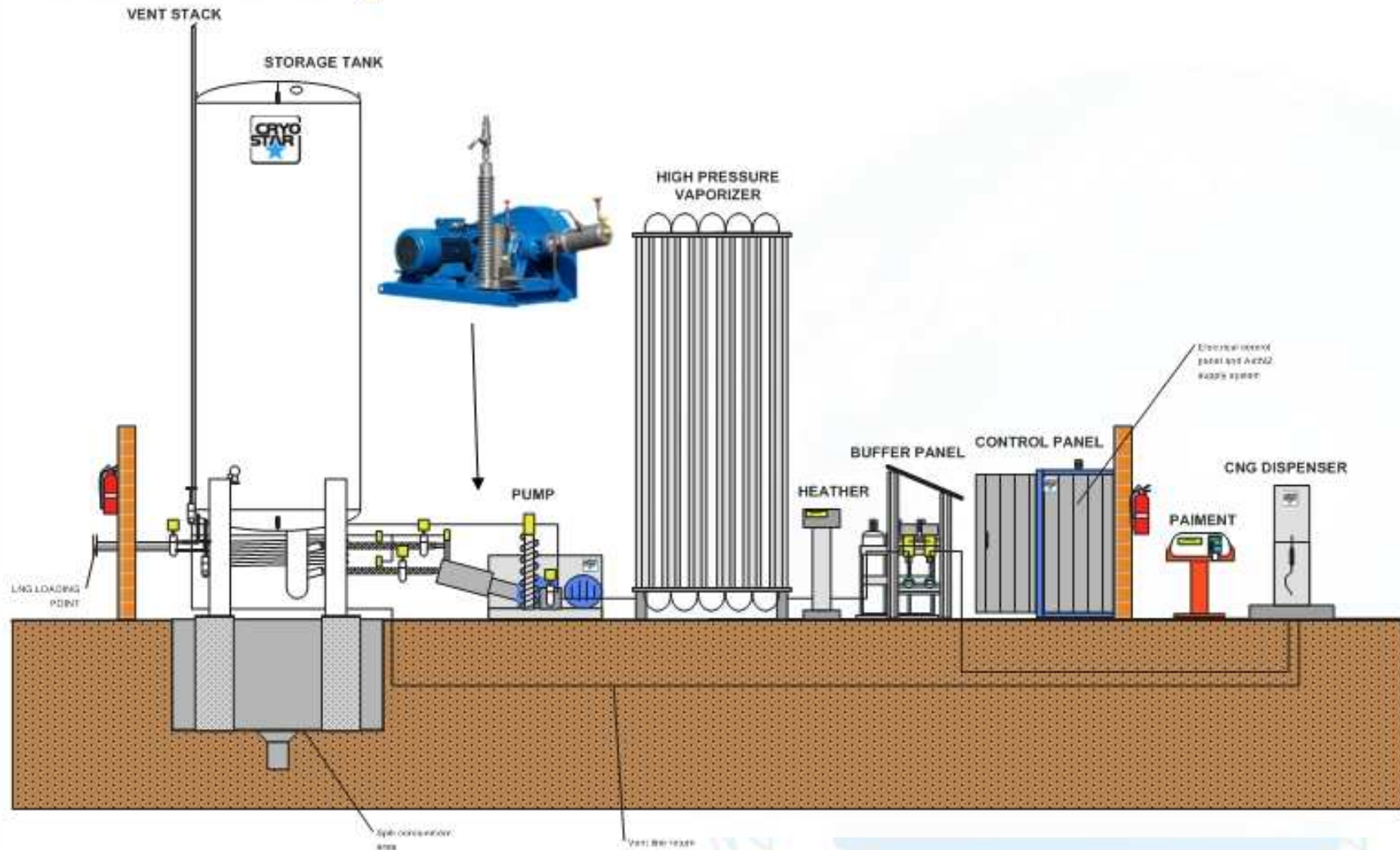


★ Typical LCNG and LNG refueling station layout





★ LCNG Station - Design





★ LCNG station - Typical characteristics

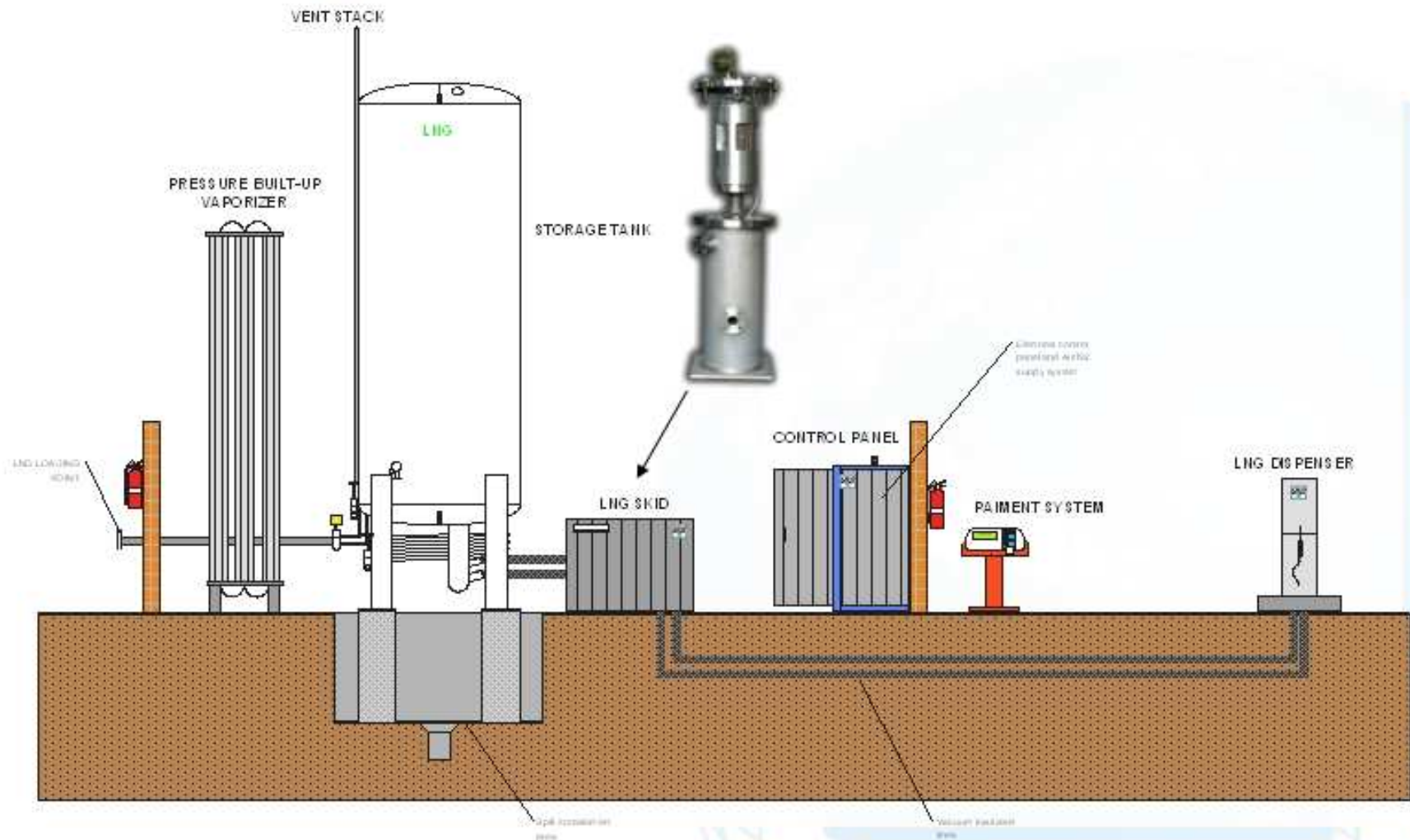
Fuelling pressure:	200 bar
Intermediate storage:	300 bar
Station flow:	500 Nm ³ /h to 8000 Nm ³ /h
Flow regulation:	with VFD
Average refueling time:	3-4 minutes @ 200 bar
Number of vehicles per hour:	12 vehicles/dispenser
Fuelling flow per dispenser:	70 Nm ³ /min
Measurement accuracy:	99,9% (Coriolis)



Environmental advantages: Low gas losses



★ LNG Station - Design





★ LNG station - Typical characteristics

Fuelling temperature:	-160°C
Fuelling pressure:	3 to 8 bar
Average refueling time:	5-7 minutes
Number of vehicles per hour:	10 vehicles/dispenser
Fuelling flow per dispenser:	160 l/min
CH4 vapor emissions:	Close to 0
Measurement accuracy:	99,5%
Payment system:	Credit card
Special device:	Induction video on dispenser

Environmental advantages: Close to 0 CH4 emissions





★ Dispensers for LNG

- Two different models of dispensers are available, depending to customer requirements (Retail design dispenser with advanced features, and basic industrial type dispenser...)
- All the dispensers are equipped LNG nozzles (Models on request) and insulated flexible hose.
- The dispensed gas is measured through a density measuring flow meter (coriolis) which takes in consideration the gas bubbles into the LNG
- The fuelling is achieved as soon as a certain pressure or low flow level is reached, or by pushing the stop button
- Features:
 - ✓ Digital screen showing the delivered volume, price per litter, and total price
 - ✓ Integrated credit card payment system (Retail type only)
 - ✓ Integrated induction LCD video screen (Retail type only)
 - ✓ Possibility to connect the dispenser to a fuel management system
 - ✓ Possibility to dispense both cold and saturated fuel
 - ✓ Reduction of the gas losses, and re-liquefaction of the vehicle boil off gas





★ CRYOSTAR References - 22 Stations worldwide

Customer	System	Qty.	Project	Nation	world region
M1 ENGINEERING	LCNG + LNG station	1	Hardstaff LCNG station project	UK	Northern europe
GASLOCAL	LCNG station	1	LCNG refuelling stations 2 pumps	Brazil	America
GASLOCAL	LCNG station	1	LCNG refuelling stations 2 pumps	Brazil	America
GASLOCAL	LCNG station	1	LCNG refuelling stations 4 pumps	Brazil	America
GASLOCAL	LCNG station	1	LCNG refuelling stations 4 pumps	Brazil	America
CLEAN ENERGY	LNG station	1	Port of long beach	USA	America
PTT - CRYOTECH	LNG station	1	LNG station with 1 LNG dispenser	Thailand	Asia
CITY OF LA	LNG+LCNG station	1	Large LNG + LCNG station	USA	America
CITY OF COMMERCE	LNG+LCNG station	1	LNG + LCNG station	USA	America
AGA SWEDEN	LCNG station	1	LCNG station for Biogas	Sweden	Northern europe
LNGR - BOC	LNG station	6	LNG station for forest trucks	Australia	Pacrim
KRI	LNG station	1	LNG station for buses	Poland	Central Europe
LNGR - BOC	LNG station	3	LNG station for forest trucks	Australia	Pacrim
AGA SWEDEN	LCNG station	1	LCNG station for public use	Sweden	Northern europe







Thank you for your attention

