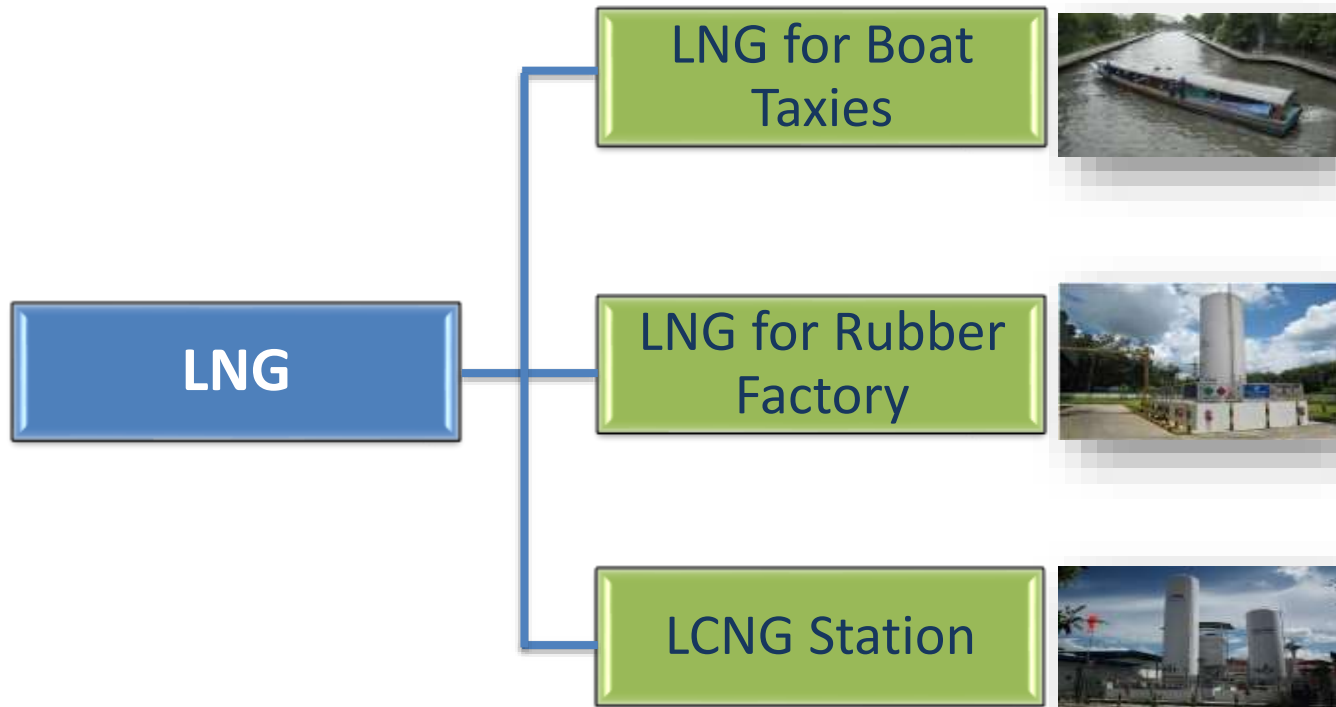


# LNG Application in Transportation





# LNG Application





# LNG Application



LCNG Station,  
Chiang Mai



LNG for Boat Taxis,  
Bangkok



LNG in Industrial Sector



Small LNG Plant, Sukhothai

# LNG for Canal Taxis

- Family Transportation (2002) Co.Ltd., a boat taxis servicer on Saen Saeb canal, has joined with PTT in using LNG by converting 72 boat taxis to run on LNG/Diesel Dual Fuel
- Each boat taxi is equipped with Cummins engine, 270 hp.
- The project started in November 2009. 26 boats were installed with LNG (DDF) conversion equipments and one boat was installed with dedicated engine.
- LNG replacement is 50 percents.



**LNG refueling station for Saen Saeb canal taxis**

- Two LNG tanks with capacity of 36,000 liters each
- One hose dispensing 120 liters of LNG per minute



**17,000-Liter  
LNG Truck**



**LNG production Plant at  
Sukothai province**



**Boat Taxis**



**Boat Machine Using LNG**



**450-Litre LNG Cylinder**



# LNG for Canal Taxis

## LNG Station



**LNG Tanks**  
**(36,000 Liters x 2)**



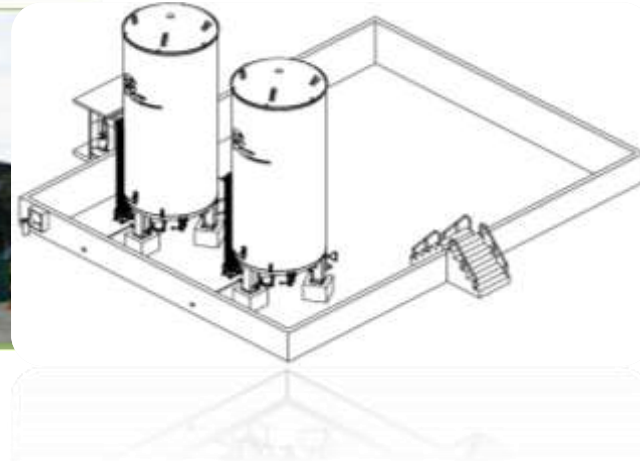
**LNG Pump**  
**120 Liters/minute**



**LNG One Hose**  
**Dispenser**



**Gas Detector**



# LNG for Canal Taxis

## Canal Taxis equipped with LNG conversion kit and cylinder



**Diesel Dual Fuel (DDF)  
Cummin Engine:  
Big Cam 270 HP**



**LNG Refueling**



**LNG Cylinder  
Capacity 450 Liter**



**Heat exchanger using hot  
water from the engine**



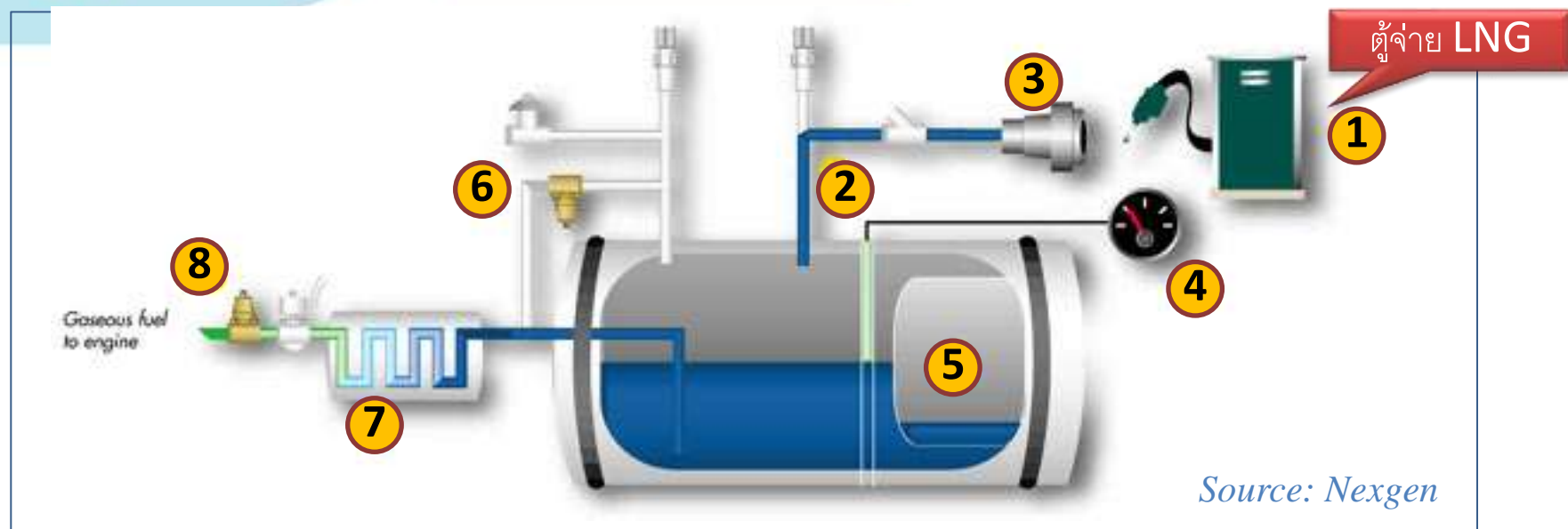
**Pressure Regulator**



**Gas-Air Mixer**



## อุปกรณ์เติม LNG และอุปกรณ์ LNG ที่ติดตั้งในเรือ



1. ตู้จ่าย LNG แบบ 1 หัวเติม
2. & 3. หัวรับ LNG แบบเติมด้านบน (Top Fill) เพื่อช่วยให้การเติม LNG ทำได้รวดเร็วขึ้น โดยมีการติดตั้ง Check Valve เพื่อป้องกันแรงดันไหลย้อน
4. เกจวัดปริมาณ LNG ในถังเก็บ
5. ผู้ผลิตบางรายอาจมีการออกแบบให้มี LNG Vapor Space ในถัง LNG ที่ติดตั้งบนเรือ เพื่อรองรับความดันไอของ LNG ในกรณีที่เพิ่มสูงขึ้น และช่วยขยายระยะเวลาในการเก็บ LNG เมื่อไม่มีการใช้งาน
6. อุปกรณ์ที่ทำหน้าที่ควบคุมความดันในถังให้อยู่ในระดับความดันในการใช้งานปกติ
7. อุปกรณ์เปลี่ยนสถานะ LNG ให้เป็นก๊าซ ซึ่งโดยปกติแล้วจะใช้น้ำร้อนจากเครื่องยนต์ ในการให้ความร้อน
8. อุปกรณ์ควบคุมความดันก๊าซก่อนเข้าเครื่องยนต์ไม่ให้สูงเกินกว่าที่ผู้ผลิตเครื่องยนต์กำหนด





# Personal Equipment (PPE)

## LNG Fuel Dispensers

Unlike diesel, the following Personal Equipment (PPE) **MUST** be worn when dispensing or off-loading LNG in order to protect against accidental exposure to the cold LNG, piping or other cold surfaces.

- ☐ Face shield
  - ☐ Safety glasses
  - ☐ Long sleeve shirt or coat
  - ☐ Cryogenic approved gloves
  - ☐ Full length pants without cuffs
  - ☐ Proper footwear - No running shoes!
  - ☐ Full length smock without pockets
- (For LNG Off-Loading)







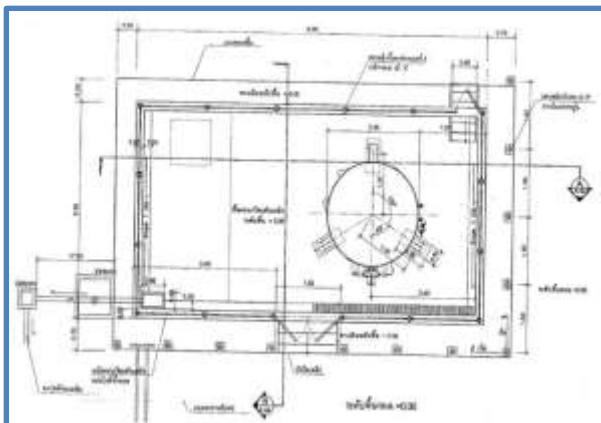
# LNG Application in Industrial Sector (Rubber Industry)



LCNG Station



Rubber Oven



LCNG Layout



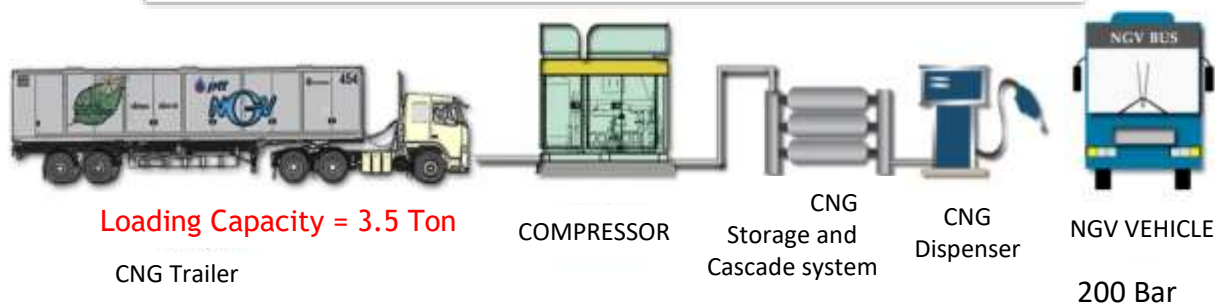
CONCENTRATED LATEX STR-20

- In association with Rubber Latex Fund Cooperative
- LNG is used as a fuel for heating in rubber latex factory substitute diesel.
- LCNG supply station comes with LNG storage with the capacity of 17,000 liters
- LNG Consumption 1 TPD

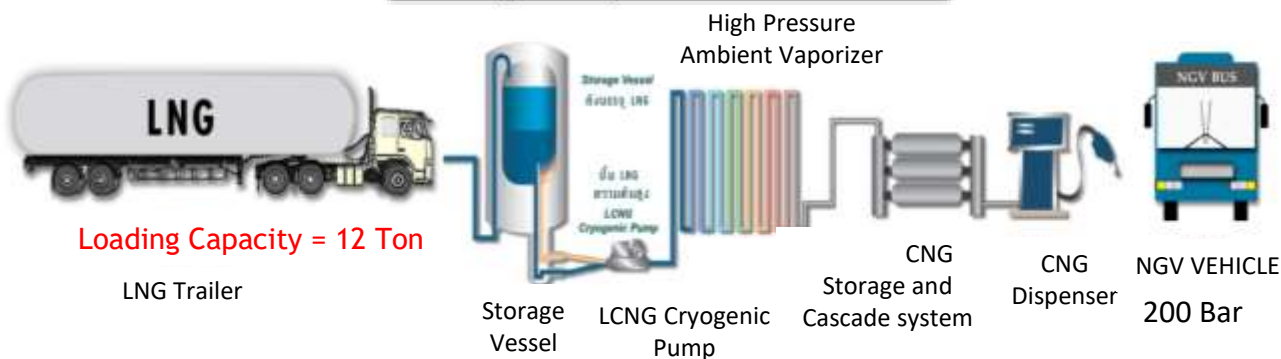


# Modification of CNG Station to LCNG Station

## CNG Station



## LCNG Station



### Objective:

1. Pilot Project to Introduce LCNG Station in Remote Area and also Reduce NGV Operating Cost
2. Reducing Transportation Cost (due to higher loading capacity of trailer) and Electrical Cost (due to usage of high pressure cryogenic pump instead of compressor)

#### Site Location:

NGV Station in Northern Area (Chiang Mai Province)

#### LNG Supply Source:

Sukhothai Boutique LNG Plant

Capacity:  
per day

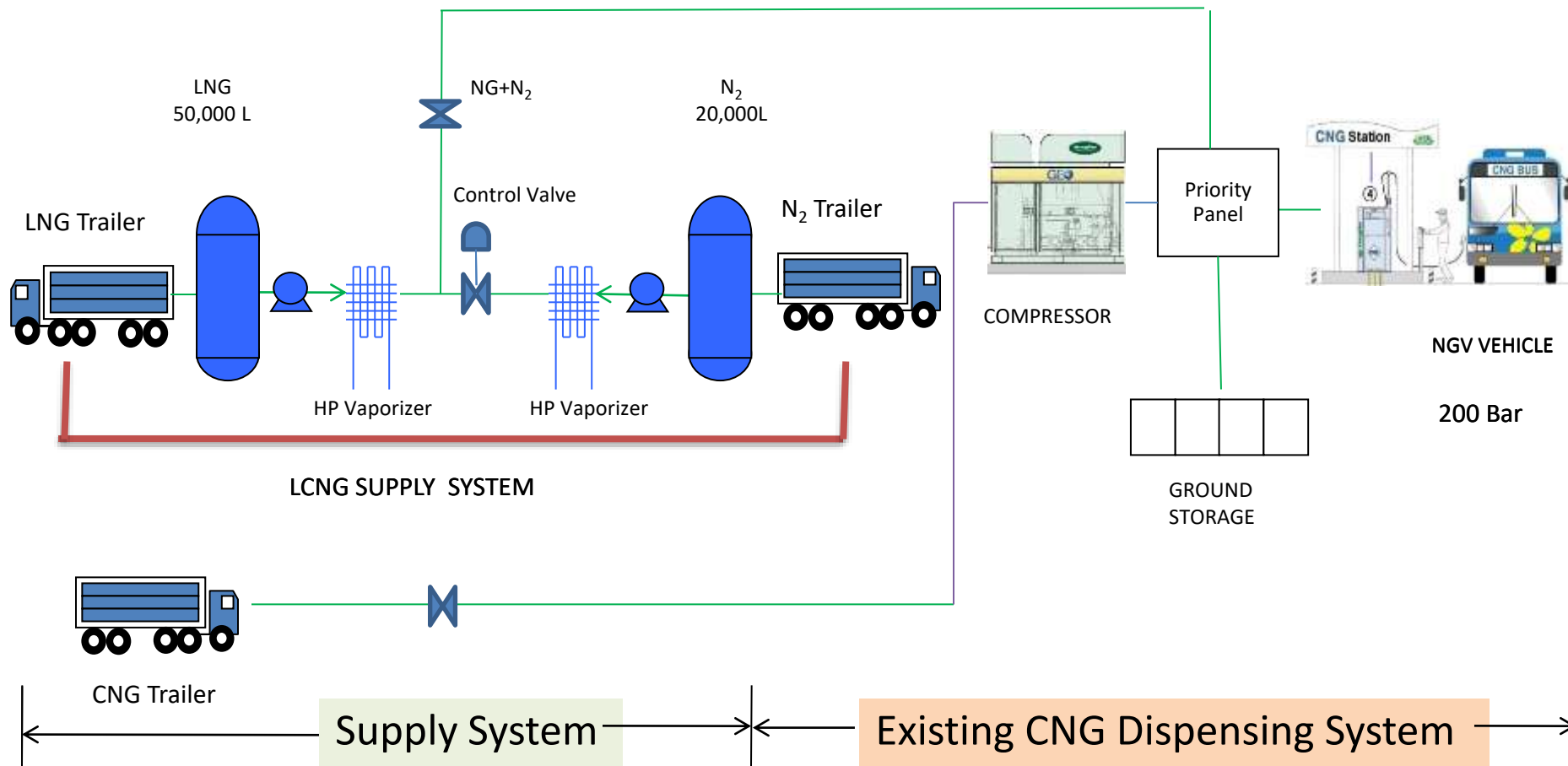
6-8 tons

Starting Commercial Phase:  
November 2011





# Modification of CNG Station to LCNG Station



Remarks : Supply Sources can be selected between LCNG System or CNG Trailer





# Modification of CNG Station to LCNG Station



Landscape of Chiang Mai LCNG Station



LNG Truck Loading to LNG Storage Tank



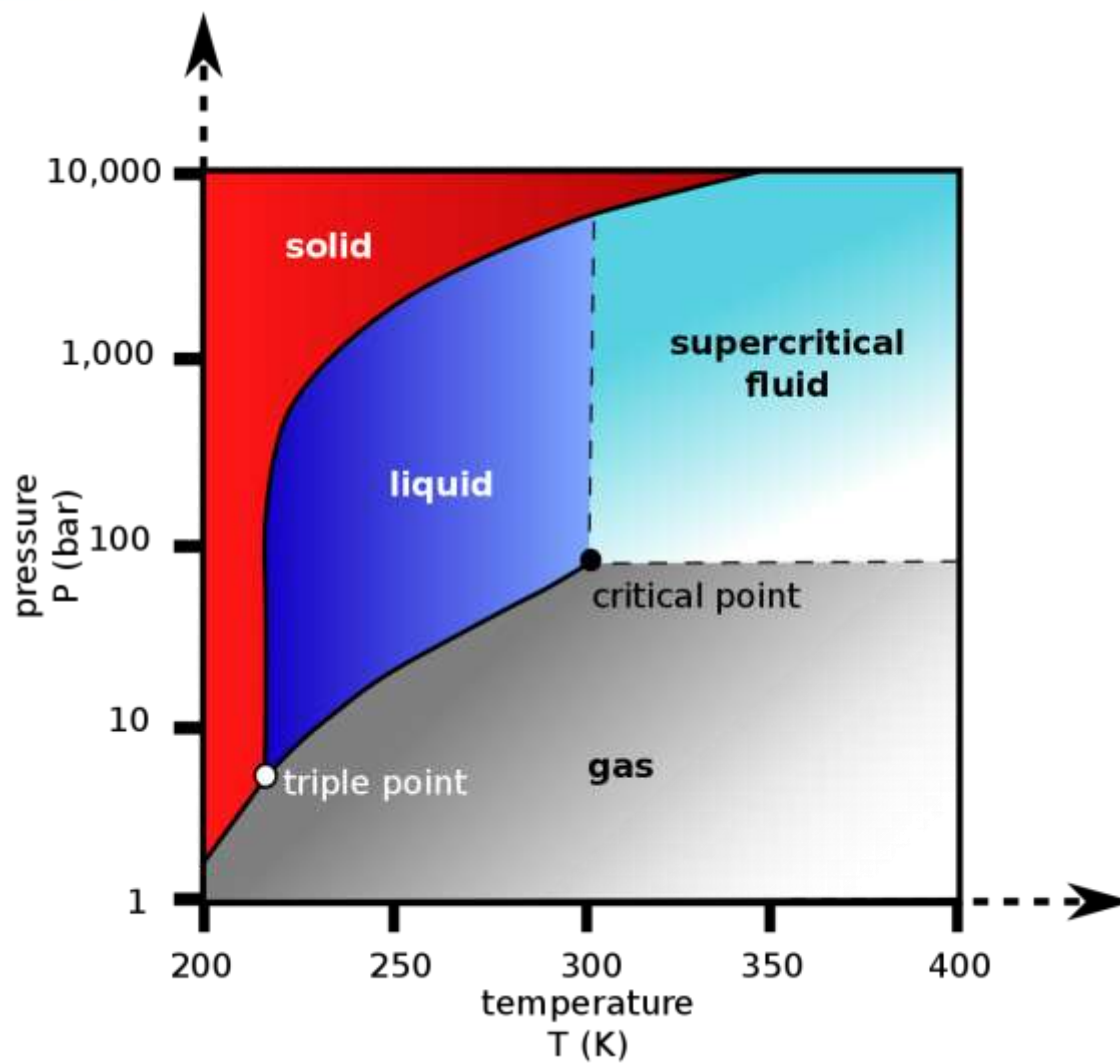
LNG & Liquid Nitrogen Vaporizers



LNG & Liquid Nitrogen High Pressure Pumps



## Super Critical Carbon dioxide





## Modification of CNG Station to LCNG Station

### Advantage of LCNG Station :

- Lower Operating & Maintenance Cost
- Lower Power Consumption
- No Lube Oil Contamination Problem in Onboard CNG Tank
- Lower Noise Level

### Disadvantage of LCNG Station :

- Gas Loss due to LNG Vaporizing
- LNG Cost Higher Than CNG
- Higher Investment Cost due to Equipment Designed for Cryogenic Condition
- Methane Number is not meet the regulation.





# The LNG Blue Corridors Project



**These initially proposed Blue Corridors will also develop with connection to other LNG distribution initiatives as:**

- **Danube Inland Waters Blue Corridor, from Romania to Viena**
- **AGRI (Azerbaijan-Georgia-Romania-Interconnection) project to transport LNG from Azerbaijan to the EU through Georgia and Romania.**

NGVA Europe is working in the preparation of a European Program to develop the concept of **European LNG Blue Corridors**

The intention is to define four initial pan European routes with strategically placed LNG filling stations that would allow the heavy, long distance truck transport throughout Europe:

- Portugal-Spain to France, Netherlands, UK and Ireland
- Portugal-Spain to France, Germany, Denmark, Sweden
- Mediterranean arch to Italy and with another branch to Croatia
- Ireland-UK to Austria



# The LNG Blue Corridors Project

From the North to the South, from the West to the East, we have to implement the European L-CNG infrastructure that will allow us full gas run mobility across Europe and will also help to reduce oil dependence.

- 2,500 LNG dedicate Trucks/ 16 L-CNG Refueling Stations



Existing LNG stations



LNG Blue Corridors station under construction



Opened LNG Blue Corridors station



**L-CNG filling station in Goteborg (Sweden)**

**L-CNG filling station in Lleida (Spain)**





# The LNG Blue Corridors Project



- Existing LNG stations



- LNG Blue Corridors station under construction



- Opened LNG Blue Corridors station



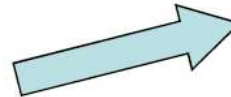


# The LNG Blue Corridors Project

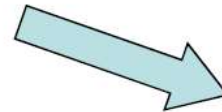
## LNG trucks for long distance transport



Diesel vs CNG & LNG.  
Autonomy equivalence



1 liter Diesel oil



**CNG**  
5 litre



**LNG/LBG**  
1,8 litre



**Volvo FM MethaneDiesel**



**Iveco Stralis LNG**



**Hardstaff Mercedes Benz Actros**



# The Shell LNG Project

Australia –Chart technology. 250 LNG trucks in operation



Map of LNG filling stations

- Factory-built LNG trucks from Kenworth Australia available today
  - Australian Ratings:
    - 500 - 578HP @ 1800 RPM
    - 1,650 - 1,850 lb-ft @ 1200 RPM
  - Dual - and Triple - Tank LNG configurations
  - 95% gas substitution
  - Lower operating costs
  - ~25% reduction in GHG vs. diesel
  - Lower noise
- Full OEM support (ordering, delivery, parts, service, and warranty)
- Helps meet corporate goals for energy security and carbon reductions







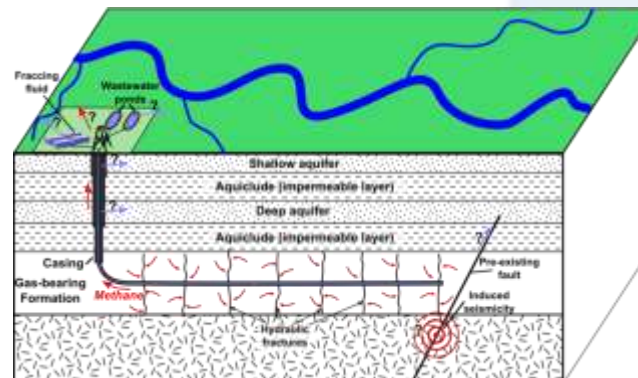
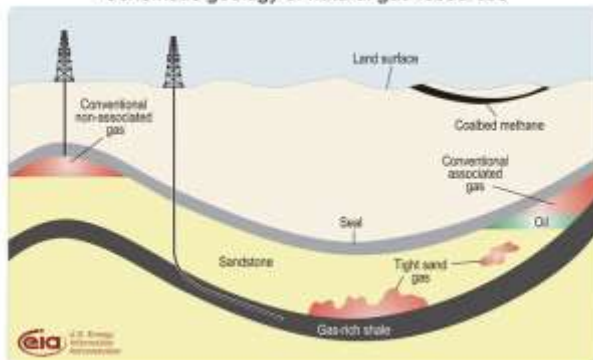
# LNG trucks and busses in USA



## Shale gas

Rank	Country	Trillion cubic feet
1	China	1,115
2	Argentina	802
3	Algeria	707
4	United States	665
5	Canada	573
6	Mexico	545
7	Australia	437
8	South Africa	390
9	Russia	285
10	Brazil	245
<b>World total</b>		<b>7,299</b>

Schematic geology of natural gas resources



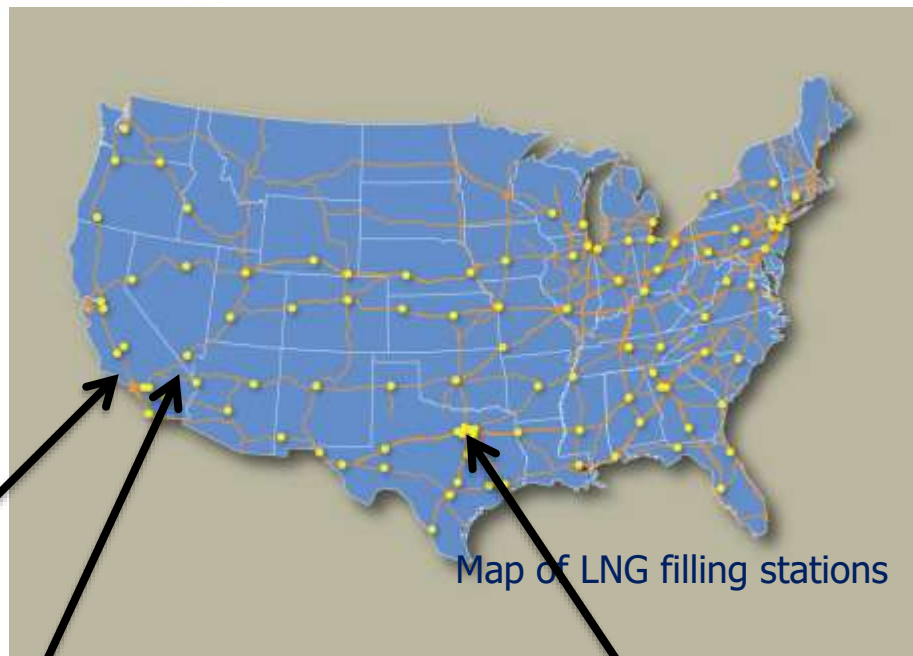




## LNG trucks and busses in USA

USA – started 1993, Chart  
technology  
7,000 vehicles  
70 public LNG filling stations

In 2020  
175,000 trucks on LNG  
140 LNG Stations and 1,600 CNG  
Stations  
(mostly long distance transportation)



Map of LNG filling stations



California



Nevada



Texas

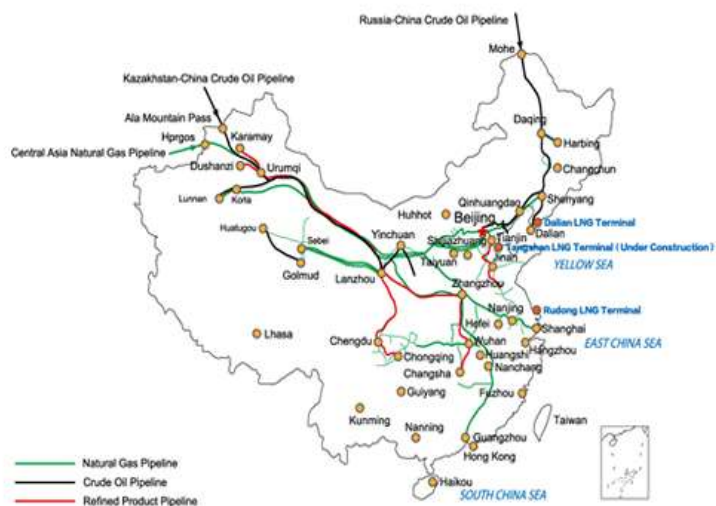


# LNG trucks and busses in China

582,000 LNG heavy-duty trucks operating in 2020



LNG bus in HangZhou



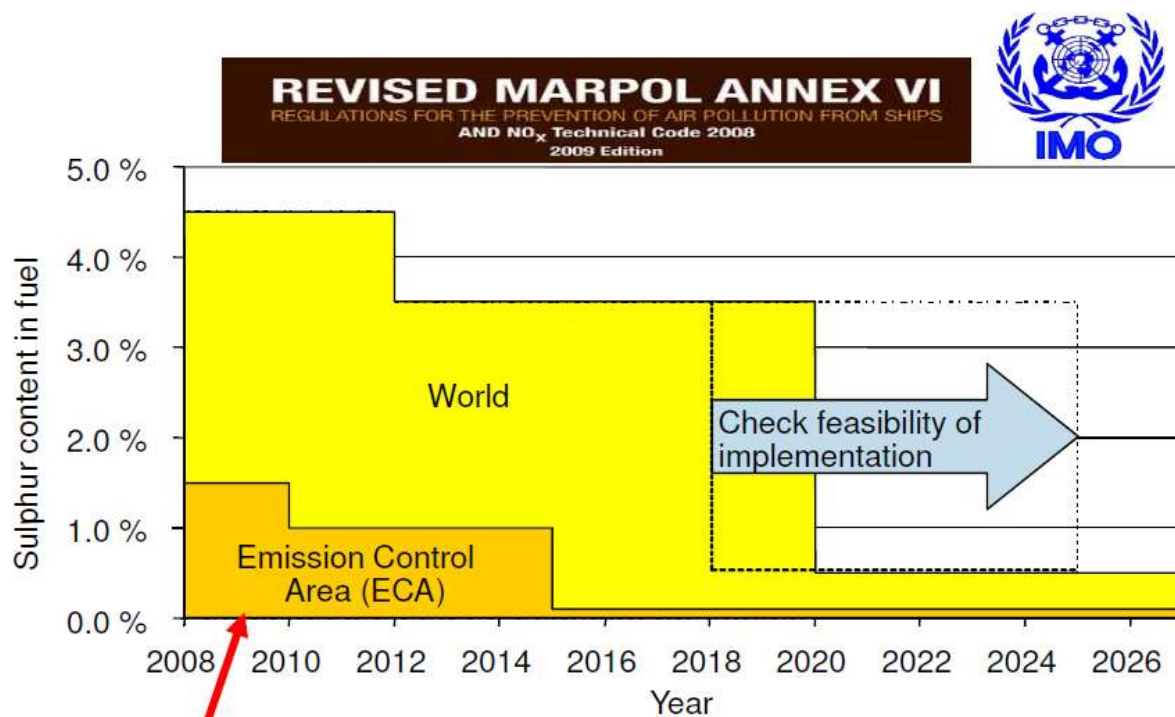
100 LNG Buses with LNG hybrid system

## Sulfur content limit in Fuel

- 0.5%wt Globally, 2020\* \* *Availability of low S fuel will be reviewed by 2018. (If postponed, 2025.)*
- 0.1%wt in ECA, 2015

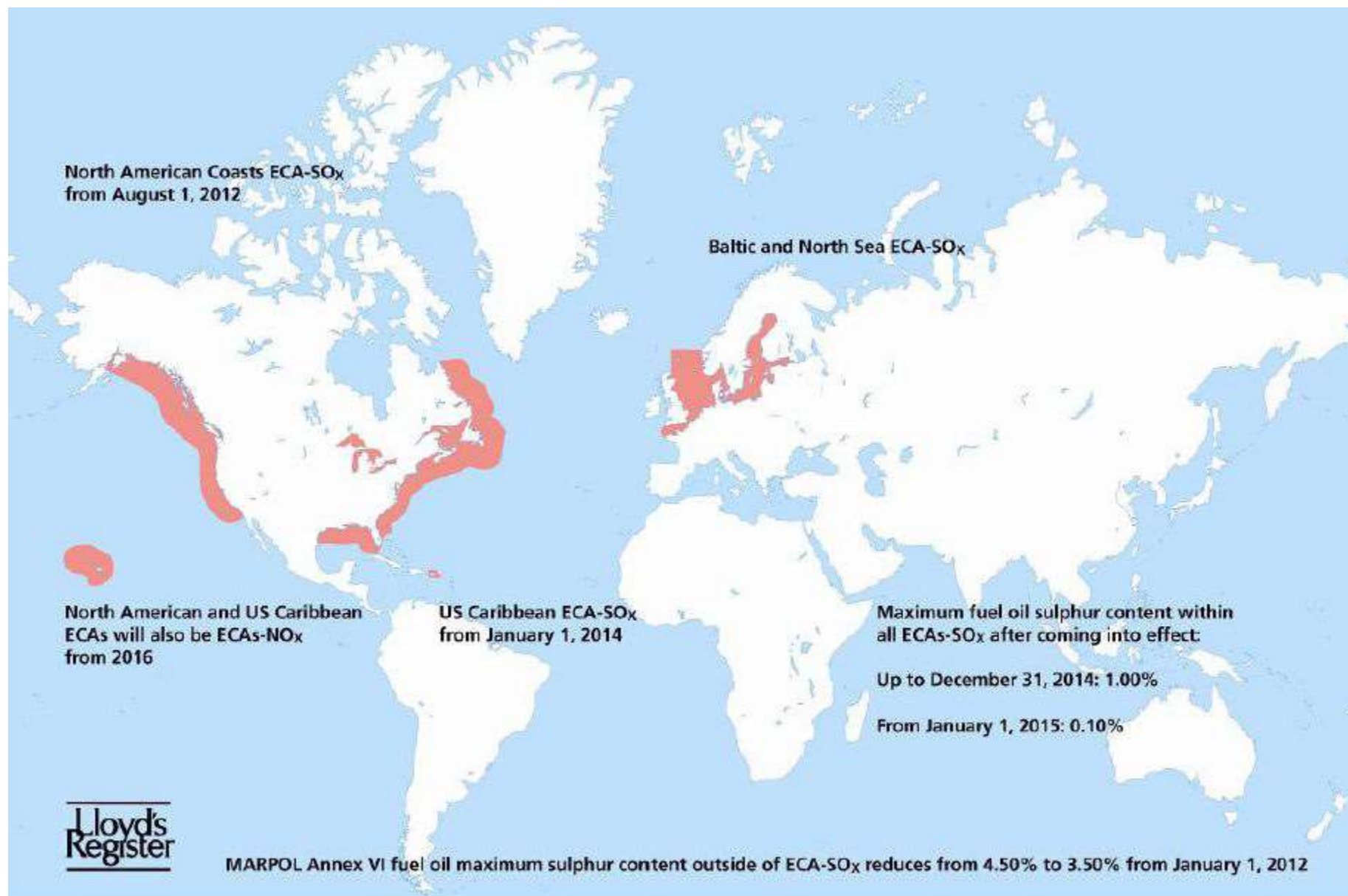
## Sulphur Limits Tightened

Planned reduction of maximum Sulphur content in marine bunkers



- ☐ **Applied to both new and existing ships**
- ✓ High degree of reduction
- ✓ Maker to develop technology
- ✓ Shipowner to make decision

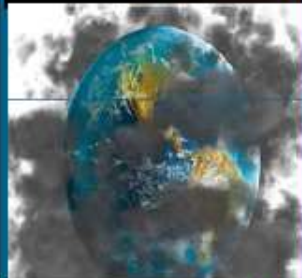






# Revised MARPOL Annex VI – 2008

## Sulphur Oxides (SOx) and Particulate Matter (PM)



Sulphur limit of any fuel oil used **globally**:

- 4.50% m/m S prior to 1 January 2012
- 3.50% m/m S on and after 1 January 2012
- 0.50% m/m S on and after 1 January 2020/25

Sulphur limit of any fuel oil used in designated Emission Control Areas **(ECA)**:

- 1.50% m/m S prior to 1 July 2010
- 1.00% m/m S on/after 1 July 2010
- 0.10% m/m S on/after 1 January 2015

or “alternative technologies” to be used

## ❑ Use of Low Sulfur Fuel

- ✓ **CAPEX is negligible**, but **OPEX will increase** considerably.
- ✓ Availability of such low sulfur bunker fuels – if **refinery industry** will be prepared?
- ✓ **Poor ignition?** – may damage combustion chamber

## ❑ SOx Scrubber

- ✓ Enables the existing propulsion system burning **high sulfur heavy fuel oil**.
- ✓ Manufacturers claim that **payback time** of SOx scrubber installation will be **a few years** and that the ship operators will obtain economical advantages against use of low sulfur fuels.
- ✓ **Turbine back pressure** acceptable?

## ❑ LNG-fuelled Vessels

- ✓ **No SOx** emission and **less CO2/NOx** emission.
- ✓ **Design** standards of vessels?
- ✓ **Infrastructure** and supply-chain?
- ✓ **Building cost** increase and **safe** operation of LNG-fuelled vessels?
- ✓ LNG fuel **price in future?**



Compliance option	LNG	HFO	MDO/MGO
CO2 removal	10-20%	Abatement technologies	No
SOx removal	100%		MDO: <2%; MGO: 0.01 -1%
NOx removal	Up to 80-90%		Abatement technologies
Particulate matter	98 -100%		
Regulation in place	Developing	Yes	Yes
Infrastructure	Early stages	Yes	Yes
Cultural factors	Higher	Established	Established
Cost of use	LNG storage tank size; LNG fuel price uncertain; possible loss of cargo space	Abatement technologies required	
Potential to stretch the technology	Further CO2 reduction	End of cycle	
Challenges /differences	Bunker space/cryogenics /possible methane slip	Abatement technologies Varied blends of distillates 2020	



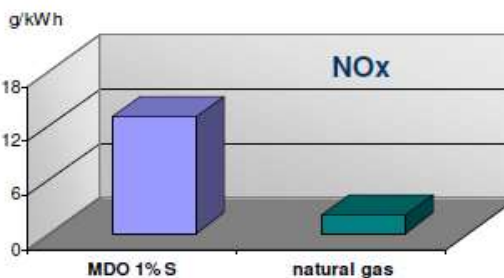
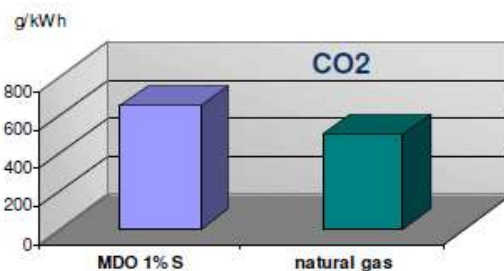
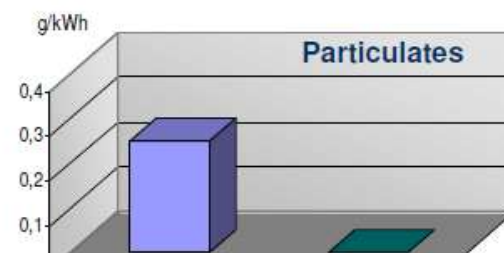
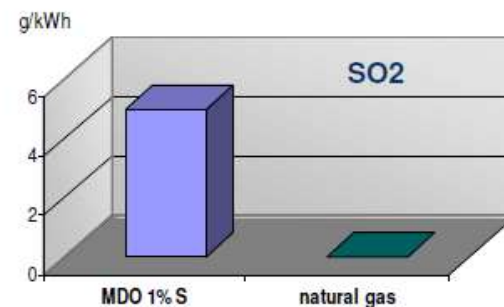
## การปล่อยมลภาวะ ก๊าซธรรมชาติ เทียบกับ MDO (Marine Diesel Oil)

: ลดการปล่อยซัลเฟอร์

: ลดอนุภาคฝุ่นขนาดเล็ก

: ลดการปล่อยก๊าซคาร์บอนไดออกไซด์ 26%

: ลดการปล่อย Nox 80-90%



# LNG Project



**เรือขนส่ง LNG**  
**(ใช้เชื้อเพลิงรวม LNG+Diesel)**  
**Gaz de France Energy**



**เรือเฟอร์รี Norway**  
**(ใช้เชื้อเพลิง LNG)**

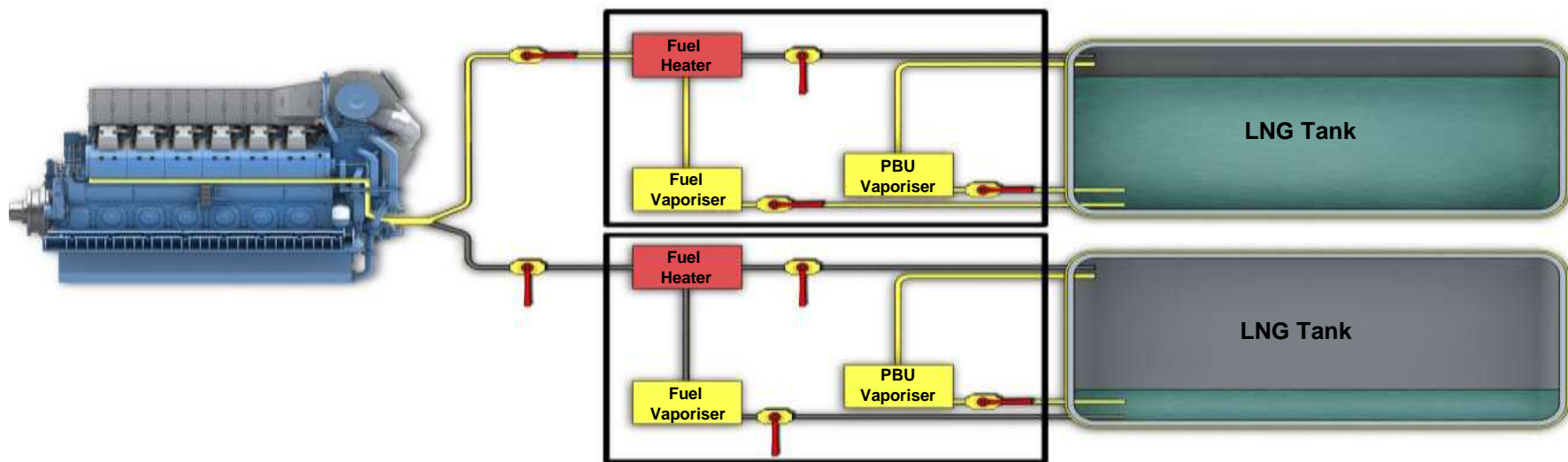


**เรือเฟอร์รี (ผู้โดยสาร 2,800 คน)**  
**Baltic Sea**  
**(ใช้เชื้อเพลิงรวม LNG+Diesel)**



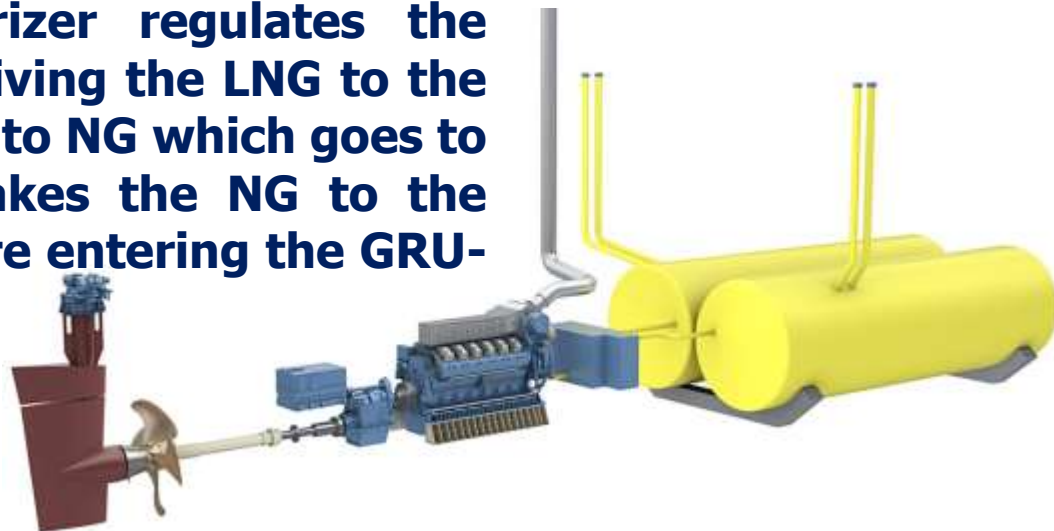


# Gas fuelled propulsion system



**Fuel consumption system: simple in operation and fully automatic; no pumps in the system.**

**The Pressure Build Up Vaporizer regulates the pressure in the tank which is driving the LNG to the Fuel Vaporizer. LNG is vaporized to NG which goes to the Fuel Heater. The heater takes the NG to the temperature level required before entering the GRU- Gas Regulating Unit**





## LNG Locomotive in USA

- ❑ New LNG powered locomotives are being developed by units of General Electric Co. and Caterpillar Inc.
- ❑ Retrofitting a diesel locomotive and adding the tanker car could add 50% to a locomotive's roughly \$2 million price tag
- ❑ Caterpillar estimates savings on fuel costs could be >50%





## LNG Locomotive in Canada

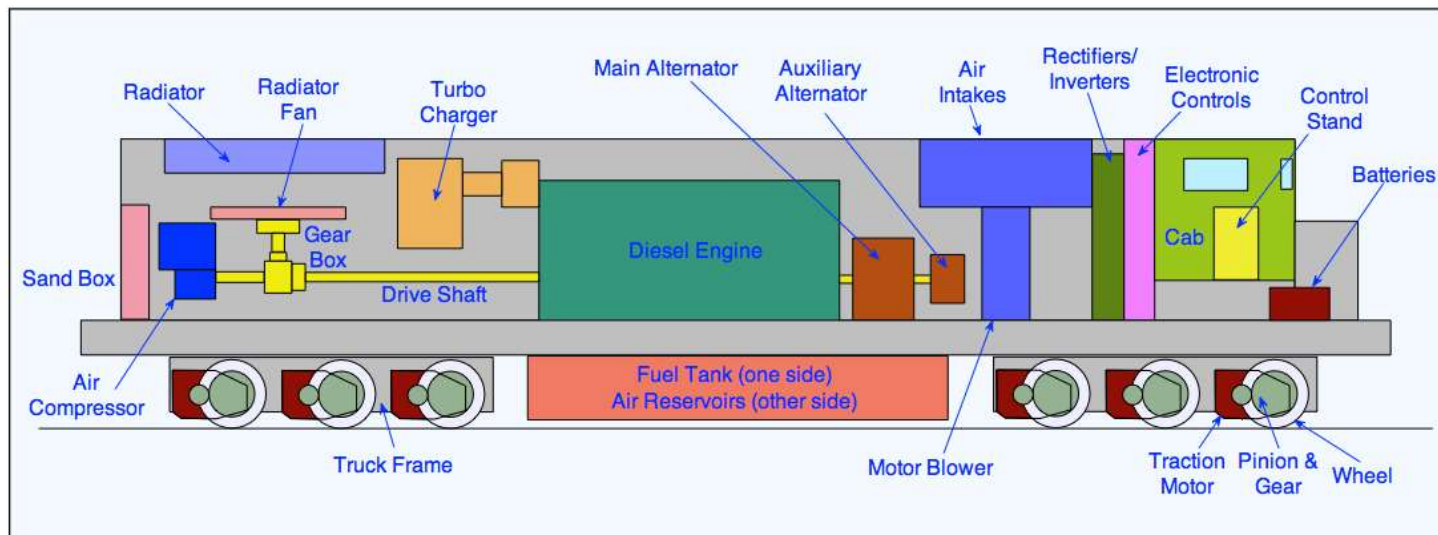
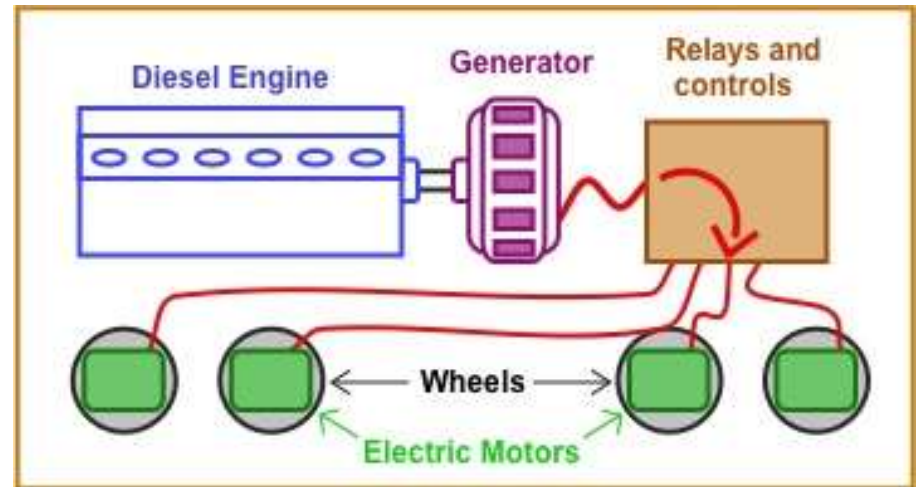
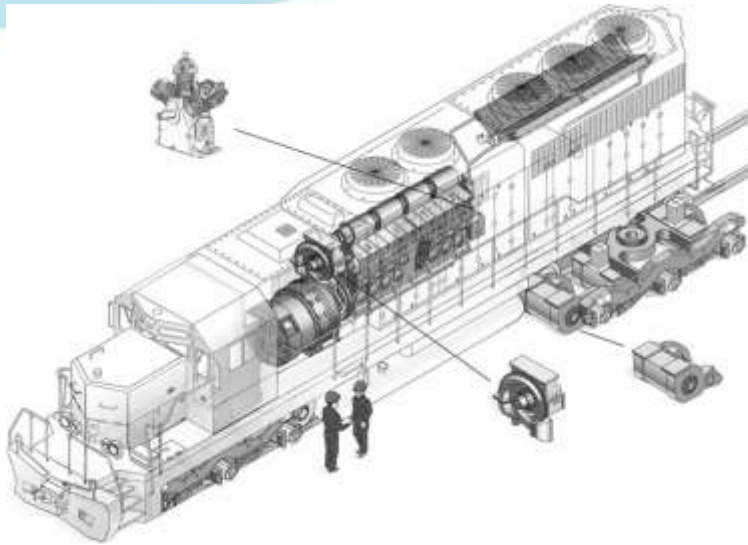
- ❑ **Canadian National Railway Co. retrofitted two locomotives (3,000-horsepower Electro-Motive Diesel SD-40) using conversion kits supplied by Energy Conversions Inc. Running on a mixture of 90% LNG and 10% diesel along the 300-mile line between Edmonton and Fort McMurray**
- ❑ **Reduce carbon dioxide emissions by 30 per cent and nitrogen oxide emissions by 70 per cent**







# LNG Locomotive Diagram





## LNG Airplane

- The LNG project is named 'SUGAR Freeze'
- Boeing Delivers LNG-Fuelled Aircraft Concept to NASA
- The study, complete with technological roadmaps, proposes that combined with all other efficiency measures an LNG fuelled aircraft could reduce fuel burn over current aircraft by as much as 62%. Additionally, LNG is projected to offer lower fuel cost because of abundant supply, even as far out at mid-century, and lower emissions.

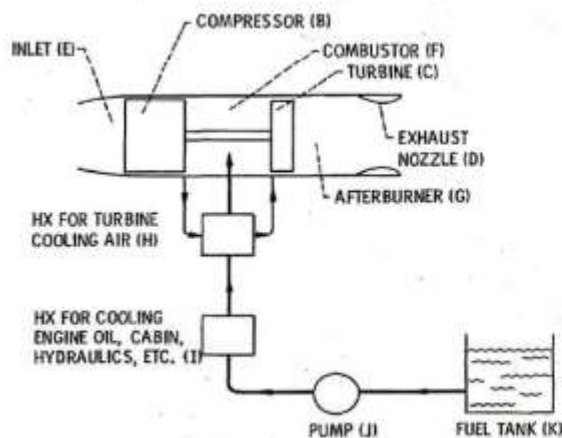
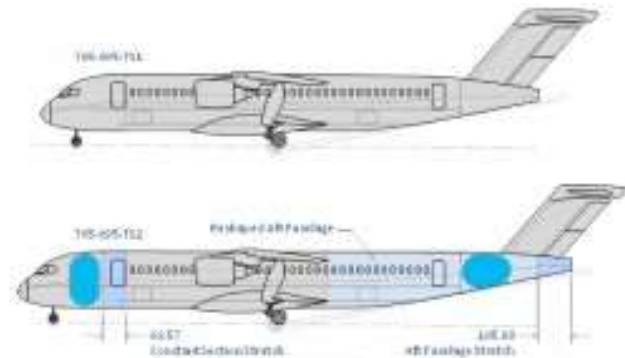
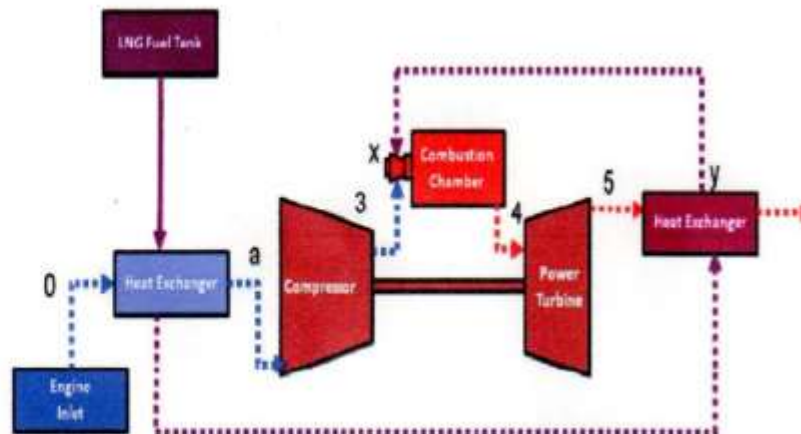


Figure 4. - Turbojet engine components (A).





**Thank You**





## LNG Production at Boron



- ❑ **LNG Plant start in November 2008**
- ❑ **Clean Energy investment of approximately \$75 million**
- ❑ **180,000 LNG gallons production per day, expandable to 270,000 LNG gallons per day**
- ❑ **1.8 million-gallon LNG storage tank**
- ❑ **Two loading scales, plus public LNG fueling, support LNG trucking operation in/out of the Boron Mine Facility**