

LNG

A Promising Alternative Energy Carrier for the Heavy Duty Segment?

Potential, Market and Technologies

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Cryoshelter GmbH

- Natural Gas Tanks for HD-Trucks
- Cryoshelter:
 - Engineering / IP
 - Production of Key Components
- Production Partners in EU/US
- Work with OEMs on series applications
- Retrofitting market entry in 2015



THE ENERGY TRILEMMA

The Energy Trilemma

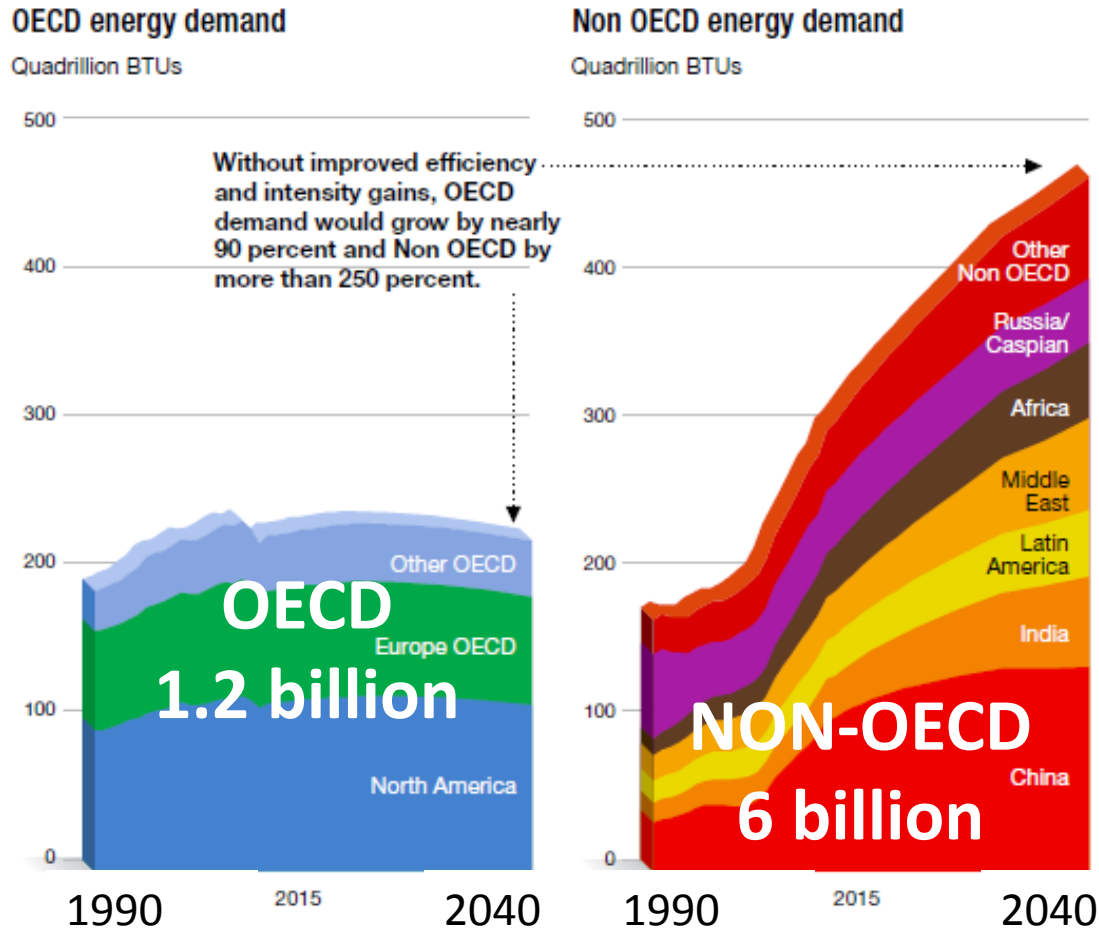
**Carbon Emissions
sustainable**



**affordable
Energy Cost**

**available
Security of Energy Supply**

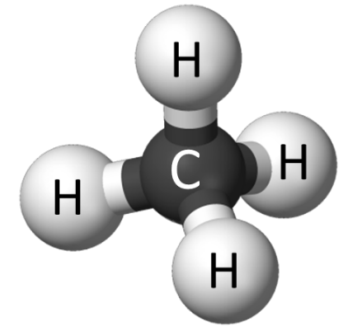
Security of Energy Supply



Exxon Mobile: 2012 The Outlook for Energy: A View to 2040

Fuel = Methane

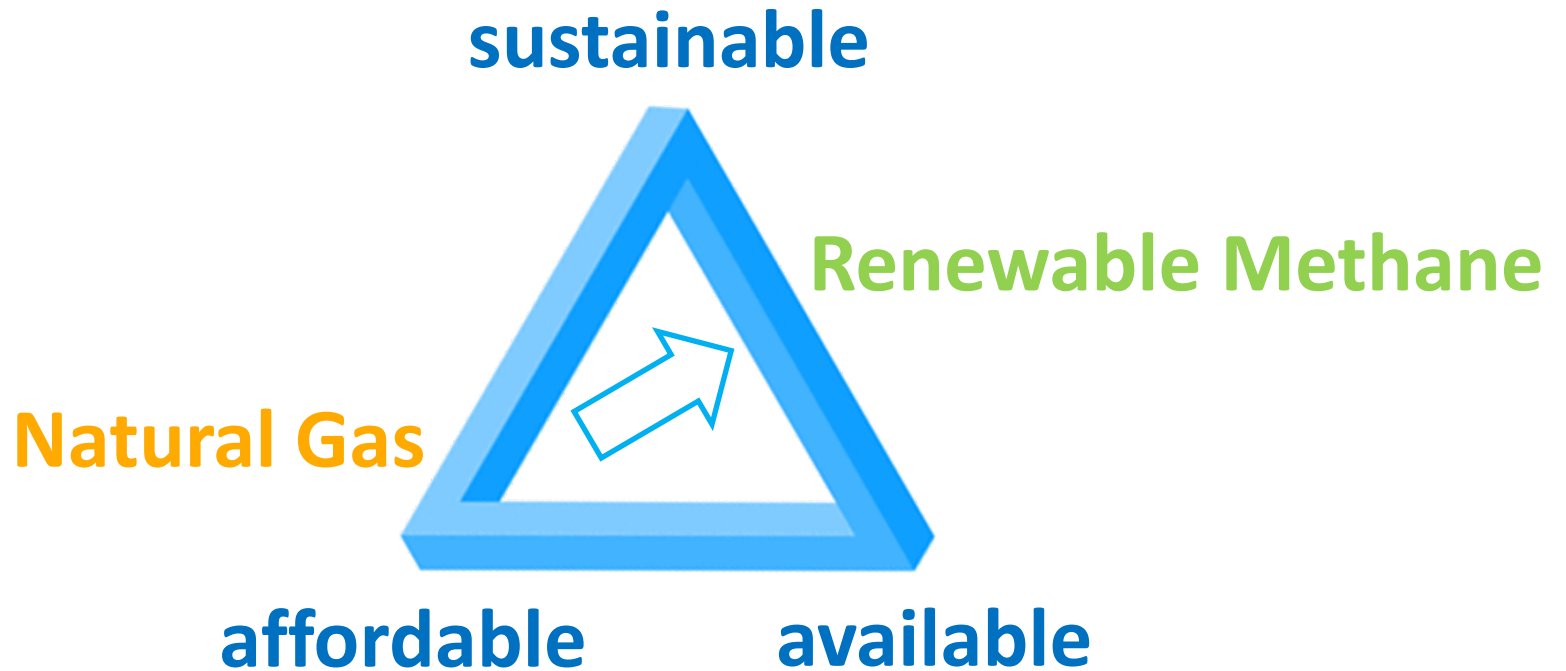
Natural Gas is predominantly Methane from fossile sources
-20% CO₂ comp. to Diesel



Methane CH₄

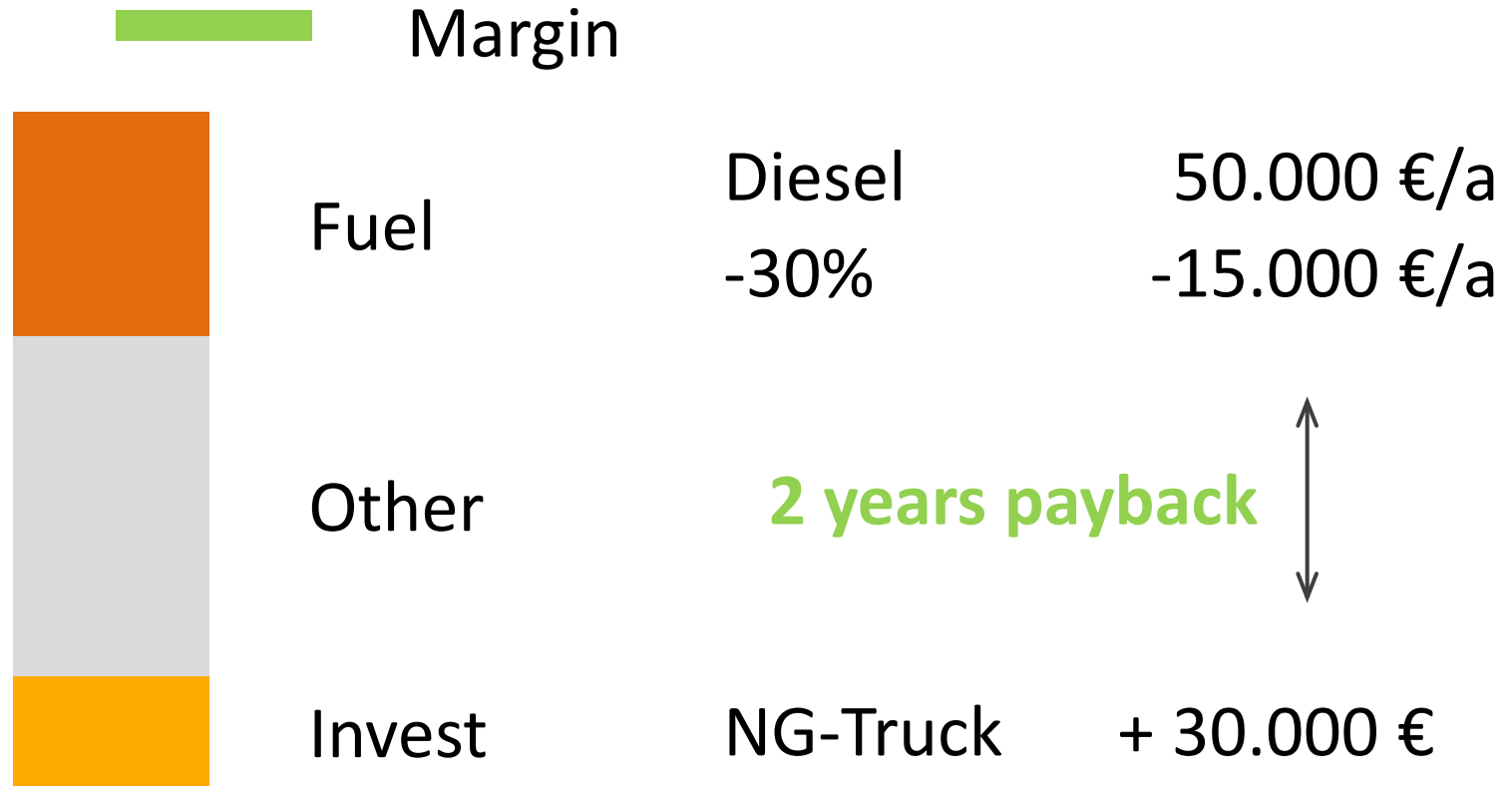
Bio Gas is predominantly Methane
produced from biodegradable materials
renewable → substantial CO₂ reduction

The Energy Trilemma



HEAVY DUTY TRUCKS

Total Cost of Ownership - TCO

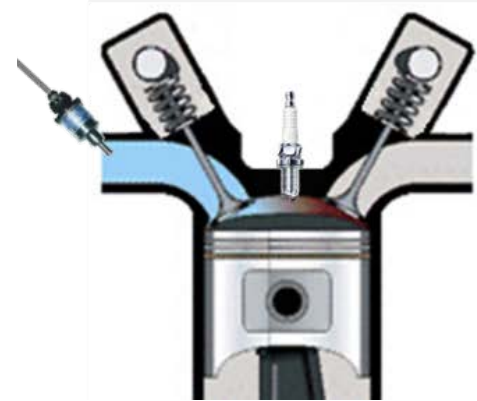




Natural Gas Tank

CNG / CBG

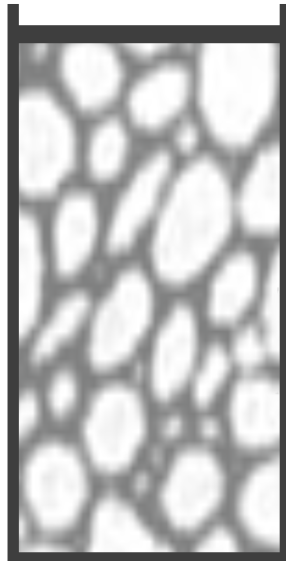
LNG / LBG



Natural Gas Engine

2 ways to store Methane

gaseous



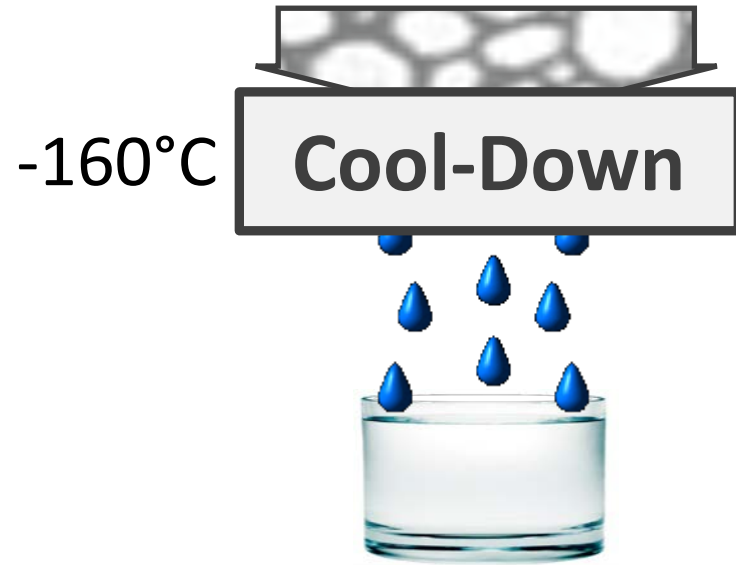
250 bar

Compression

250 fold increase

CNG / CBG

gaseous

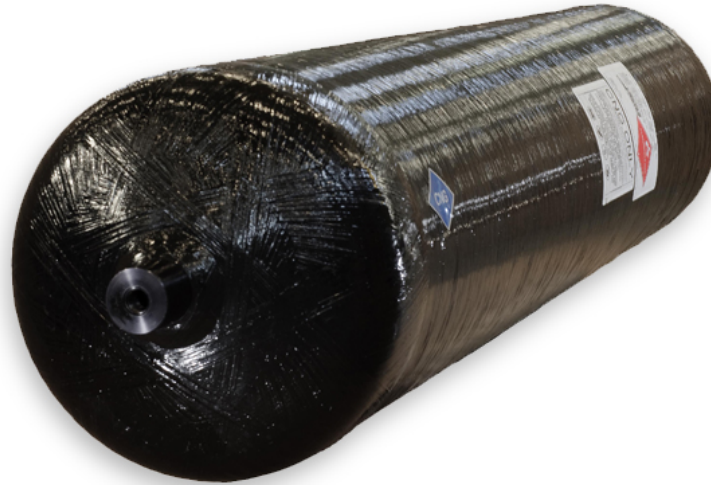


Liquefaction

600 fold increase

LNG / LBG

CNG - Compressed Natural Gas



- Limited range
- lossfree storage of Natural Gas over extended periods of non-use
- fast fill: 70% capacity (15 minutes)
- time fill: 100% capacity (overnight)

CNG - Compressed Natural Gas

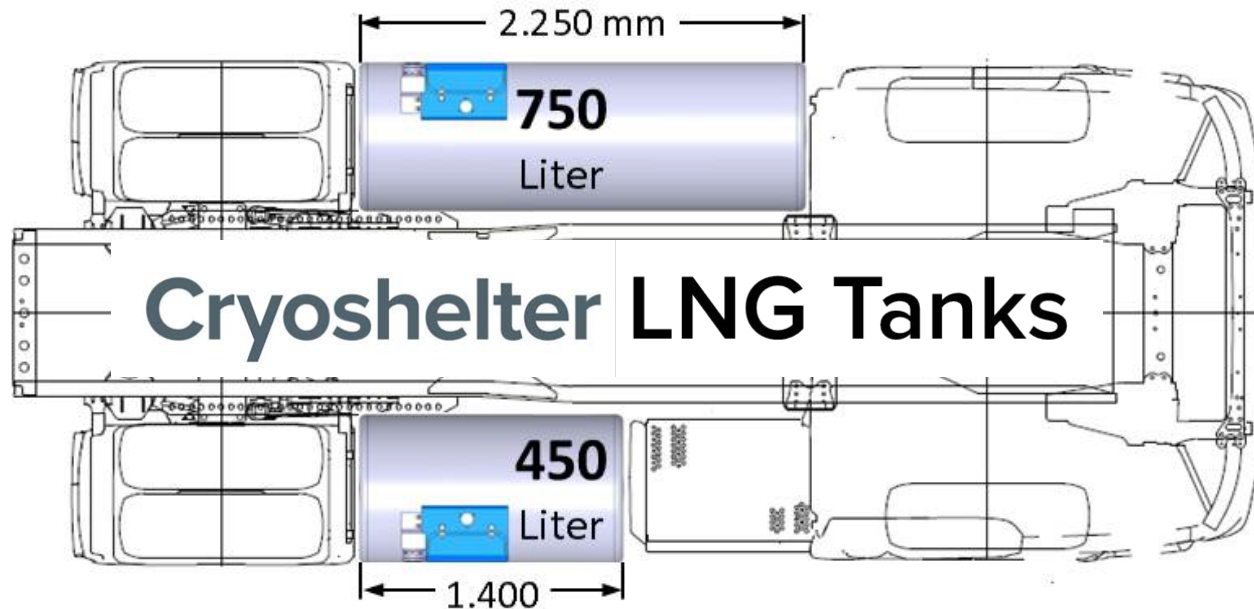


LNG Liquefied Natural Gas



- Vehicle range: 3 times of CNG
- 30% lighter than CNG tanks
- Filling time: equal or faster than Diesel
- Loss free operation

LNG Liquefied Natural Gas

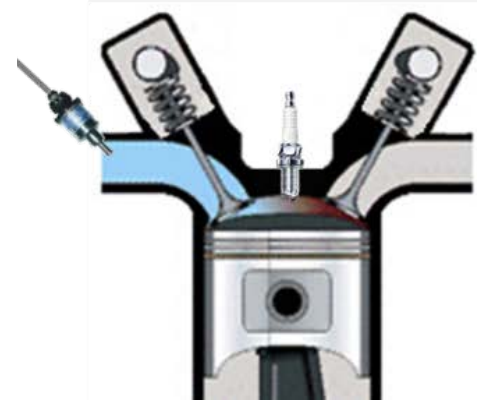


1.200 Liter LNG \approx 2.000km range

30% more range than LNG-competitors



Natural Gas Tank



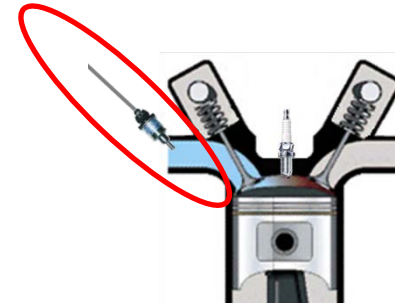
Natural Gas Engine
Spark Ignition **SI**

Compression Ignition **CI**

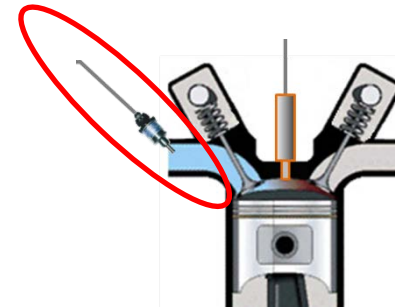
Natural Gas Engines

- 100% Natural Gas
- Clean
- Quiet
- efficiency penalty comp. to Diesel
- 50% to 80% Natural Gas + Diesel
- Retrofittable to Diesel trucks
- Diesel only mode possible
- **So far no EURO VI / EPA10**

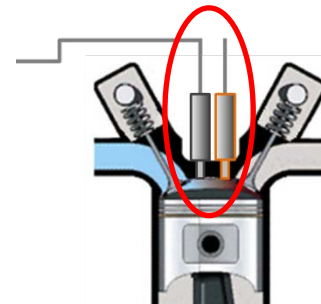
- 90% to 95% Natural Gas + Diesel
- Most challenging technology
- Highest CO₂ reduction
- High Torque



SI



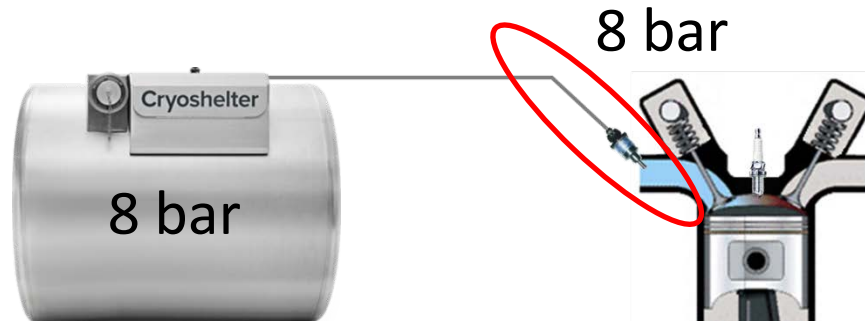
CI
DFM



CI
DFD

Natural Gas Engines

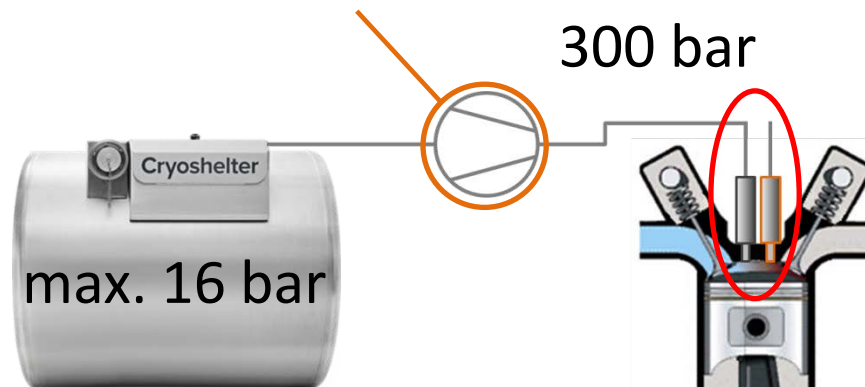
Tank Pressure
equal or greater
Injection Pressure



- SI
- CNG
- LNG

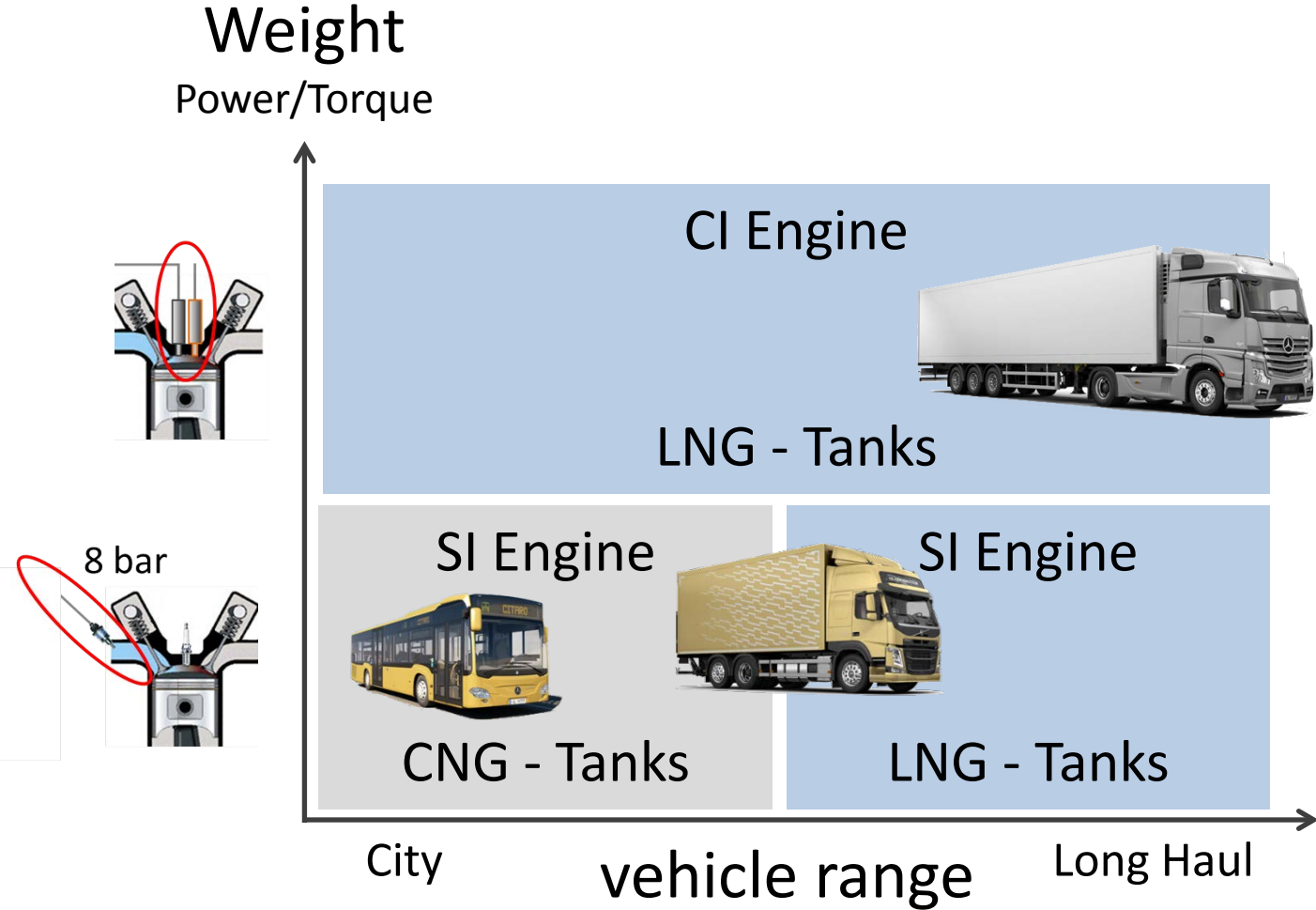
Pressure Increase required → **LNG**

Tank Pressure
lower
Injection Pressure



- CI
- DFD
- LNG

HD-Market Segments



INFRASTRUCTURE

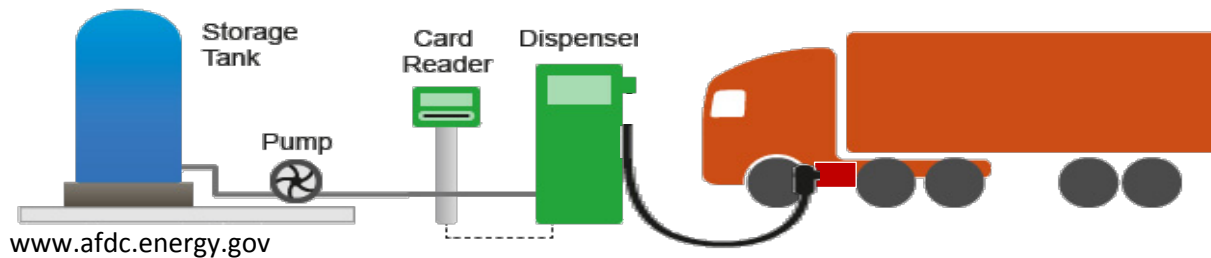
Infrastructure for LNG HD-Trucks

existing

since 1960!



to be built:



www.afdc.energy.gov

SUMMARY

Summary



THANK YOU FOR YOUR ATTENTION

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