

**Matthews
International
Presents: LNG
Solutions for a**

Brighter Future



1 Product
Overview

2 Environmental
Case

3 Business
Case

4 Future Fuels



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1. Product Overview...



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A Step in the Right Direction



In order to move forward as an industry, we need to evaluate the following factors:

- Viability of current technology
- Cost of commercial solutions
- Market willingness to adopt and support operators who invest in emerging Eco Solutions
- Long-term prospects for investment in necessary infrastructure
- Price volatility of new eco fuels

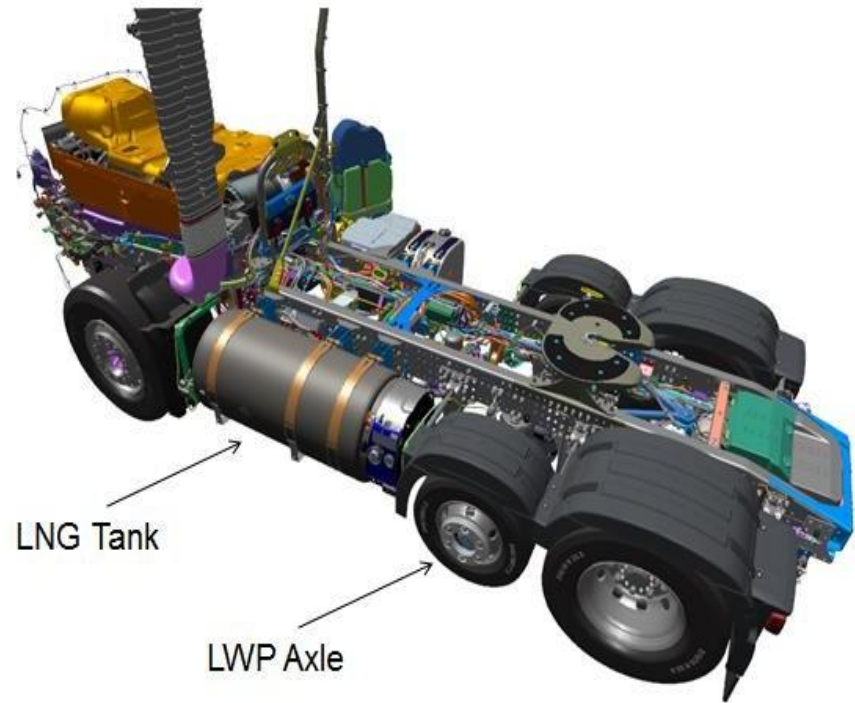


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For the UK & International Markets

**6x2 Artic
Lightweight Pusher
or
4x2 Artic**



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The LNG Tank



- Integral hydraulic pump
 - Submerged in liquefied gas
 - Unique technology extends range by utilising “cold” LNG
- Double-shell Structure
 - Separate inner & outer casing both made from 4 mm stainless steel
 - Inner tank vacuum insulated from the outer tank

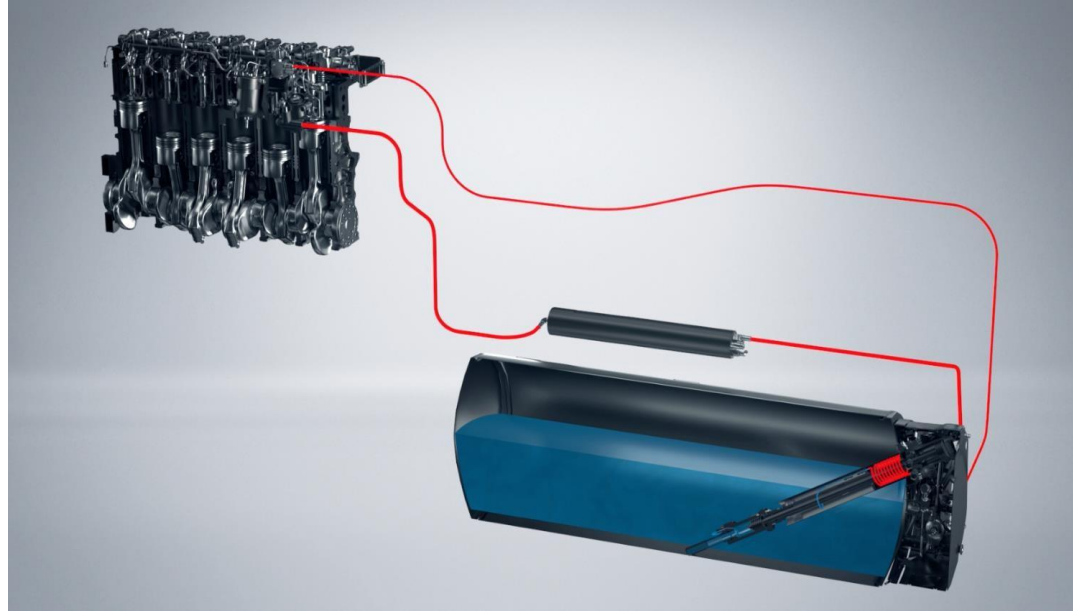


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Methane Slip Prevention - Return to tank

- Returns non-combusted methane to the tank
- Direct injection controls the amount of gas being injected
- A valve system prevents leakage of unburnt methane into the exhaust
- Vaporized LNG cools down until it is liquefied



Fuel Capacity



Artics	Wheelbase (m)	Tank size (kg)
4x2	3.7 / 3.8	205
6x2 Pusher	4.1	115
6x2 Pusher Lite	3.8 / 4.1	115 / 155



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Vehicle Range



115kg = circa 300 miles

155kg = circa 400 miles

205kg = circa 500 miles

Calculated at 8.5 mpg diesel equivalent



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If you fuel at 10 bar and -125°C, you get approximately - 10% of LNG in the tank



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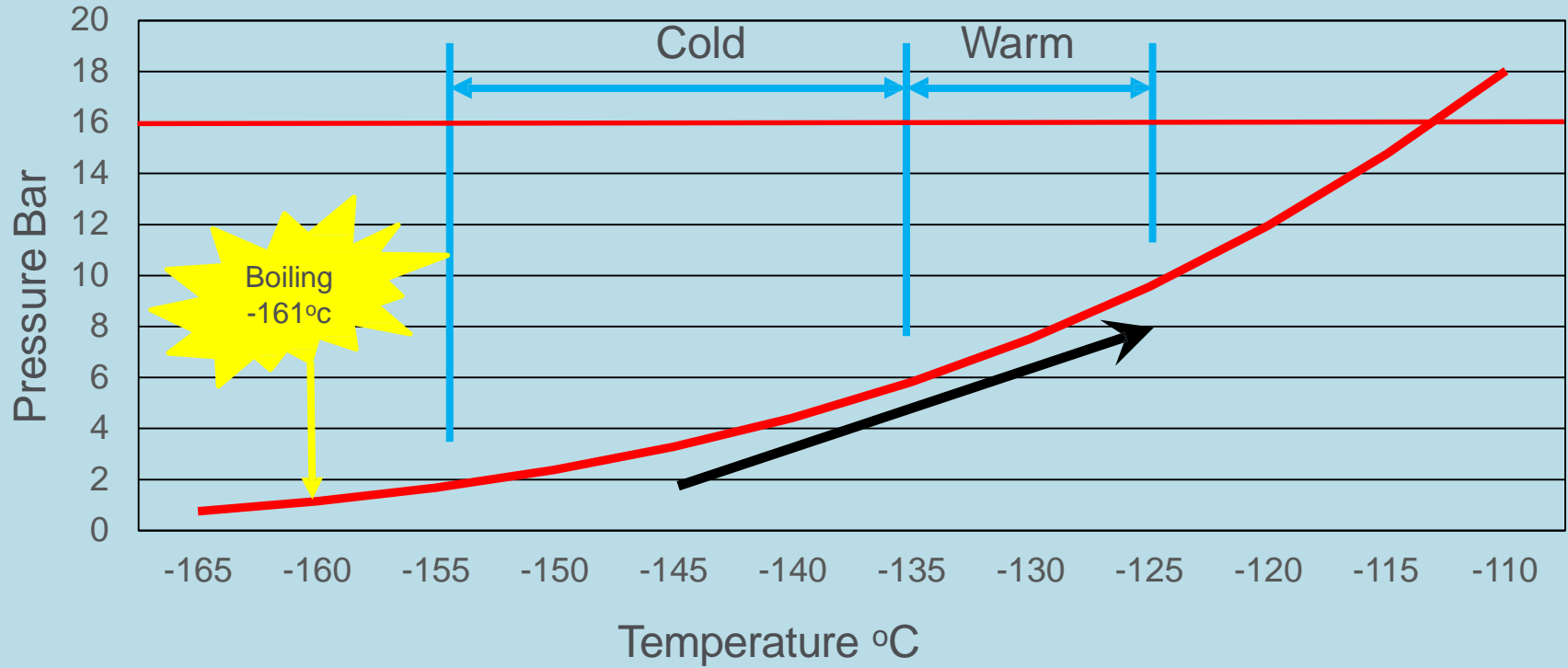
We don't want venting – to avoid it, it is important to understand the tank holding times.



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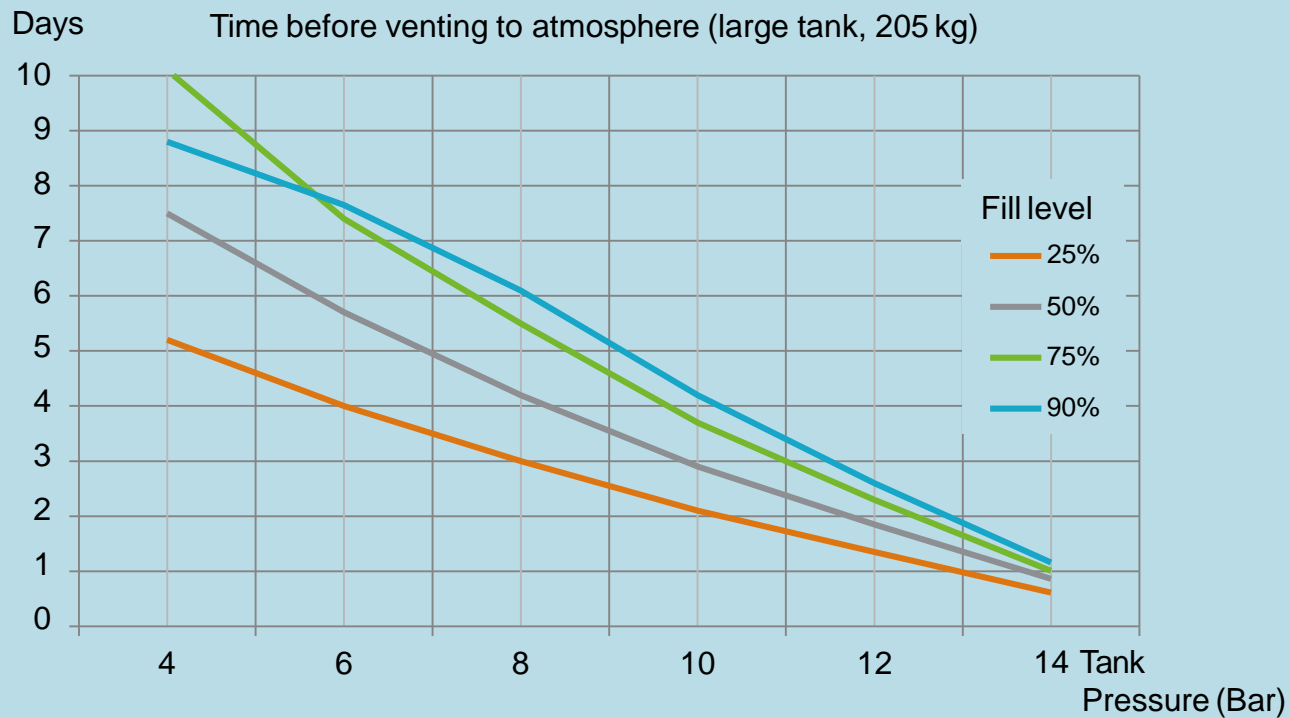
LNG – Pressure vs Temperature



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Avoid venting – keep track of the pressure!



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Commercial Example: Volvo G13

13 litre

6 cylinder in-line

420 hp

2100 Nm

460 hp

2300 Nm



High torque is achieved by using conventional diesel cycle timing and injection system without spark plugs



Euro VI -HPDI Technology

- A small amount of diesel is injected on the compression stroke
 - It is compressed which creates heat and it ignites
- Natural gas is then injected at high pressure
 - It is ignited by the ignited diesel
- Minimal diesel usage
 - Over 90% gas in all conditions
- Engine performance is:
 - Similar power and torque to a diesel engine
 - Similar fuel efficiency to a diesel engine
 - Full engine braking performance across rpm range
- Tolerant to a wide range of fuel methane composition



2. Environmental Case. . .



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Climate change is real

Scientists forecast the global average temperature will rise 5-6°C by 2100

Global warming is caused by the greenhouse effect, which is directly impacts Matthews International and our entire industry. We must all start taking measures to offset our carbon emissions



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Human Activity leads to Global Warming

Since the beginning of the industrial revolution, the atmospheric concentration of CO₂ has increased by 40%

CO₂ and methane are both examples of greenhouse gases that contribute to global warming



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Use of fossil fuels adds to global warming

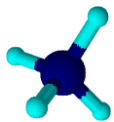
- Oil
- Coal
- Natural Gas

Oil, coal and natural gas are all fossil fuels. Natural gas is the least harmful

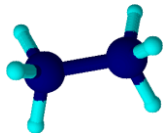


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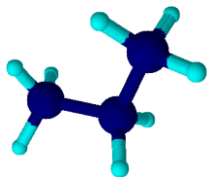
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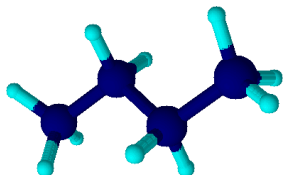
Methane CH_4 = 25% Carbon



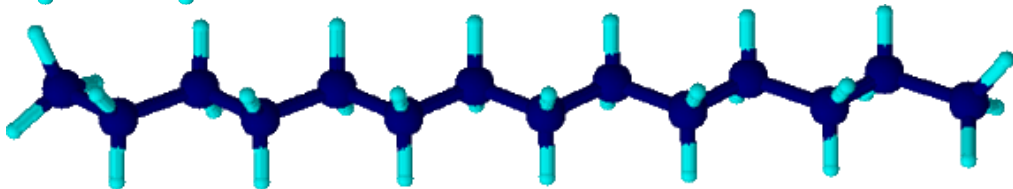
Ethane C_2H_6 = 33% Carbon



Propane C_3H_8 = 38% Carbon




Butane C_4H_{10} = 40% Carbon



Diesel $\text{C}_{14}\text{H}_{30}$ = 47% Carbon



A large offshore oil rig is silhouetted against a bright, hazy sunset sky. The rig's complex structure of steel beams and platforms is reflected in the calm water below. The sun is positioned high in the sky, creating a strong lens flare and illuminating the scene with a warm, golden light.

Analysts predict oil and coal usage will
flatten out in the next decades
Natural gas is expected to increase.

Source: IEA WEO2016



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Switching to LNG



20% lower CO₂ emissions

100% lower CO₂ when using
liquefied bio-LNG and Synthetic
Diesel (HVO) – tank-to-wheel

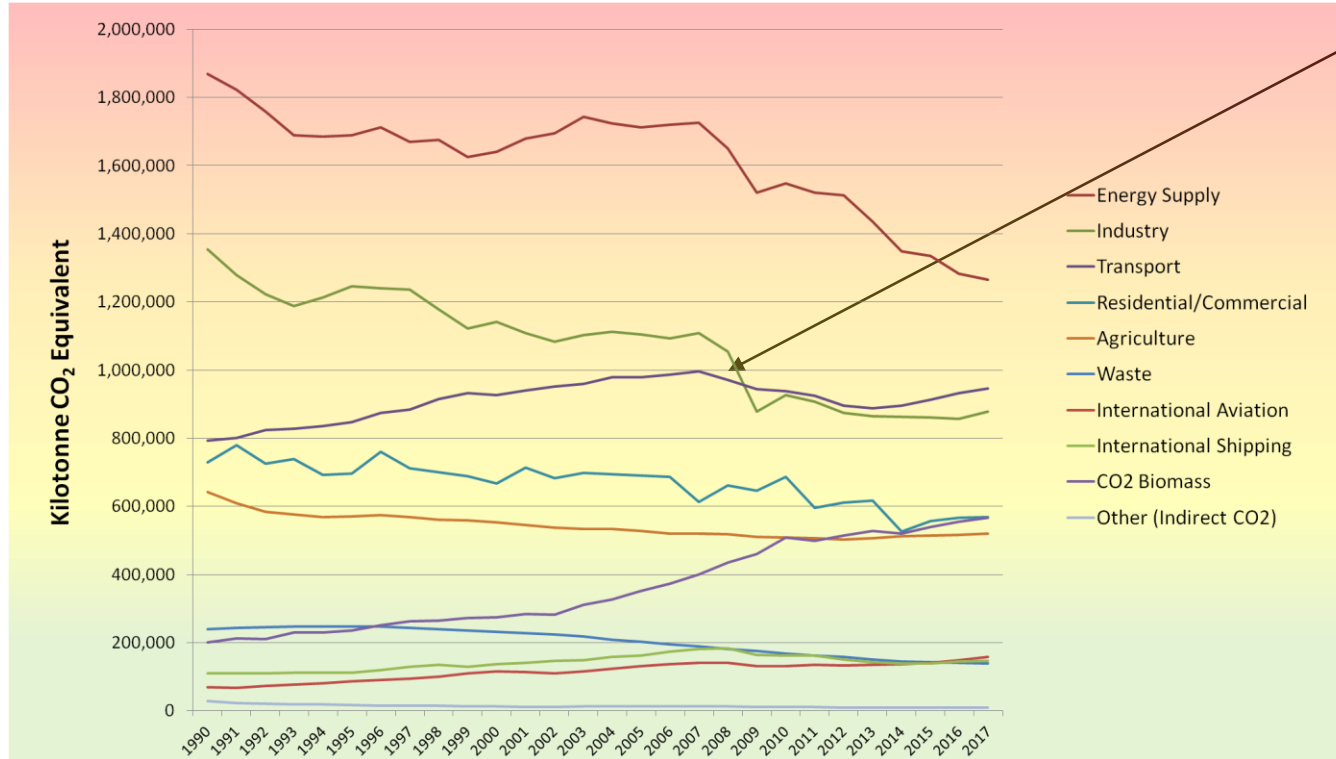


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Greenhouse Gas Emissions by Aggregated Sector

(Source: European Environment Agency Jan 2020)



Oct 2008: Euro V diesel engine technology introduced to commercial vehicles.

Emissions and combustion were separated as part of this new technology. Overall greenhouse gas emissions from the Transport sector began to reduce, in line with most other sectors.

Here we can see the actual mass of emissions, alongside the other key carbon producing industries.

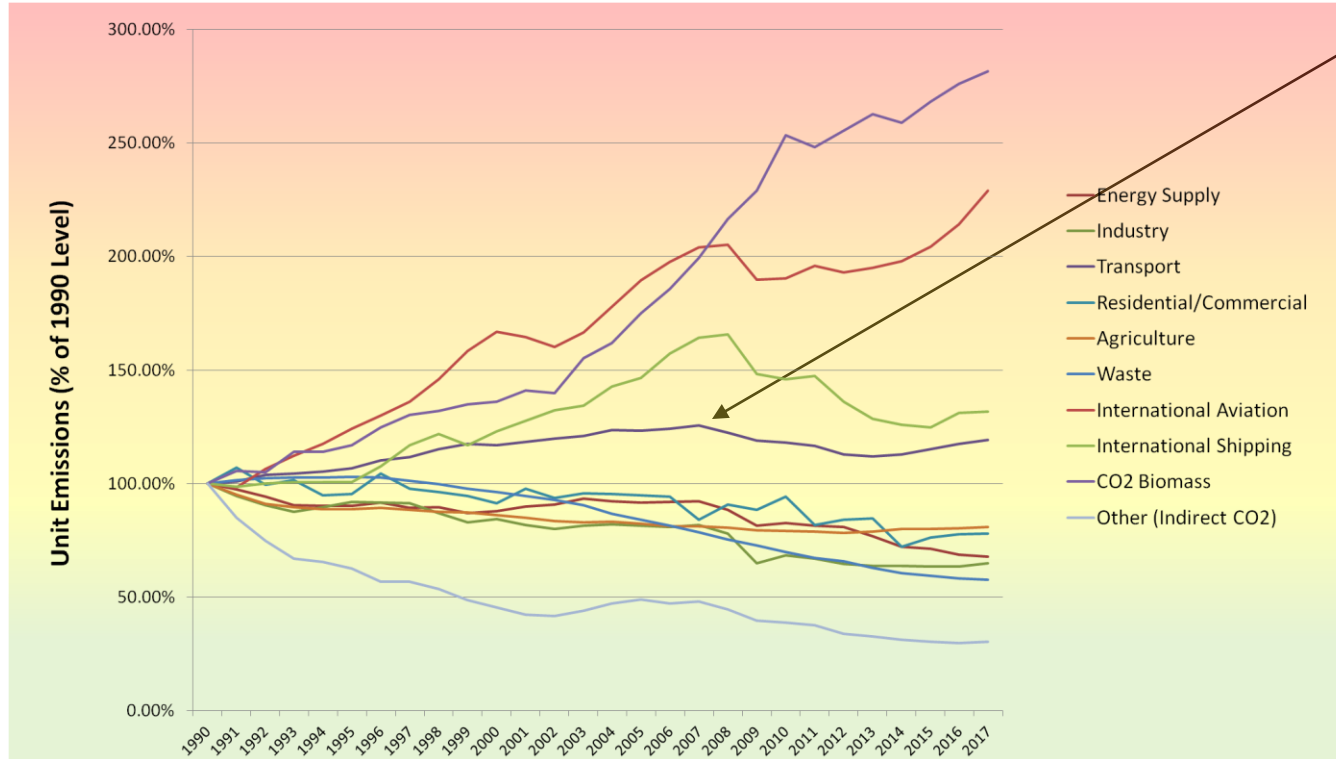


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Greenhouse Gas Emission Trends by Aggregated Sector

(Source: European Environment Agency Jan 2020)



The introduction of the Euro V Diesel engine technology in Oct 2008 clearly initiates a reduction in CO₂ emissions in the Transport industry.

Here we can see its steady reduction trend alongside the other key carbon producing industries.



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The European market is dominated by long and regional haul



72%
Long and
regional haul

Total European market 2016



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3. Business Case. . .



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Diesel Substitution Factor **90–95% LNG**

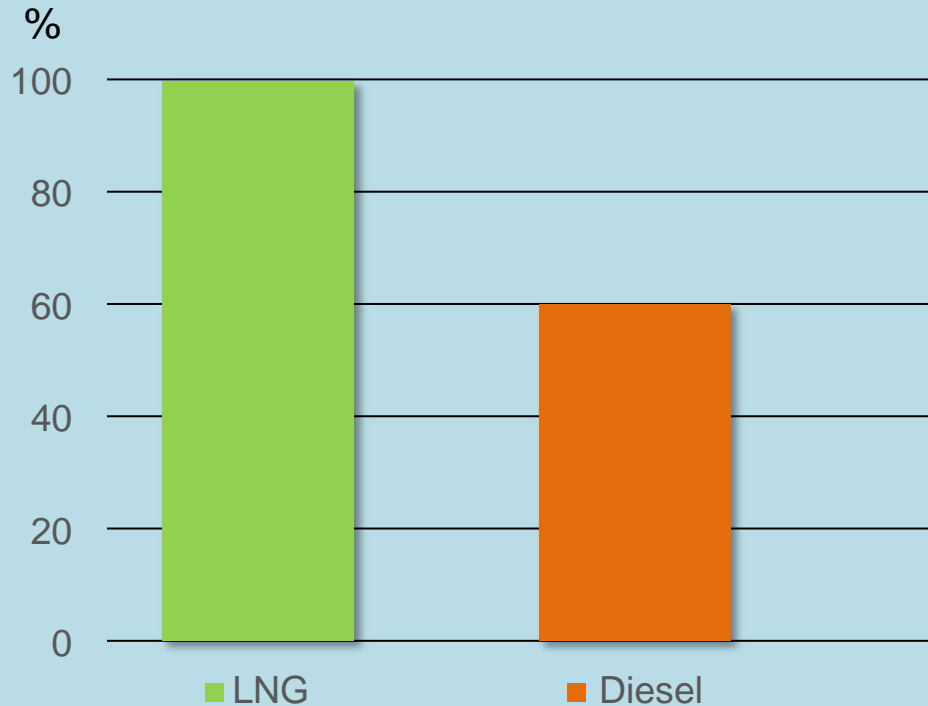
Each injection contains a fuel mixture of approximately 90%– 95% LNG and 5%–10% diesel.



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New Truck Purchase Cost



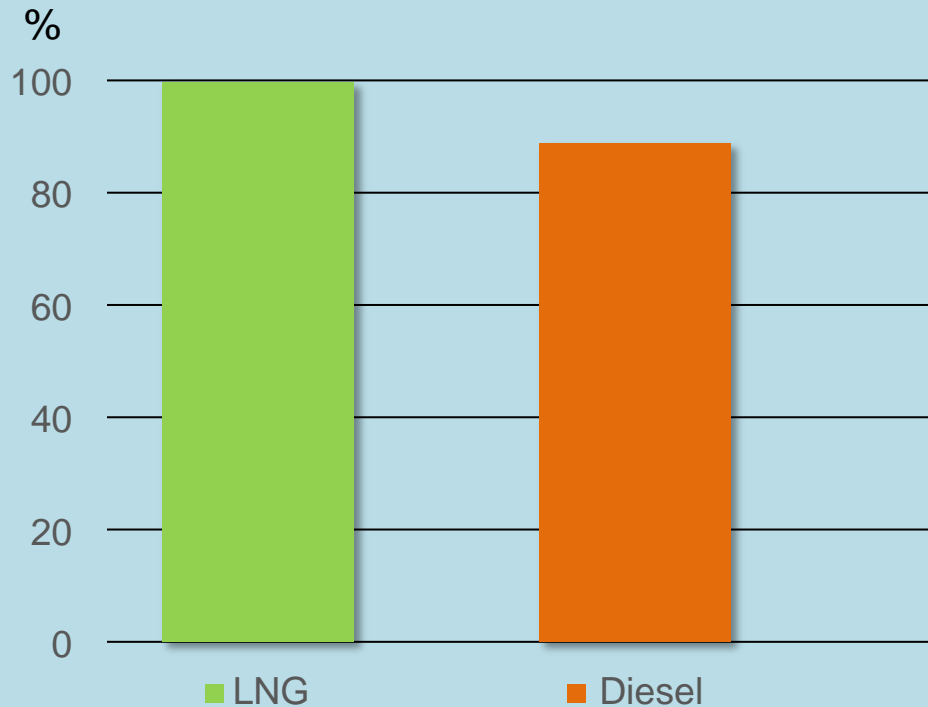
The Price of Progress: New LNG Articulated Trucks currently cost 40% more to buy than Diesel



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Truck Maintenance Cost



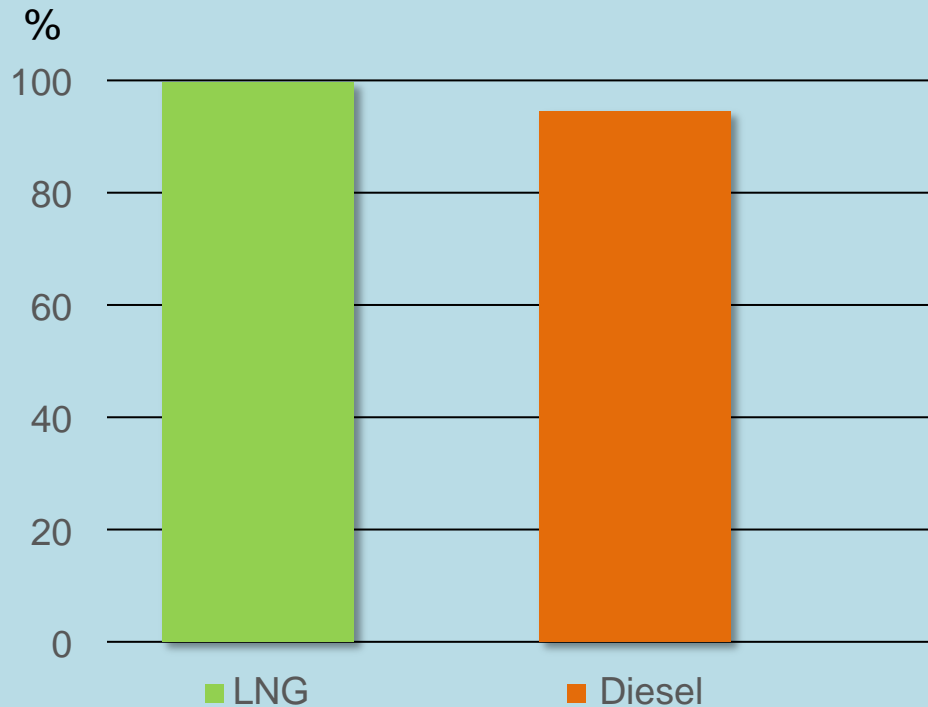
Maintenance Costs for LNG Articulated Trucks currently cost between 5% & 7% more than Diesel



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Real-World Comparison



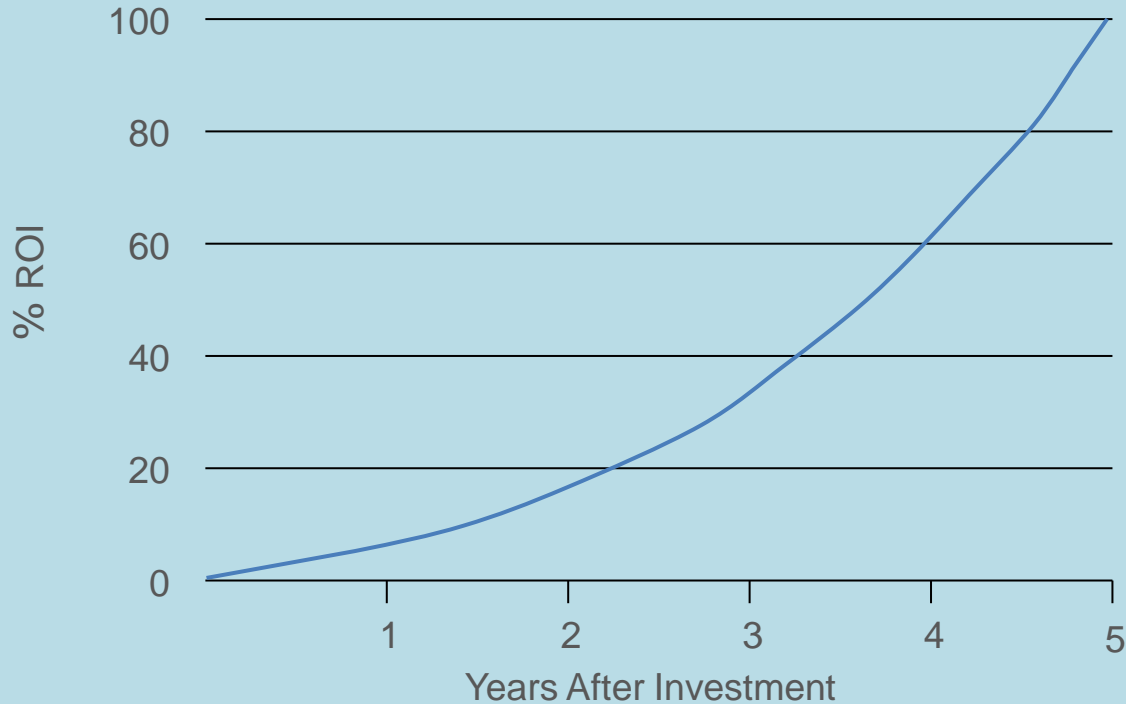
Operational Cost for the Regular Antwerp to Macclesfield job 5% Higher using LNG Truck



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ROI Period



Projected Period to
achieve Return On
Investment for LNG
Truck purchase = 5
Years



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Carbon Footprint Benefits for You



- Typical single round-trip journey = 700 Miles
- Typical CO₂ Emitted per round-trip journey = 980 kg
- Five round-trip journeys per week = 4,900 kg CO₂ per week = 254,800 kg per annum
- Switching to LNG returns approximately 20% lower CO₂ emissions
- Switching to LNG therefore generates approximately 203,840 kg CO₂ per annum
- Overall CO₂ Footprint Reduction per annum therefore = Approximately 50,000 kg



4. Future Fuels: Why LNG?...

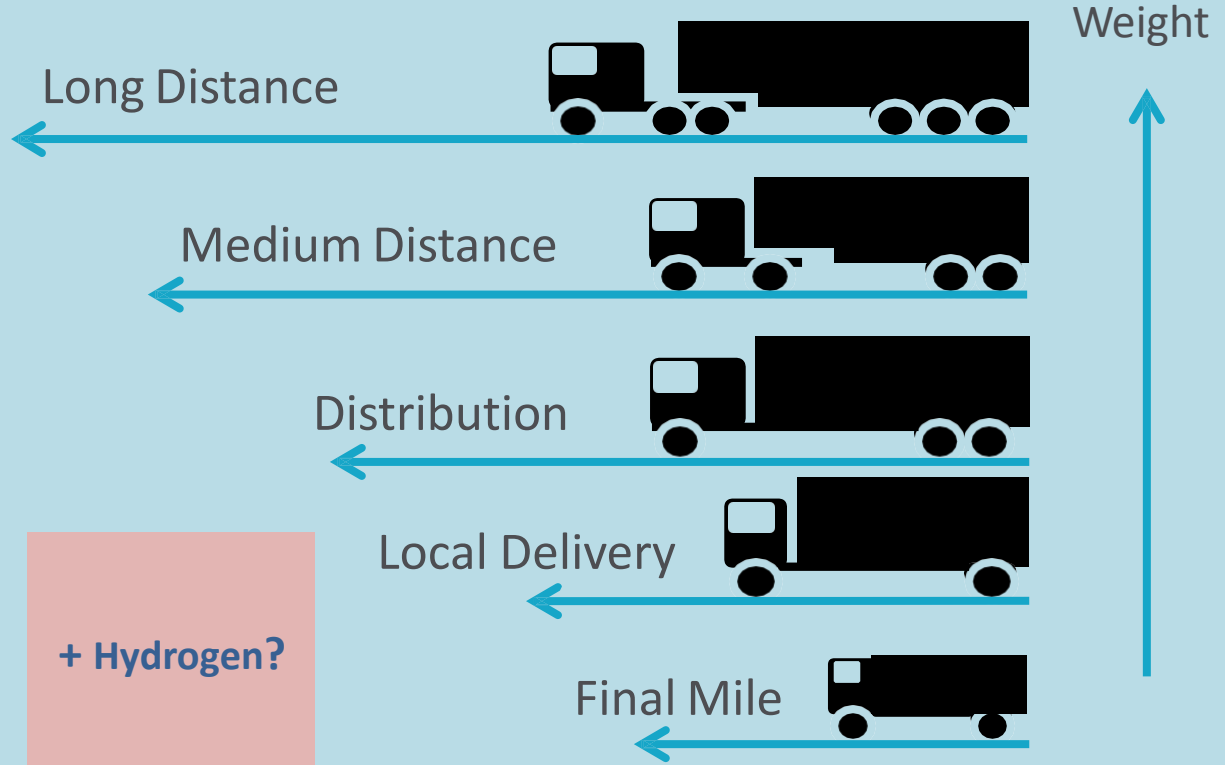
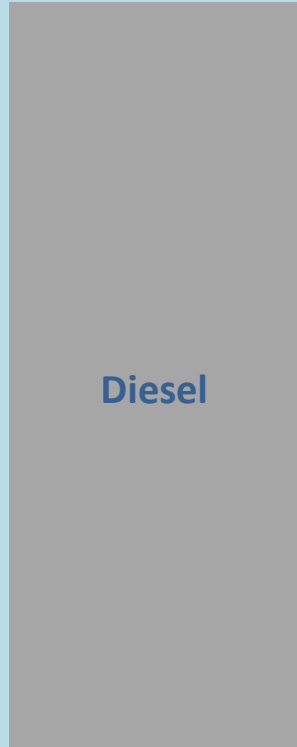


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Today

Tomorrow



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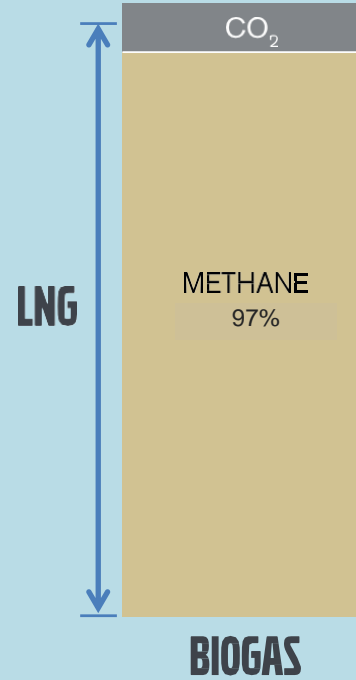
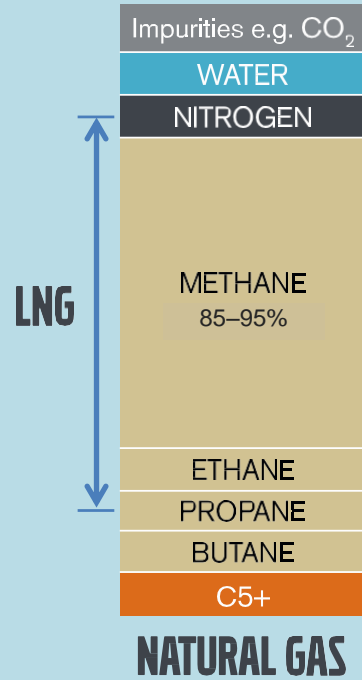
- 
- Climate impact
 - Energy efficiency
 - Land use efficiency
 - Fuel potential
 - Vehicle adaptation
 - Fuel cost
 - Fuel infrastructure



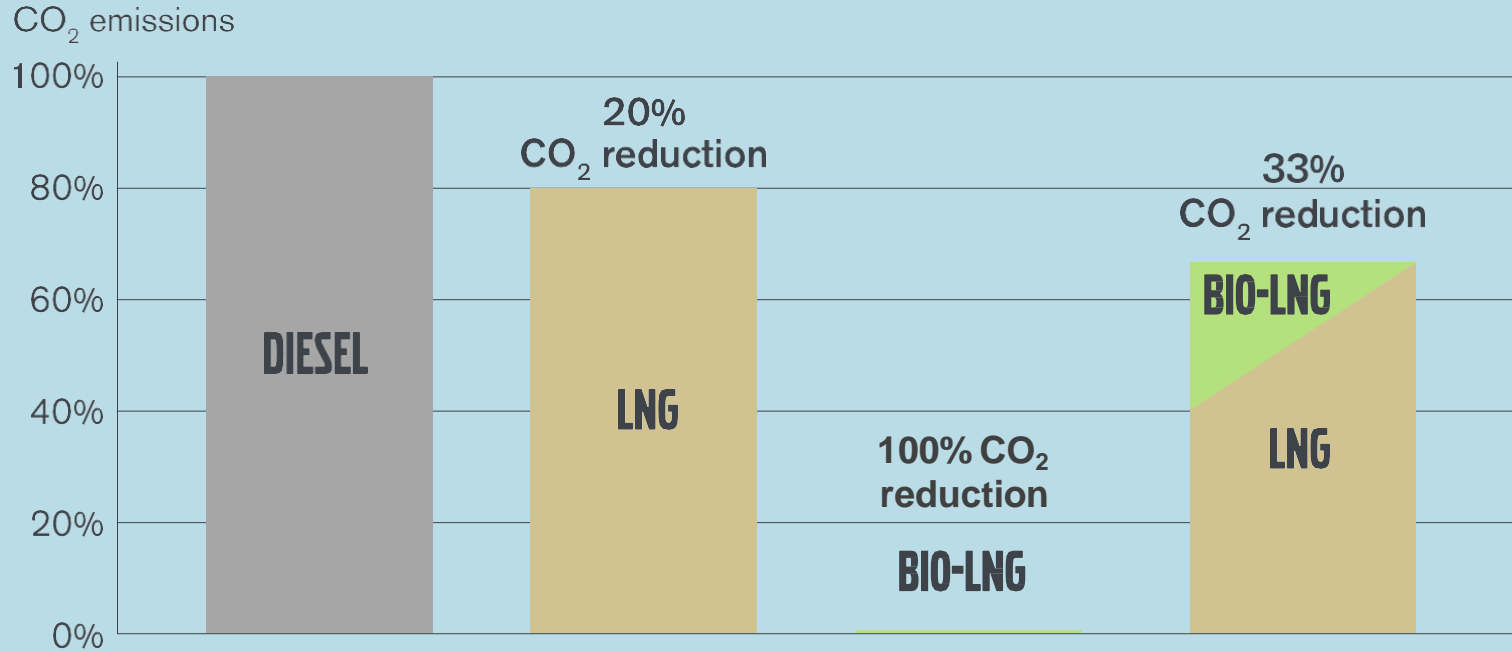
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LNG is liquefied Natural Gas or Biogas



LNG – CO₂ Saving Potential



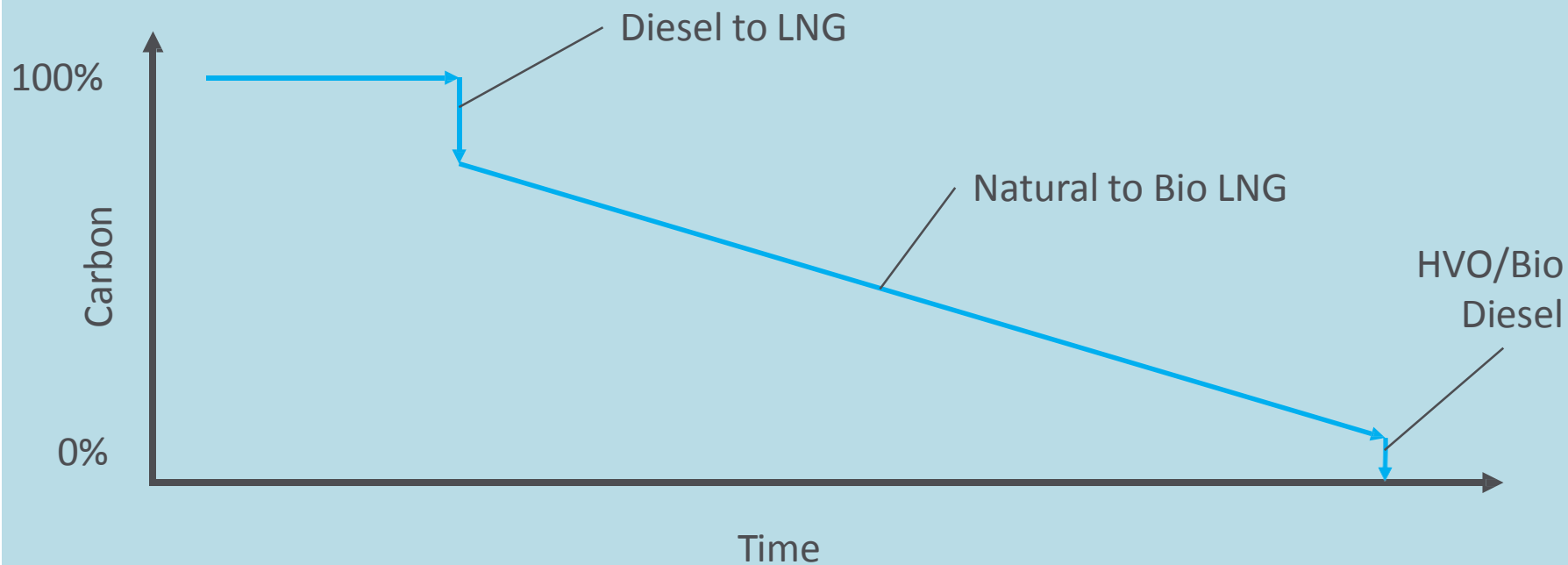
Valid for tank to wheel



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Transitioning to 100% Sustainability



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Why LNG Euro VI?

- Diesel efficiency - diesel performance – diesel robustness
- Using 90 - 95% LNG and diesel as ignition
- Long and regional haul segment
 - Best environmental impact - 20% CO₂ saving
- Diesel engine cycle is circa 10 -15% more efficient than spark ignited engines



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Viable Commercial Option: The Volvo Euro VI LNG



20% less CO₂

100% Bio fuel compatible



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