



## Task 37 Workshop Austria UK Update on Biomethane as a Truck Fuel

15<sup>th</sup> April 2021

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# CNG Services Ltd

**Low Carbon Innovations**

**cng services Ltd**

**17,500,000 tonnes**

Over the next 20 years, CSL's projects will contribute towards a CO<sub>2</sub> emissions saving of.....

Celebrating over 16 years of innovation in gas

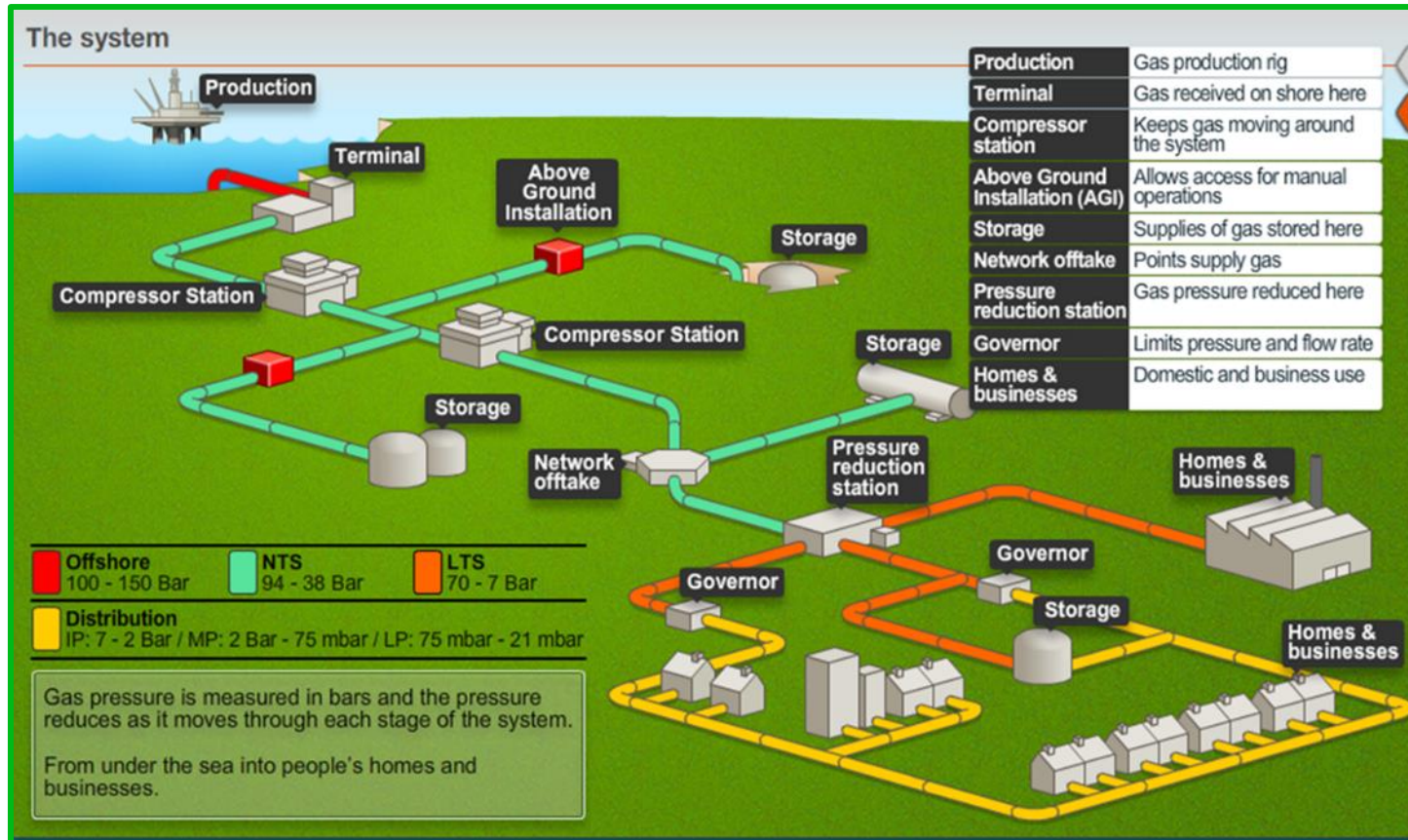
- CNG Services Limited (CSL) provides consultancy, design and build services to the biomethane industry, all focused on reducing Greenhouse Gas (GHG) emissions
- In the past 10 years our efforts have produced a material impact with an estimated 20 year project life reduction in CO<sub>2</sub> emissions of 17,500,000 tonnes through:
  - Biomethane injection into the gas grid
  - Running trucks on Bio-CNG
  - Acting as developer and design and build contractor for the Highlands Bio-CNG Project
- Part owner of CNG Fuels Ltd, a company set up to build a national network of Bio-CNG stations on the high pressure grid
  - National network of CNG Stations
  - 84% saving in GHG compared to diesel
- Part owner of Barrow Shipping Ltd, GB's leading shipper of biomethane and a company that only buys and sells biomethane, no fossil gas
- CSL is an ISO 9001, 14001 and 45001 approved company and has also achieved Achilles certification. CSL is GIRS accredited for design and project management and has been certified as a competent design authority by DNVGL



Certificate Number 17464  
 ISO 9001  
 ISO 14001  
 ISO 45001



# UK Gas Network

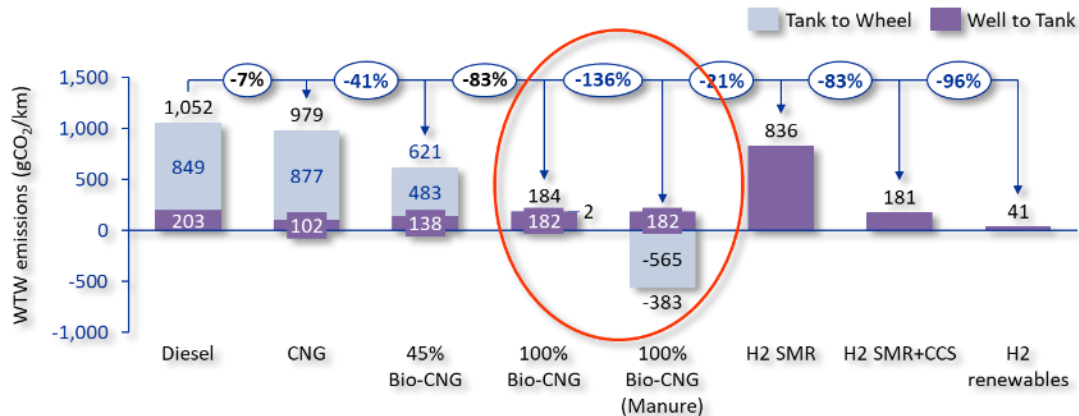


- **MP**
  - Lowest pressure tier used
  - Very high coverage across UK
  - PE or metal construction
  - 50 biomethane projects
- **IP**
  - 6.9bar Good coverage across UK
  - PE or metal construction
  - 40 biomethane projects
- **LTS**
  - Ranges from >12bar to 70bar
  - Usually 19 bar or 38 bar systems
  - All metal – however new high pressure PE up to to 100 bar is now approved
  - 25 biomethane projects
  - Ideal for Bio-CNG (eg Leyland/Erdington)
- **NTS**
  - 50 – 85 bar
  - 1 biomethane injection and 1 Bio-CNG Mother station

Best option is to inject biomethane into MP or IP (no compression needed) and then take out of LTS or NTS to make Bio-CNG

# Todays' Biomethane Trucks have CO2 Emissions Over 80% Lower than Diesel

- Modelled Well-to-Wheel (WTW) emissions for CNG trucks<sup>1</sup> suggest that a 100% emissions saving is possible when using 100% biomethane, compared to diesel equivalents. This is comparable to real-world trial data<sup>2</sup> which estimated WTW emissions savings of 76-81% with pure biomethane
- The CO<sub>2</sub> emissions associated with biomethane are primarily incurred during the production process, from the electricity consumption of the plant required to clean and compress the gas. This is largely dictated by the carbon intensity of the grid



1. Element Energy, *Development of a Well to Tank Emissions Model for Heavy Duty Vehicles*, 2018 and Element Energy for TSC and DfT, *Hydrogen to Smart Mobility: Review of Opportunities for Hydrogen for Heavy Vehicles*, 2019; 2. Cenex, *An Innovative UK Research Project to Assess the Viability of Gas Vehicles*, 2019; 3. Wet manure has an emission factor of -103 gCO<sub>2</sub>e/MJ under the Renewable Energy Directive



<https://documents.cadentgas.com/view/957927673/>

Moving from diesel is very hard – Bio-CNG is a great start

- **HGVs are difficult to decarbonise with the most challenging requirements for driving range and carrying capacity**
- There are alternatives to diesel:
  - Battery electric vehicles (BEVs) are commercially available and well-suited for light, short-range transport sectors (cars, vans and trucks up to 8t) but there are few or no options for long-haul freight and farm tractors
  - Hydrogen fuel cell electric vehicles (FCEVs) are expected to provide a solution for HGVs in the long term but the technology readiness is low and its not an option at present
  - **Methane** – in the form of bio-compressed natural gas (Bio-CNG) and bio-LNG is currently the only proven, commercially available option for long haul vehicles

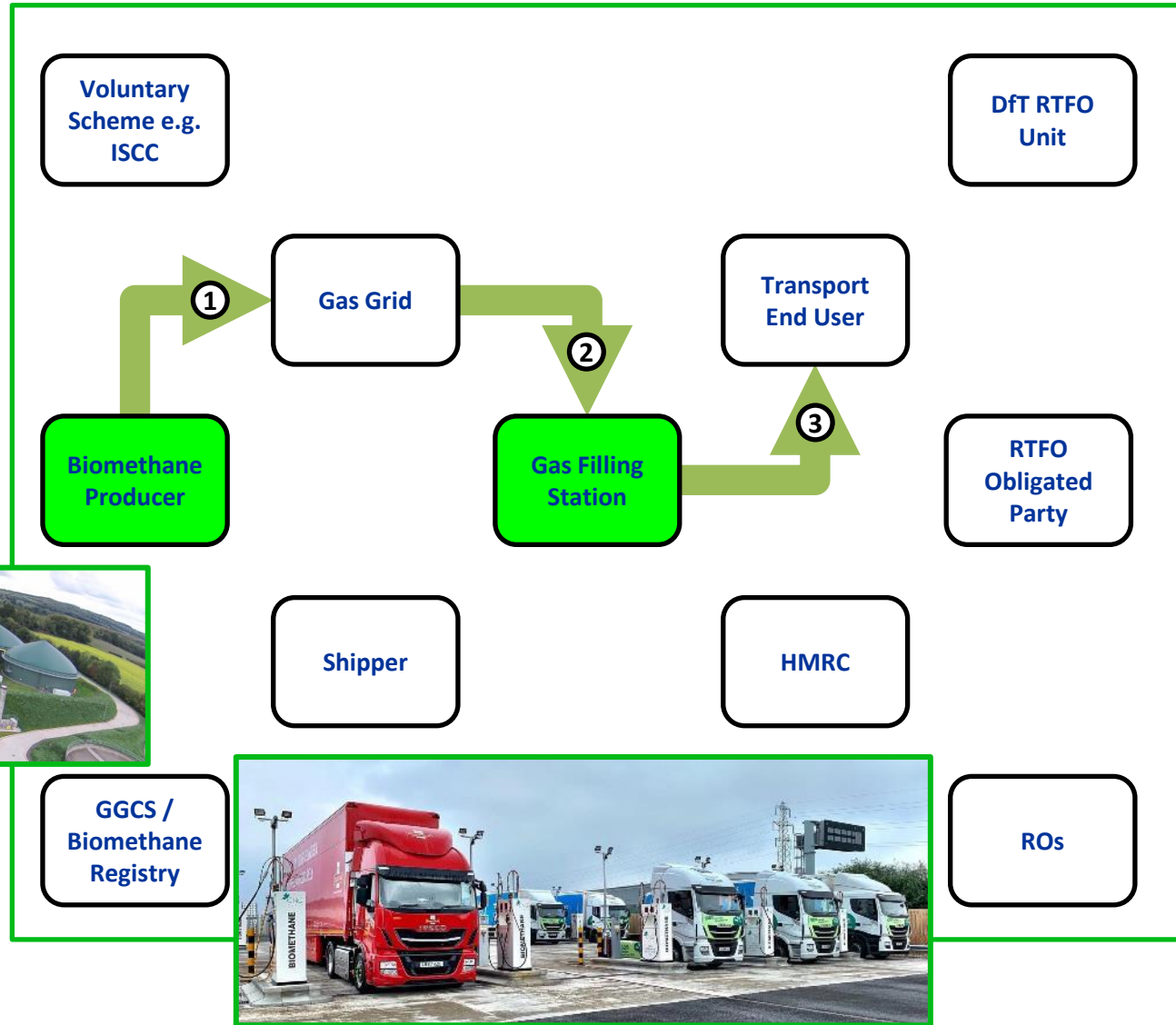
Comparison of range and availability of low carbon fuel technologies in UK/Europe

	Maximum range (km)			Vehicle availability					
	Cars	Vans	HGVs	Cars and vans	HGV sector (gross vehicle weight in tonnes)				
					3.5-8	8-18	18-26	26-38	Over 38
BEV	600	200	300-885*	Green	Green	Green	Green	Green	Red
Bio-CNG		600	700	Green	Green	Green	Green	Green	Green
H <sub>2</sub> FCEV	660	350†	500-1200*	Green	Yellow	Yellow	Yellow	Yellow	Yellow

Green Vehicles commercially available Yellow Vehicles in development/trial Red Not currently available

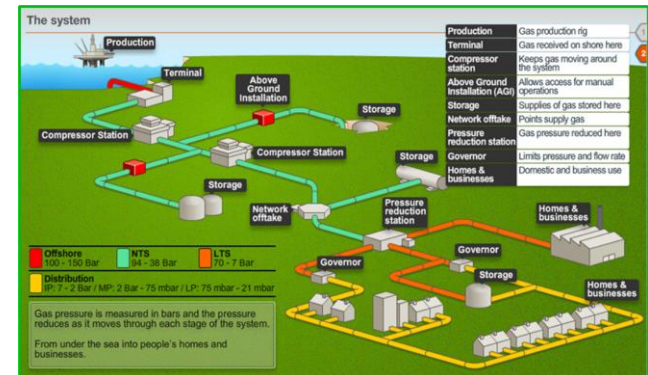
\*Theoretical – vehicles not currently in production †H<sub>2</sub> range extender

# Bio-CNG Delivered from the AD plant to the Distribution Depot via the Gas Grid

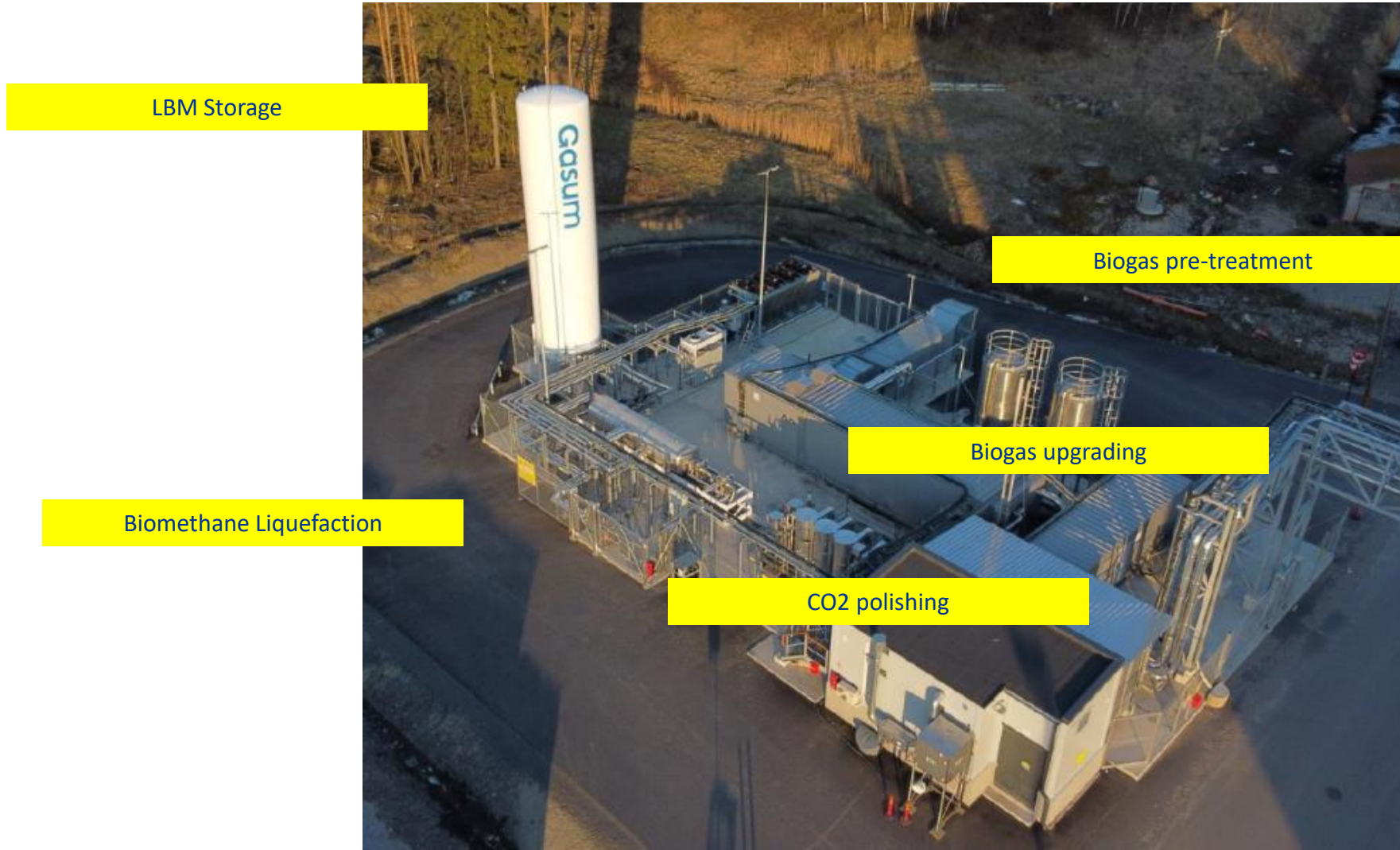


Biomethane and fossil gas are chemically identical and therefore the buying and selling of renewable gas is evidenced by certificates.

1. Biomethane is injected into the gas grid; this can take place anywhere (in Europe) under the mass balance rules, as long as there is a continuous working gas grid between the entry point and the exit point.
2. Gas is withdrawn from grid by fuel supplier (i.e. it goes into the gas filling station). The fuel supplier can evidence the origin of the gas
3. Gas is dispensed to a vehicle

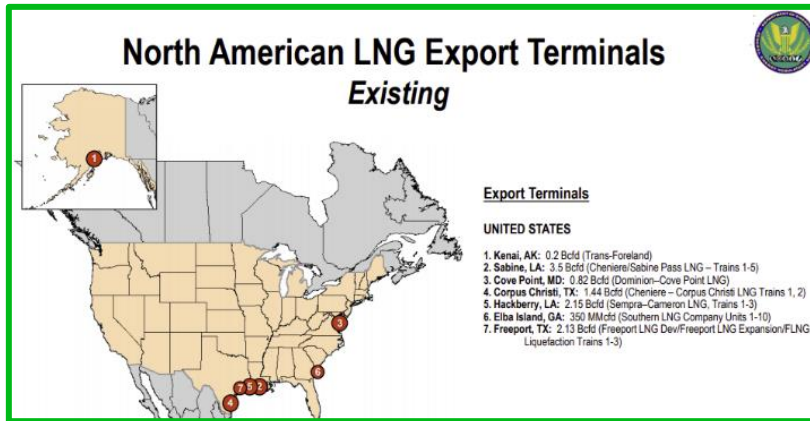


# Liquefaction of Biomethane – no plants like this in GB and no plans for any...instead GB Bio-LNG trucks use US/Qatar LNG....



# Bio-LNG

US/Qatar LNG – ship to UK – load into road tankers at Isle of Grain – deliver to truck depot  
Match with Green Gas Certificate to become Bio-LNG



There is no plant in GB that makes Liquid Biomethane or LNG – it is (mostly) all imported from US or Qatar

# Bio-CNG Vehicles – OEM Products from Scania, Iveco, Mercedes



[How to refuel a CNG \(Compressed Natural Gas\) Truck - Bing video](#)



Whisky industry  
Launch April 2021



## Iveco 6 x 2 CNG

FEB 19, 2021

### Granville Ecopark welcomes two new biomethane-fuelled trucks

Granville Ecopark has introduced two new CNG-powered trucks to its operations, the first of their kind in Northern Ireland.

The new IVECO Stralis NP trucks will be fuelled by food waste-derived biomethane, produced through anaerobic digestion.

Dubbed their 'Smart Loop Lorries', Granville Ecopark's new vehicles and AD technology create a circular economy, where nothing is lost or wasted. The new lorries will be used to collect food waste, which in turn is converted into vehicle fuel and used to deliver other sustainable products created at the plant, such as natural fertiliser and biomethane for renewable electricity production.



The company has praised the environmental benefits of biomethane, which reduces CO<sub>2</sub> emissions by up to 95% compared to diesel, and reduces air polluting NOx emissions by up to 70%.

"We believe that biomethane has a huge part to play in the future of vehicle fuel as a fossil fuel alternative," said Granville's chief technical officer, David McKee.

"We are excited to be leading the way in the haulage and renewable markets in Ireland and will continue to follow our company mission to make our future here more sustainable."

CNG Fuels



# Scania 6 x 2 Bio-CNG Tractor Unit



- 640 Litres CNG @ 200Bar giving 350-400km range
- Increased tank capacity in development by Scania
- Currently meets legal requirements for up to 40ft trailer applications
- General €23k-30k premium over diesel tractor unit
- Currently available up to 410hp, 2000Nm Torque

## Ideal for the Following Applications:

- Bulk Haulage – Quarry/Aggregate, Animal Feed, Tarmacadam, Fertilizer, Dairy, Fisheries etc
- Specialized Tanker Haulage – Pharmaceutical/Chemical, Food and Beverage, Bitumen, Water treatment and Waste/Recycling industries
- Shipping Container Haulage – Conventional Container and ISO Tank up to 40ft Long
- AD/Biomass Haulage – Feedstock, Digestate and Bio-Gas haulage

# Cement Mixers that run on Bio-CNG

## “Green Concrete for Construction”

### Iveco Bio-CNG

**IVECO** 131,649 followers · 2w · 🌐

Les transports Faugere ont mis à la route la première bétonnière 100% GNV en Ile de France, pour le compte du bétonnier Unibeton. Cet Iveco Stralis NP, fruit de la collaboration entre Iveco, la concession Le Poids Lourd et Les transpo ...see more

Rate this translation · 🌐

Faugere transport has put the first 100% GNV cement mixer on the road in the Ile de France, on behalf of the cement maker Unibeton. This Iveco Stralis NP, the result of the collaboration between Iveco, the Le Poids Lourd and Faugere transport concessions, is perfectly suited to urban deliveries: thanks to a range equivalent to that of diesel vehicles and a load capacity of 8m3, it proves to be uncompromising on productivity.

"We are totally satisfied with the vehicle and want to expand this experience with our carriers," said Renaud Boucherat, Chief Operating Officer at Unibeton. #NaturalPower0



1ère bétonnière 100% GNV IVECO

### Mercedes Benz Bio-CNG

Powerful drive for all operation sites.

The familiar operational capabilities are made possible by the compact and powerful OM 936 in-line six-cylinder engine with a displacement of 7.7 litres – available in the three power ratings of 200 kW (272 hp), 220 kW (299 hp) and 260 kW (354 hp). A real alternative, especially in inner-cities subject to exhaust fumes and high noise levels: the Eonic NGT with the M 936 natural gas engine of the same displacement, delivering 222 kW (302 hp) of output.



### Scania delivers natural gas concrete mixers to Asturias-based company

September 9, 2020



Comercial Iberoamericana de Servicios, S.A. (Combersa), belonging to the Masaveu corporation and mainly dedicated to the logistics of the purchase management of vehicles, recently acquired five Scania concrete mixers powered by compressed natural gas for General de Hormigones, a company that is part of Masaveu's Industrial Division. Combersa's fleet is made up of a total of 166 vehicles, of which 27 are Scania.

### Scania Bio-CNG

#### First natural gas-powered ready-mixed concrete truck in France

Currently, almost all concrete mixer trucks are powered by diesel engines. At Unibeton (a subsidiary of HeidelbergCement), we have made the next step: We've just introduced the first 100% natural gas-powered concrete mixer truck in France, which hit the roads of Bordeaux in September.



## New Holland Bio-CNG Tractor



# Bio-LNG Vehicles – OEM product from Volvo, Scania, Iveco

[How to refuel a LNG \(Liquefied Natural Gas\) Truck - YouTube](#)



# Types of Bio-CNG Station



- There are three options for a haulier wanting to adopt Bio-CNG trucks:
  - **Option 1 – Depot based Bio-CNG Station**
    - Only possible if gas grid is close by
  - **Option 2 – Mother/MRU Station**
    - Mother must be on Transmission Grid
    - MRU parked at hauler's depot
    - Gas delivered by road from the Mother Station
    - Good option if hauler load <500,000kg or if hauler load >500,000kg but there is no gas grid
  - **Option 3 – Public access Bio-CNG Station**
    - Best option if available
- **There are 3 costs:**
  - Gas commodity
  - CNG Duty
  - Compression charge

## High Pressure Grid CNG: The low CO<sub>2</sub> option for HGVs

14<sup>th</sup> November 2012

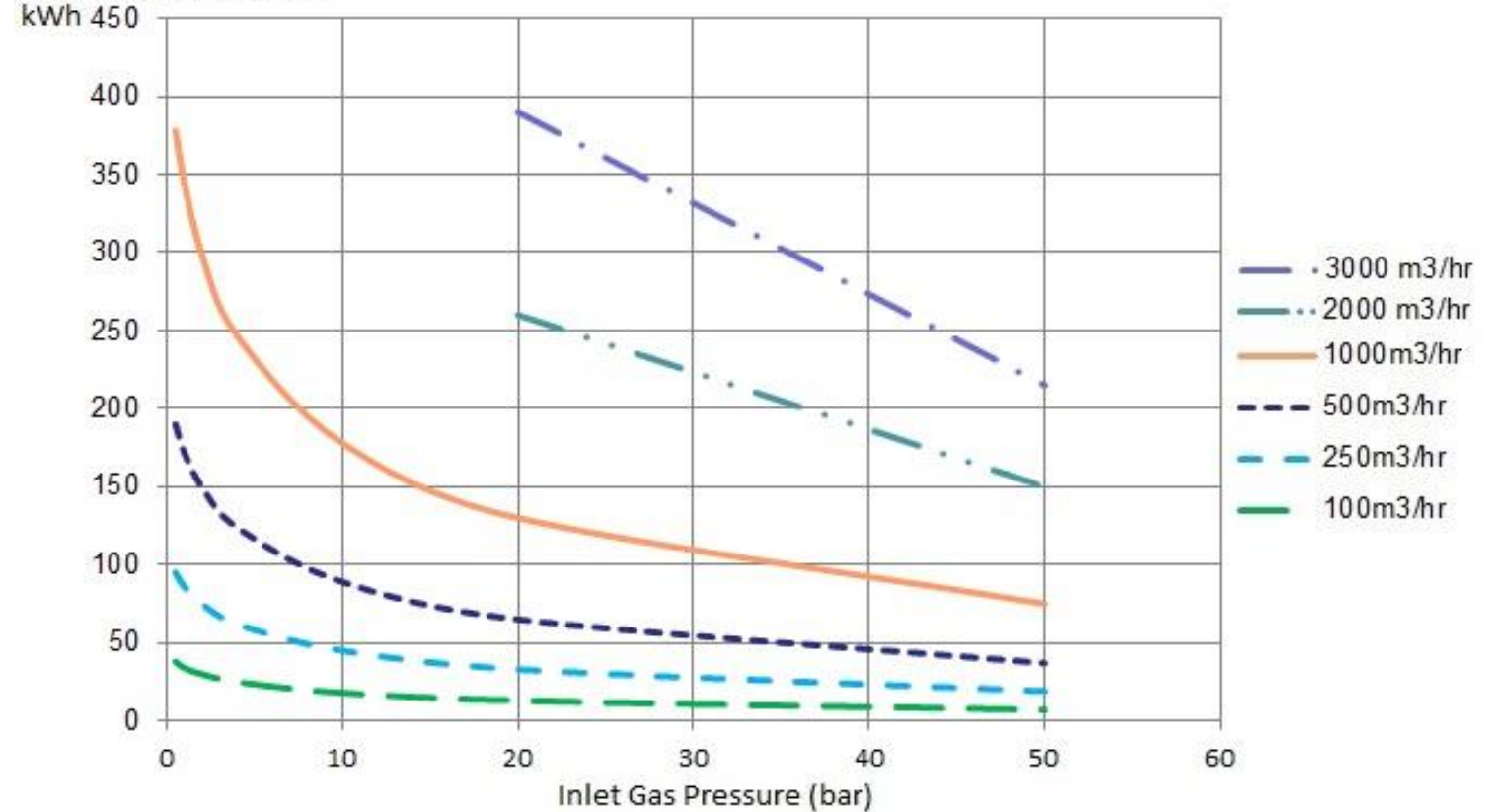
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- **IMECHE 2012 Presentation**
- Fordoun, Leyland, Erdington and others in build prove the huge benefits of Transmission pressure
- Its like climbing Everest but starting at 26,000 feet
- Lower unit capex, low maintenance, low electricity consumption
- Fordoun 55 bar inlet flows 7,000 scmh with 350 kWh electricity

## Energy Used in Compression

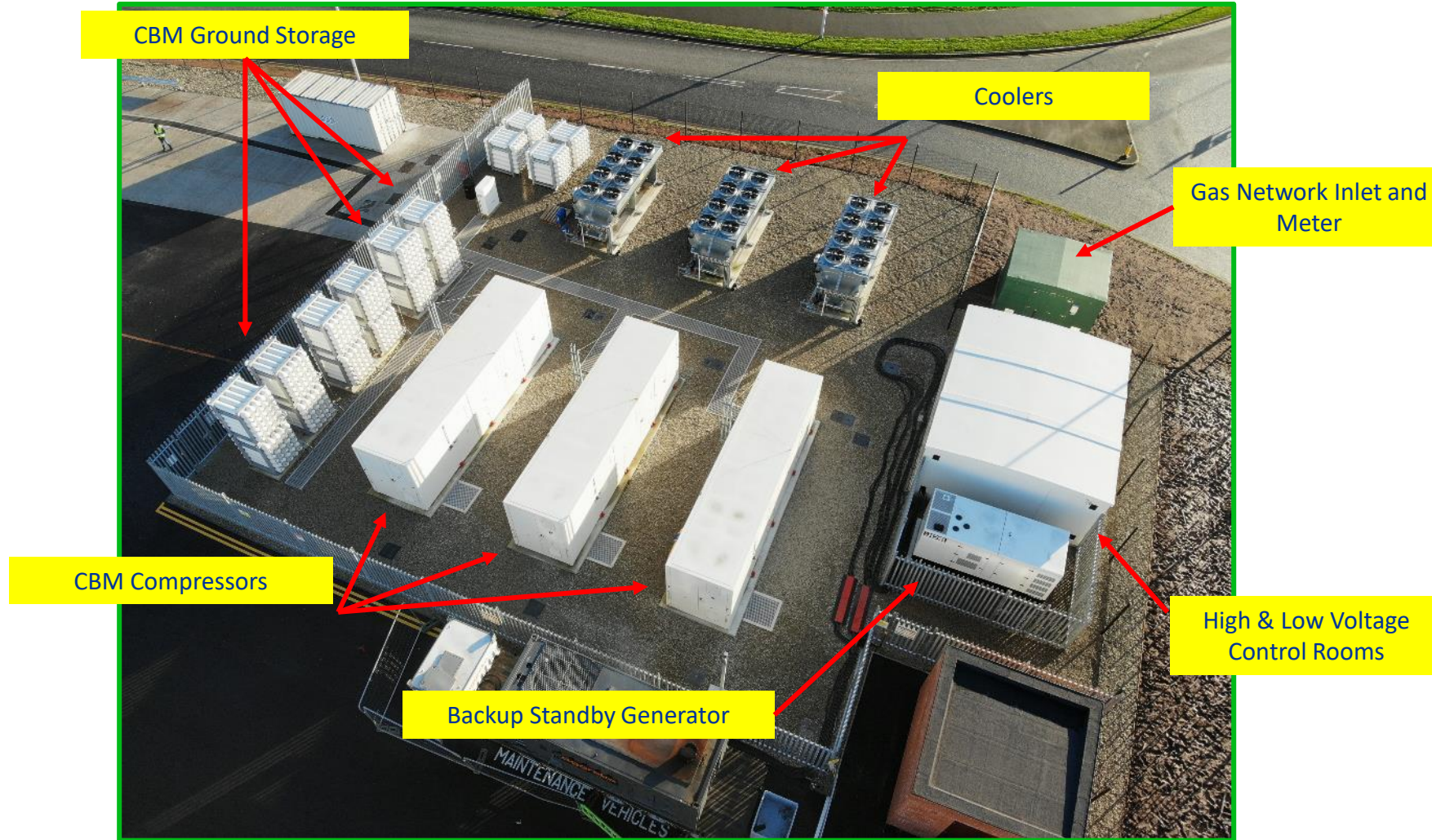
Electricity Consumption



As the grid (inlet) pressure increases the electricity used in compression decreases and higher flow rates of above 2,000m<sup>3</sup>/hr are possible which reduces the running hours of compressor and/or provides very high capacity

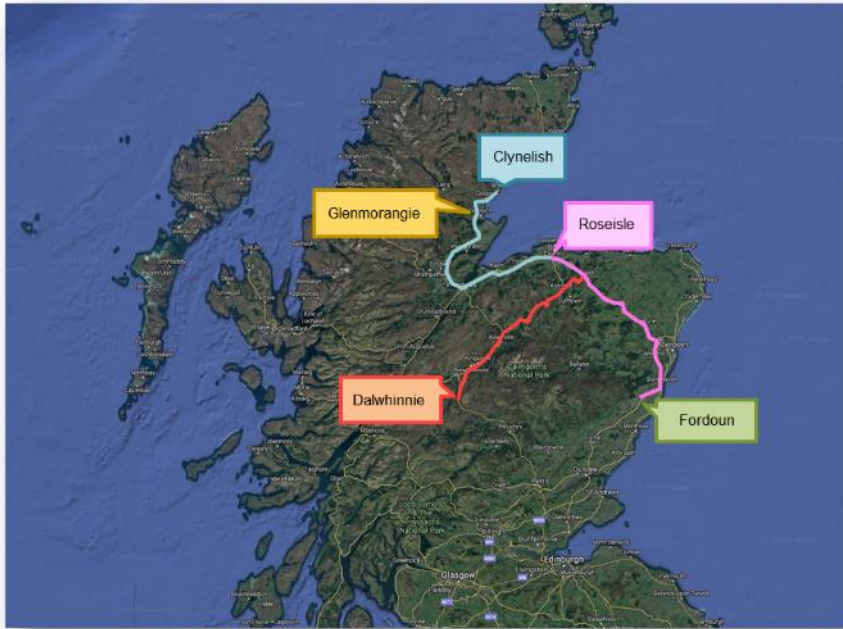
# Typical Grid Connected Bio-CNG Station

*Can be public access (Option 3) or private on a depot (Option 1)*





# UK's Biggest CNG Mother Station – Bio-CNG Supply to four off-grid distilleries



- **Basis:**
  - **Air Liquide Owned and Operated Project**
  - **Distilleries:** Glenmorangie (LVMH), Clynelish, Dalwhinnie and Roseisle (Diageo).
  - **Compression:** Gas is taken from the NTS grid and compressed to 250barg into CNG Trailers before being transported to the distilleries
  - **Transportation:** Gas is transported via road using X-Store CNG trailers. At 250barg these hold ~10 tonnes of gas (~13,000 Sm<sup>3</sup>)
  - **Decanting:** Gas is decompressed at the decanting station down to 2barg and is piped to the distillery boiler-house.
- **Connection/Pipeline:** Fordoun is located near the NGT NTS grid. A connection was made in an existing NGT AGI and a customer ROV was installed just outside the AGI. A 3" carbon steel pipeline was installed, running from the ROV outlet to the meter inlet onsite.
- **Design Gas Loads**
  - **Fordoun :** Max 6,500 Sm<sup>3</sup>/hr (each compressor)
  - **Glenmorangie:** Maximum 1,200 Sm<sup>3</sup>/hr
  - **Clynelish:** Maximum 1,200 Sm<sup>3</sup>/hr
  - **Dalwhinnie:** Maximum 1,200 Sm<sup>3</sup>/hr
  - **Roseisle:** Maximum 2,400 Sm<sup>3</sup>/hr

# Mobile Refuelling Unit (MRU)

## Option 2 supplied from Gas Transmission Connected Mother Station



*This is parked at the truck depot. It needs a relatively small electricity supply only. Otherwise, it is standalone and can be topped up by a Bio-CNG trailer. Two of these have been built and have been used in Milton Keynes since November 2020*

**Basic Operation** – The gas arrives at the site in a Bio-CNG trailer and is decanted from the trailer into the high-pressure storage on the mobile ‘MRU station’ using a hydraulic compressor, which is also installed on the ‘MRU station’ trailer. The mobile trailer also holds a dispenser which can fill Bio-CNG Vehicles.

**Trailer** - 45’ foot flat bed trailer with access ladders

**Compressor** - Hydraulic Booster compressor mounted in ISO container able to compress out of low and middle storage to maintain pressure to high bank

- **Priority Panel** - 3-line priority panel to Bio-CNG storage
- **Bio-CNG Dispenser and Fuel Management**
- **Connection to Bio-CNG Trailers**

**Storage** - 20’ ISO containerised storage unit (shown in top-left photo)

- **Material** - Type 4 (composite) storage cylinders
- **Capacity** – 3,500kg of gas

**Filling** - Bio-CNG trailer can deliver gas from the Bio-CNG Mother Station and park alongside the MRU

- The compressor runs to top up the storage on the MRU
- Repeats at other MRUs and keeps all MRU station storage units full of Bio-CNG
- When the Bio-CNG trailer pressure is around 25bar it travels back to the Mother Station and fills up



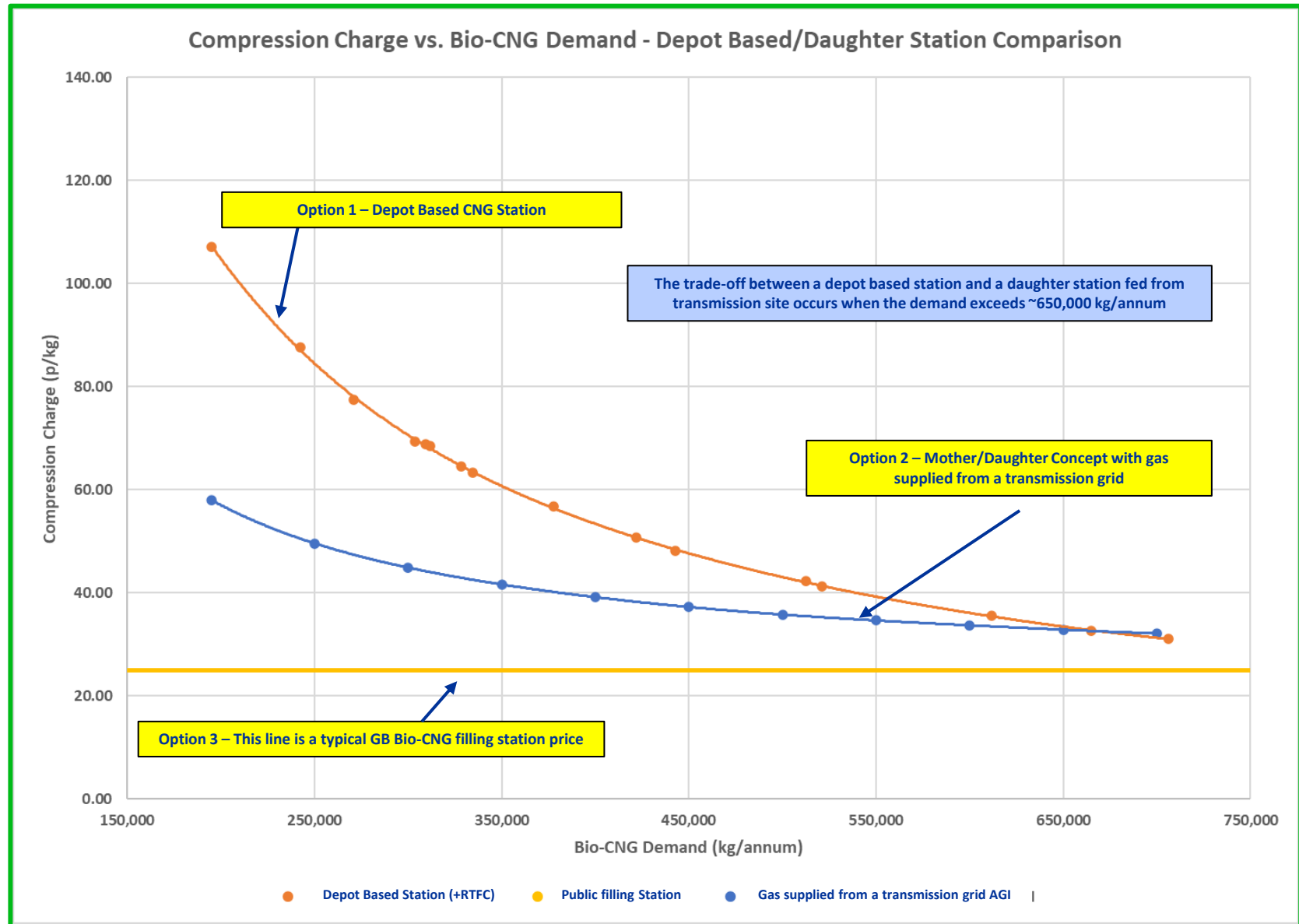
# Indicative Comparison – Option 1 vs Option 2 vs Option 3

**Option 1 – Depot based Bio-CNG Station**

**Option 2 – Mother/Daughter Station**

**Option 3 – Public access Bio-CNG Station**

Each line is based on Bio-CNG in Great Britain



# Bio-CNG Station Roll-out Plan



**HGV & Van Fleets:**

- Waitrose
- ASDA
- John Lewis
- Royal Mail
- Hermes
- Clipper
- New Look
- Home Bargains
- Argos
- Suma Foods
- DHL
- Cadent
- HPH
- Dixon Transport
- Virginia Logistics
- Brit-European
- Howard Tenens
- Ocado
- Farmfoods

**Waste/City Council Fleets:**

- Liverpool City Council – 20 RCV's & New Small Fleet
- Various Councils ordering vehicles in next 12 months
- Veolia operate a fleet of 20 CNG RCV's in London
- Warrens & Bio-Collectors are other Waste companies currently running CNG vehicles in their fleet

DEC 4, 2020

## Foresight Group invests £80m in CNG Fuels refuelling stations network

Foresight Group has partnered with CNG Fuels to develop a network of refuelling stations in the UK, providing an initial £80 million (£89 million) in funding.



The stations will enable heavy-goods vehicles (HGVs) to run on carbon-neutral fuel.

CNG Fuels opened its fifth refuelling station near Birmingham last week, and the funding will see it develop at least 14 further public access stations on major routes over the next two years. This will quadruple the firm's capacity and enable it to refuel 8,000 vehicles per day.

Additionally, CNG Fuels will make carbon-neutral fuel available from Glasgow to Bristol, meeting growing demand from major brands keen to switch their fleets away from diesel.

The company is a major UK supplier of bio-CNG, the lowest-carbon, most cost-effective alternative to diesel for HGVs. The fuel is 35-40% cheaper than diesel and cuts vehicle greenhouse gas emissions by up to 85%.

Richard Morse, chairman of JLEN, Foresight Group's listed environmental infrastructure fund, said: "We are pleased to make this investment into biomethane refuelling infrastructure, helping to decarbonise one of the most emission-intensive parts of the transport sector."

"We consider that the two pillars of better environmental performance and lower-cost operations for customers combine to support our investment case, and we look forward to supporting the growth of a national biomethane refuelling network."

According to Baden Gowrie-Smith, chief financial officer at CNG Fuels, the company expects the number of CNG trucks on UK roads to double in 2021, as fleet operators take steps to support the government's net-zero targets.

"This exciting partnership with Foresight demonstrates their enthusiasm for biomethane as a solution to decarbonise heavy-duty transport at scale," said Gowrie-Smith, "and the near-term development of more stations will enable us to serve our customers even better by delivering carbon-neutral bio-CNG nationwide."



## Leyland Station



## Warrington Station



<https://youtu.be/JUysC8PwmUA>

# Not Such a Shit Idea - Carbon Negative Transport Fuel

## *Double negative with CO2 capture*

MARCH 4, 2021

### Clean Energy and Total Sign Joint Venture to Develop Carbon-Negative Fuel and Infrastructure

*Up to \$400 Million of Equity Including Credit Support Available for Upstream Renewable Natural Gas Projects and Downstream Fueling*

**NEWPORT BEACH, Calif.** – March 4, 2021 – [Clean Energy Fuels Corp.](#) (Nasdaq: CLNE) and its largest shareholder, [Total SE](#), today announced a 50/50 joint venture to develop carbon-negative renewable natural gas (RNG) production facilities in the United States, as well as credit support to build additional downstream RNG fueling infrastructure. The initial firm commitment is \$100 million and can increase to \$400 million as development opportunities progress. Since Clean Energy and Total will be providing the equity portion of the investments, the actual amount of capital invested in RNG projects may be higher than \$400 million depending on the amount of leverage that is deployed. In addition, Total will be providing credit support for Clean Energy development in the RNG value chain, including \$45 million for contracted RNG fueling infrastructure.

Carbon-negative RNG is produced when carbon emissions are captured from dairies and turned into a transportation fuel, reduce the harmful effects on long-term climate change. As a result, the California Air Resources Board gives these carbon-negative RNG projects a weighted average carbon intensity (“CI”) Score (gCO<sub>2</sub>e/MJ) of -317 compared to 100 for diesel and 19 for electric batteries. Clean Energy is the largest provider of RNG as a transportation fuel in the United States, and the largest RNG fuel provider under the California LCFS program. RNG can be used directly as a vehicle fuel or can be used as a feedstock to produce “green” hydrogen or “green” electricity and still generate LCFS environmental credits.

The companies have already partnered to expand the use of RNG in the heavy-duty truck market with the [Zero Now](#) program, which allows fleets to purchase RNG trucks for the same price as diesel trucks. The demand for carbon-negative RNG has rapidly accelerated through the Zero Now program with trucking companies such as Kenan Advantage, KeHE Distributors, Estes Express Lines, Tradelink Transport, among many others, taking advantage of the economic savings while powering their new fleets with the cleanest fuel in the world.

MARCH 10, 2021

### Clean Energy and bp Create JV to Invest in RNG Fuel Production

*Demand for RNG Continues to Rapidly Increase*

**NEWPORT BEACH, Calif.** – March 10, 2021 – [Clean Energy Fuels Corp](#) (NASDAQ: CLNE) today announced that it has finalized a joint venture (JV) with [BP Products North America Inc](#), a subsidiary of [BP p.l.c.](#) (NYSE: BP) to develop, own and operate new renewable natural gas (RNG) projects at dairies and other agriculture facilities.

Each company will retain 50% voting control in the JV, which will be initially funded with \$50 million previously provided by bp and another \$30 million from Clean Energy. The JV anticipates adding preferred stock and debt to increase committed investment capital. Clean Energy will be the operating partner.

The JV will produce RNG using methane captured from dairies’ waste. RNG is used as a transportation fuel and has lower GHG emissions on a lifecycle basis when compared to conventional gasoline and diesel. The California Air Resources Board (CARB) has given similar projects a carbon intensity (CI) score of a weighted average of -317 compared to CI scores of 100 for conventional diesel fuel and 16 for electric batteries.

The demand for RNG has significantly accelerated over the last few years with some of the largest heavy-duty fleets in the world such as UPS, Republic Services, New York Metropolitan Transportation Authority and LA Metro, successfully operating tens of thousands of vehicles on RNG.

# And finally – Hythane Wind/Solar/Battery to H2 to Hythane

- Direct wire from wind/solar/batteries to electrolyser
- Electrolyser produces H2, compresses and stores at 80 bar
- H2 is decanted into returning Bio-CNG trailer (typically at 25 bar) from customers and increases pressure to around 50 bar (for 10% by Volume H2)
- This creates 10% H2/90% Bio-CNG blend when the trailer is filled to 250 bar with Bio-CNG from waste and 10% H2 from renewables, this is a very good low GHG option
- Scania's Industrial gas engine is rated for 12% - aim for 20/30% in trucks
- Not expected to be any technical issues – loss of range of around 13% (based on 20% H2) but this is not material in NetZero context
- Good news for H2 supply chain in that this truck can accept interruptible H2 supply
- This is not an option for Bio-LNG trucks



Fuel

### Other quality requirements

Requirement	Value	
	Natural gas	Biogas
Supply pressure to gas regulator <sup>1</sup>	20-35 mbar (0.3-0.5 psi)	15-35 mbar (0.2-0.5 psi)
Fuel temperature	10-40°C (50-104°F)	
Max. water content	A maximum of 80% relative humidity at the lowest fuel temperature. There is no water, other visible impurities or condensation.	
Max. sulphur content (H <sub>2</sub> S)	20 mg/Nm <sup>3</sup>	
Max. sulphur content (total)	350 mg/Nm <sup>3</sup>	
Max. ammonia content	20 mg/Nm <sup>3</sup>	
Max. level of halogenide compounds	65 mg/Nm <sup>3</sup>	
Max. hydrogen content	12% (v/v)	



# Conclusions

- NetZero is hard for heavy goods vehicles. However:
  - Use of waste to make biomethane is proven and deliverable
  - Running trucks and farm tractors on Bio-CNG biomethane is feasible today as the vehicles exist, the fuel exists and the tax and incentive regime in GB is attractive
- For dairy and beef, making biomethane from manure and capturing and using the waste CO2 is double GHG negative
  - Booming in California
  - And Cheshire
    - We are aiming for 50 km of biogas pipelines to a central upgrader for injection into 30 bar grid
    - Then take out of 70 bar NTS on the adjacent site
    - MRU Option 2
- The whisky industry is moving to running all its trucks on Bio-CNG made from its own waste, and the sewage industry and the dairy industry
  - Not such a shit idea after all
  - With a bit of Hythane from solar/batteries on top

In GB we say – NEVER burn any biogas and NEVER vent any CO2 and NEVER use diesel

