



## “Thoughts from the UK - the Best Ideas for New Biomethane Markets”

**Biomethane, Bio-CO<sub>2</sub>, CCS, Bio-CNG Trucks, Solar/Wing/Heat Pumps,  
Green H<sub>2</sub> and the High Pressure Gas Grid**

1<sup>st</sup> March 2023

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# CNG Services Ltd



- 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 CNG Project
- Working on a number of Biomethane, H<sub>2</sub> and CCUS innovation projects including:
  - Biomethane from manure with CCS
  - Biomethane direct into the NTS
  - Green H<sub>2</sub> into the NTS and Hydrogen Business Model Projects
  - Reverse Compression to Create Capacity for Biomethane Injection
- 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 organisation for high pressure UK onshore natural gas works by DNVGL

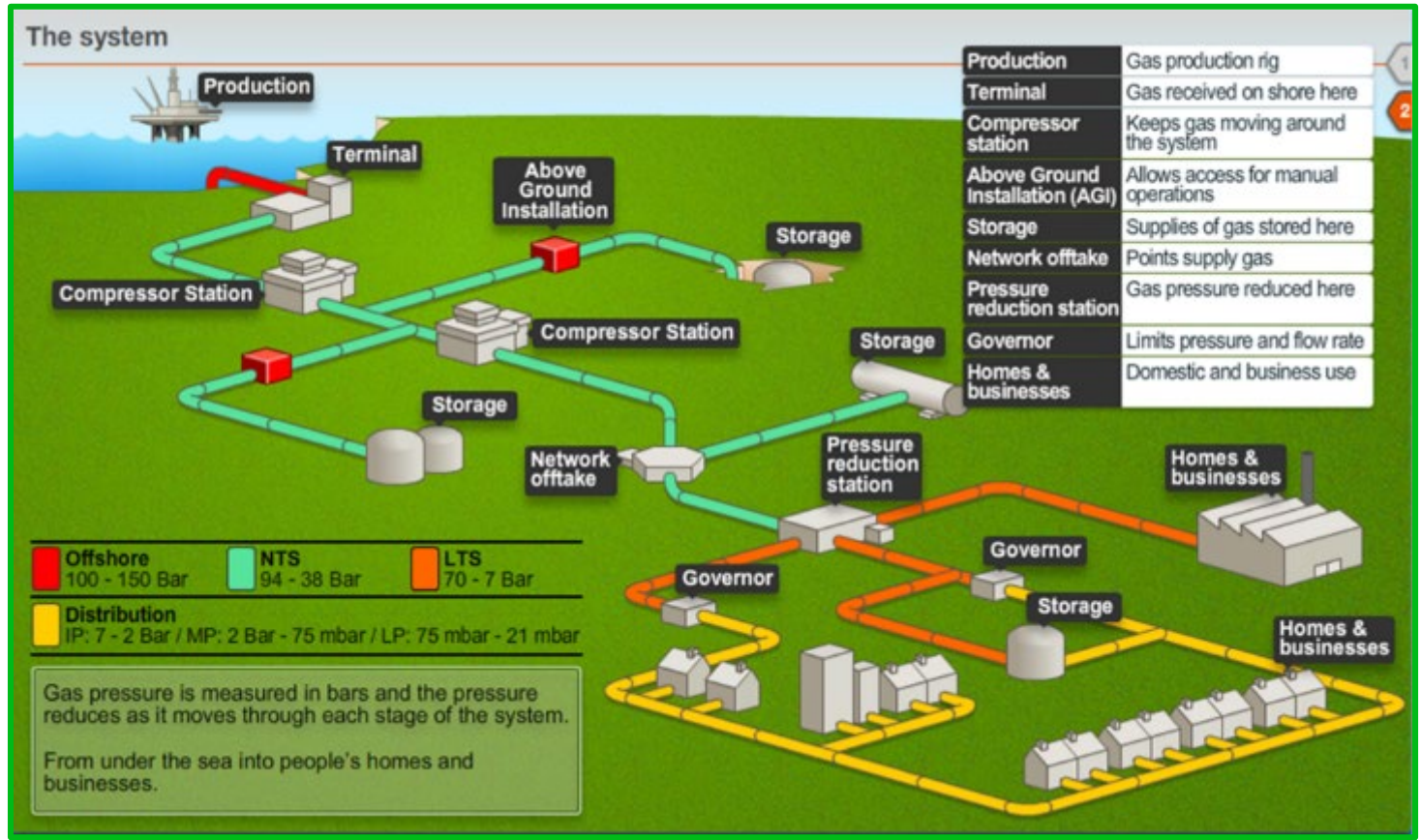


# Thoughts from the UK - the Best Ideas for New Biomethane Markets

1. Biomethane made from manures and wastes such as food waste, sewage and straw is the best fuel
2. Inject biomethane into the gas grid if at all possible
3. Reverse compression means every gas pipeline has capacity
4. Capture all the Bio-CO<sub>2</sub> and send it to CCS so all biomethane projects remove dinosaur era CO<sub>2</sub> from the atmosphere
5. Electricity prices mean that direct solar and direct wind to provide the electricity for new Biomethane projects is very attractive
  - By 2030, we can expect most ADs to have local solar, batteries and maybe wind to aim to secure 50% of their electricity from their own renewables, balance from the grid
6. Green H<sub>2</sub> very attractive and AD sites will be ideal places to make that – land, electricity grid connection, on site solar/wind/batteries
  - Green H<sub>2</sub> and biomethane are twins
7. Utilisation of biomethane will change over time but the truck use is very good today
8. Utilisation of Bio-CO<sub>2</sub> will also change over time – the key point is that it is valuable and should never be vented
9. Green H<sub>2</sub> made from wind/solar/surplus electricity goes very well with biomethane
10. Conclusions



# 1. 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

## 2.1 Cheshire Biomethane Project Overview

### Project Summary

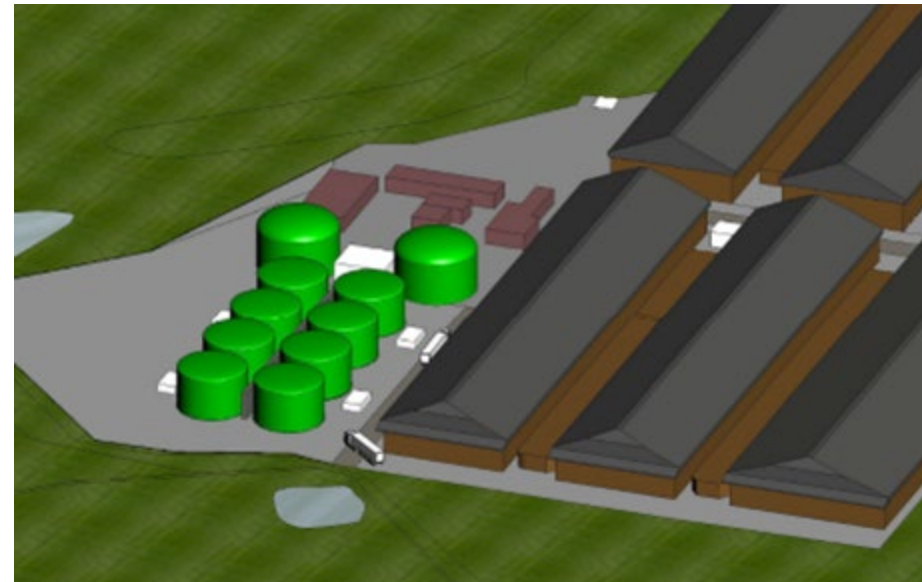
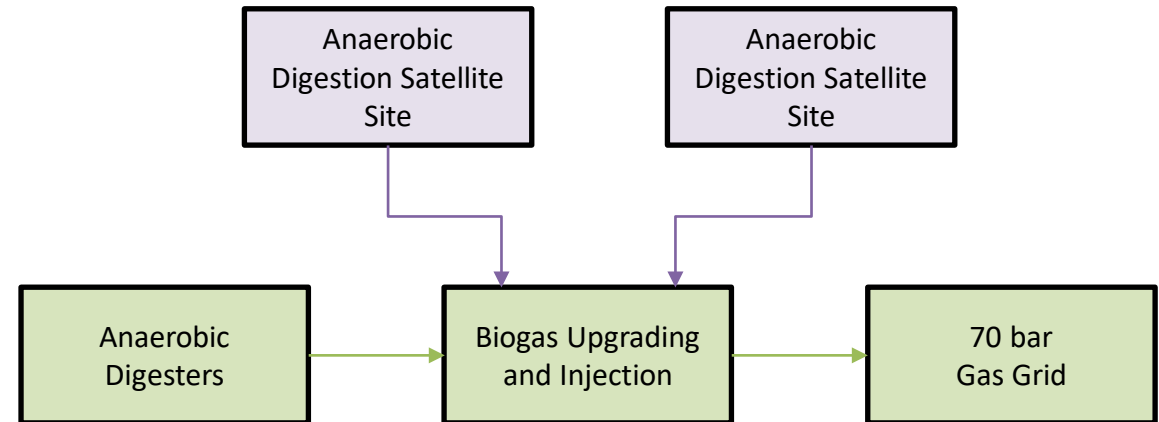
- Build a network of Anaerobic Digestion sites
- Pipe biogas to a central hub site
- Upgrade the biogas to biomethane and inject it into the grid
- First satellite site and Hub by end mid 2024, after that focus on further ADs:

### Key Project Goals

- Enable (relatively) large scale biogas production whilst:
  - Reducing CO<sub>2</sub> emissions
  - Harness methane emissions
  - Integrate green and innovative technologies
  - Ensure no negative impact on surrounding environment
- Design for a 'hub-satellite' injection model

### Key innovations/technologies used to achieve these goals

- CO<sub>2</sub> Capture
- Sand Removal
- Bio-CNG tractors
- Compressed Biomethane Decanting for remote sites
- Heat pumps (later)



## 2.2 Overview – Satellite Sites

### Step 1 - Anaerobic Digesters

- Solid and liquid farm waste used
- Hydrolysis, acidogenesis, acetogenesis and methanogenesis produces biogas (50-60% CH<sub>4</sub>) from the digestate



### Step 2 - Biogas Bag

- Biogas produced by the digesters stored at low pressure in the gas bag
- Biogas level monitored and used to control flowrate of biogas to the hub site



### Step 3 - Biogas Booster Skid

- Biogas pressurised from gas bag for piping to the hub site
- Impurities (H<sub>2</sub>S and VOCs) and water removed using activated carbon and rejected if out of spec



### Step 4 - Clean, Dry Biogas Pipeline

- Pipeline(s) used to transport biogas to the hub site
- Relatively low pressures used where possible



## 2.3 Overview – Hub Site

### Step 5 – Biogas Upgrading & CO<sub>2</sub> Capture

- Membranes remove CO<sub>2</sub> to create 'biomethane'. CO<sub>2</sub> is liquefied.
- Off-gas from LCO<sub>2</sub> (CH<sub>4</sub>, O<sub>2</sub> and N<sub>2</sub>) plant re-added to biomethane stream



### Step 6 – Gas Quality Skid

- Biomethane is analysed (using fast acting devices), with out-of-specification biomethane rejected
- Rejected biomethane sent to BUU inlet (recombined with CO<sub>2</sub> stream)



### Step 7a - Compression

- National Transmission System at the hub site runs at 70 barg so biomethane is compressed
- Oil 'free' compressors used to minimise oil into the NTS



### Step 7b – Metering

- Energy measurement after compression



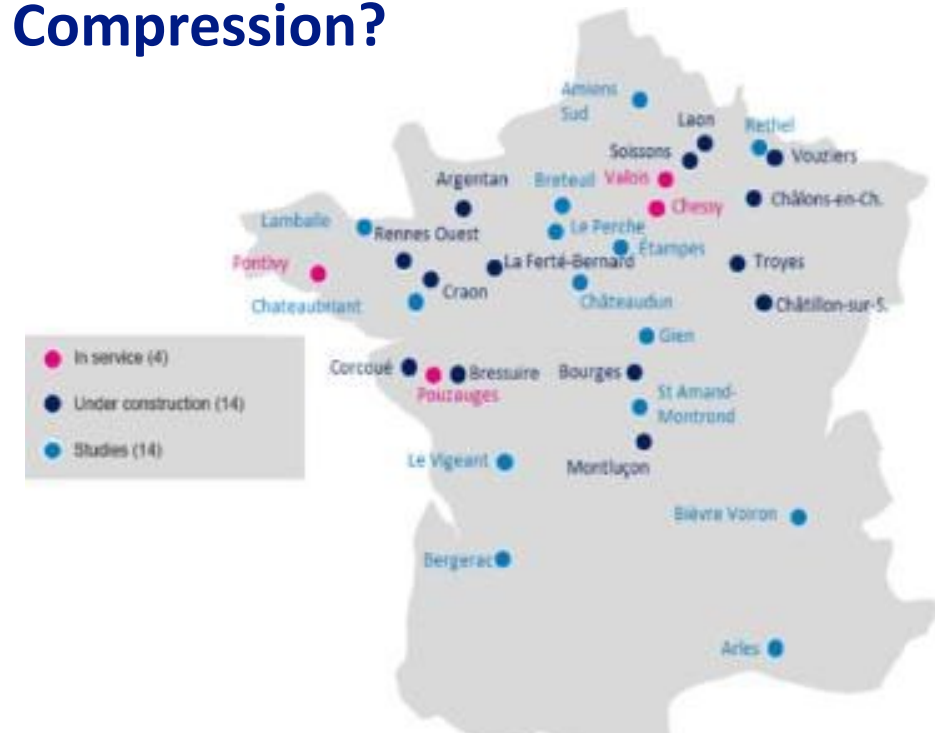
### Step 8 – NTS Injection

- National Grid approved process to be followed
- Only ~30m of high pressure pipeline



### 3. What is Reverse Compression?

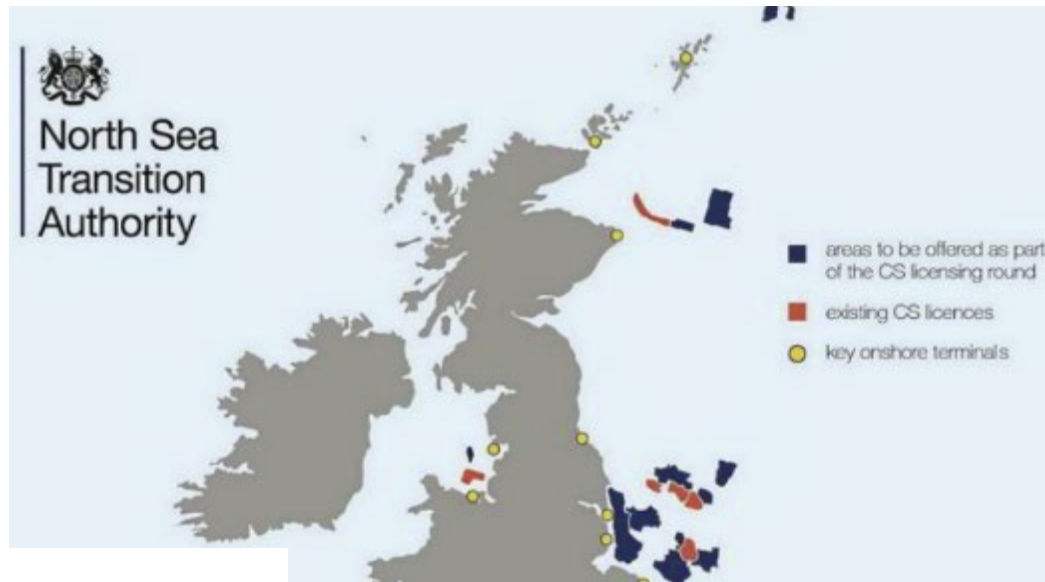
- For capacity, best option is smart pressure control but this only helps 10% of projects
- For 90% of projects it is necessary to install a compressor where a lower pressure tier meets a higher pressure tier gas pipeline – Reverse Compression
- At times when the lower tier pipeline reaches its maximum pressure:
  - Compressor operates injecting gas from the lower pressure tier to the higher pressure tier pipeline
  - Operates on pressures ensuring that there is not circular flow
  - Only operates as required – saving OPEX as not having to inject into a higher pressure tier pipeline all the time. This should be a few hours every night, mainly summer
- Removes capacity constraints in the lower pressure tier pipeline
- Common practice in France, Denmark, Netherlands, Germany
  - Series of “Reverse Compressors” installed across the network
  - Allows new projects to inject green gas into the network
  - Reduces risk of flaring





## 4. Bio-CO2 is Valuable

- When we have talked before at Green Gas Day, it had a price of £50/tonne, today it is more like £200/tonne given the end of fertilizer manufacture in UK (though prices today may be several times higher?)
- We are not involved in new biomethane projects that aren't capturing and selling Liquid Bio-CO2. Why would you vent something so valuable? Indicative numbers below
- The Biomethane industry is very fortunate that UK Govt going all in for CCUS and future Biogas/Northern Lights supports a floor for Bio-CO2



Parameter	Value	Unit
<b>Biogas and AD Data</b>		
Biogas Composition (%CH4)	60%	
Biogas Production Rate (60% CH4, 40% CO2)	1,000	Nm3/h
Biogas Production Rate	1,055	Sm3/h
AD Operation	100%	
Upgrader availability	97%	
AD Annual Production Hours	8,760	hours
Annual Biogas Production	9,241,319	Sm3/annum
Annual Biomethane Production	50,318,065	kWh/annum
<b>CO2 Production</b>		
Description	Value	Unit
Biogas Composition	40%	CO <sub>2</sub> (vol)
CO2 Capture Efficiency	90%	-
Potential CO2 Production	380	Sm <sup>3</sup> /h
CO2 Recovery Plant Availability (Relative to BUU)	97%	-
CO2 Recovery Plant Operating Hours	8,497	h/annum
Annual CO2 Production (Mass)	6,103,217	kg/annum
Annual CO2 Production	6,103	tonnes/annum
Liquid CO2 Value - sold at the AD plant (indicative)	£150	/tonne
Annual CO2 Income	£915,483	/annum

### Hydrogen

117. Hynet Hydrogen Pipeline
118. INOVYN Hydrogen Storage (Hynet Cluster, NW)
119. East Coast Cluster Hydrogen Pipeline
120. Aldbrough Hydrogen Storage (East Coast Cluster, Humber)
121. Hydrogen Electrolyser Capacity Deployment

### Carbon Capture and Storage (CCUS)

122. Hynet Cluster – CCUS cluster in the North West
123. East Coast Cluster – CCUS cluster in Teesside and Humber

## 5. Direct solar/wind/batteries to provide electricity for Biomethane Projects

- A typical AD is a semi-industrial site something between a farm and a factory
- It can be used to become a hub for multi-renewables with direct wire solar, wind (now its back) and batteries
- Being a source of 'electricity demand' is valuable
  - Heat Pumps for heating the digesters, liquid Bio-CO2 and Bio-CNG plants provide additional sources of electricity demand
- By 2030 ish, most ADs can be expected to have local solar, batteries and wind to secure 50% of their electricity from their own renewables, balance from the grid
- As batteries and solar fall in price the 50% can become 60% etc
- In addition, curtailed electricity from wind/solar will be available to bought at zero price (at times) and stored or used to make Green H2 (see next slide)

### Onshore wind rules to be relaxed after Tory revolt

1 hour ago

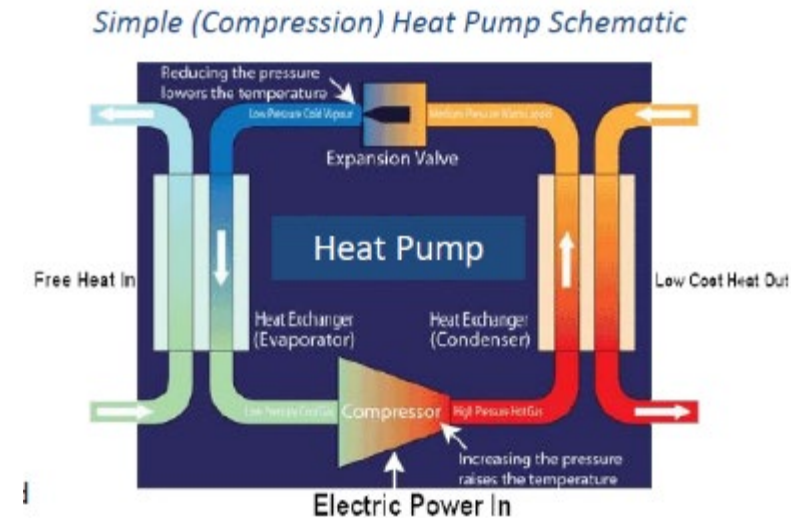


The government has pledged to relax restrictions on building onshore wind farms in England after a threatened rebellion from Conservative MPs.



## 6. Electrification of AD plants - Heat Pumps to Heat Digesters

- With the growth of offshore wind, there is going to be a lot of electricity when its windy
- Plus the local direct wire renewables opportunity
- One good option to use this electricity is to Make Green H2 and supply industrial customers but another one is to use electricity to heat digesters
- As per earlier slide, an AD with heat pumps becomes a source of electricity demand
- Once you think about heating the digesters with electricity, there are a few questions:
  - Can you recover heat from the digestate leaving the AD to heat slurry feedstock prior to it going into the AD?
  - Can you use 40 deg C digestate as the source of heat for the heat pumps (appears attractive but not yet proven as variable digestate flow)
  - Can you use a few Ha of buried field array ground source heat pumps (an AD is a bit like a swimming pool)?
  - Can you find a local river or lake
  - Can you recover heat from biogas upgrader and Liquid CO2 plant
- Fundamentally in 2022 it seems the *'right'* thing to do to future proof a new project and (of course) to be able to sell all the Bio-CO2 arising on site



*Industrial Heat Pumps*

*Final report*

**cng** services ltd

22<sup>nd</sup> December 2019

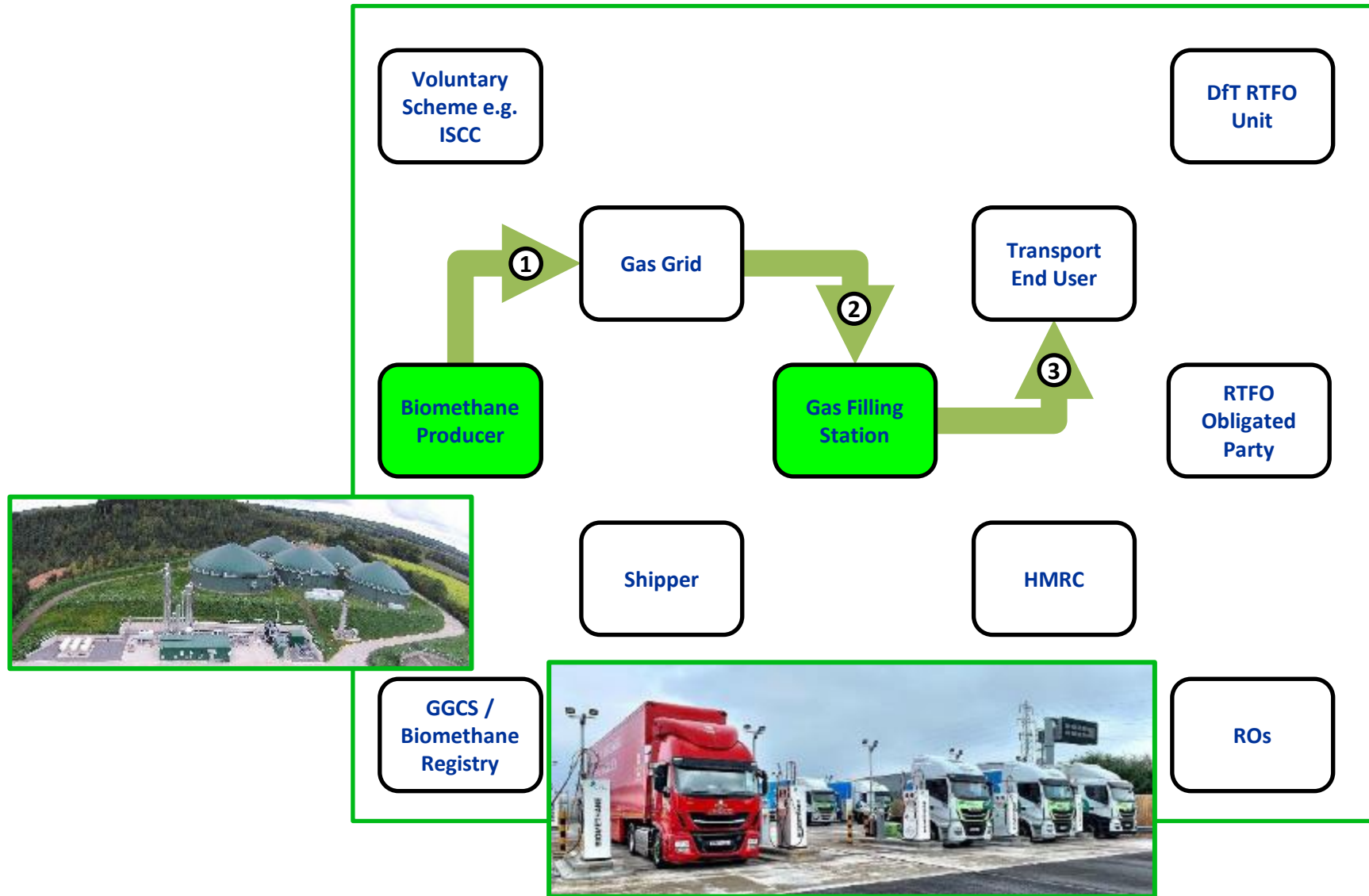
**elementenergy**



## 7.2 New Holland Tractor



## 8. 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 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

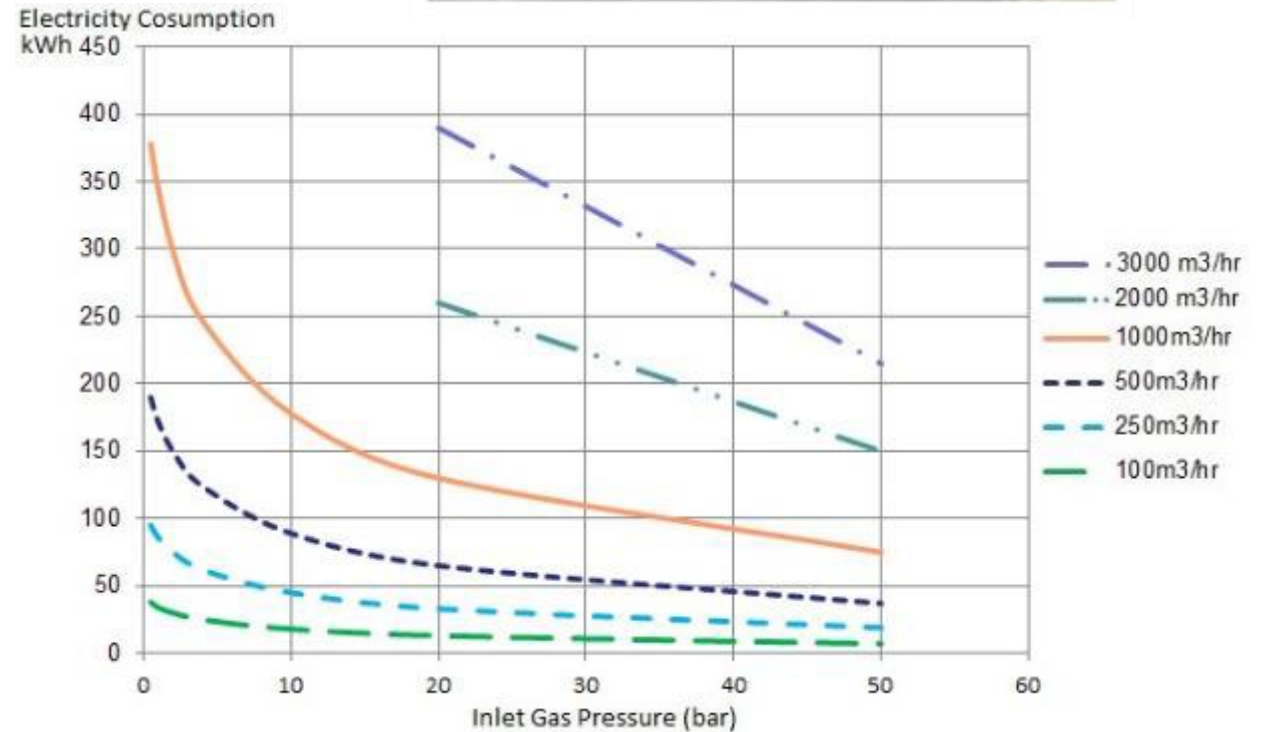
## 9.1 Bio-CNG Made at NTS/LTS station

### NTS – LTS Benefits:

- “climbing Everest but starting at 26,000 feet”
- Lower unit CAPEX, low unit maintenance, low unit electricity consumption
- Fordoun 55-barg inlet flows 7,000 Sm<sup>3</sup>/h with 350 kWh electricity
- Portable Refuelling Station supplied by an NTS/LTS Mother station is great

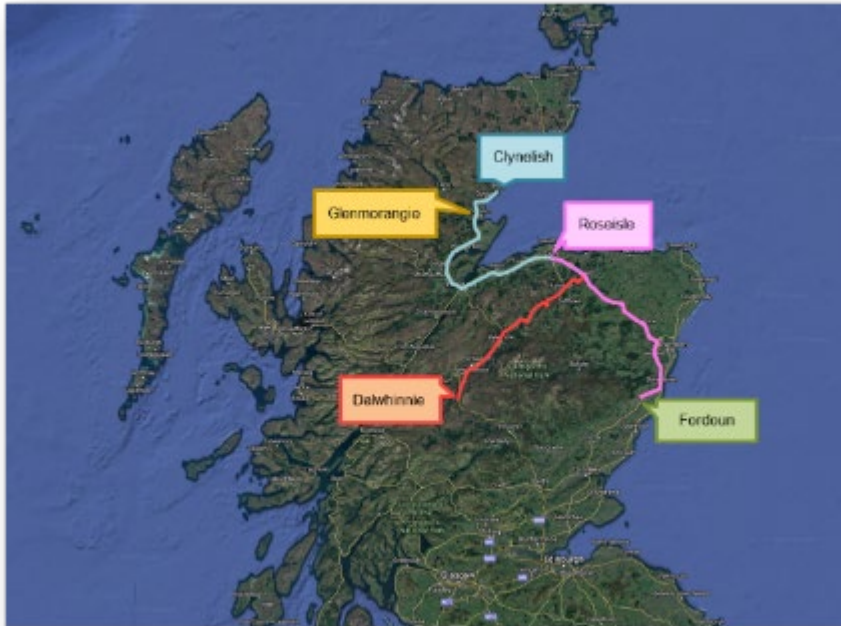


Fordoun NTS Mother Station



## 9.2 Delivery of Bio-CNG Supply to four off-grid distilleries

- **Aim:** Supply off-grid whisky distilleries with natural gas to fuel their boilers, producing steam for their production process
- **Basis:**
  - **Funding:** Air Liquide fund and operate a CNG filling station at Fordoun with a network of CNG decanting stations across Scotland.
  - **Distilleries:** Four distilleries signed up, Glenmorangie (LVMH), Clynelish, Dalwhinnie and Roseisle (Diageo).
  - **Compression:** Gas is taken from the grid and compressed to 250barg into CNG Trailers before being transported to one of the decanting stations
  - **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. The gas is then further reduced in pressure (down to hundreds of mbar) before entry into the boiler.
- **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 Load:**
  - **Fordoun :** Max 11,500 Sm<sup>3</sup>/hr (pipeline), Max 5,500 Sm<sup>3</sup>/hr (each compressor)





# 9.3 Fordoun Bio-CNG Mother Station on the National Transmission System (85 bar)



## 9.4 Fordoun – Finished Site



**Meter, Odorant Unit, CV Measurement and Dispensers**

- Downstream of the pipeline the gas is metered (yellow pipework) and analysed (green kiosk behind the yellow pipework)
- The gas is then odourised using an odourant unit
- Following compression, gas is dispensed onto trailers (four dispensers installed)



**Compression Compound**

- Two compressors (duty/standby) were installed, designed to flow a maximum of 5,500 – 7,000 Sm<sup>3</sup>/hr of gas
- The compressors and the gas are cooled by water-based systems, with one large air cooler installed per compressor.
- Gas is further cooled on compressor outlet by chillers

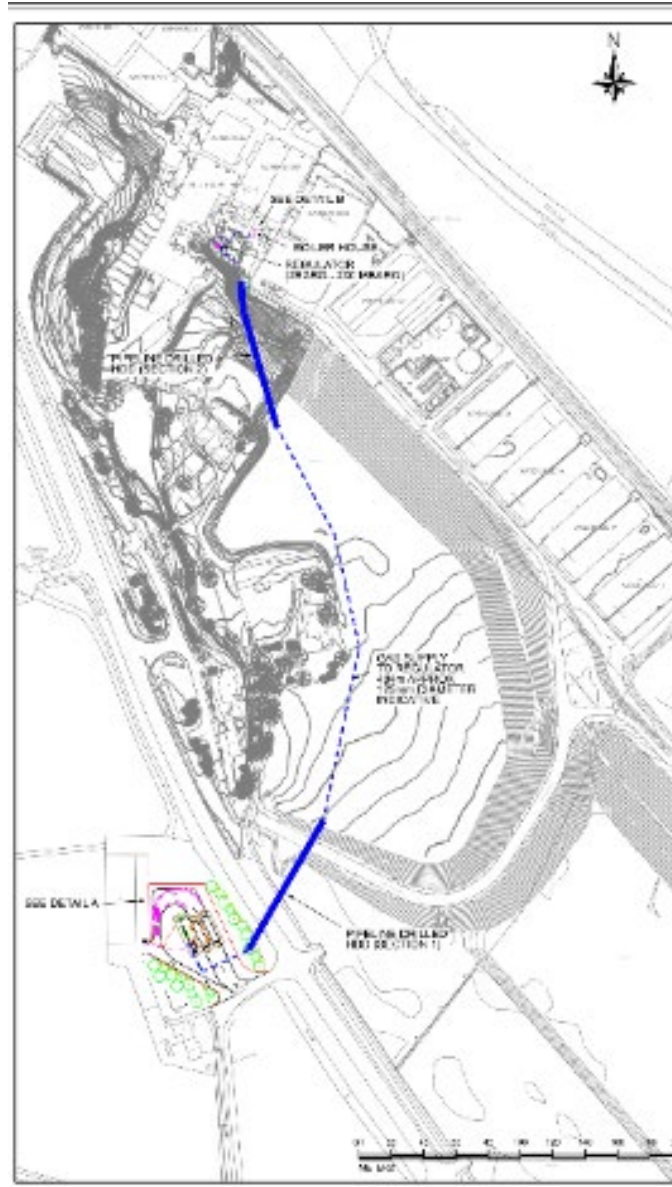
## 9.5 Filling Bio-CNG Trailers



## 9.6 The first customer – Glenmorangie Distillery



## 9.7 Glenmorangie Decanting Station - 500m from the distillery



## 9.8 Dalwhinnie Distillery



## Clynelish Distillery



# 9.9 Roseisle Distillery



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



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



## 10.2 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."

## 10.3 Glenfiddich Iveco 6 x 2

- Glenfiddich moving to compressed biomethane
- >25 on the road



JUL 28, 2021

### Glenfiddich's vehicles to use biogas derived from whisky waste

Scottish whisky producer Glenfiddich has announced it will run its vehicles on biogas generated from whisky waste.

The distiller's parent company, William Grant & Sons, launched the closed-loop system at the site in Dufftown, Moray, converting the residues from the distilling process into biogas. The technology converts production waste into an ultra-low carbon fuel gas that produces minimal CO<sub>2</sub> and other harmful emissions.

Fuelling stations have been installed at the distillery and the biogas now powering specially-converted trucks that transport Glenfiddich at all stages of production, through to bottling and packaging, covering four sites in central and western Scotland.

Stuart Watts, distilleries director at William Grant & Sons, said: "It has taken more than a decade for Glenfiddich to become the first distillery to process 100% of its waste residues on its own site, then to be the first to process those residues into biogas fuel to power its trucks, and finally, to be the first to install a biogas truck fuelling station supplied by our on-site renewable energy facility."

Watts said the biogas will help reduce CO<sub>2</sub> emissions at the company by more than 95% and other harmful greenhouse gas emissions and particulates by up to 99%, compared to diesel and petrol trucks.

Each truck should displace up to 250 tonnes of CO<sub>2</sub> annually, equivalent to planting up to 4,000 trees every year, or displacing the fossil fuels from 112 households.



## 10.4 Iveco 4 x 2 for John Lewis, Royal Mail, Hermes, Amazon etc



Amazon is increasing the number of Compressed Natural Gas (CNG) vehicles available to our partners across Europe as we work with vehicle manufacturers and start-ups to test and develop more sustainable technologies. The move will bring us closer to our vision of operating a fully sustainable fleet within our Amazon Freight Partner program.

Amazon has already taken over more than 200 IVECO 5-WAY CNG trucks to be handed over to the partners across Europe. In addition, Amazon has just ordered more than 800 CNG trucks from Iveco to be available to its European Amazon Freight Partners in 2022, bringing its European CNG fleet to more than 1,000 vehicles by the end of 2022.

CNG vehicles reduce CO2 emissions by at least 75% compared to diesel when refueled with renewable natural gas (RNG), helping create a more sustainable future.

Ian Thomson, Transport Manager of Forge Logistics Ltd, an Amazon Freight Partner in the UK, says: "We already operate nine CNG trucks from Iveco and will increase to ten in late November, with more to follow in 2022. Our experience has been good so far, we especially appreciate reduction in fuel cost as compared to diesel trucks. Even at the backdrop of gas prices going up we see positive impact, though we hoped and still hope for more once the environment changes".



## 10.5 Scania 4 x 2

CNG Fuels are thrilled to see the first **Warburtons** CNG vehicles filling through our Leyland Bio-CNG Refuelling facility...

These vehicles are the first of a batch of 14 CNG Scania UK Trucks to hit the road in 2021... the new vehicles will be based throughout the country and will be making use of the network of Bio-CNG Stations that we now have operational!

The vehicles will be filling with 100% Renewable and Sustainable Biomethane - taking on average 85% CO2 eq. off the UK roads vs. their Diesel counterparts...

Thanks to **Steven Gray** and **Jonathan Heaton** for their efforts in making this project a reality... we look forward to welcoming many more of these vehicles through our stations in the future!



Colin Kennedy replied to Tilmann SCHULTZE'S comment on this



Colin Kennedy • 1st

Operations and Technology Leader, Board Member at DPD Ireland

1d • 🌐

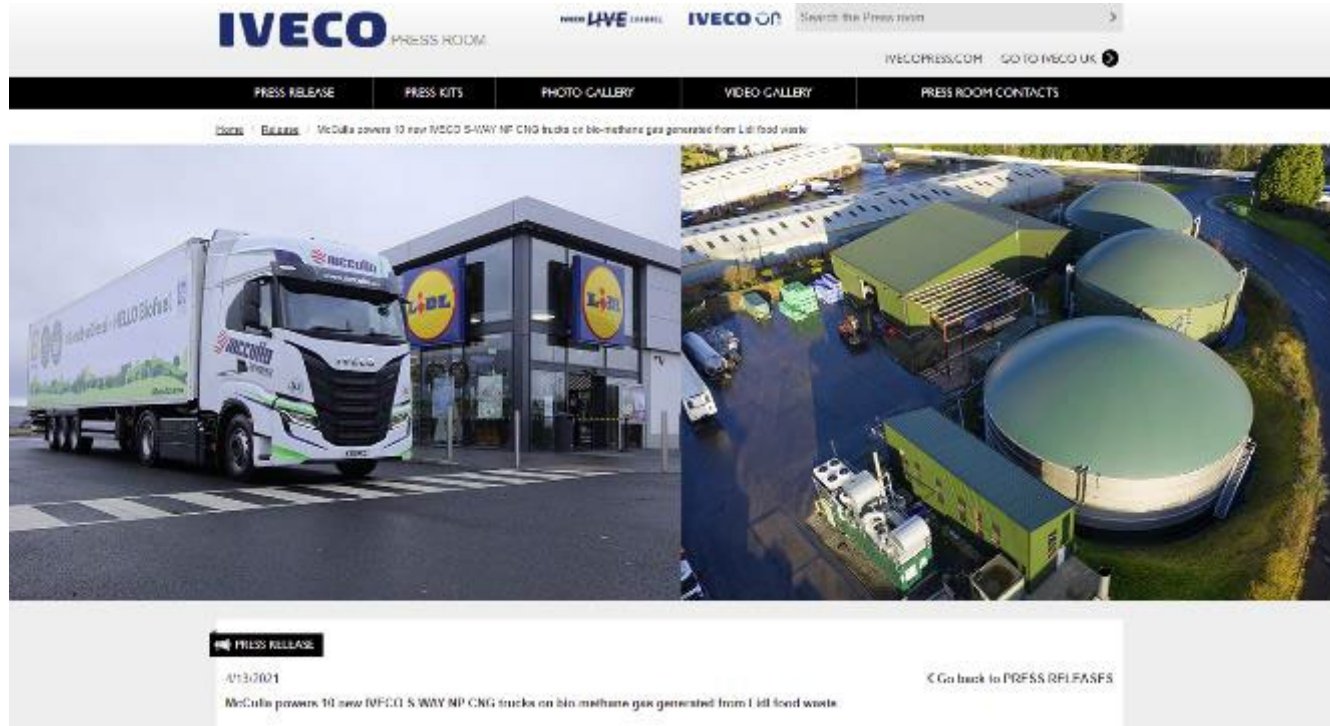
Thank you to **David Hanahoe** and all from **Gas Networks Ireland** for their support today.

We need some additional help from the Minister **Eamon Ryan** and the regulator **Commission for Regulation of Utilities (CRU)** to open more gas service stations needed to put CNG Trucks on the road.

#YourDeliveryExperts  
#DPDGoGreen



## 10.6 Iveco 4 x 2



The screenshot shows the Iveco Press Room website. At the top, there is a search bar and navigation links for 'LIVE CHANNEL', 'IVECO ON', 'IVECOPRESS.COM', and 'GO TO IVECO UK'. Below this is a menu with 'PRESS RELEASE', 'PRESS KITS', 'PHOTO GALLERY', 'VIDEO GALLERY', and 'PRESS ROOM CONTACTS'. The main content area features a headline: 'McCalla covers 10 new IVECO S-WAY NP CNG trucks on bio-methane gas generated from Lidl food waste'. Below the headline are two images: one of a white Iveco S-WAY NP CNG truck with 'IVECO' and 'S-WAY NP CNG' branding, and another of a large industrial facility with several large green storage tanks. At the bottom of the page, there is a 'PRESS RELEASE' section with the text '01/10/2021 McCalla covers 10 new IVECO S-WAY NP CNG trucks on bio-methane gas generated from Lidl food waste' and a link to 'Go back to PRESS RELEASES'.



Javier Rodriguez • 1st

Fleet & Specialist Vehicle Director at South West Truck & Van  
2d • Edited •

Sorry.... what is diesel!?!?!?

Biomethane is the only way forward

85% CO2 Reduced ✓

99% Particulate Matter Reduced ✓

80% NOX Reduced ✓

40% Fuel costs Reduced ✓

Just remind me why people are still buying the oldest technology going!?!?!?

Companies like Romac are not brave they are innovative and move with the times.

#sustainability #climatechange #environment #swtv #Iveco #CNGFUELS

#romaclogistics



# 10.7 Cement Mixers that run on Bio-CNG

## “Green Concrete for Construction”

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 Econic NCT with the M 936 natural gas engine of the same displacement, delivering 222 kW (302 hp) of output.



Mercedes Benz Bio-CNG

The foundations for safe work. Set on construction sites and the streets of Berlin: an Econic cement mixer.

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

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

September 9, 2020

Scania Bio-CNG



Comercial Iberoamericana de Servicios, S.A. (Comibersa), 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. Comibersa's fleet is made up of a total of 106 vehicles, of which 27 are Scania.

### 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.



# 10.8 RCV Example - Liverpool City Council

## Liverpool City Council unveils biogas-powered refuse trucks

11 March 2020, source [edie newsroom](#)

Liverpool City Council has commissioned a fleet of refuse collection trucks to operate within the city that will be powered by low-carbon biogas.



The city has cut its carbon emissions by 18% since 2012

The City Council has agreed a deal for 20 new Mercedes-Benz refuse collection trucks that will run on compressed natural gas (CNG). According to the council, the vehicles will produce 80% less carbon, 90% less nitrogen oxide pollutants and cut fuel costs by 35% compared to diesel-powered alternatives.

The Econic NGT 2630 L models will be operated by Liverpool Streetscene Services (LSSL), and will cover more than 150,000 miles a year, mainly in the city, collectively.

- UK's largest fleet of Bio-CNG RCVs

### Knowsley

Postcode: L34 9SL  
Daily Capacity: +500  
No. of operators: 6

Simultaneous rehellings: 7  
No. of trailer loading bays: 1

Completed

15%



Scania Bio-CNG RCV – photos showing filling for trial (typically 5 days only)



# 11.1 GB Bio-CNG Station Network

## Available Now

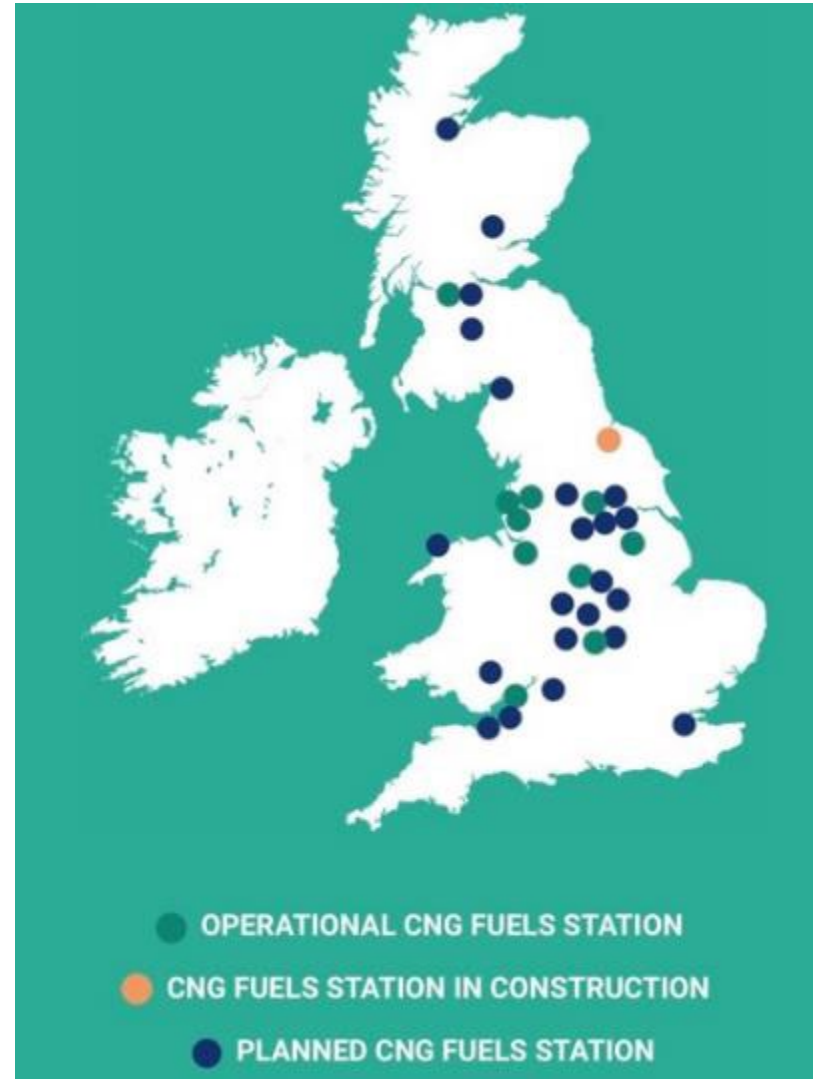
- Leyland, M6
- Weston Road, Crewe
- Northampton, Junction 16, M1
- Warrington, M62
- Erdington, Birmingham
- Newark, A1
- Knowsley, Liverpool, M57
- Bellshill, Scotland
- Avonmouth North
- Castleford, M62

## In Construction

- Newton-Aycliffe
- Corby

## In 2023 our aim is to open a station per month – including:

- Livingston
- Swindon
- Goole
- Magor
- Milton Keynes
- Larkhall
- Barnsley
- Doncaster
- The list continues.....





## 11.2 Typical Grid Connected Bio-CNG Station



### 11.3 Avonmouth Bio-CNG station



## 12. AD sites will be ideal places to make Green H2 – land, electricity grid connection, on site solar/wind/batteries

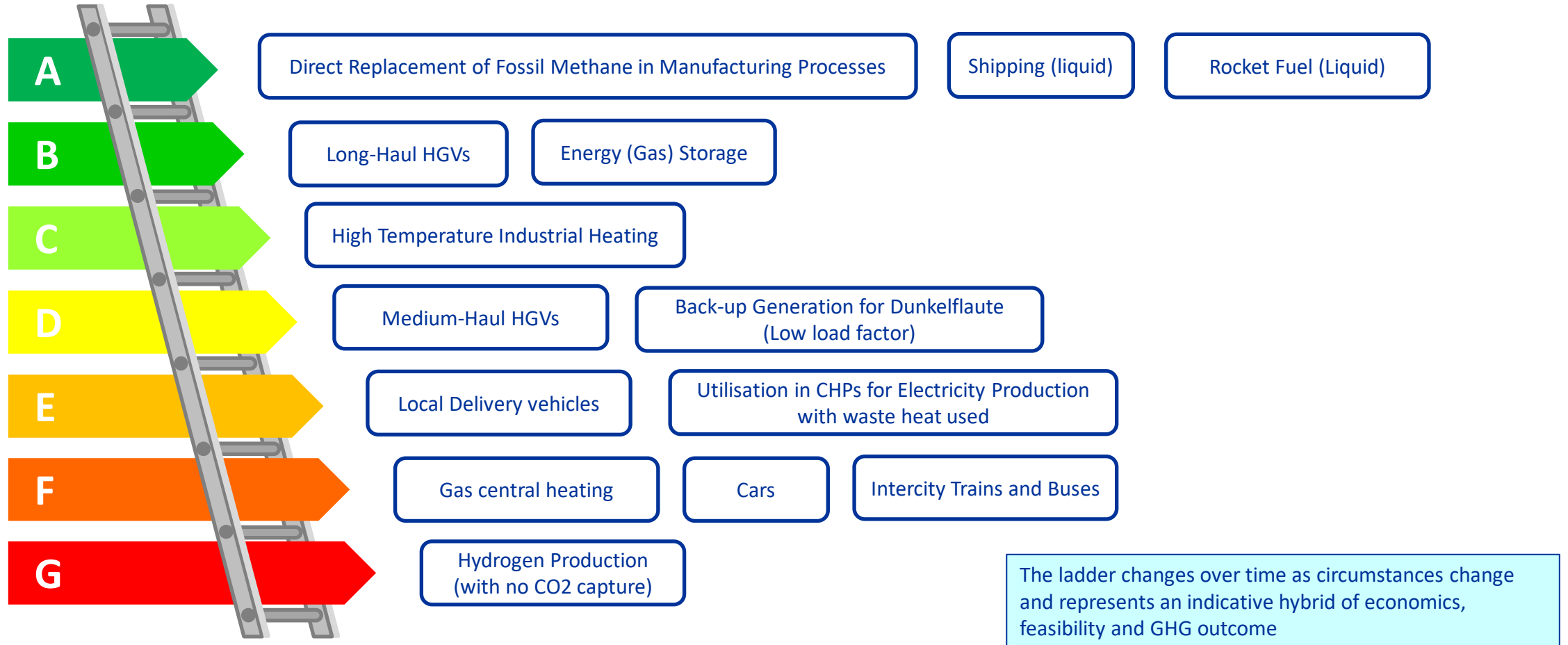
- No more staff required and probably no planning issues. AD sites are all connected to the electricity grid
- Green H2 may be able to react with Bio-CO2 to make more renewable methane or it may have local uses for industry or transport
- The point is all the ingredients to make Green H2 will be on site (catch rainwater from the digester roof as well)

Item	New Biomethane	Hydrogen	Comments
Key Plant	AD + Upgrader + GEU + compressors	Electrolyser + 30 bar H2 Storage vessels	Bought in from expert suppliers
Site works	Civils, electricity and gas grid connections, welded pipework	Civils, electricity grid (and maybe gas grid) connections, welded pipework	Similar skills
Feedstock	Agricultural/food industry waste with some crop (solar)	Solar/wind with batteries to improve load factor & elec grid to bring renewable elec	Zero carbon or GHG negative
Safety/Regulation	HSC/COMAH/DSEAR/PSR	HSC/COMAH/DSEAR/PSR	Same
Energy Product	Renewable CH4 and Bio-CO2 Compressed or liquid	Renewable H2 Compressed or liquid	Similar gases Inject into gas grid, use locally or move my road (compressed/liquid)
Nature of the gas	Heavy, relatively hard to ignite	Light and leaky	There are important differences
Use as Truck Fuel	Compressed or Liquid, local or remote via Grid or via truck deliveries	Compressed or Liquid, local or via truck deliveries	Use of gas grid for biomethane is main difference
Route to market for the Energy Product	Inject into the gas grid, use on site for trucks or take off site in 250 bar compressed biomethane trailers	Direct to I&C customer, use on site for trucks, inject into gas grid or take off site in 500 bar H2 trailers	Similar
Long term financial case	Cost to emit 1 tonne of CO2	Cost to emit 1 tonne of CO2	Similar
Security of supply impact	Every 1 kWh of biomethane saves 1 kWh of natural gas imports to Europe	Every 1 kWh of H2 saves 1 kWh of natural gas imports to Europe	Similar

# 13. Biomethane Ladder (Dec 22)

And it is assumed that all the Bio-CO2 from the AD plant is captured, liquefied and used as per the Bio-CO2 ladder

Good options

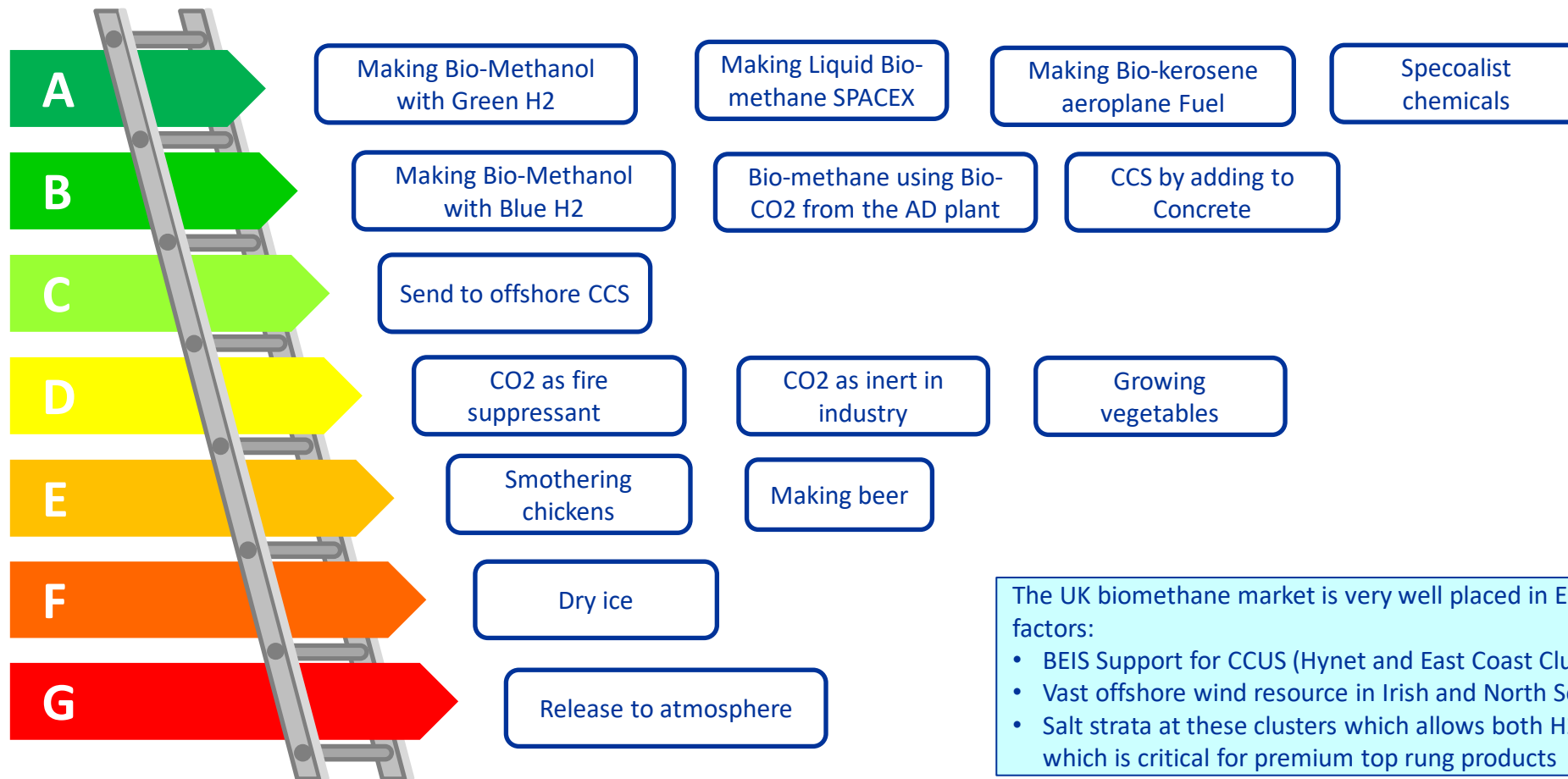


Poor options

# 14. Bio-CO2 Ladder (Dec 22)

And it is assumed that all the Biomethane goes into the gas grid and is used as per the Biomethane Ladder

## Good options



The UK biomethane market is very well placed in Europe because of 3 critical factors:

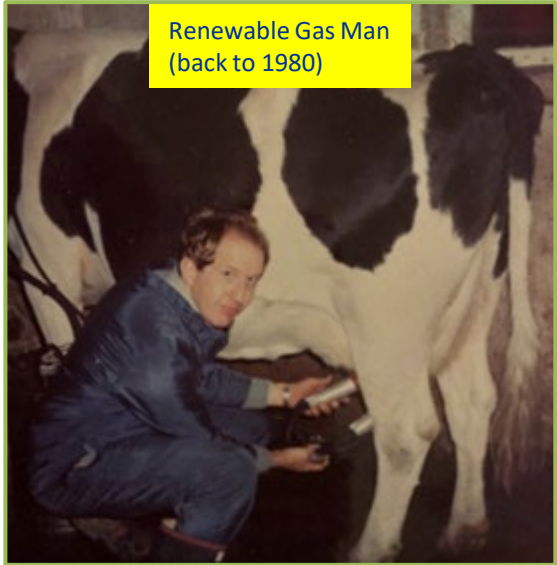
- BEIS Support for CCUS (Hynet and East Coast Clusters)
- Vast offshore wind resource in Irish and North Sea
- Salt strata at these clusters which allows both H2 (and Bio-CO2) to be stored which is critical for premium top rung products

## Poor options

Based on 'The Clean Hydrogen Ladder' by Liebrich Associates

# 15. Conclusions

- Use of manures to make biomethane is proven and deliverable and food waste, sewage, straw etc mean abundant resource to make biogas
- The gas grid is the way to get the biomethane to market
- Reverse compression means there is always gas grid capacity
- Bio-CO2 is valuable, never vent it
- Running trucks and farm tractors on Bio-CNG feasible today as the vehicles exist, the fuel exists and the tax and incentive regime in GB is attractive
- Use the high pressure gas grid and build big Bio-CNG stations
- In the future, AD plants should use heat pumps for heating and direct wire solar and renewables
- Green H2 fits alongside AD plants as it goes very well with biomethane
- Long term utilisation options for Biomethane and Bio-CO2 will change by 2050 but trucks is best use today for the biomethane and industrial use for the Bio-CO2
  
- If Poland has any empty gas pipelines in the east then it can use them!



**Remember – as soon as possible NEVER burn biogas, NEVER vent CO<sub>2</sub>, NEVER burn diesel and NEVER move biomethane by road if you have a gas grid**

## Project Photos

# Northwick 2017





## Hemswell 2018

Completed 1000Nm<sup>3</sup>/hr  
BUU shown with dryer, chiller, compressor, carbon vessels and high  
level vent all on single plinth



# Bonby 2019



cng services ltd



cng services ltd

# Spaldington 2019



## Barnes Farm 2019



## Bio-Dynamic Nottingham 2021 Food waste Biomethane



# Roundhill



# Somerset Farm 2020



# Theddlethorpe





# Brinklow



# Colony Farm



# Methwold



# Raynham

