GNI Northwest Virtual Gas Pipeline Study


30th September 2021

John Baldwin
Managing Director
CNG Services Ltd

john.baldwin@cngservices.co.uk
www.cngservices.co.uk
07831 241217

cng services ltd

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_2 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
- 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
- Working on a number of H_2 and CCUS innovation projects

cng services ltd

Briefing

- CSL has received funding from GNI as part of the Gas Innovation Fund to conduct a study to understand the feasibility of developing a virtual gas pipeline in the North-Western region of ROI. This pipeline will provide access to gas for non-connected grid customers. As the project has progressed, participating stakeholders have mutually agreed to widen the scope to also consider the South-Western region for the same purpose

- Compression of gas from an existing AGI/BV (termed mother station) will supply specially engineered transport vehicles to deliver gas to off-grid businesses with large power demands. This is referred to as a 'Virtual Pipeline'. If deemed feasible, businesses can benefit from the advent of gas while supporting their transition to greener alternatives, while simultaneously reducing their operating costs. **The long term implications of this project will assist in the transition to a low carbon economy for all of Ireland**

- The study examines the technical feasibility of the proposal. Information gathered from surveys of potential launch customers have been modelled to determine the financial cost and the environmental benefits when compared to their existing fuel sources (heavy oils)

- The study is supported by a high-level Excel model that analyses the delivered gas cost against existing fuel costs. This was designed to be repeatable for other clients/projects for future use

The **two projects** considered are mother stations strategically located at:

1. Site 1
2. Site 2

The **high level model** considers the following:

- CNG base load when compared to existing fuel use
- Fuel Economics
  - Gas Delivery Economics and Offloading Charge
  - Gas Compression Charge including:
    - Compression Site CAPEX and OPEX
  - Gas Transmission and Distribution Charges
  - Fuel Cost Comparison of Gas vs Existing Fuel

The outcome of this project can **amplify future innovations of the gas network**, acting as a case study for all of Ireland. CSL have considered the future potential for:

- Domestic applications
- CNG Filling stations for HGVs
- CNG/biomethane blend
- 100% biomethane
- H_2 blends (HCNG)

This report is split into 9 sections as follows:

Introduction | Operation Overview | Site Locations | CNG to Hauliers | Displacing Fossil Oil | Case Study | Additional Considerations | Implementation Plan | Conclusion

Acknowledgment

CSL would like to take this opportunity to express their gratitude to all participating stakeholders for their support, guidance and feedback throughout the project. Support from Ian Kilgallon, Niamh Gillen of GNI, John Doran, Chris McCallum of LYIT, Ann Fingleton, Tim Conroy of Fingleton White and Stephen Robb of Drumbuoy Farm is gratefully acknowledged.

Gas Networks Ireland

Fingleton White

DRUMBUOY FARM Est. 1954

lyit

cng services ltd

Nomenclature & Abbreviations

AD – Anaerobic Digester
AFHDV - Alternatively Fuelled Heavy Duty Vehicle
AGI – Above Ground Installation
BEVs - Battery Electric Vehicles
Biomethane – Renewable Natural Gas (>95% methane)
BV – Block Valve
CAPEX – Capital Expenditure
CGI – Central Gas Injection
CNG – Compressed Natural Gas
CO2 – Carbon Dioxide
COMAH - Control of Major Accident Hazards
Daughter Station – Offloading decanting station for gas deliveries
EU – European Union
FCEV - Fuel Cell Electric Vehicles
GNI – Gas Network Ireland
GRAZE - Green Renewable Agricultural & Zero Emissions
GWh – Gigawatt hour
HCNG – Composite blend of CNG with Hydrogen
HGV – Heavy Goods Vehicle
HSC - Health and Safety Commission
kWh - kilowatt hour
LNG – Liquified Natural Gas
LPG – Liquified Petroleum Gas
Mother Station – Grid connection station where gas is taken from the grid and compressed onto trailers
MRU – Mobile Refuelling Unit
NTS – National Transmission System
NW – North West
OPEX – Operating Expenditure
Preliminary FEED - Preliminary step taken before basic engineering level work
PRMS – Pressure Reduction Metering System
RHI - Renewable Heat Incentive
RHO - Renewable Heat Obligation
ROI – Republic of Ireland
ROV – Remotely Operable Valve
RTFO - Renewable Transport Fuel Obligation
SEAI - Sustainable Energy Authority of Ireland
SW – South West
ULEZ – Ultra Low Emission Zone
WTW – Well-to-wheel

Executive Summary (1)

1. The North-Western region of Ireland is isolated from the existing GNI network, leaving businesses vulnerable as society embraces the transition to green energy.

2. Oil is known for its high cost and emissions when compared to natural gas - this creates an opportunity for a CNG virtual pipeline network to support power-intensive operations and support businesses with their long term goal of decarbonising their energy chain.

   Further, Fingleton White has completed a 'satellite network' study in Sligo with a number of additional customers identified.

3. *Summary of operation* - Gas is taken from the grid-connected mother stations and compressed into CNG trailers before being transported to one of the decanting stations (daughter station). Gas is then decompressed using a PRMS for boiler compatibility.

4. Site 1 is the proposed mother station. The list below highlights some of the site benefits (among others):
   - Excellent road network for transportation, strategic location, good land availability
   - Isolated and rural area - adjacent to wind farm with good electrical connectivity
   - There may also be opportunities for capacity market gas back-up generation plants and green Hydrogen generation

Executive Summary (2)

5. The scope of work has been expanded to explore a second mother station that would service the Southern region. An array of AGI/BV's were assessed to judge suitability. Site 2 was deemed favourable for its road network connection and strategic location.

6. CNG for trucks has also been considered within the study. MRU model is well suited for the proposed mother station which can simultaneously support a mobile refuelling unit to allow businesses with large HGV fleets to decarbonise their logistical supply chain. Ireland has attractive grant support schemes that align with this proposition.

7. The proposed 'Renewable Heat Obligation' under public consultation aims to incentivise the use of renewable heat fuels. The report highlights that Ireland is mandated to increase the use and generation of renewable energy to meet EU targets. Ireland currently has 6.3% of its heat sector demand met by renewable fuels, which is the lowest percentage of any member. Anaerobic digesters has been identified as a great option for Northern Ireland to work towards these targets.

8. The dramatic increase in natural gas price in Q3 2021 has adversely impacted the economics of switching from oil to CNGF. However, this is expected to revert to a saving by Q3 2022 though it is likely that the historic differential between oil and gas may be reduced going forward due to increased LNG demand from China

Section 1 – Introduction

Introduction

Donegal is one of three counties in the western region of Ireland which isn't connected to the national gas grid. Industries within the area are heavily reliant on fossil fuels as their primary energy source. Public perception concerning fossil fuels, coupled with associated fuel costs hinders regional economic development. The lack of gas infrastructure may disincentivise future regional investment, reducing competitiveness and further increase the disparity between different regions of Ireland; a **quality energy network with a net zero pathway is essential**

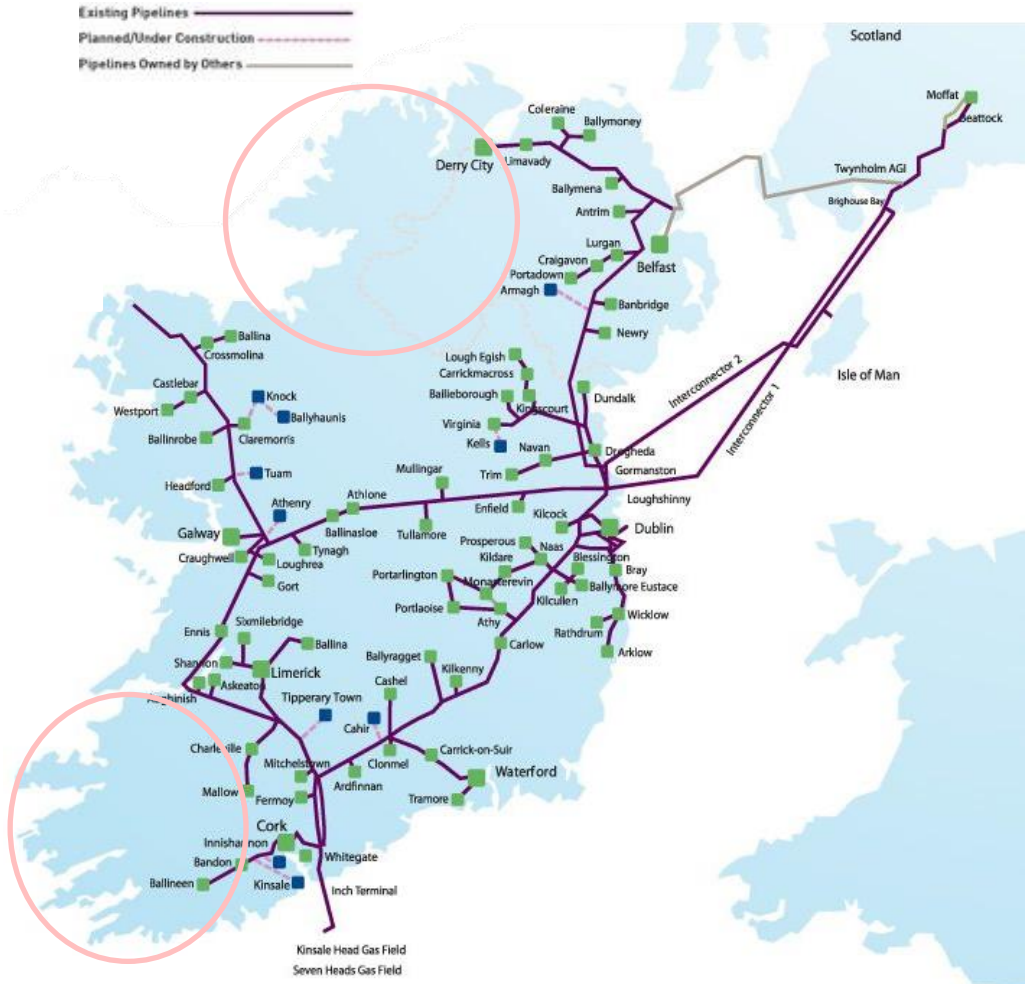
Natural Gas – A Feasible Solution

- Regional access to natural gas often stimulates economic development
- Businesses with access to the natural gas grid have reduced energy costs and lower CO_2 emissions compared to fossil fuels
- Continual expansion of the gas grid can serve both commercial and domestic purposes to further decarbonise the region
- Future proofing – Provides a pathway to biomethane and hydrogen markets
    - Subject to incentives provided by ROI government, it is possible that within the next decade, over 200 biomethane production facilities could be constructed in the ROI, providing fuel for heating and vehicle fuels for HGVs
    - By 2030, up to 20% of natural gas usage could be displaced by renewable biomethane

Assist In The Transition To a Low Carbon Economy

It is envisaged that this project will serve as a model that can be replicated in other parts of ROI, creating an opportunity for a significant contribution towards regional and national ambitions to achieve carbon neutrality by 2050. The success of this project opens a pathway to further innovations:

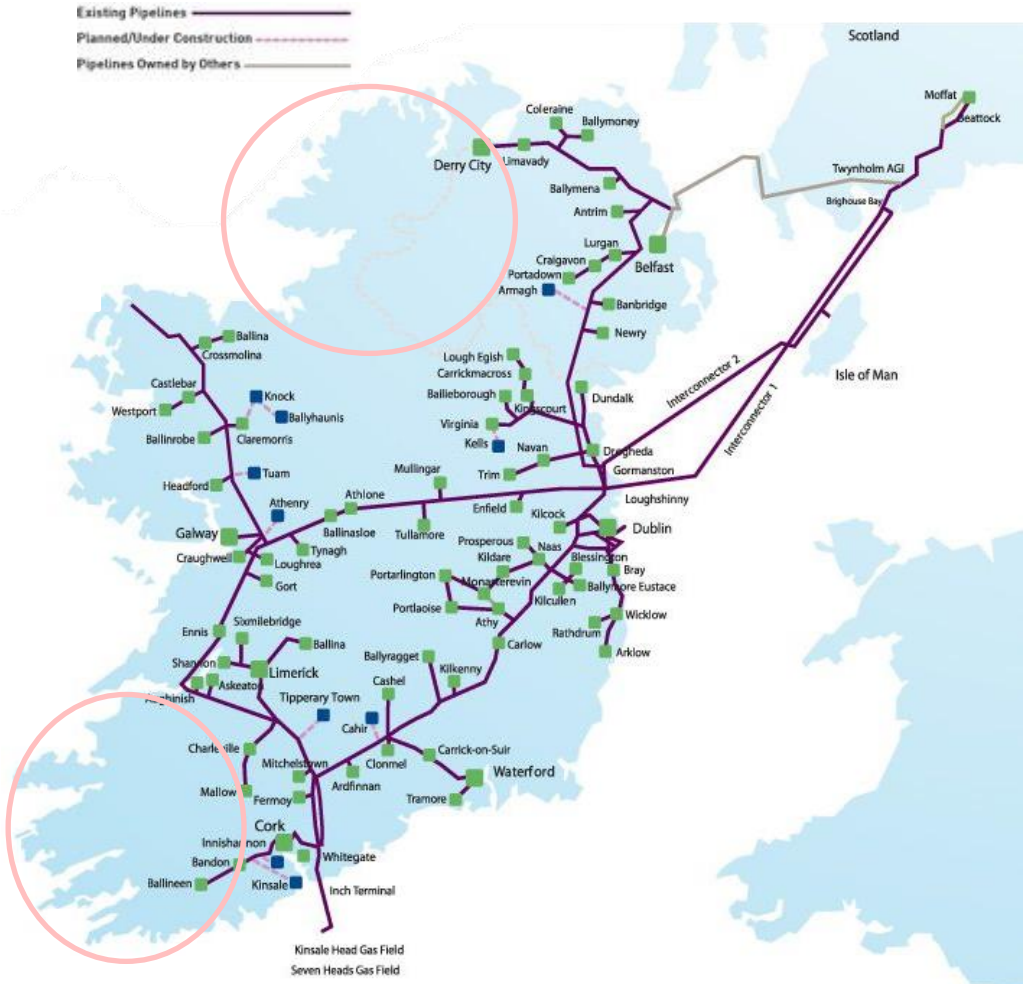
- Renewable biomethane and green H_2 presents a cost effective opportunity to decarbonise heat users in the future. This project will facilitate the conversion of a company's heat usage from fossil fuels to firstly natural gas, then to a composite natural gas blend consisting of Hydrogen or biomethane.
- This will assist in the development of a circular economy, allowing industries to tap into the renewable gas market – This in turn will lead to an increase in demand for renewable gas. Developing the virtual infrastructure will also ease the transition to hydrogen in the future



Introduction

Proposal

- This project is aiming to address this regional disparity by conducting an assessment on the feasibility of developing a compressed natural gas (CNG) station, allowing the compressed gas to be transported via road within specially engineered trailers to customers with large power requirements.
- A similar project in Scotland (The Highland project) is a working case study of this proposal; a cluster of four off-grid distilleries are supplied with natural gas via a virtual gas network.



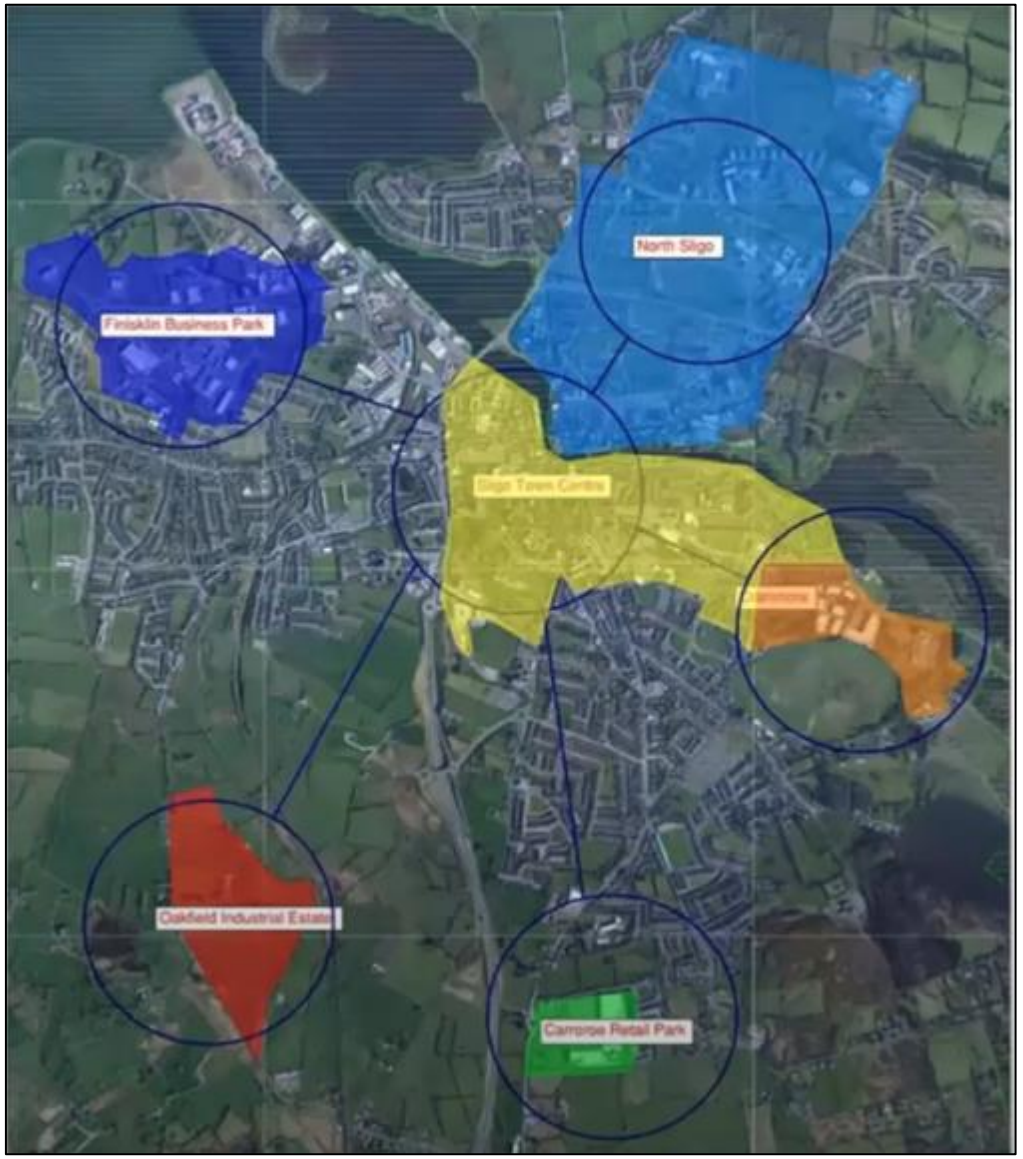
cng services ltd

Sligo

A proposal for a satellite virtual pipeline gas network in the town of Sligo which is independent from the national gas grid was **deemed feasible in a study* conducted by Fingleton White**. The proposal of a virtual network negates the high capital costs and time requirements of a pipeline expansion project. It was stated that the expansion of the national transmission line is both a timely and cost intensive project which would only support a localised area. In addition, the magnitude of such investment does not align with the 2050 carbon neutrality targets, with more cost effective options available.

On the contrary, a virtual pipeline will support businesses in the interim, allowing them to benefit from reduce energy costs, lower carbon emissions, and more importantly act as an enabler to allow access to the future green gas markets in the long term. Simply put, a virtual network project is an opportunity to support the region both in the short term and long-term, acting a stepping stone in achieving eventual carbon neutrality.

The aforementioned satellite gas network study identified that 24 of the largest energy users in Sligo use a combined total of 43 GWh/annum of electricity, derived from 28 GWh and 15 GWh of LPG and oil respectively – *approximately €3.6 million.* In comparison, the same energy demand sourced by natural gas could provide a **27% cost saving in energy commodities** - **Equivalent saving of *€1.0 million* and 1500 tCO2 saved per annum.**



cng services ltd

Sligo

A proposal for a satellite virtual pipeline gas network in the town of Sligo which is independent from the national gas grid was **deemed feasible in a study* conducted by Fingleton White**. The proposal of a virtual network negates the high capital costs and time requirements of a pipeline expansion project. It was stated that the expansion of the national transmission line is both a timely and cost intensive project which would only support a localised area. In addition, the magnitude of such investment does not align with the 2050 carbon neutrality targets, with more cost effective options available.

On the contrary, a virtual pipeline will support businesses in the interim, allowing them to benefit from reduce energy costs, lower carbon emissions, and more importantly act as an enabler to allow access to the future green gas markets in the long term. Simply put, a virtual network project is an opportunity to support the region both in the short term and long-term, acting a stepping stone in achieving eventual carbon neutrality.

Preliminary FEED & BCA showed (courtesy of Fingleton White)**:**

- Sufficient demand in 3 main area hubs (Business Park, North Sligo, Oakfield)
- 27% cost saving (CNG compared to oil/LPG)
- 15% Carbon saving with CNG
- Biogas feedstock availability – Sufficient resources available in local region for admixing

Foreseen Advantages of A Virtual Gas Network

- Access to the future green gas market (biomethane and hydrogen)
- Circular economy
- Significant reduction of energy costs
- Promoting further regional economic development
- Green fuel for heavy vehicle transport/haulage

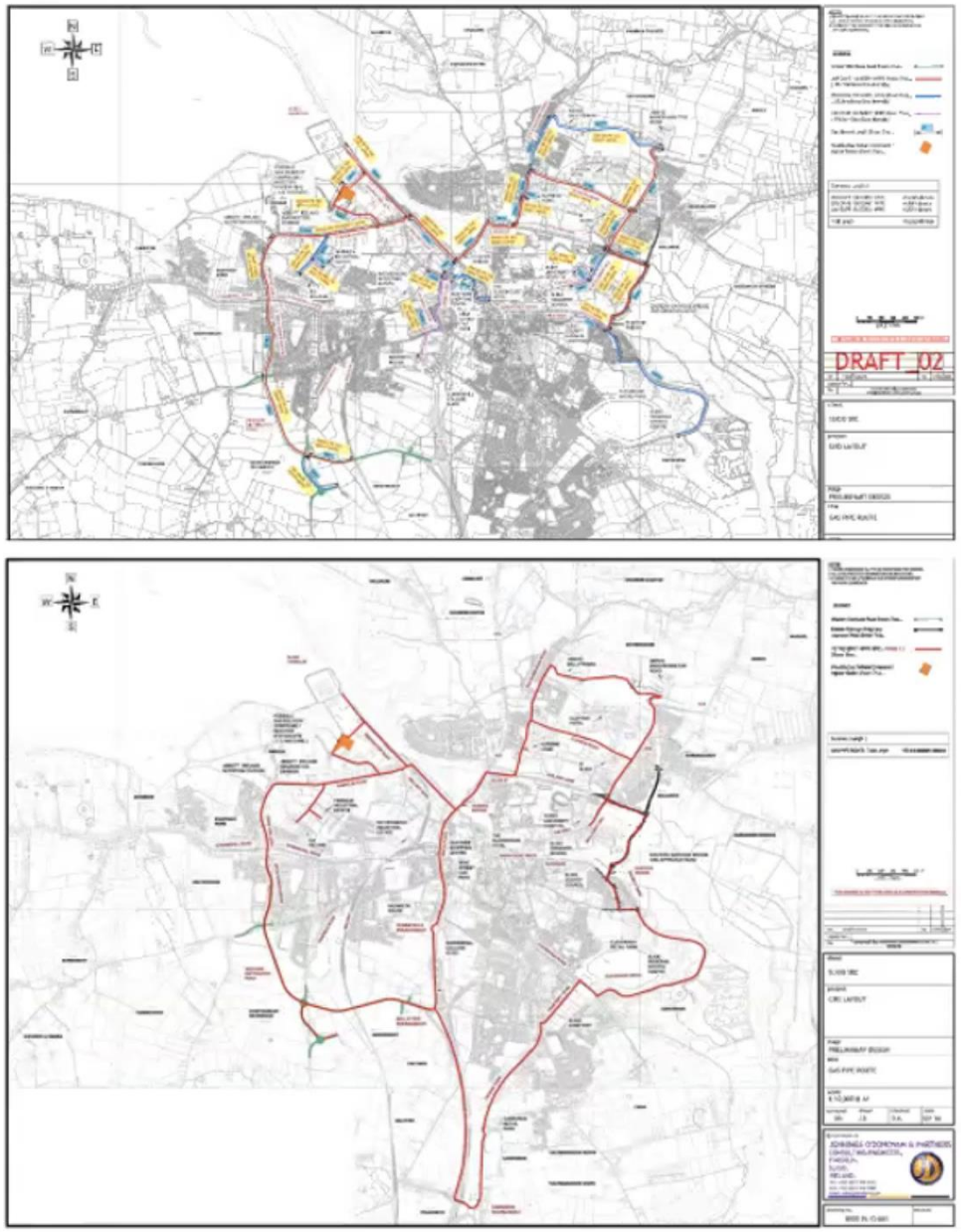
* Webinar: Sligo Local Gas Network (SLGN) – March 3, 2021

Sligo

The aforementioned satellite gas network study identified that 24 of the largest energy users in Sligo use a combined total of 43 GWh/annum of electricity, derived from 28 GWh and 15 GWh of LPG and oil respectively – *approximately €3.6 million.* In comparison, the same energy demand sourced by natural gas could provide a **27% cost saving in energy commodities** - **Equivalent saving of *€1.0 million* and 1500 tCO2 saved per annum.**

The map shown on the right hand side depicts the proposed satellite gas network route. The estimate total pipeline length involved in the expansion project **totalled 22km**, with an **estimated capex cost of *€10 million*** which includes: pipe installation, gas injection, gas transportation, consents and contingency planning. In addition to the capital, delivery of gas to businesses would be over a prolonged period; the logistics of developing such a large scale project would require the division into several phases which would see a completion date over many years. The engineering required for this project is further complicated by a number complex variables that need to be considered during pipeline route planning. These include:

- Route Length
- Future expansion of the network
- Proximity to possible future I/C users
- Gas injection location
- Special Engineering Difficulties (SED) (e.g. rivers, trenches, road-crossings)
- Constructability
- Traffic management requirements
- Wayleaves
- National Road Crossings (N4, N15, N16)
- Rail crossings
- Architectural areas
- Environmental concerns
- Network re-enforcement



cng services ltd

Section 2 – Operation Overview

An Introduction To CNG Stations

Purpose – CNG Stations can be developed to :

- Compression of gas to fill mobile storage trailers allowing gas to be transported via a 'virtual pipeline' to the receiving customer
- Compression of gas to fuel CNG vehicles (including HGV tractors for long distance haulage), providing a greener alternatives to diesel

Main Plant Items – Mother Station

- Compressor (Including an upstream buffer with an associated cooling and chilling system)
- Dispensers (with trailer connections kiosk)

Main Plant Items- Daughter Station

- Offloading cabinet (with associated trailer connections kiosk)
- Hydraulic compressor (only if fuelling vehicles)
- High pressure storage and priority panel (only if fuelling vehicles)
- Pressure reduction & metering system (only if supplying customer or injecting into the grid, potentially with flow control, if required)

Operation Overview

Compression: Gas is taken from the grid-connected mother stations and compressed to into CNG trailers before being transported to one of the decanting stations (off-grid installation sites or 'daughter station')

Transportation: Gas is transported via road using UMOE or X-Store CNG trailer. At 250barg, these hold approximately 7 or 10 tonnes of gas respectively (~9,000 or 13,000 Sm^3) depending on the option selected

Decanting: Gas is decompressed using a pressure reduction metering system (PRMS) at the daughter stations. Here, the highly pressurised CNG is decompressed to 2-7 barg. The gas is further reduced in pressure (mbar) before use by the I&C customer

Configuration: The daughter station can be configured to support a specific customer with on-site deliveries or, if suitable, a shared installation can used to support multiple customers from the same station through associated pipework

Gas Compression (Mother Station)

Overview & Basic Operation

Compressor during installation

Compressors and Vent-Stacks - Fordoun

Compressor Overview – To maximise transportation efficiency, gas needs to be compressed. Generally, this is achieved using reciprocating compressors. A duty/standby configuration is a good engineering practise, allowing for active and preventative maintenance to occur whilst ensuring that operation is not affected.

Basic Operation

- Gas is filtered and the pressure is regulated.
- Gas is subject to 'multistage compression' to achieve the desired pressure output
- Gas is cooled after each stage using a water circuit connected to a fan-cooled skid
- Gas is filtered at the outlet and is then chilled using a heat exchanger
    - Hydraulic Compressors allow compression at a large range of inlet pressures and can be used at the daughter station to help offload a CBM trailer into CBM storage

Trailer Filling (Mother Station)

Dispensers & Trailer Connections Kiosk

CBM Dispensers – Gas is loaded onto CNG trailers using dispensers. These involve a series of valves which direct the gas where required. Typically, CSL have used SAFE as a supplier for dispensers.

- **Hoses -** They come with CBM hoses which connect onto the trailer using special nozzles. The hoses are often considered the biggest safety issue onsite and considerations should be made to ensure that sufficient protection is included in the design.
- **Metering** - Optionally, dispensers can include a metering system with pressure/temperature correction

Trailer Connections Kiosk – This is used to house a number of useful trailer connections that are important for safe operation:

- **Earth cable** – Trailers need to be earthed to prevent static build up. A smart earthing system can monitor the earth connection and halt the fill if the earth is lost
- **Compressed Air** – This can be used to control an emergency slamshut valve on the trailer (removal of air = closed slamshut)
- **Instrument Monitoring** – If PT's or TT's are installed in trailer cylinders, this can be used to prevent a breach of trailer design conditions

CNG Trailers

UMOE CBM Trailer

Hexagon-Xperion CNG Trailers at Fordoun

Trailers comprises a skeletal framework upon which a container holding high-spec gas cylinders is installed. For high-volume transportation, 'Type 4' cylinders are used, which are filament-wound composite cylinders wrapped around a plastic former. The composite is generally either glass or carbon fibre.

Two options have been used on previous CSL projects

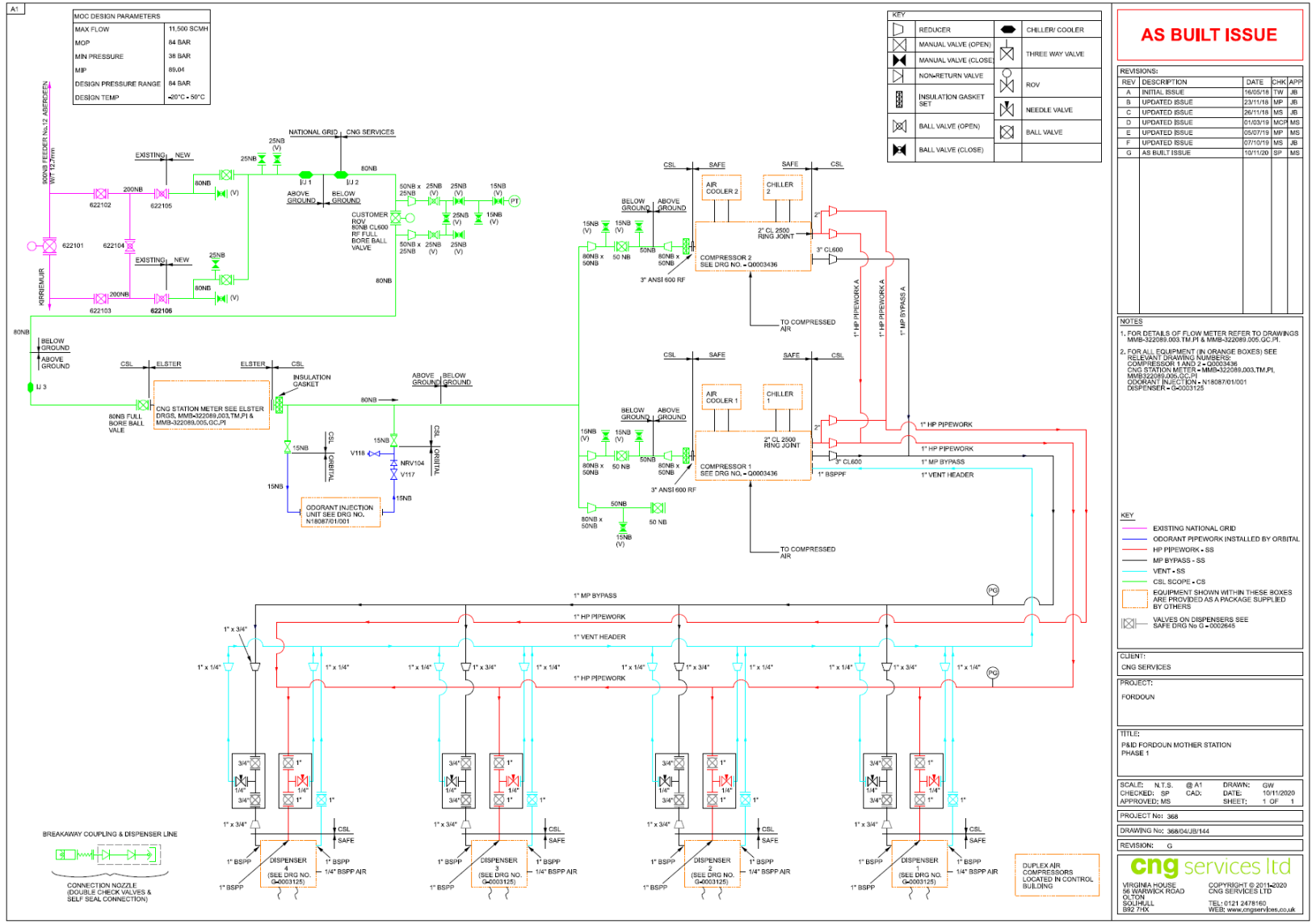
Option 1:

- Manufacturer – Hexagon/Xperion/Wystrach – Type 4 – 45ft
- Cylinder Material - Carbon Fibre
- Total Capacity – 9.6-10 tonnes
- Transported Capacity – 8.9 tonnes

Option 2:

- Manufacturer – UMOE Advanced Composites - Type 4 – 40ft
- Cylinder Material - Glass Fibre
- Total Capacity – 6.5-6.9 tonnes
- Transported Capacity – 6 tonnes

Example P&ID of a Compression Station



Daughter Station
Operational Overview

Example Site – Clynelish Distillery

- An offloading cabinet is installed at the back of the trailer bay to interface with trailers
- Trailers arrive to site and offload via a pressure reduction system to step pressure down
- Trailers arrive containing compressed natural gas at 250barg
- Offloading bays will be provided where trailers can park and connect into offloading cabinets using CNG hoses, routing gas to the PRMS
- The CNG in the PRMS units will be heated upstream of each pressure reduction stage, metered and analysed.
- Daughter stations will be unmanned sites but will be monitored online, with alerts sent to operators in the event of a process warning or trip

Automatic switchover system:

While on site CNG storage can provide fuel security in the event of a failed delivery, such configuration adds unnecessary complication to the design and the associated cost is not perceived to be valuable considering the recipient will inevitably revert to a back-up fuel source.

To reduce the added complication and offer a more economic solution, an automatic switchover system is recommended. Here a control system for dual fuel burner has a function whereby a remote signal from a external controller can select the fuel source of choice. Therefore, a simple signal (digital input or via Modbus) from the CNG pressure reduction plant can be relayed to maintain operation with minimal input.

Section 3 – CNG to Hauliers, An Overview

CNG For Trucks

There are three possible options for hauliers who are wanting to adopt CNG trucks.

Option 1 – Depot based CNG Station

- Only possible if distribution grid is close by
- Requires a relatively large local demand since capital costs are high and offset any fuel saving

Option 2 – Mobile Refuelling Unit (MRU)

- MRU permanently parked at hauler's depot
- CNG delivered by road from a mother station

Option 3 – Public access CNG Station

- E.g. in GB, the CNG Fuels network, in ROI, the GNI Network

Mobile Refueling Unit (MRU)

The MRU is typically parked at the truck depot. It requires a relatively small electricity supply but otherwise it operates as a standalone unit and can be topped up by a CNG trailer. Two of these have been built and used in Milton Keynes since November 2020.

Basic Operation – Gas is transported from the mother station using a CNG trailer where it arrives to the delivery site. Here, the stored gas is decanted from the trailer into the high-pressure storage unit on the mobile MRU using a hydraulic compressor (integrated on the MRU trailer). The mobile trailer holds a dispensing unit to which CNG compatible vehicles can fill from.

Trailer – 45" flat foot bed trailer with access ladders

Compressor – Hydraulic booster compressor mounted in ISO container is able to compress out of low and middle storage to maintain pressure to high bank

- Electrics – 34kW, 400V electric motor
- Priority Panel – 3 line priority panel to CNG storage
- CNG Dispenser and Fuel Management system
- Connection to CNG Trailers

Storage – 20' ISO containerised storage unit from UMOE (shown in top-left photo)

- Material – Type 4 (composite) storage cylinders
- Capacity – 3,800kg of gas stored in 11 cylinders

Filling – CNG trailer deliver gas from the CNG Mother Station and park alongside the MRU

- The compressor runs to top up the storage on the MRU
- This is repeated at other MRUs and keeps all MRU station storage units full of CNG
- When the CNG trailer pressure reaches 20bar, it travels back to the Mother Station to fills up

Section 4 – Site Locations to Supply I&C Users

Site 1

With support from GNI, a number of potential AGI/BV sites were assessed to determine suitability for the proposed mother station/MRU (mobile refuelling unit). Each site was subject to an assessment which provides merit based on a defined criteria to determine the highest ranking site. Parameters in the assessment considered: distance to recipients, land size and availability, road network for transportation, site access and proximity to nearby houses/businesses..

Benefits

- Located in a rural and isolated area
- Excellent site access and road network for transportation - Well placed to be a mother station for a distributed MRU model
- Good site electrical infrastructure
- Excellent land topography - level fields all round

Possible Concerns

- land owners would have to agree to provide land provisions
- Whilst the site is located in a rural and isolated area, obtaining planning permission can be difficult

Site 2

10 possible AGI's/BV's were subject to a site assessment to deem feasibility for this project. The same parameters (as with the NW site) were considered (Details of the assessment can be viewed in the appendix).

For the proposed station to serve the South-Western region, appears favourable. For logistical purposes, close access to both national and motorway networks is a crucial assets for route planning and delivery efficiencies whist also offering an opportunity to further serve additional regions with ease. While adjacent land is readily available, the large site footprint may provide a cost effective opportunity to develop the mother station assets directly on site.

Benefits

- Located in a rural area that is relatively isolated - There is no new development near the site
- Excellent site access and road network for transportation.
- Good land topography
- Space availability on site is excellent – Suitable for on site development
- Good land availability adjacent to site

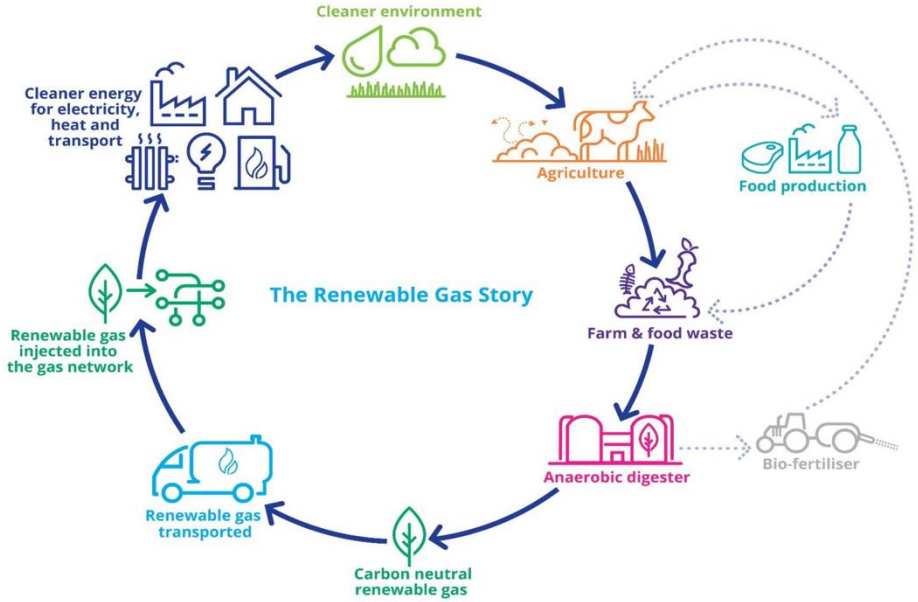
Possible Concerns

- Electrical infrastructure is questionable - 98 kVA ~1km away. For greater capacity (250-500 kVA), a connection to Mitchelstown is required which is approximately 3km away. Sites with limited electrical access will require gas generator (500-1000 kWe) to support compressor operation
- Old storage structure nearby site - appears to be a small silage pit

Mitchelstown - GRAZE (Green Renewable Agricultural & Zero Emissions) Gas Project

GNI has identified Michelstown AGI as a potential CGI point which could inject large volumes of renewable natural gas (biomethane) into the Irish gas grid. The CGU facility will be serviced by nearby anaerobic digestion plants. The evolved biogas will be captured and upgraded before being transported in specially engineered tanker vehicles which will supply the CGI facility with renewable natural gas for export. Mitchelstown has been chosen as the CGI point because of the biogas potential in this area for farm-based AD plants that will be fed by a variety of feedstocks (food waste, slurry and other farm wastes)

This project is part of a large investment made by GNI for the long term adoption of renewable natural gas within the network. More specifically, this project could be one of many in series of projects under 'GRAZE' and could be a catalysing step in achieving GNI's target to deliver a decarbonised gas network by 2050. It is intended that the Mitchelstown facility will be one of 17 CGI points delivering renewable natural gas into the gas network. This announcement confirms the Government's support for GNI's long-term vision for how the gas network can play a key role in decarbonising Ireland's energy, transport and agriculture sectors.

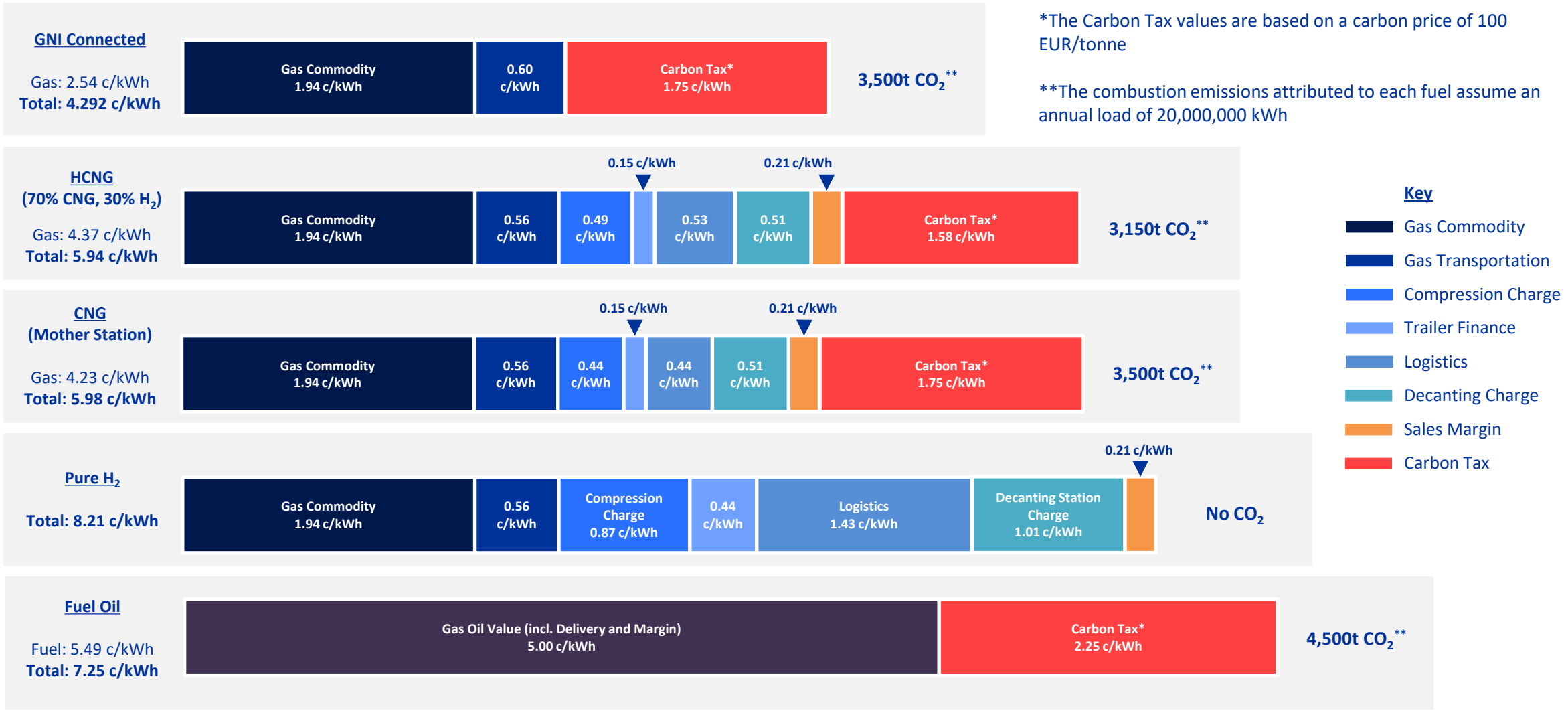


In addition, the 'GRAZE' project will fund the development of two compressed natural gas stations. These stations will be part of a nationwide network consisting of 70+ dispensing sites which will work in tandem with current CNG Vehicle Grant Scheme to encourage HGV operators to switch from fossil diesel to renewable gas.

Once operational, the Mitchelstown facility will inject enough renewable gas to supply green energy to approximately 56,000 homes. It is estimated that at maximum capacity, the Mitchelstown project alone would reduce Ireland's annual CO2 emissions by up to 170,000 tonnes per annum.

Section 5 – Displacing Fossil Oil

Unit Fuel Cost Breakdown Comparison (per kWh)



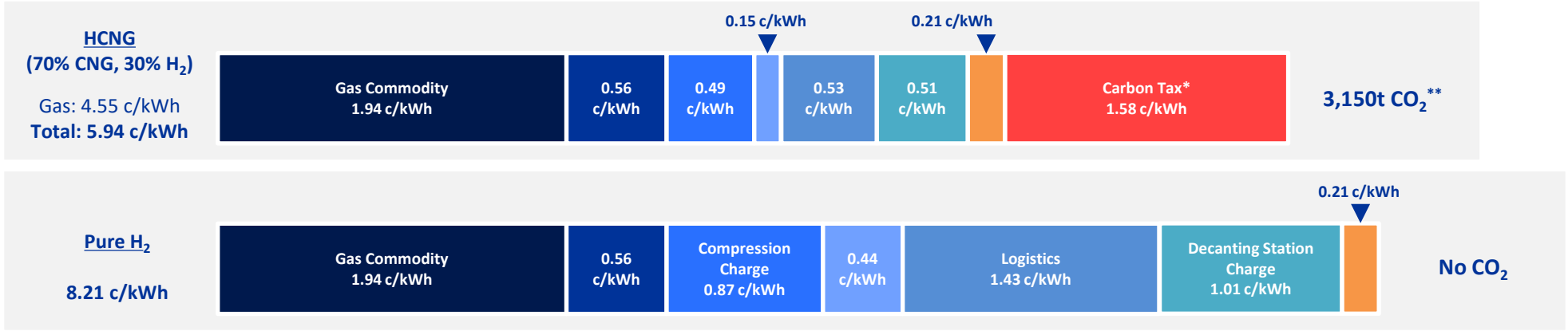
*The Carbon Tax values are based on a carbon price of 100 EUR/tonne

**The combustion emissions attributed to each fuel assume an annual load of 20,000,000 kWh

The carbon emissions have been estimated using natural gas properties with a composition of 97% CH_4, 2% CO_2, 1% balance

cng services ltd

Hydrogen Value (as HCNG)



- The values shown are the comparative costs of HCNG and Hydrogen to the fuel user
- Due to the low volumetric energy density of hydrogen, the production, compression and delivery costs to meet a given energy demand are considerably higher for pure hydrogen than HCNG. The combustion of hydrogen does not generate any carbon emissions however, which eliminates any carbon tax payments
- By selling fuel 'HCNG', local industrial heat users can be targeted without considerable additional capital since it would take advantage of the proposed Mother Station infrastructure and logistics. Due to the properties of hydrogen, bespoke equipment would need to be installed to utilise pure hydrogen as a fuel, which currently would be uneconomic to the user
- For HCNG, it is estimated that the consumer would pay 4.55 c/kWh per unit of fuel, of which the hydrogen producer would receive the commodity value of the gas (1.94 c/kWh), the network transportation charges (0.56 c/kWh) and the sales margin (0.21 c/kWh) – **2.71 p/kWh total**. If sold at the same value as CNG, some logistics charges may be deducted to account for the additional processing and haulage costs
- The compression charge, trailer finance and logistics charges would be retained by the Mother Station operator to cover the cost of delivery the gas to the consumer
- It may be possible to agree a share of some of the carbon tax saving to incentivise hydrogen production

Hydrogen Value – Worked Example

- A case study has been established based on an industrial user demanding 20,000,000 kWh of energy per annum using the estimated unit values
- For HCNG with a 30% by volume concentration of H_2, approximately 5% of the energy value will by from hydrogen, resulting in a much smaller demand and sales value than catering for the entire demand with pure hydrogen

Parameter	HCNG (30% H_2)	Pure Hydrogen
Cost of Fuel to User	873,810 EUR/a	1,290,533 EUR/a
Total kWh of H_2 Required	1,030,825 kWh/a	20,000,000 kWh/a
Mass of H_2 Required	26,190 kg/a	508,130 kg/a
Value to H_2 Producer	**10,948 EUR/a**	**212,414 EUR/a**

Effective Carbon Value to User

The effective unit carbon cost for averted emissions can be estimated based on the value of HCNG/hydrogen vs. a reference fuel (i.e. CNG). The difference in value between CNG and HCNG is 0.14 c/kWh, so a carbon saving of 350 t/a is achieved at 0.14 c/kWh (80 EUR/t). Pure hydrogen is 2.23 c/kWh more than CNG, which to save 3,500 t/a of CO_2 breaks down as 127 EUR/t

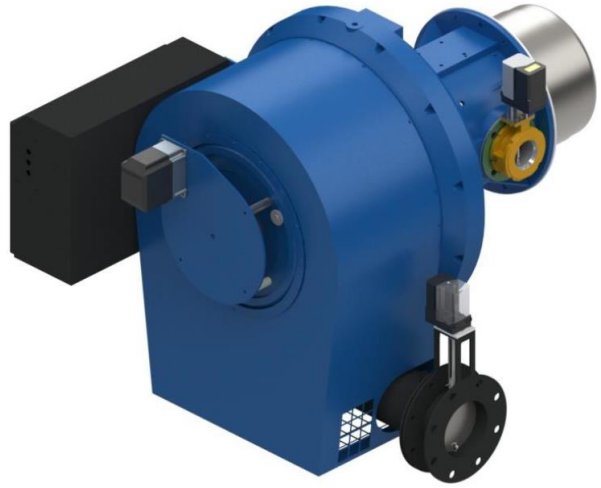
Parameter	CNG	HCNG (30% H_2)	Pure Hydrogen
CO_2 Emissions	3,500 t/a	3,150 t/a	0 t/a
Averted CO_2 Emissions (vs. CNG)	0 t/a	350 t/a	3,500 t/a
Carbon Value	100 EUR/t	80 EUR/t	127 EUR/t

Dunphy Multi-fuel & H_2 burners

Excerpt from Dunphy Brochure:

Dunphy T' Series burners are supplied for a wide range of applications and de-signed to match specific customer needs and site requirements. Units sup-plied are usually therefore variants of a basic, standard design. Standard features of the bespoke burner range are:

- Low NOx combustion head
- Up to 10:1 turn down ratio
- High precision digital servo motor control
- Low leakage, fully digital modulating air damper control
- Built to last, high quality, robust design whilst ensuring ease of maintenance and serviceability
- All models approved to current British & European Standards
- Designed, manufactured & assembled in our UK factory to the highest quality
- All burners are tested and pre com-missioned in our R&D lab before being dispatched to the end customer, ensuring the highest performance is achieved, whilst retaining unrivalled re-liability.
- ATEX and SIL approved options avail-able.



Available on request:

- O2 Trim
- Multi-fuel
- Simultaneous firing
- Gas families 1, 2 & 3. Typically mines gas, hydrogen, syngas and waste gas
- Low pressure drop variants.
- Inbuilt Flue Gas recirculation

Use of CNG & Biomethane to Fuel HGVs

- Heavy Goods Vehicles (HGVs) contribute 21% of surface transport CO2 emissions, but make up only 1.5% of road vehicles. The HGV sector needs to make a contribution to meet the 2050 target outlined in the 2008 Climate Change Act

- Despite some improvements in fuel consumption efficiency in recent years, these emissions are still rising, mainly due to increasing road freight traffic. Long-haul and regional delivery duty cycles account for around 70% of HGV emissions

- The EU-wide CO2 emission standard for heavy-duty vehicles have set targets for reducing the average emissions of new lorries from 2025 *(Regulation (EU) 2019/1242).* The regulation includes mechanisms to incentivise the uptake of low-emissions vehicles. Methane gas engine technologies (CNG, LNG, biomethane) has been identified as having the best potential to deliver the greatest carbon savings

- The Renewable Heat Incentive (RHI) provides a subsidy for biomethane grid injection, while the Renewable Transport Fuel Obligation (RTFO) provides an incentive for the supply of biomethane as a transport fuel

- Electric and hybrid powertrains are already in use for smaller delivery cargo. These are commonly used in urban delivery cycles that are confined by ULEZ (ultra low emission zones). **These technologies are not mature nor suitable for long distance HGVs**

In Ireland, there is almost **€5 million available in grant support schemes to help operators transition to greener fuel options.**

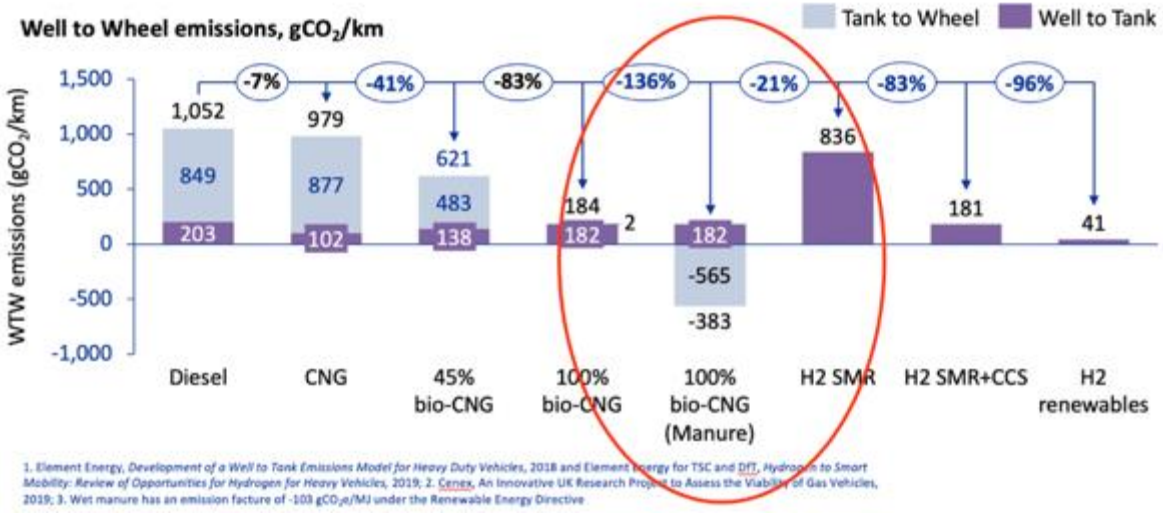
- GNI recently launched a €2.9 million CNG Vehicle Grant Scheme to support the purchase of up to 400 new CNG compatible vehicles. This funding will help Irish fleet operators transition to new, cleaner CNG vehicles and support the decarbonisation of Ireland's transport sector

- The Department of Transport launched a €2 million Grant Scheme - 'Alternatively Fuelled Heavy Duty Vehicle' (AFHDV). This scheme will subsides the purchase of greener vehicles (gas and electric) by up to 60% of the sale price for up to 20 vehicles or €500,000

A Case For Biomethane HGVs

Modelled Well-to-Wheel (WTW) emissions for CNG trucks suggest that an 100% emissions saving is possible when using 100% biomethane, compared to diesel equivalents. This is comparable to real-world trial data which estimated WTW **emissions savings of 76-81% with pure biomethane.** With biomethane from manure, emissions can be net-negative using official accounting.

The CO2 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.



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*						
Bio-CNG		600	700						
H_2 FCEV	660	350†	500-1200*						

Vehicles commercially available | Vehicles in development/trial | Not currently available

*Theoretical – vehicles not currently in production
†H_2 range extender

HGVs are difficult to decarbonise with the most challenging requirements for vehicles being range and carrying capacity.

Current 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. However, this is currently a novel technology and not a feasible option at present
- **Methane** - In the form of bio-compressed natural gas (Bio-CNG) and bio-LNG. This is currently the only proven, commercially available option for long haul vehicles

cng services ltd

Support for Biomethane

Anaerobic digesters (AD) have great potential in Northern Ireland. Until recently, the low uptake of AD plants in Northern Ireland was leaving a large, untapped biomass resource in the province. A growing number of digestion plants have been constructed in Ireland as the agricultural and industrial industry identify ways to recycle organic matter to generate renewable forms of energy. The future of renewable gas in Northern Ireland is bright; a European Commission report suggests **Ireland has the highest potential for biogas production per capita within the EU.** Since 2015, 24 new plants have been commissioned providing £28.5m in revenue and generating 22.8 MWe of electricity each year. This figure is expected to grow significantly; a recent announcement suggests there are **currently 103 AD sites either in construction or approved within the region**. If completed, these will be capable of processing around 1.4 million tonnes of feedstocks a year**.**

Ireland has ambitious targets in relation to energy efficiency. This includes a energy saving target of 20% of the historic average used during the period 2000–2005 by 2020. In addition, Two further binding EU targets for renewable energy by 2020 have also been set:

- 16% of final energy use (all sectors) must be sourced from renewables. To achieve this target, national sub-targets have been set for heat and electricity at 12% and 40% respectively
- 10% of energy use in the transport sector must be renewable

A study by the Sustainable Energy Authority of Ireland (SEAI) in 2017 reported that generating renewable gas from ADs could contribute to the nation's ability to meet these targets. The findings, summarised by Agri-news platform, Agriland highlight that Anaerobic digestion plants could:

- Provide 28% of Ireland's overall gas needs by 2050
- Cut carbon emissions by 200 million tonnes annually
- Sustain rural businesses, and
- Lead to the creation of 3000 new permanent jobs in the industry

Proposed Renewable Heat Obligation (RHO) for NI

The following outlines the key implications of a proposed renewable heat obligation (RHO) on the virtual gas pipeline. A public consultation is currently open on the introduction of such an obligation. If implemented, the obligation would commence in 2023 with a two year lead in period. The information contained in the RHO consultation is summarised below.

Policy context

The RHO is supported under Article 23 of the Renewable Energy Directive where Ireland is mandated to 'endeavour to increase the share of renewable energy in that (heating and cooling) sector by an indicative 1.3 percentage points as an annual average calculated for the periods 2021 to 2025 and 2026 to 2030. Ireland's National Energy and Climate Plan, published in August 2020, sets out that Ireland will have at least a 34.1% share of renewable energy by 2030 contributing to the overall EU target of achieving 32% renewable energy by 2030.

Current Progress In the Heat Sector

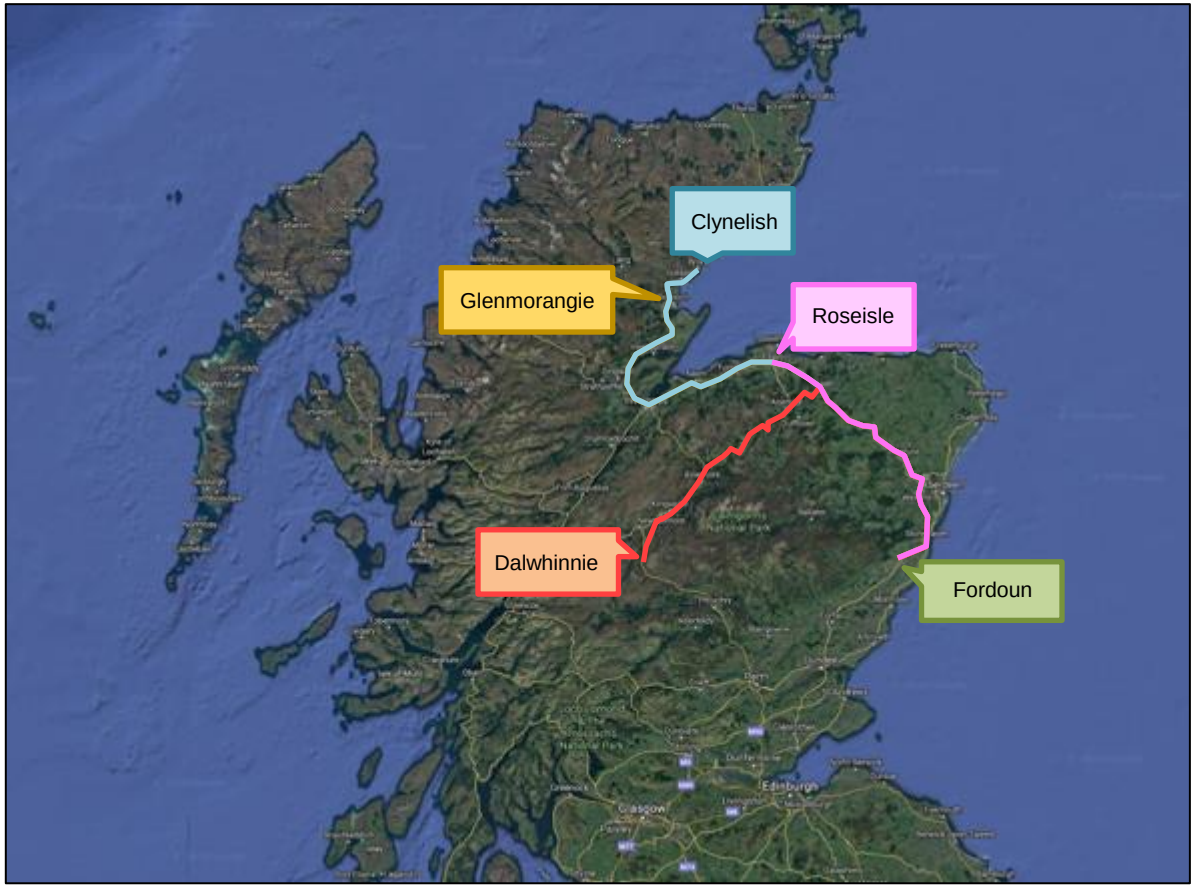
- Ireland did not meet its 2020 target of 16% for renewables in the country's final energy consumption.
- Ireland currently has 6.3% of its heat sector demand met by renewable fuels, which is the lowest percentage of any Member State and well below the European Union average of 22%.
- While some progress is being made in terms of increasing renewable heat in Ireland, more needs to be done. In particular, there will be a need to be other renewable sources of liquid and gaseous fuels use for heating purposes – in particular to decarbonise high temperature heat where electricity may not provide a practical solution.

How it works

- An obligation in the heat sector will incentivise the use of renewable heat fuels while spreading the obligation across all non-renewable fuel types. The obligated parties are the retail heating fuel suppliers and will cover suppliers of all fuels supplied in the heat sector including oil, liquid petroleum gas (LPG), natural gas, coal and peat.
- The Heat Obligation Rate would then be increased over the decade to at least 3%. This would equate to at least 1.6 TWh of renewable heat by 2030, or up to 10% (5.5 TWh) by 2030 at the more ambitious level.
- EU ambitions are rising, and it is possible (based on the new draft of the Renewable Energy Directive – RED3) that higher GDP countries like Ireland could be bound to an even higher target of up to 13% (7 TWh) by 2030.

Section 6 – Case Study

Delivery of 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:

- **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^3)
- **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 (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 Loads

- **Fordoun :** Max 11,500 Sm^3/hr (pipeline), Max 5,500 Sm^3/hr (each compressor)
- **Glenmorangie:** Maximum 1,200 Sm^3/hr, Average 500 Sm^3/hr
- **Clynelish:** Maximum 1,200 Sm^3/hr, Average 400 Sm^3/hr
- **Dalwhinnie:** Maximum 1,200 Sm^3/hr, Average 200 Sm^3/hr
- **Roseisle:** Maximum 2,400 Sm^3/hr, Average TBC

Fordoun Block Valve Site & CSL ROV Compound

- Remotely Operable Valve (ROV) is located approximately 50m downstream of the connection to the NTS block-valve site which is owned by National Grid
- Downstream of the ROV is a ~900m 3” carbon steel pipeline which feeds into the CNG Mother Station
- The ROV is operated locally via a dedicated button at the CNG site and from the ESD buttons locally and at the CNG Mother Station

CNG Mother Station
Compressors & Aftercooler/Chiller

- Compressors flow a maximum of 7,000 scmh
- Trailers are filled up to ~65barg on a bypass line and then filled to 250barg using the compressor

- Heat has to be removed from the gas to ensure temperature measured in the Type 4 trailer cylinder is <65 Deg C
- Also, to give full fill of 250 bar at 15 Deg C, heat has to be removed

Filling CNG Trailers, Fuel Management System, Priority Panel & 300 bar CNG Storage

Trailers connected to dispensers

Dispenser & Fuel Management System (Leyland)

Priority Panel example (Leyland)

300barg CNG Storage (Leyland)

cng services ltd

Roseisle Distillery – Offloading Cabinets

Section 7 – Additional Considerations

Key Learnings & Legal Aspects

Key learnings from Highlands CNG Project and Colony Farm

Highlands CNG Project

- When compressing gas into trailers, it is advised to compress the gas to a higher pressure than the allowed settled pressure (250barg at 15 degC). This means that, when the gas cools (it is often at 40-50 degC at the end of a fill), the pressure reduces down to a level whereby the trailer is full, as opposed to below its threshold at 15 degC
- When offloading gas, using CNG Storage as a backup fuel supply drastically increases capital cost and site complexity; as a backup fuel supply would be required anyway, it is proposed that the end-user install an auto-switchover system that switches the fuel used from CNG to another fuel source if there are issues with the CNG supply

Colony Farm

- When compressing gas, it is recommended to install a buffer downstream of the CNG compressors. This allows the compressors to start/stop in a more consistent manner, preventing unwanted trips on high pressure

Potential for CNG to supply domestic customers

Supply to Domestic Customers

When reviewing opportunities to supply I&Cs with gas, it is also worth considering the supply of gas to nearby domestic customers. Whilst this has been considered to some degree in the 'Sligo' study, shown earlier, CSL have had some experience with similar studies following the 'Tain Innovative Gas Grid' Ofgem bid, carried out in 2018. Some issues were identified as a result of this study when considering CNG supply to domestic customers. These included:

- **Security of Supply –** It is difficult to guarantee security of supply of gas to customers for two reasons. Firstly, the transportation of gas by road is relatively reliable, but there could be possible issues (i.e. closed roads, poor weather) that could lead to delayed deliveries, and therefore a lack of gas supply. Secondly, although relatively reliable, in a case that the offloading and pressure reduction site trips (due to high pressure, low temperature or other reasons), the gas supply would again be removed. This is generally considered unacceptable unless there are reliable backup energy sources for all connected properties

- **Competition –** When supplying energy to domestic customers, it is important that appropriate fuel price competition is available to the customer. If gas is supplied by road by a single producer into the gas grid, this leads to an effective 'monopoly' on pricing; this is a difficult hurdle to overcome

- **Heat Pumps –** The above issues could potentially be overcome by considering a system based on the use of heat pumps as a primary source of heat, with the gas system installed as a backup only. This causes other, economical challenges though to any compression station developers looking for a significant load of gas

Section 9 – Implementation Plan

Work Programme

Work underway

- Donegal Feasibility Study underway
- Joint Venture Agreement and Draft Business Plan
- Aim to agree in Oct 2021 and fund initial work programme
  - Agree delivery strategy for Mother and MRU

Work required in Oct/Nov/Dec 2021

- Planning applications for North-West and South-West
- Initial marketing to customers
  - MRU model
- Develop Business Plan and Financial Model
- Project Jan 2022

The Indicative Delivery Plan*

*** drafted prior to gas price rise in Q3 2021**

Phase 1a (complete by Jan 2023)

- Launch I&C customers
- Launch MRUs

Phase 1b - 2023

- Mother Station South

Phase 2 - 2024/25

- **HCNG**

Project Capex

- Mother Station South - 2.5 million Euros
- CNG MRU Station capex – assume 8 MRUs in Phase 1 = fund via HP as far as possible
- 4 x CNG shuttle trailers each fund via HP

Section 9 – Conclusion

Conclusions

The contents of this report not only demonstrates the feasibility of developing a virtual gas pipeline but the significance of designing and implementing infrastructure at an early stage which can be used to support the regions ability in accessing the renewable market (thereby increasing demand – circular economy).

It is envisaged that this initial project will serve as a model for other areas where off-grid natural gas could be supplied.

Key Take Away Points

1. A CNG Virtual Pipeline concept is feasible to supply off grid customers
2. However, the dramatic increase in natural gas price in Q3 2021 has adversely impacted the economics of switching from oil to CNGF
3. The use of the MRU model to supply trucks coupled with a Transmission Mother station appears attractive