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The Biomethane Ladder – Use Cases for Biomethane and Bio-CO_2

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Saul Parry
Project Engineer
CNG Services Ltd

saul.parry@cngservices.co.uk
www.cngservices.co.uk

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EXHIBITION AND CONFERENCE 2023

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
- Working on a number of Biomethane, H_2 and CCUS innovation projects including:
  - Biomethane from manure with CCS
  - Biomethane direct into the NTS
  - Green H_2 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

What will best practice for biomethane producers look like in 2030?

1. 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 and batteries
- Being a source of 'electricity demand' is valuable
- Heat Pumps for heating the digesters, liquid Bio-CO_2 and Bio-CNG plants provide additional sources of electricity demand
- By 2030, 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 potential load factor should increase
- In addition, curtailed electricity from wind/solar will be available to bought at zero price (at times) and stored or used to make Green H_2 (see next slide)

Onshore wind rules to be relaxed after Tory revolt

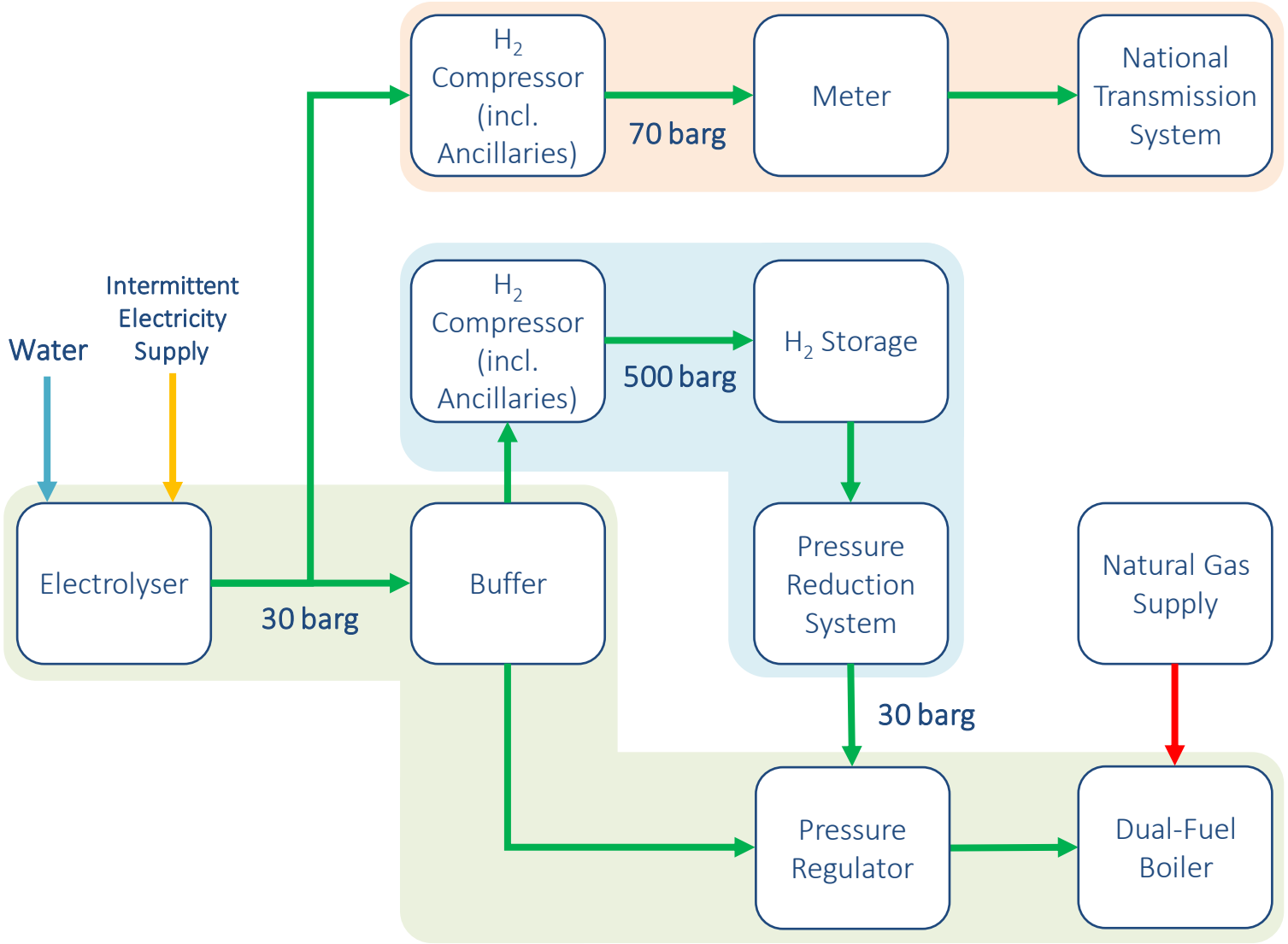
1 hour ago

GETTY IMAGES

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

2. AD Sites are Ideal Places to Make Green H_2 (1)

- No more staff required and probably no planning issues. AD sites are all connected to the electricity grid
- Green H_2 may be able to react with Bio-CO_2 to make more renewable methane or it may have local uses for industry or transport
- The point is that all the ingredients to make Green H_2 will be on site (land, electricity), including rainwater from the digester roof!



2. AD Sites are Ideal Places to Make Green H_2 (2)

Item	New Biomethane	Hydrogen	Comments
Key Plant	AD + Upgrader + GEU + Compressors	Electrolyser + 30 barg H_2 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 (which is solar with integrated storage)	Solar/wind with batteries to improve load factor & electricity grid to bring renewable electricity	Zero carbon or GHG negative
Safety/Regulation	HSC/COMAH/DSEAR/PSR	HSC/COMAH/DSEAR/PSR	Same
Product	Renewable CH_4 / Bio-CO_2 Compressed / liquid	Renewable H_2 Compressed or liquid	Similar gases Inject into gas grid, use locally or move my road (compressed/liquid)
Nature of Gas	Heavy, relatively hard to ignite	Light, leaky, quick to dispense	There are important differences
Use as Truck Fuel	Compressed or liquid, local or remote via grid / truck deliveries	Compressed or liquid, local or via truck deliveries (once trucks exist)	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 300 barg compressed biomethane trailers	Direct to I&C customer, use on site for trucks, inject into gas grid or take off site in 350 barg H_2 trailers	Similar trailers for Bio-CNG and H_2 made by same companies
Long-term Financial Case	Cost to emit 1 tonne of CO_2	Cost to emit 1 tonne of CO_2	Similar
Security of Supply	Every 1 kWh of biomethane saves 1 kWh of natural gas imports to Europe	Every 1 kWh of H_2 saves 1 kWh of natural gas imports to Europe	Similar

3. Dunkelflaute

Dunkelflaute 'dark doldrums' or 'dark wind lull' is a term used to describe a period of time in which little to no energy can be generated with the use of wind and solar power

For UK post 2035 here are 2 main options for Dunkelflaute periods:

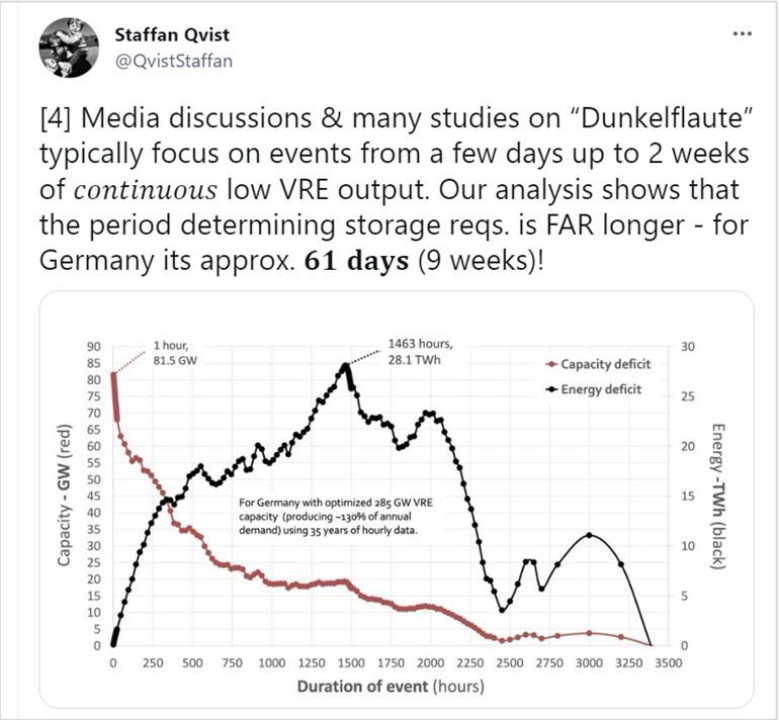
1. **Use of H_2**
- Blue/Green H_2 production plant
- H_2 storage (e.g.: salt cavities)
- H_2 pipelines
- H_2 generation plant

2. **Fossil Gas with CCUS**
- Fossil gas generation plant
- Waste CO_2 captured and sent to CCUS facilities e.g.: HyNet/Teesside/Humber/Northern Lights

But prior to 2035 its likely that the fallback option is **unabated gas engines** that can include ones on AD sites. AD sites are ideal places for them as they will (mostly) be on the gas grid

The Load Factor of all back up options (H_2, gas with CCUS and gas engines) will be <5% and falling by 2035.

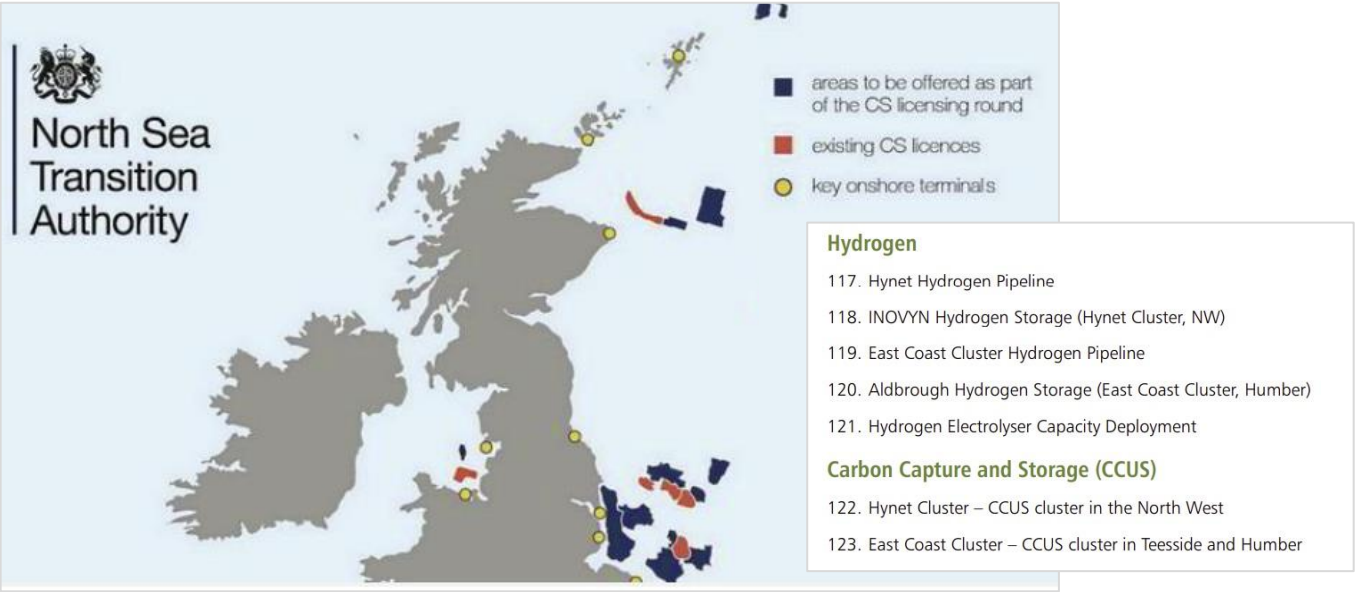
The H_2 and CCUS options will be very expensive on a cost per tonne of CO_2 basis because of such a low load factor



There may be 10 years of <5 day a year Dunkelflaute and then a year with a longer one as shown….tricky

4. Bio-CO_2 is Valuable

- From 2014–19 the producers of liquid Bio-CO_2 generally earned around £50/tonne. Today it is closer to £150/tonne given the end of fertilizer manufacture in UK
- New biomethane projects should capture and sell Liquid Bio-CO_2. Why would you vent something so valuable when the UK Govt is funding Direct Air Capture based on 420 ppm CO_2? Indicative numbers are provided in the table
- Every biomethane project has 2 components – 1) a carbon neutral cycle of biogenic Bio-CO_2 from grass to cow to milk to air to grass plus 2) by capturing the Bio-CO_2 in the AD and sending it to CCUS we reduce the amount of dinosaur era CO_2 in the atmosphere. We are fossil CO_2 hunters



Parameter	Value	Unit
Biogas and AD Data		
Biogas Composition (%CH_4)	58%	-
Biogas Production Rate	1,000	Nm^3/h
Biogas Production Rate	1,055	Sm^3/h
AD Operation	95%	-
Upgrader Availability	95%	-
Biomethane Methane Content	98%	%CH_4
Biomethane Production	629	Sm^3/h
Annual Biomethane Production	4,973,411	Sm^3/annum
Annual Biomethane Production	3,526,148	kg/annum
Annual Biomethane Production	50,940,546	kWh/annum
CO_2 Production		
Biogas Composition (%CO_2)	42%	-
CO_2 Capture Efficiency	90%	-
Offgas Production Rate	397	Sm^3/h
CO_2 Recovery Plant Availability (Relative to BUU)	100%	
CO_2 Recovery Plant Operating Hours	7,906	h/annum
Annual CO_2 Production (Volume)	3,137,617	Sm^3/annum
Annual CO_2 Production (Mass)	5,867,344	kg/annum
Annual CO_2 Production (Mass)	5,867	t/annum
CO_2 Value		
Carbon Price	£ 150.00	£/tonne
Value of CO_2 Captured	**£ 880,101.61**	**£/annum**

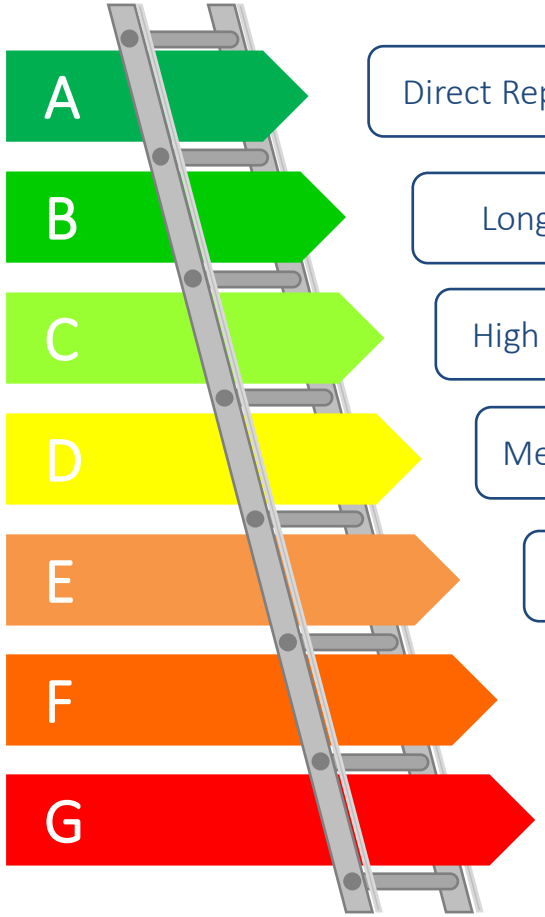
Biomethane and Bio-CO_2 Ladders:

Assessment of Use Cases

Biomethane Ladder (March 23)

And it is assumed that all the Bio-CO_2 from the AD plant is captured, liquefied and used as per the Bio-CO_2 ladder

Good options



- A: Direct Replacement of Fossil Methane in Manufacturing Processes; Shipping (Liquid); Rocket Fuel (Liquid)
- B: Long-Haul HGVs; Energy (Gas) Storage; Intercity Trains and Buses
- C: High Temperature Industrial Heating
- D: Medium-Haul HGVs; Back-up Generation for Dunkelflaute (Low Load Factor)
- E: Local Delivery Vehicles; Utilisation in CHPs for Electricity Production with Waste Heat Used
- F: Gas central heating; Cars
- G: Hydrogen Production (with no CO_2 capture)

Poor options

The ladder changes over time as circumstances change and represents an indicative hybrid of economics, feasibility and GHG outcome

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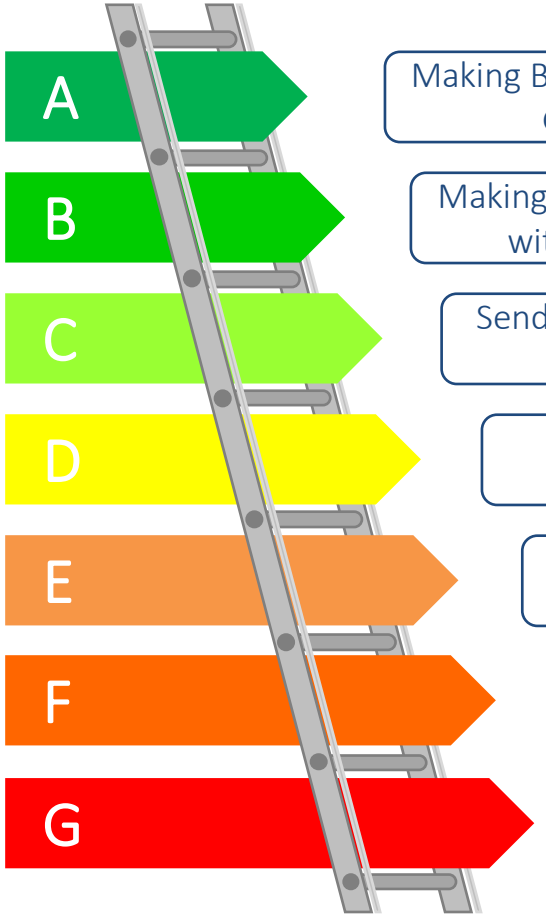
Bio-CO_2 Ladder (March 23)

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

Good options



- A: Making Bio-Methanol with Green H_2; Making Liquid Bio-Methane SPACEX; Making Bio-kerosene Aeroplane Fuel
- B: Making Bio-Methanol with Blue H_2; E-methane using Green H_2 and Bio-CO_2 from the AD Plant
- C: Send to Offshore CCS; CCS by Adding to Concrete
- D: CO_2 as Fire Suppressant; CO_2 as Inert in Industry; Dry Ice
- E: Slaughterhouse Industry; Making Beer
- G: Release to Atmosphere

Poor options

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

- DESNEZ 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 H_2 (and Bio-CO_2) to be stored which is critical for premium top rung products

Biomethane and Bio-CO_2 Conclusions

Includes all 8 of the EU's Strategic Net Zero Technologies

1. Don't burn any biogas (new projects)
2. Don't vent any Bio-CO_2 – liquefy it and sell it or send to CCUS (new and existing projects) [7]
   - Bio-CO_2 will be a valuable product to make bio-methanol and similar top rung uses
3. Build direct wire solar/wind/batteries (new and existing projects) to supply the base load electricity demand include heat pumps to heat the digesters [1,2,3,4]
4. Plan for making Green H_2 for multiple uses (new and existing) [5]
5. Plan for Dunkelflaute back-up gas engines on the AD site (new and existing)
6. Don't burn any diesel - run trucks and farm tractors on Bio-CNG (new and existing) [6]

One final thing, to keep the GB Biomethane industry moving forward, we must sort capacity for biomethane projects as well as use the NTS.

A UNC Modification is going through to allow Reverse Compression [8] and National Gas Transmission are supportive of further reforms to the NTS gas connection regime for new biomethane projects. By summer 2023 we should be able to say that every potential biomethane to grid project in GB can have capacity

Strategic Net-Zero Technologies

1.	Solar photovoltaic and solar thermal technologies
2.	Onshore wind and offshore renewable technologies
3.	Battery/storage technologies
4.	Heat pumps and geothermal energy technologies
5.	Electrolysers and fuel cells
6.	Sustainable biogas/biomethane technologies
7.	Carbon Capture and Storage (CCS) technologies
8.	Grid technologies