



The Biomethane Ladder – Use Cases for Biomethane and Bio-CO₂

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CNG Services Ltd

Low Carbon Innovations

cng services Ltd

Over the next 20 years, CSL's projects will contribute towards a CO₂ emissions saving of....

17,500,000 tonnes

Celebrating over 16 years of innovation in gas

- CNG Services Limited (CSL) provides consultancy, design and build services to the biomethane industry, all focused on reducing Greenhouse Gas (GHG) emissions
- In the past 10 years our efforts have produced a material impact with an estimated 20-year project life reduction in CO₂ 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, H₂ and CCUS innovation projects including:
 - Biomethane from manure with CCS
 - Biomethane direct into the NTS
 - Green H₂ 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-CO₂ 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 H₂ (see next slide)



Onshore wind rules to be relaxed after Tory revolt

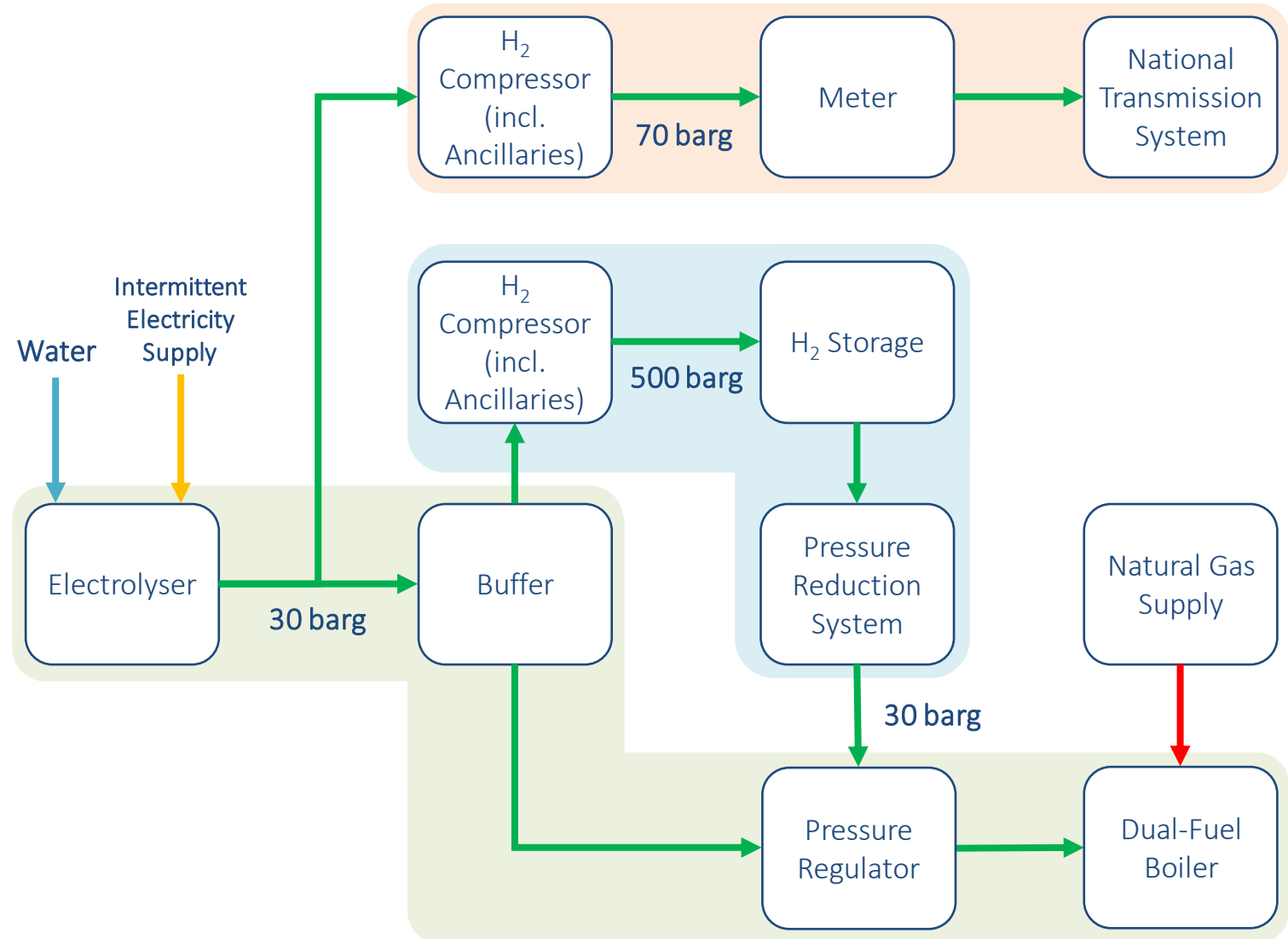
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The government has pledged to relax restrictions on building onshore wind farms in England after a threatened rebellion from Conservative MPs.

2. AD Sites are Ideal Places to Make Green H₂ (1)

- 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 that all the ingredients to make Green H₂ will be on site (land, electricity), including rainwater from the digester roof!



2. AD Sites are Ideal Places to Make Green H₂ (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 H₂

- Blue/Green H₂ production plant
- H₂ storage (e.g.: salt cavities)
- H₂ pipelines
- H₂ generation plant

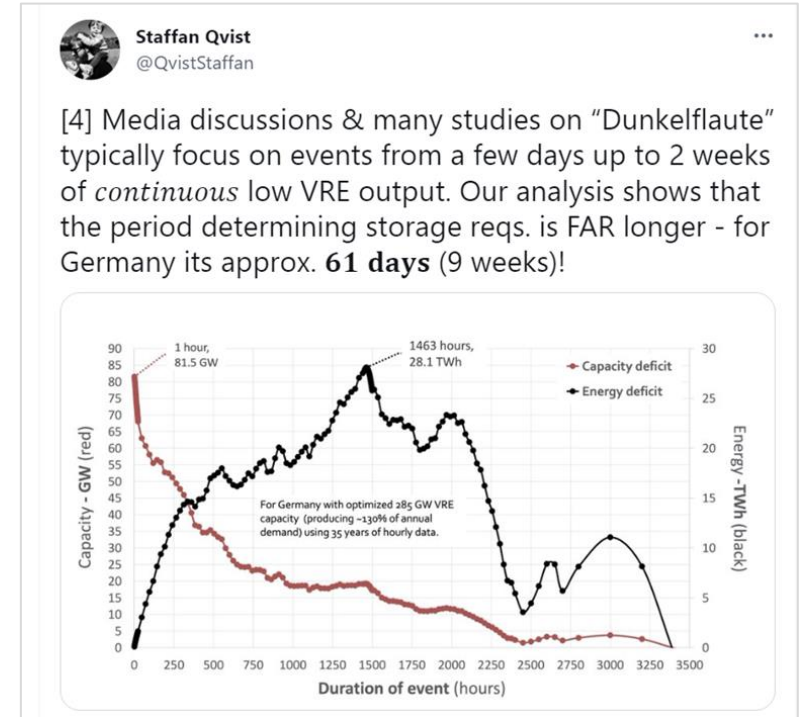
2. Fossil Gas with CCUS

- Fossil gas generation plant
- Waste CO₂ 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 (H₂, gas with CCUS and gas engines) will be <5% and falling by 2035.

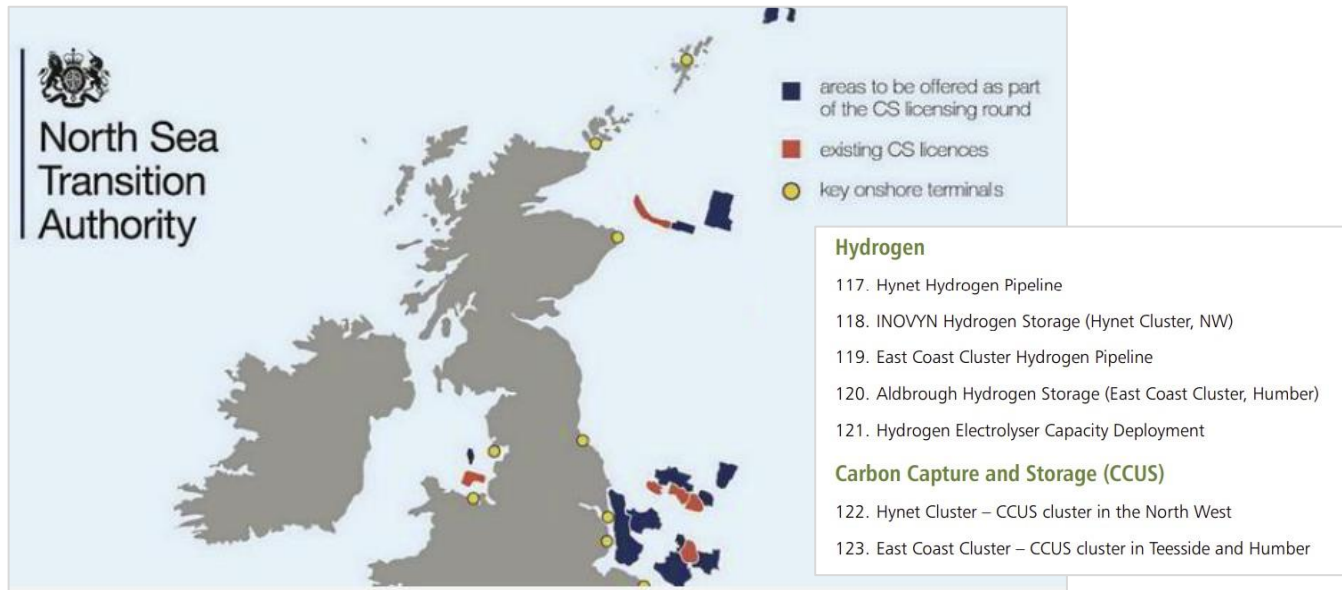
The H₂ and CCUS options will be very expensive on a cost per tonne of CO₂ basis because of such a low load factor



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

4. Bio-CO₂ is Valuable

- From 2014–19 the producers of liquid Bio-CO₂ 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-CO₂. Why would you vent something so valuable when the UK Govt is funding Direct Air Capture based on 420 ppm CO₂? Indicative numbers are provided in the table
- Every biomethane project has 2 components – 1) a carbon neutral cycle of biogenic Bio-CO₂ from grass to cow to milk to air to grass plus 2) by capturing the Bio-CO₂ in the AD and sending it to CCUS we reduce the amount of dinosaur era CO₂ in the atmosphere. We are fossil CO₂ 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
CO₂ 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
CO₂ Value		
Carbon Price	£ 150.00	£/tonne
Value of CO₂ Captured	£ 880,101.61	£/annum

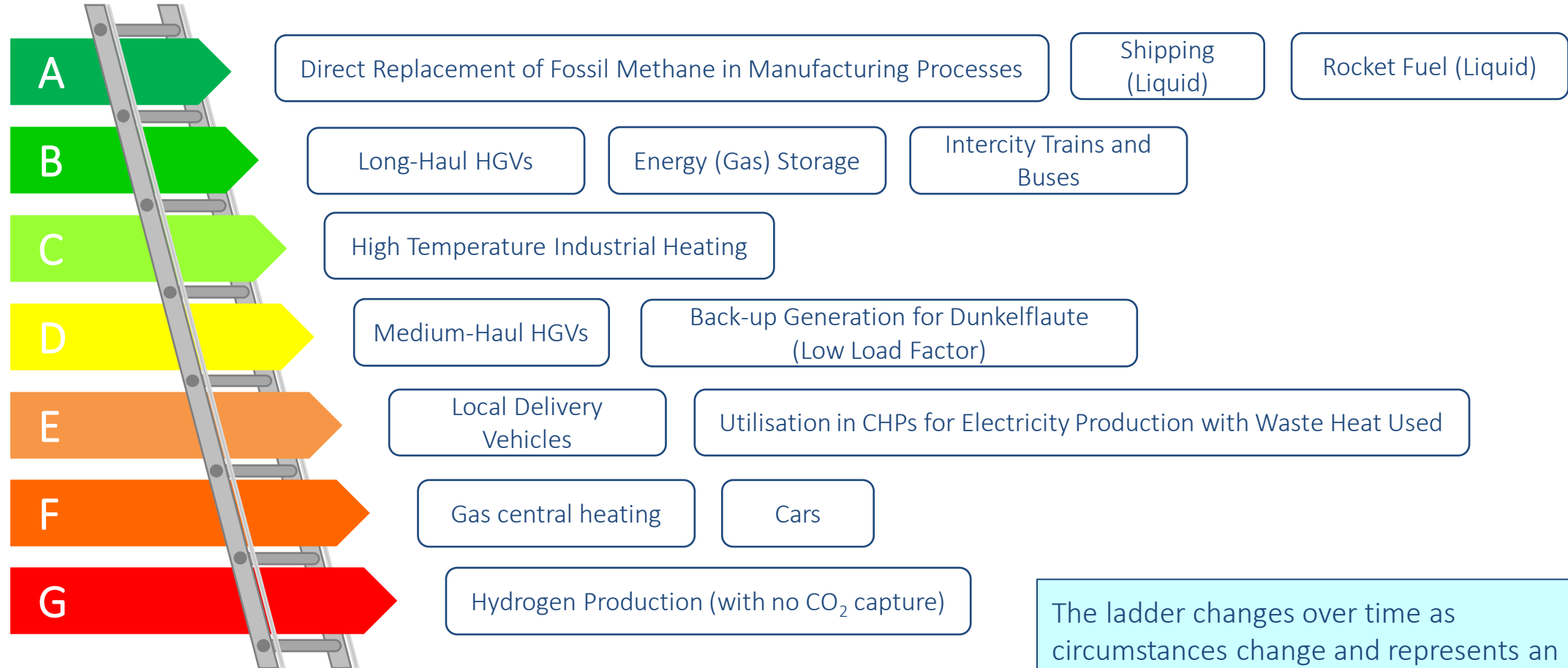
Biomethane and Bio-CO₂ Ladders:

Assessment of Use Cases

Biomethane Ladder (March 23)

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



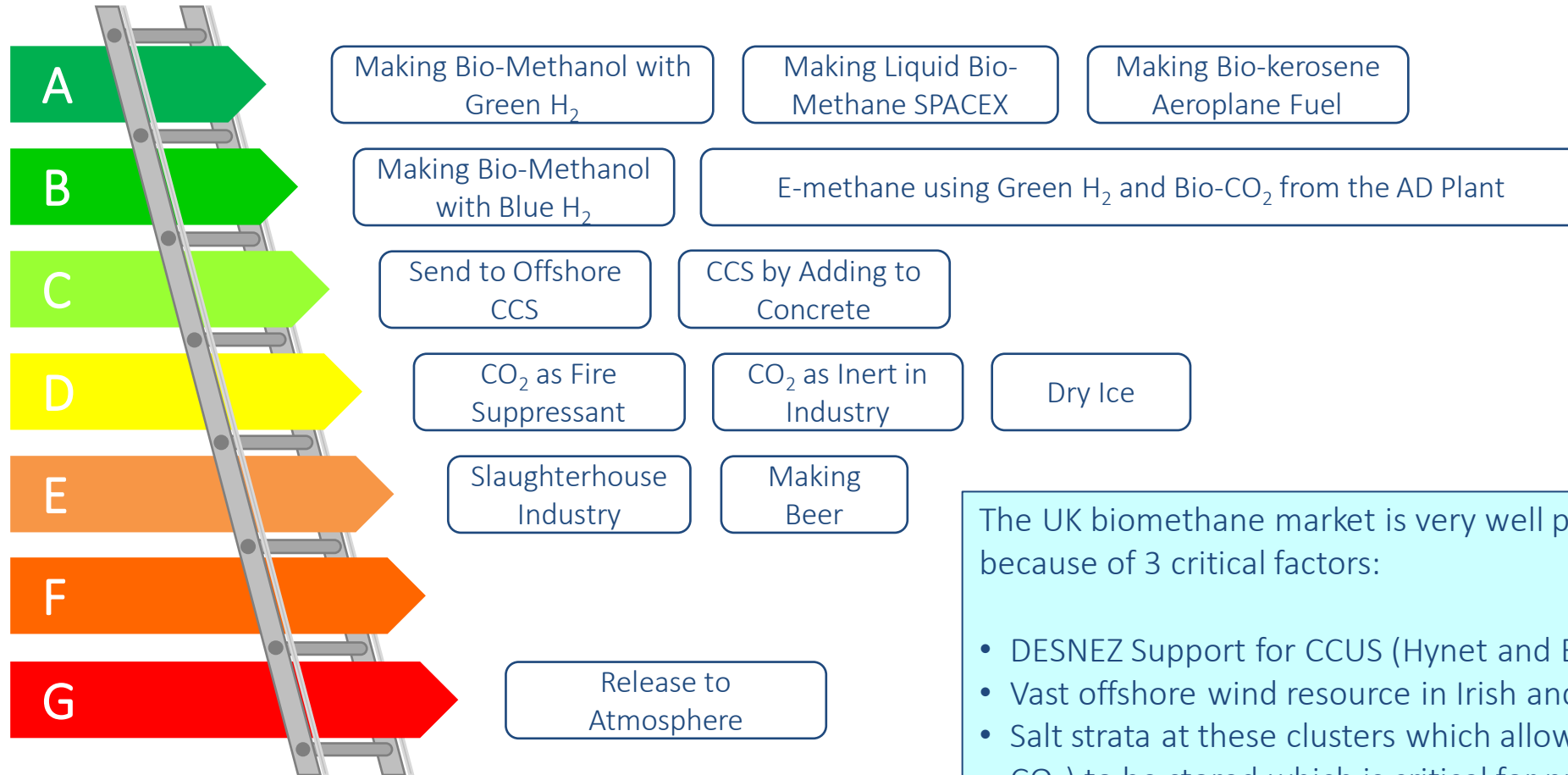
Poor options

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

Bio-CO₂ 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



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 H₂ (and Bio-CO₂) to be stored which is critical for premium top rung products

Biomethane and Bio-CO₂ 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-CO₂ – liquefy it and sell it or send to CCUS (new and existing projects) [7]
 - Bio-CO₂ 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 H₂ 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