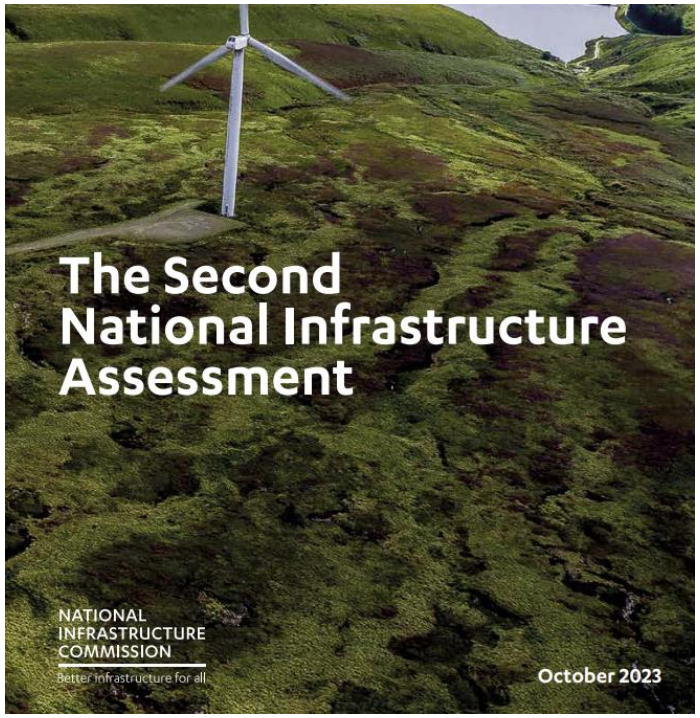


Introducing Green Gases to 2050 NetZero Plans

(and safeguarding the biomethane industry access to customers via pipeline)

Note – this is not intended to be a presentation to REA Biogas Group. Rather it's a proposal for a strategy with a detailed Work Programme to inform CCC's Seventh Carbon Budget in Q1 2025

22 Jan 24

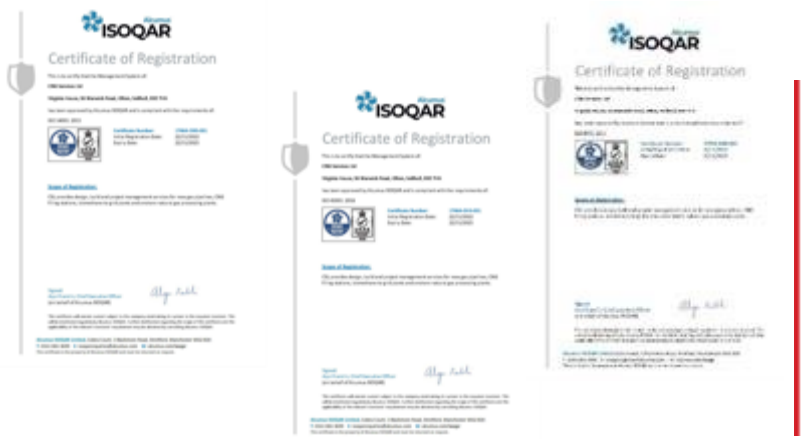
John Baldwin
Managing Director
CNG Services Ltd

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 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



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Why is this on the Agenda today?

1. The **Committee on Climate Change (CCC)** think biomethane flat lines at around 10 TWh/annum from 2030
    - They like it, but it is not material
    - They ask for evidence to justify more biomethane in their Seventh Carbon Budget Q1 2025
2. The **National Infrastructure Commission (NIC)** do not support hydrogen for domestic heating
    - Government also needs a plan for phasing out the use of fossil fuels which addresses how the gas network will be decommissioned
    - But they do recognise the Dunkelflaute is an issue and unabated gas will be allowed beyond 2040

What is REA Biogas asking us all to think about?

1. The CCC may not be fully appraised of the benefits to the Green Gas sector of the CCUS projects going ahead. We need to explain that, the Ecotricity grass idea, Future Biogas Carbon Harvest, Bio-SNG, E-CH4 or imports etc and we must prepare evidence for them
2. The NIC 2 bullets above may be in conflict and REA can help to reconcile these points

One important point – there is a family of Green Gases and Biomethane does not cover them. It's proposed to talk about Green Gases (mostly CH4 but Green H2 and Green C3H8 Futuria) are also in this family

The Dunkelflaute Curveball (1)

What do we use the gas for in the Dunkelflaute? CCC say 25 GW of unabated gas generation in 2035 – see last slide

Security of supply and peak demand

More extreme but rare extended periods of low weather-dependent generation (often referred to as dunkelflaute periods), possibly lasting up to several weeks, also have the potential to pose a security of supply risk, since a combination of flexible technologies will be needed to ensure security of supply as these periods could cause storage options to be exhausted. There is still considerable uncertainty around the length and regularity of these periods. Their level of impact will be determined by how low renewable generation is and how much it fluctuates relative to demand.

To manage dunkelflaute periods, dispatchable thermal power plants (gas and/or hydrogen), depending on the scenario and year, are likely to be required. A combination of LDES (e.g.

These backup capacities increase when modelling a “low wind year” based on 2010, which the CCC judges to have been a 1-in-50 year event.

They would need to be slightly higher again to cope with the artificial extreme 30-day wind drought used to stress test the modelling results

In these cases, the capacity of low-carbon dispatchable sources would reach 20 and 25GW, respectively, while unabated gas capacity would rise to 25GW.

The Dunkelflaute Curveball (2)

The gas industry design standard for the pipeline capacity is for the coldest day likely in a 20 year period. But for secure supplies of the gas itself, we used to look at 1 year in 50….The Dunkelflaute is not related to size of wires, but to the availability of power. Its analogous to looking into an LNG tank on a cold February and it being empty. You may never get one at all or you may have one next year. But you are not allowed to fail.

There will have to be a Dunkelflaute Standard for Electricity System design. It's probably looking at the lowest wind period possible in Jan/Feb in a 50 year period. You may never get one but to survive the Big 50 Dunkelflaute, molecules are required.

They could be H2 but you need a vast investment in H2 pipelines, H2 centrifugal compressors, HP salt cavity storage (and very big gas reciprocating compressors) , H2 Pressure Reduction Stations, H2 generation plant. All these assets are technically difficult but that's not the main issue. There may never be a Big D 50 which may not be used ever (other than testing once a month in winter). Imagine working in an industry for 50 years that never has anything to do. Like working in UK pandemic preparation from 1919 to 2020. So tedious, Good luck recruiting anyone with any umph.

Never mind it would cost in multiples of HS2 capex…..why would you do that?

In reality, Electricity Consumers will want to keep the gas grid as the lowest cost option with the existing gas grid, storage and LNG importation terminals. No scrappage scheme.

So, we are going to keep most of the gas grid. Some Low Pressure networks could be replaced with heat pumps/district heating but most will remain

There is already 10,000 MW of gas generation on the Distribution Network (gas engines + CHP)

At the REA Biogas meeting with CCC in April 2010,(Slide 20) this was in the meeting notes:

CCC had not compared the cost of using heat pumps with the cost of continuing to use the gas grid but using biomethane.

CCC accepted that this should be done as the cost per tonne of CO2 abated was their key driver in allocating resources and incentives.

Indicative Demand for Gas in 2050

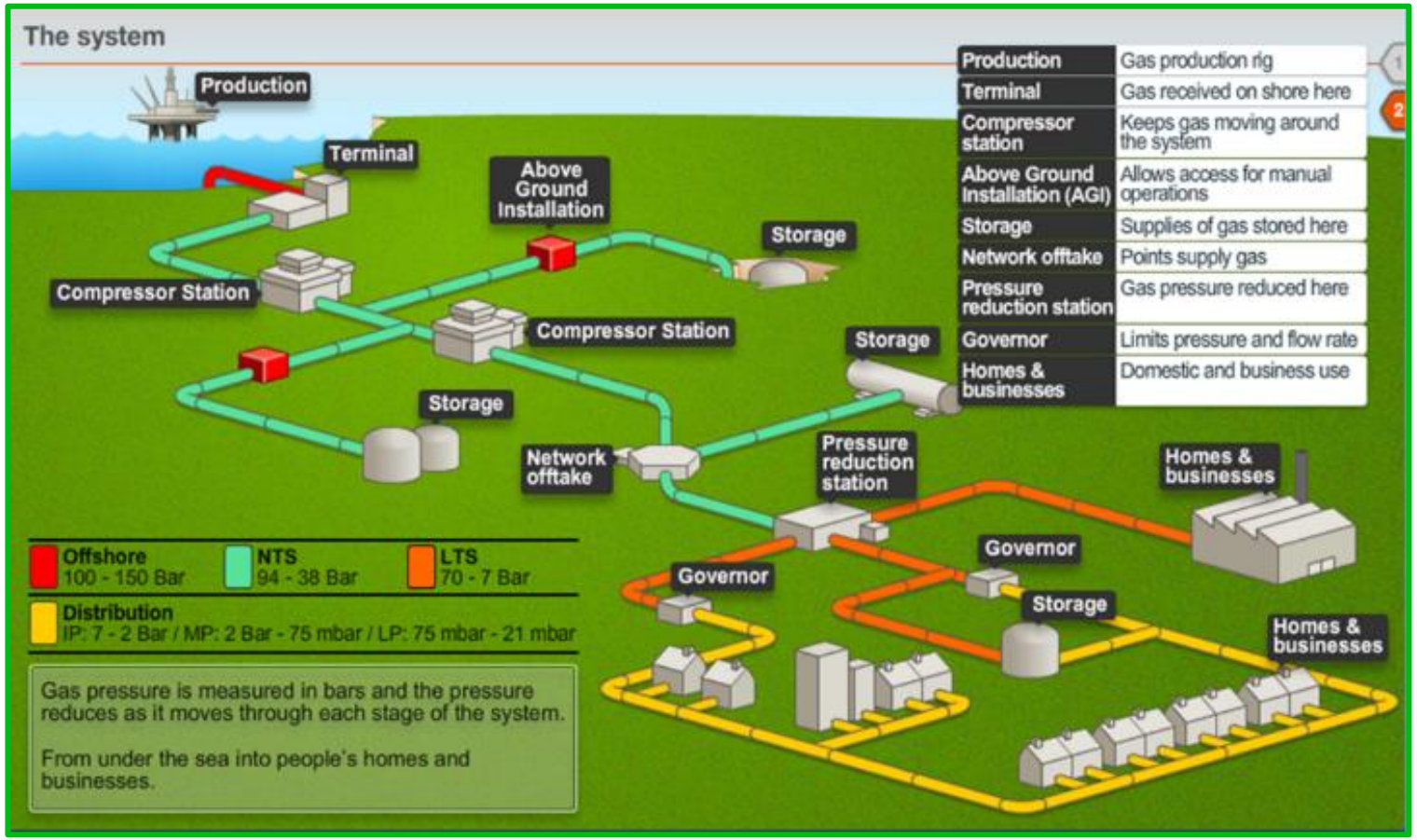
(excludes Green H2 direct to industrial customers as under Hydrogen Business Model)

Use for Green Gas in 2050	Annual TWh/annum
Dunkelflaute – back up for electricity generation –low load factor	50
10% back up for industrial customers on Green H2	20
I&C customers with no good Electricity/H2 option	30
District Heating support	10
Domestic customers with hybrid system	30
Trucks and other vehicles with no good EV/H2 option	50
Sustainable Aviation Fuel	50
Total	**240**

So, we have a gas grid and we need a lot of gas……how about the family of Green gases supplying it all….9 categories

Note 1 - Last 6 slides give an extract from FES 2023 on Heat Pumps, District Heating, H2, Unabated gas
Note 2 – Gas storage is very important, the above figures are annual. The Dunkelflaute TWh may be next to nothing in one year and very high in another

GB Gas Network



LP

- Supplies >20 million houses at mbar pressure,<20% cast iron and being replaced
- Not used at all for gas engines or Bio-CNG or biomethane but does supply I&C customers

MP

- 40% of biomethane injection, 50% of 20MW back up gas generation and Industrial CHP and electricity for district heating/glasshouses

IP

- 40% of biomethane projects, 40% of 20 MW back up generation, Industrial CHP and electricity for district heating
- Good for Bio-CNG

LTS

- 19% of biomethane projects, 5% of back-up generation
- Very good for Bio-CNG (eg Leyland/Erdington)

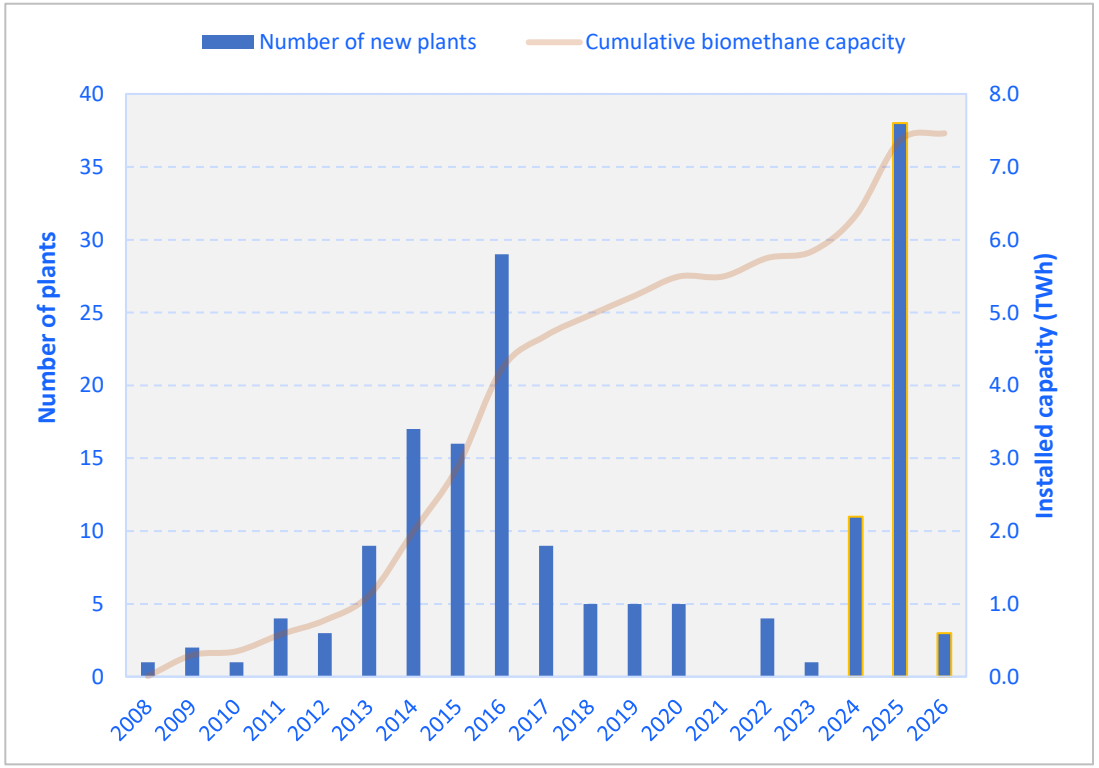
NTS

- Best for 50 MW gas engines for back-up generation
- Best for making Bio-CNG for trucks (eg Fordoun)
- Best for the new generation of large biomethane projects with Liquid Bio-CO2 production (no propane)

Biomethane

1. New and Existing AD

- This is new and existing from some crop (earning RHI) and waste and is around 7 TWh/annum in 2023.
- At present there is around 19 TWh of biogas burnt in combined heat and power plants (CHP) and >75% of this should be upgraded to biomethane and injected into the gas grid with reverse compression providing capacity and ADs using grid electricity and direct renewables for parasitic load
- UK developers using straws and manures are working on much bigger than the typical 0.04 TWh/annum size that dominated from 2012 – 2020 and earned RHI
- We can aim for 30 TWh by 2035 from these wastes as there is already a lot of biogas used to generate electricity (total renewable methane is already at >20 TWh/annum). Easing planning will help
- This category does not include Ecotricity grass fed nor Future Biogas Carbon Harvest with BECCS



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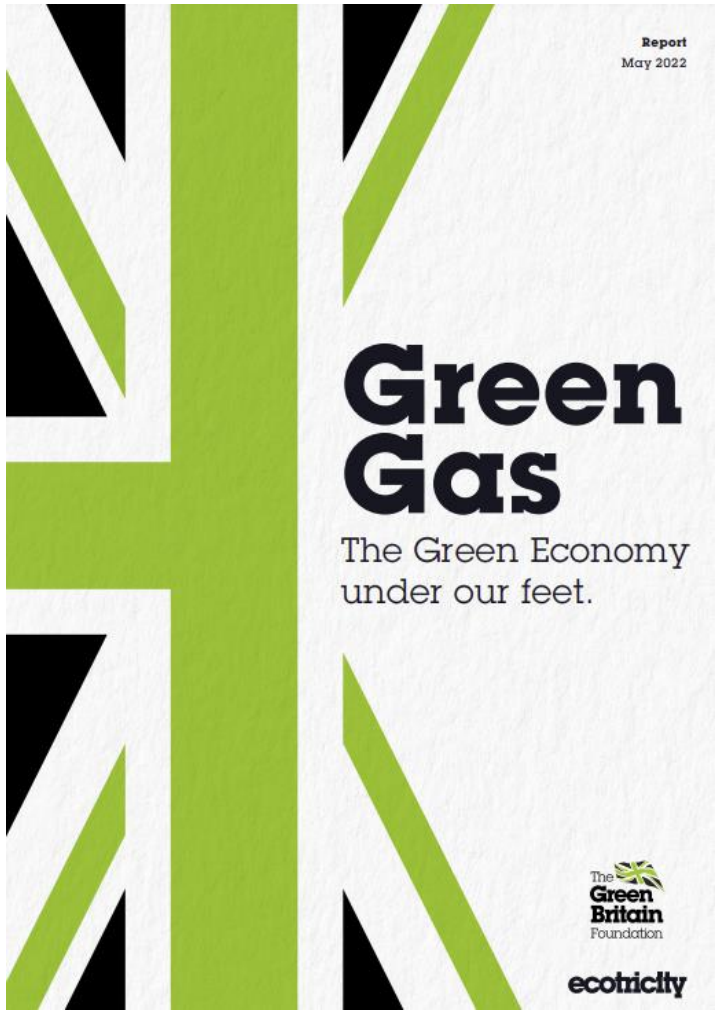
2. Ecotricity Grassland



https://downloads.ctfassets.net/620j9bwnh4b6/2gSQuZOgxxs4dvkMW5mZDV/2356be083369cb8c68d87ed798ccf02e/Green_Gas_Report_2022.pdf

https://www.ecotricity.co.uk/our-green-energy/green-gas-mills-fact-sheet

Biomethane

3. Future Biogas Carbon Harvest

September 14, 2023 02:00 AM Eastern Daylight Time

CAMBRIDGE, United Kingdom--(BUSINESS WIRE)--Powering AstraZeneca's transition to net zero, the Company has agreed a 15-year partnership with Future Biogas to establish the UK's first unsubsidised industrial-scale supply of biomethane gas, and is investing in major energy efficiencies in its operations, totalling a commitment of £100m.

Energy from the biomethane facility will supply AstraZeneca's sites in Macclesfield, Cambridge, Luton and Speke with 100 gigawatt hours (GWh) per year, equivalent to the heat demands of over 8,000 homes.[i] Once operational in early 2025, the partnership will reduce emissions by an estimated 20,000 tonnes CO_2 equivalent (CO_2e), adding renewable energy capacity to the national gas grid.

The Future Biogas Carbon Harvest plants are very important and a great idea, linking best practice farming with the CCUS facilities being built in UK and Norway. This removes dinosaur era CO2 from the atmosphere and 10 TWh/annum by 2035 is feasible. This is a new category as does not exist today
https://www.futurebiogas.com/beccs/

And we do need to be on top of husbandry as far as CH4 leakage and NH3 are concerned

4. Imports on LNG Ships

With higher long term gas prices of around 3 p/kWh there is new interest in making biomethane in countries with huge resources of organic feedstock and shipping that to the UK.

From these ADs, Bio-CO2 can be captured and sequestered, and the AD plant produces valuable organic fertiliser

The existing liquefied natural gas (LNG) supply chain can be used to transport this biomethane to Europe from countries with organic waste resource such as in central and South America, Africa and the Far East.

This model doesn't burn anything, except ship fuel, uses organic waste to make biomethane and captures the Bio-CO2. 20 TWh/annum by 2035 is feasible, thankyou Brazil (that's equal to 20 LNG ships of 70,000 tonnes). Needs high price in UK or can go elsewhere

5. Ukraine

Ukraine can provide 20% of EU's needs for biomethane

Nieuwsbericht | 27-10-2023 | 11:27

The energy potential of biomass in Ukraine is more than 25 million tonnes of oil equivalent per year.

KYIV. Oct 26 (Interfax-Ukraine) - Ukraine can potentially provide up to 20% of the European Union's demand for biomethane production, said Deputy Minister of Agrarian Policy and Food of Ukraine Vitaliy Holovnia.

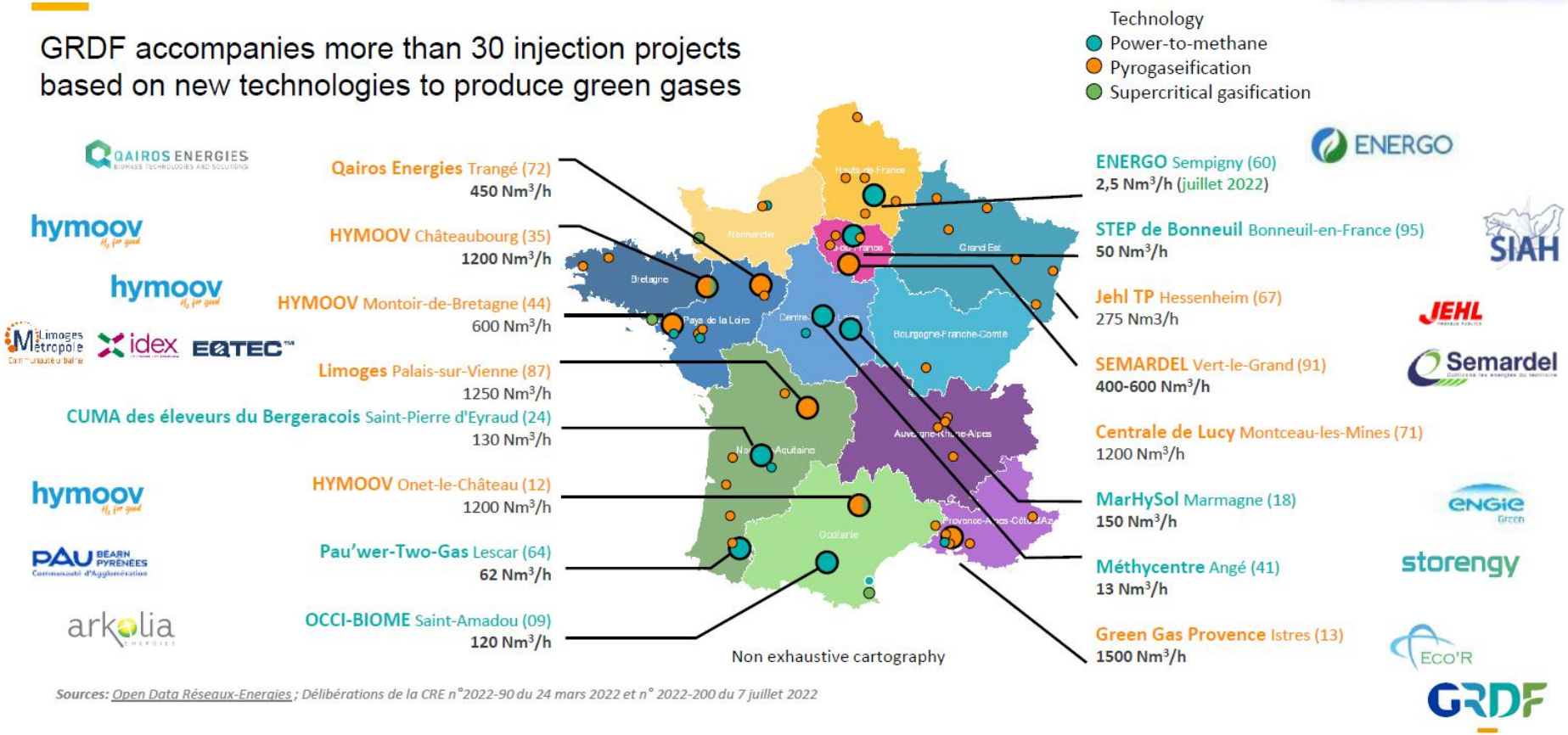
"In the production of biomethane, Ukraine can compete with any country and offer the cheapest raw materials. Ukraine has the largest area of agricultural land in Europe and, accordingly, one of the best potentials in the world for the production of biomethane," he said.

6. Bio-SNG

Biomethane potential in France

Paving the future: pyrogasification, supercritical gasification, e-methane

GRDF accompanies more than 30 injection projects based on new technologies to produce green gases



Sources: Open Data Réseaux-Energies ; Délibérations de la CRE n°2022-90 du 24 mars 2022 et n° 2022-200 du 7 juillet 2022

7. E-CH4

Going forward (obviously), all Bio-CO2 from AD will be captured and so by 2035 we should have something like 5 million tonnes of Bio-CO2

Lets aim to around 50% of this Bio-CO2 with H2 to make around 10 TWh/annum of E-CH4 (maths to be checked!)

NOV 6, 2023

Nature Energy and Andel inaugurate power-to-gas facility in Denmark

Global biogas producer Nature Energy and energy and fibre network Andel have made "world history", according to Danish Minister for Industry, Business and Financial Affairs, Morten Bødskov.

He was speaking during the inauguration of the first plant in the world to commercially increase the production of biogas via electrolysis and biological methanation. The new Power-to-X plant was built in just one year.

In a partnership formed in the autumn of 2022, the two companies have invested DKK 100 million (€13.4 million) in a biological Power-to-X plant in Glansager on Als in Denmark, which is now ready for production.

Here, Andel's electrolysis plant converts excess electricity from the sun and wind into hydrogen that is fed into Nature Energy's methanation plant, where it combines with CO_2. It forms e-methane, thereby increasing biogas production from the existing biogas plant and reducing the amount of CO_2.

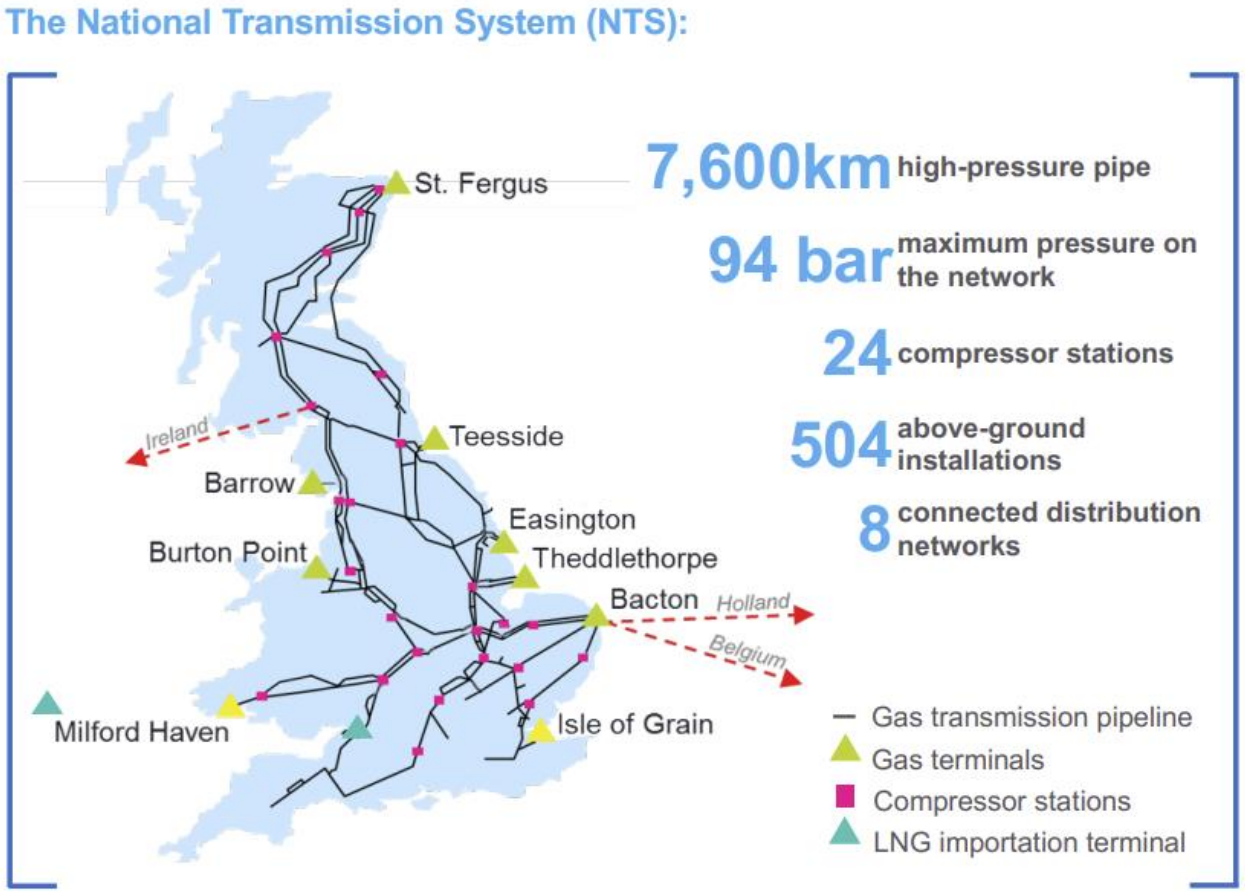
The **Sabatier reaction** or **Sabatier process** produces methane and water from a reaction of hydrogen with carbon dioxide at elevated temperatures (optimally 300–400 °C) and pressures (perhaps 30 bar [1]) in the presence of a nickel catalyst. It was discovered by the French chemists Paul Sabatier and Jean-Baptiste Senderens in 1897. Optionally, ruthenium on alumina (aluminium oxide) makes a more efficient catalyst. It is described by the following exothermic reaction.[2]

$$CO_2 + 4\,H_2 \xrightarrow[\text{pressure + catalyst}]{400\ ^\circ C} CH_4 + 2\,H_2O \qquad \Delta H = -165.0\ \text{kJ/mol}$$

8. H2 blended into CH4 Gas Grid

In addition, we expect to see green hydrogen produced and injected in the National Transmission System starting in 2025 with a volumetric target of 5% by 2035 indicating around 10 TWh/annum

NTS has no CV target and capacity exists due to current high gas demand



9. Direct Air Capture and CCS at St Fergus

Fossil era gas

Direct Air Capture and CCS at St Fergus and we can aim for 100% zero carbon impact gas in 2050

RENEWABLES/ENERGY TRANSITION

Storegga pushes forward with plans for 'critical' north-east direct air capture facility

24/06/2021, 6:00 am

So, unabated natural gas goes to a consumer and is burnt, creating CO2….but over the year, all the CO2 emissions at the house/factory are captured with DAC at St Fergus and sent to CCS

Interim Total by 2035

120 TWh/annum by 2035 is a good start and probably that will represent around 25% of total annual gas demand of 500 TWh/annum by 2035

That is highly material and can be doubled by 2050 so around 200 TWh/annum when total gas demand may be around 200 – 300 TWh/annum

It sorts out the Dunkelflaute which needs sorting out

Source for Green Gas in 2035	Annual TWh/annum
Existing biomethane (7 TWh) plus additional food waste, manufacturing waste, sewage, straws, manures. Includes a part of the 19 TWh of biomethane in biogas CHP at present	30
Grass as per Ecotricity	10
Future Biogas Carbon Harvest BECCS	10
Liquid Biomethane imports	20
Ukraine via pipeline	10
Bio-SNG from woody waste	10
E-CH4 from Green H2 and Bio-CO2	10
Green H2 into the NTS	10
DACS at St Fergus removing CO2 emitted by unabated gas	10
Total	**120**

Futuria (bio-propane) not included as it will not be blended into the gas grid

The TWh of Low C H2 delivered to Industrial customers via on site generation or new H2 pipelines is not included

Work Programme in 2024

1. Establish the biomethane and other green gas estimates in published work from FES, TCCC, Govt BioEnergy Strategy
2. Identify Green Gas plans from other EU countries
3. Review in detail each of the 9 TWh/annum sources and identify growth scenarios to 2035 and 2050
4. Prepare a credible and deliverable target for 2035
5. Identify key steps required to deliver that 2035 target
6. On the Green gas demand side, review projects from other bodies in GB and prepare a robust estimate by sub sector (as slide 8)
7. For the Dunkelflaute, review studies on size of requirement for unabated gas and dispatchable gas/CCS and H2 and also load factor of such generation. Review also design standard proposed for the setting of the requirement for dispatchable gas/CCS and H2 and unabated gas
8. Establish cost pre tonne of the 100% electric heating model with the Dunkelflaute assets compared to [80]% electric and [20]% green gas but using the gas assets that exist (all classes of assets
9. Produce Executive Summary linking the Green Gas Supply and the Green Gas Demand that can help to get this option in play (and keep the pipelines we use to get biomethane to customers)

Delivery Resources – 5 Full-Time MBA students at Imperial College are interested in working on this

REA Biogas members can hopefully volunteer to provide input with these 5

If we can get support from Imperial Engineering Professors G Strbac and N Shah that would be very valuable

Conclusions (1)

1. Whilst individual homes have moved from gas grid to heat pumps, and areas of towns with new development have district heating, there are no examples of entire villages or parts of towns moving off the gas grid

    - This is probably because it is very difficult in a democratic society with private housing to persuade everyone to do the same thing
    - If there have been failed attempts its probably due to lack of local electricity infrastructure

2. There have been difficulties in relation to the H2 village trials

    - Not having H2 in the kitchen may resolve many of the customer perceived safety issues but that's not the plan

3. CCS developments at Hynet and Net Zero Teesside and with Norway's Northern Lights well advanced, represent a fundamental change to the outlook for Biomethane

    - An AD projects is no longer 'carbon neutral' over the life cycle but becomes a significant dinosaur era CO2 removal project
    - The cow is a black and white portable Direct Air Capture device with useful by products

Conclusions (2)

4. There is no evidence that CCC and NIC have fully appreciated the seismic impact of CCS alongside biomethane

5. Nor is there any evidence from their publications that they have considered the Future Biogas Carbon Harvest initiative, the Ecotricity grass initiative, Bio-SNG, E-CH4 and biomethane imports via ship or pipeline

6. Given that, the REA and friends in industry can use 2024 to produce evidence that changes Biomethane from a 'lovely but irrelevant 10 TWh/annum' to a highly significant 200 – 300 TWh/annum from a family of Green Gases

    - This type of analysis has been done in France and Denmark but not in GB and its time we did it
    - Relatively abundant Green Gases opens up new opportunities for de-carbonisation including the Non Road Mobile Machinery sector which is perfect for Bio-CNG and not at all suited to H2 or EV

7. On the demand side there is uncertainty as to the extent of Green Gas demand but there are some drivers:

    - The Dunkelflaute is a huge curveball and gas/CCS or H2 appear to be uneconomic technologies compares to existing gas grid and associated assets (storage, generation plants etc)
    - Compared to historic gas industry 1 in 20 and 1 in 50 planning, the Dunkelflaute sems to have been largely ignored
    - The REA Report can help to inform this issue
    - There is a General Election in 2024 – the Green Gas – Electricity hybrid approach will be very attractive to politicians if it can be substantiated
        - No politician wants to ban gas central heating in a town

From the Archives

REA Biogas Group meeting with CCC April 2010

Meeting between REA Biogas Group/NG and The Committee on Climate Change

Date - 21 April 2010

Attendees

John Baldwin - Chair, REA Biogas Group
David Pickering - NG
Nina.Meddings@theccc.gsi.gov.uk
Alex.Kazaglis@theccc.gsi.gov.uk
David.Joffe@theccc.gsi.gov.uk

JB explained that REA was responding to RHI in relation to (amongst other things) biomethane and its relative benefit compared to electricity.

David Joffe said that he believed that in the 2020 + period it would not be appropriate to generate electricity locally using biogas due to the decarbonisation of the electricity grid. Any biogas would be a premium fuel in that context and should be used for applications that could not be met with electricity.

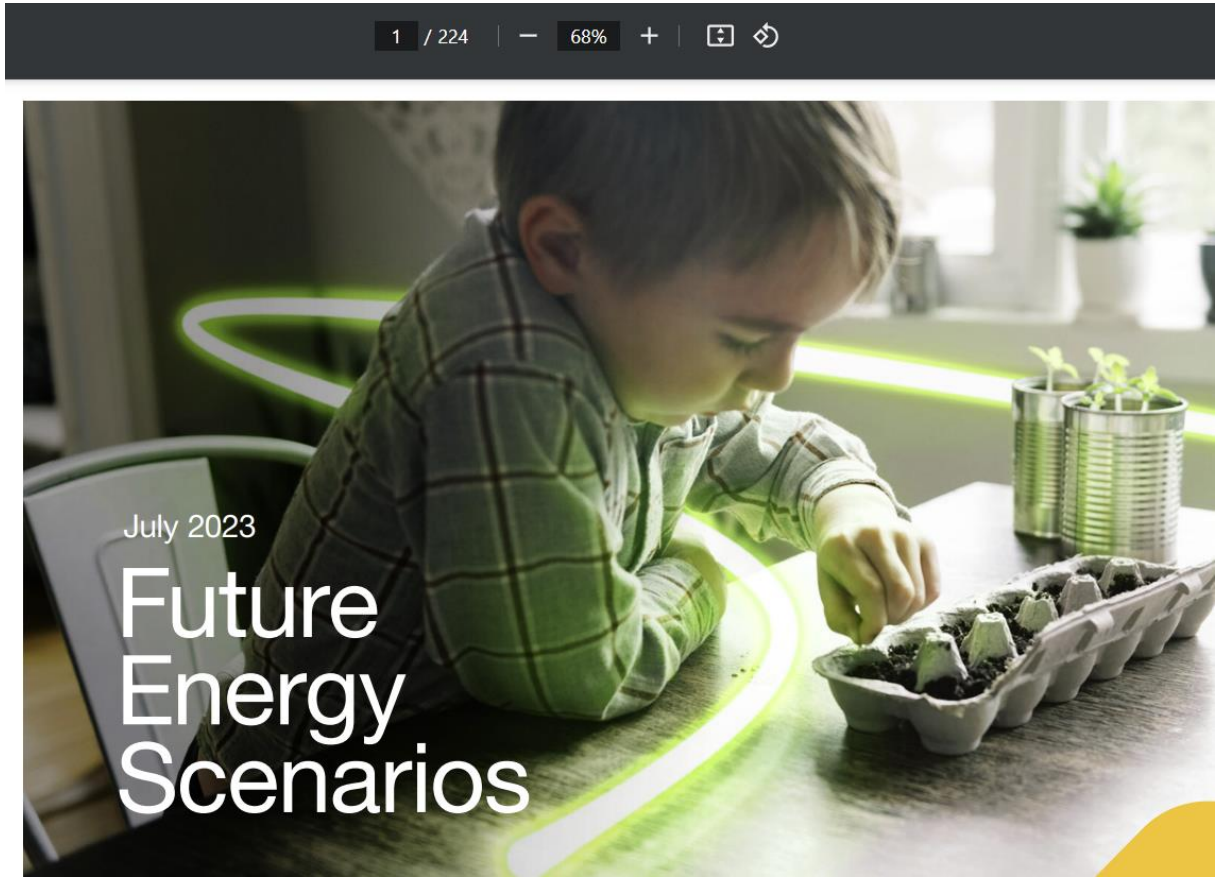
However, TCCC have not made any public statements to this effect yet. They stated that the availability of biomass for energy use would be limited (possibly c.250TWh home grown plus c.70TWh imported), and that there were a number of competing possible uses, including combustion or co-firing for electricity generation, AD/gasification for electricity or gas production, and conversion to biofuels for transport. The optimum use of biomass was not yet clear - a hierarchy was needed but it did not exist yet and TCCC would not look at it before 2011.

TCCC's current thinking was that there may be no requirement for the gas grid beyond 2030 as heat could be provided by electricity as the electricity grid is decarbonised via wind, nuclear, CCS. David Pickering made the point that the shape of the load duration curve is such that peak heat (e.g. the peak 100+ days) would be very expensive to replace with electricity. DP also suggested that it was important to keep the gas option open in respect of the need for high temperature process heating for industry. TCCC said 'is it worth keeping the gas grid just for that'? They suggested that if biomethane could only provide c10% of the gas demand it would not be sufficient to provide significant decarbonisation of the gas grid and so would not support the continued use of gas for heat.

JB/DP made the point that the biomass gasification + methanation route would open up additional feedstocks for biomethane production and may be a more attractive option than replacement of the gas grid with electricity. Centrica and National Grid had commissioned a study to examine this option. TCCC had not really considered this - TCCC are working on a report for November which will look at the least cost decarbonisation pathways for the 2023- 2028 period. Any information that NG/Centrica could provide in relation to this would be helpful.

TCCC's model is for heating to be from heat pumps combined with renewable or low carbon electricity. They suggested that biogas should be kept for the sectors where it is not possible to use heat pumps. They had not compared the cost of using heat pumps with the cost of continuing to use the gas grid but using biomethane. TCCC accepted that this should be done as the cost per tonne of CO2 abated was their key driver in allocating resources and incentives.

Extracts from 2023 FES

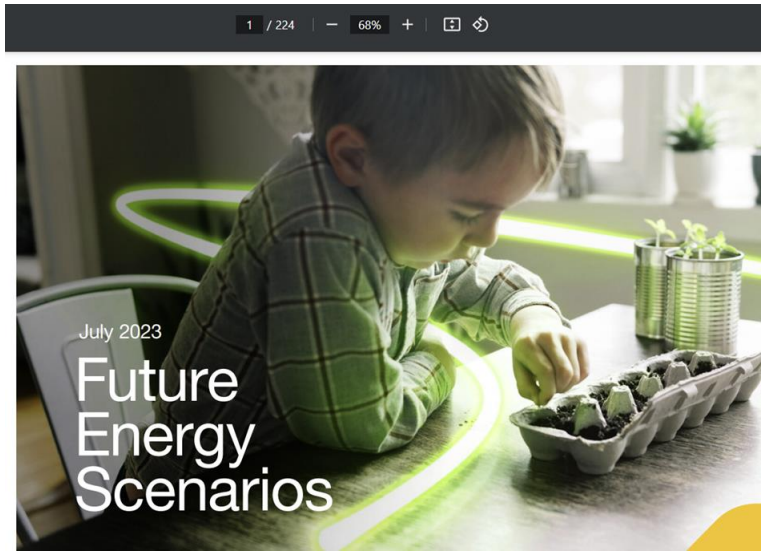


Heat Pump Growth is Below Required Rate in FES 2023

Residential Heat Pump (including hybrids) annual installations

Number of homes										
	2020	2021	2022	2023	2024	2025	2026	2027	2028	
Consumer Transformation	47,686	63,625	86,306	147,177	228,599	335,252	474,686	700,373	959,813	
System Transformation	47,686	63,625	71,039	102,424	115,424	162,218	164,521	181,529	178,399	
Leading the Way	47,686	63,625	99,998	160,003	259,974	370,074	600,120	850,008	1,099,990	
Falling Short	47,686	63,625	65,288	74,806	65,878	126,216	187,854	181,943	260,028	
Five Year Forecast	47,686	63,625	77,038	82,762	90,425	150,918	171,012	180,586	179,674	
Government 2028 annual installation target	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	600,000	
Actual no of heat pumps in 2023			**32,910**	**39,268**						
% of the number required to meet the CT growth rates			38%	27%						
% of the number required to meet the LW growth rates	LW		33%	25%						

Jan 24



To meet the 600,000 target in 2028 there are 59 months to go. Growth needs to follow Leading the Way or Consumer Transformation paths which have 4 x as many heat pumps installed in 2023 as were actually installed

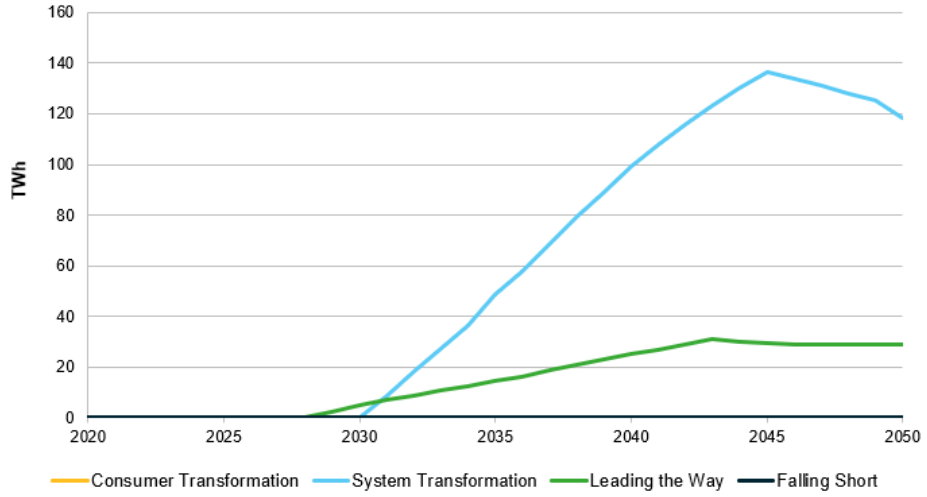
We cannot say its impossible but we can say its unlikely given the time it takes to reinforce the electricity grid

Heating Technology Mix

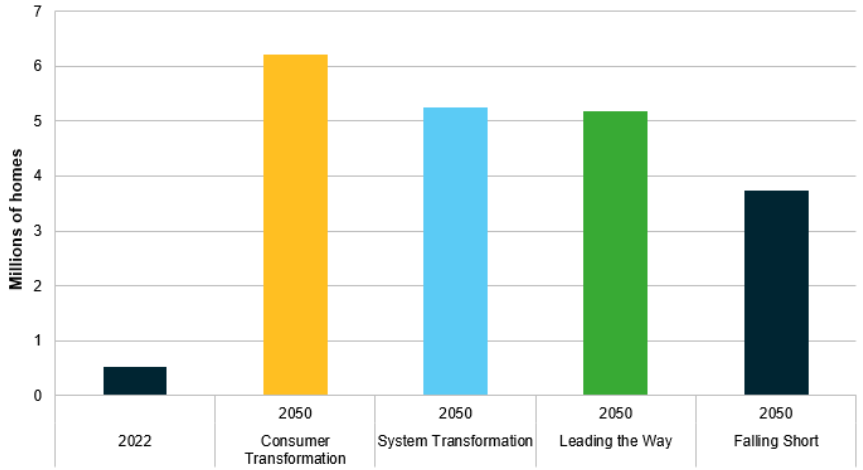
Overall heating technology mix

Number of homes	2021	2035				2050			
		CT	ST	LW	FS	CT	ST	LW	FS
Gas boiler	23,993,139	15,158,290	19,634,959	11,659,987	23,177,296	5,279	48,787	34	12,879,016
Direct electric	2,358,311	2,060,042	1,862,382	1,988,387	1,908,289	1,737,630	757,939	1,744,680	1,754,150
GSHP	61,519	3,488,393	643,392	3,500,018	613,089	8,835,201	1,058,774	7,115,109	3,941,553
ASHP	192,862	7,053,537	1,331,053	8,420,552	2,578,076	14,458,394	5,954,787	10,806,501	9,212,099
Hybrid (ASHP + Hydrogen boiler)	0	0	82,792	636,595	0	0	7,022,658	2,568,800	0
Hydrogen boiler	0	0	4,935,232	1,646,641	0	0	11,427,149	3,175,966	0
Biofuel boiler or hybrid	3,566	789,290	578,131	720,500	262,174	1,215,611	957,757	1,841,327	529,403
District heating	745,588	1,758,967	1,133,853	1,762,991	1,441,289	6,222,862	5,247,044	5,177,302	3,934,051
Other	1,520,438	310,210	416,822	283,055	638,515	439	8	0	225,146

EC.D: Hydrogen demand for home heating



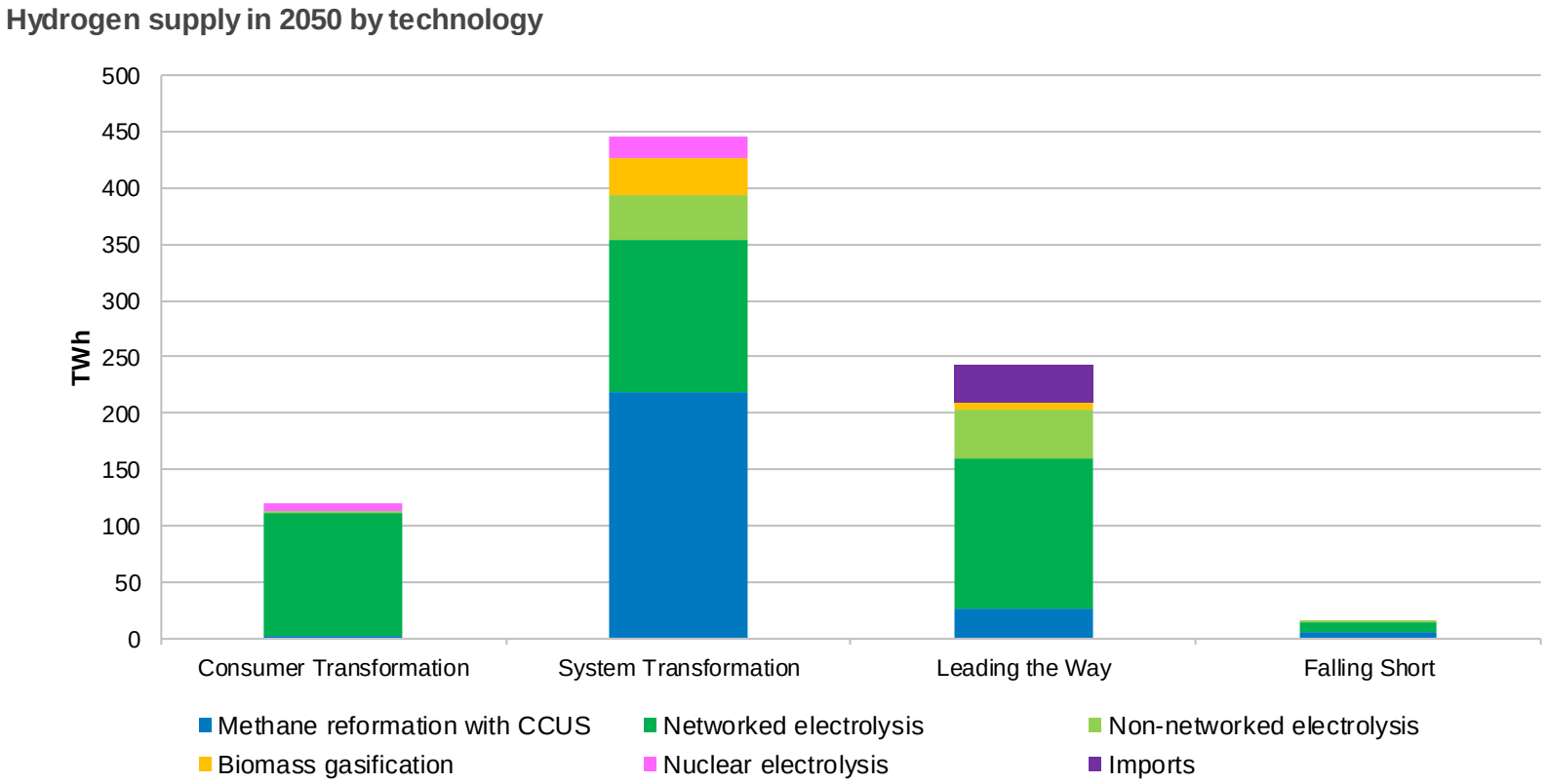
EC.I: District heat network connections in 2050



All future district heat schemes not served by waste heat sources are powered by heat pumps, with biomethane thermal storage providing flexibility

What will we use the gas grid for in 2050?
1. Making H2

H2 supply in 2050



The blue one represents use of gas to make H2 with CCS

What will we use the gas grid for in 2050?
2. Supplying I&C and Domestic customers

Industrial and Consumer (commercial/domestic) gas demand to 2050

Figure EC.16: Industrial gas demand

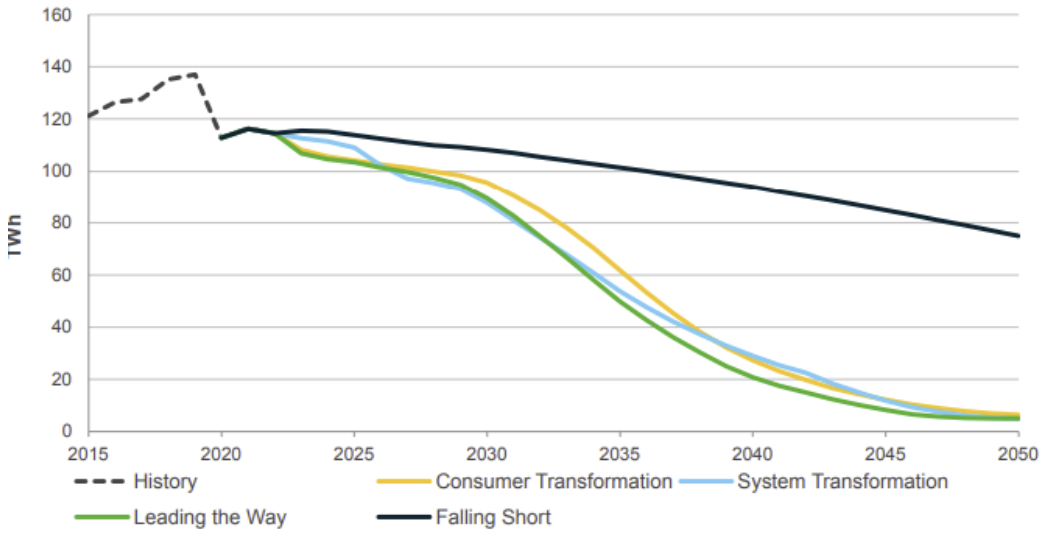
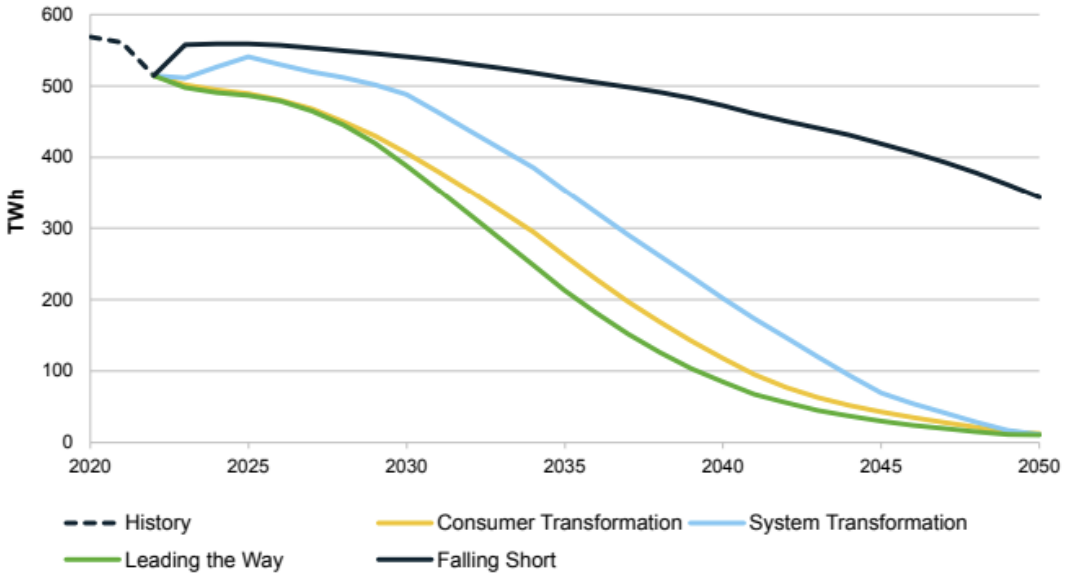


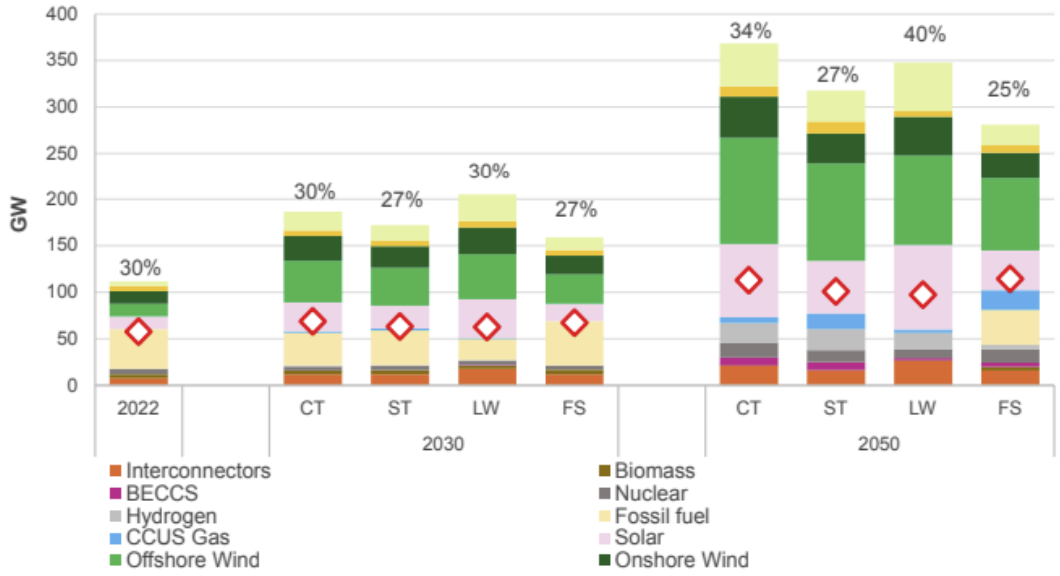
Figure EC.04: Total annual consumer gas demand



What will we use the gas grid for in 2050?
3. Generating electricity during the Dunkelflaute (including District Heating CHP)

In the 4 FES 2023 Scenarios, there is no unabated gas generation* but some gas CCUS and H2

Figure ES.10: Installed generation capacity, peak demand and percentage of decentralised generation (GW)



*Dunkelflaute not considered

cng services ltd

CCC say 25 GW of unabated gas back-up generation in 2035

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These backup capacities increase when modelling a “low wind year” based on 2010, which the CCC judges to have been a 1-in-50 year event.

They would need to be slightly higher again to cope with the artificial extreme 30-day wind drought used to stress test the modelling results

In these cases, the capacity of low-carbon dispatchable sources would reach 20 and 25GW, respectively, while unabated gas capacity would rise to 25GW.

It seems that this was just looking at the issue low wind. That’s part of it but the main challenge is very high heating demand because it’s very cold (and low wind) This would be probably be another 25,000 MW of unabated gas that operates for 2 weeks every 20 years

And obviously if we need this in 2035 we may need more in 2045 as electricity demand will be up but the Dunkelflaute risk will not have changed. If there is a new national H2 grid then that will sort it