

Cutting methane emissions is quickest way to slow global warming **UN report** May 2021



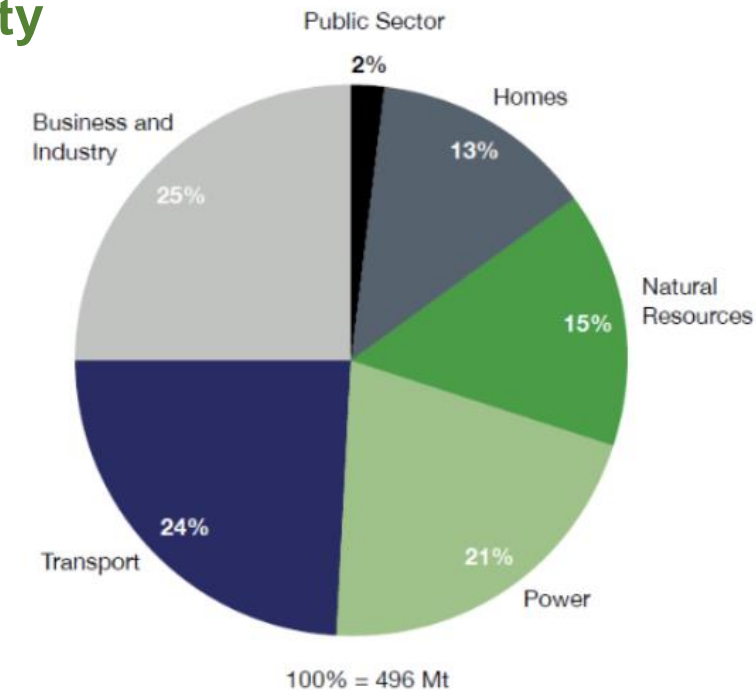
“The big take-home nugget for me is they said if you look at all the warming activity done by humans over the last century ... carbon dioxide has contributed 0.75 degrees Celsius, while methane has contributed to 0.5 degrees Celsius.” **Bob Howarth, Professor of ecology and environmental biology at Cornell University**

Cutting human-caused emissions by 45% will help hit 1.5C targets.

These emissions are from three sectors: fossil fuels, such as oil and gas processing; landfills and waste; and agriculture, chiefly related to livestock.

This would avoid nearly 0.3°C of global warming by the 2040s

It would prevent 255,000 premature deaths, 775,000 asthma related hospital visits, 73 billion hours of lost labour from extreme heat, and 26 million tonnes of crop losses globally each year.

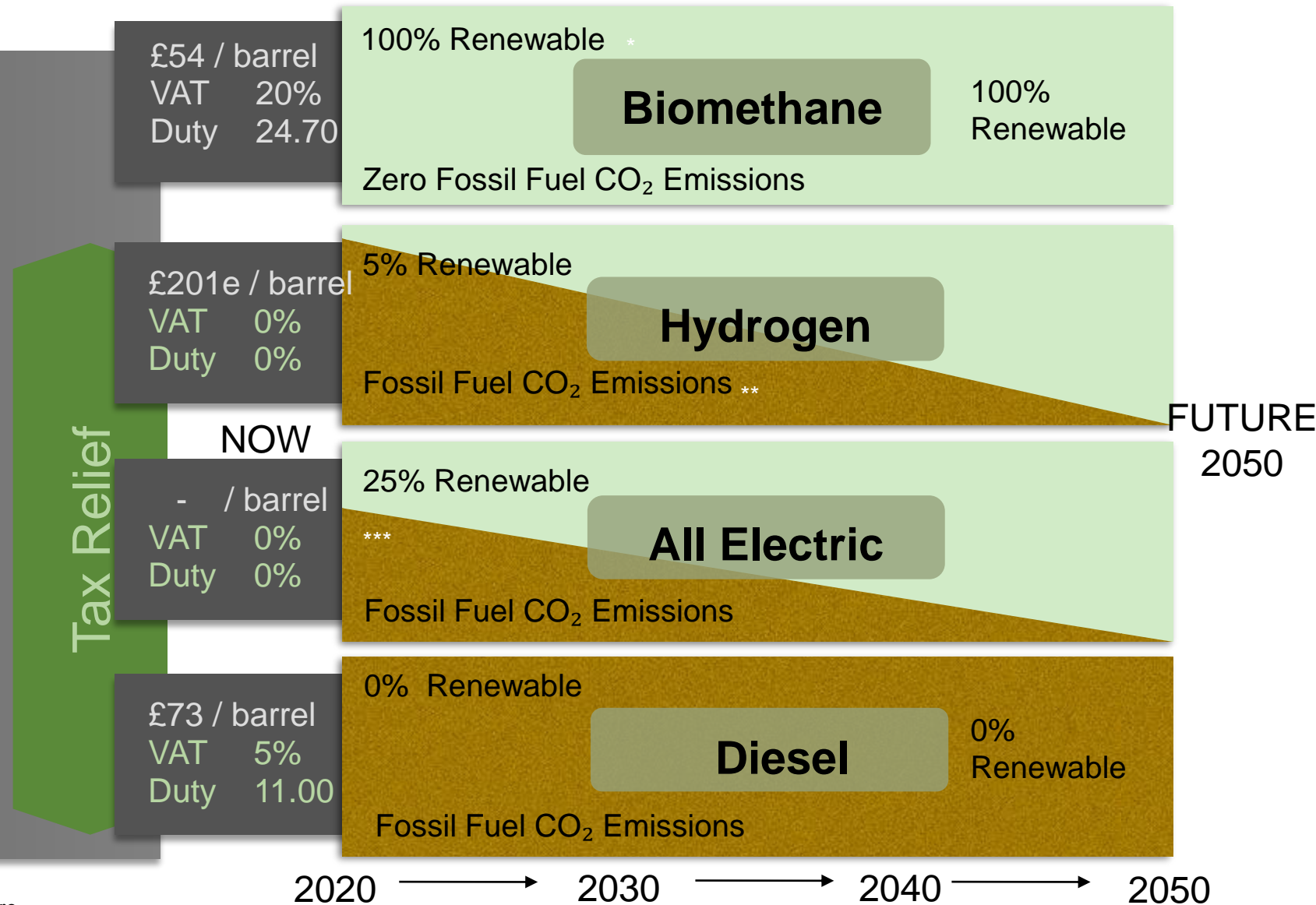


Environmental Impact

Transport Energy Types

Biomethane is 100% renewable and is carbon neutral.

It is available and under used. Of the 90m tonnes of animal manures produced each year in the UK only 3% is used.



Barrel prices are comparable units of refined fuel . Duty is pence per litre

* When produced from waste matter ** Current energy mix to make brown H₂ *** Doesn't account for power transmission losses. Currently the rail power supplier (EDF) are far below 27% with their ROC & REGO purchases

Biomethane: circular economy

Global Warming

Prevents fugitive methane emissions 34 times more harmful than CO₂ emissions – ‘better than zero’ solutions

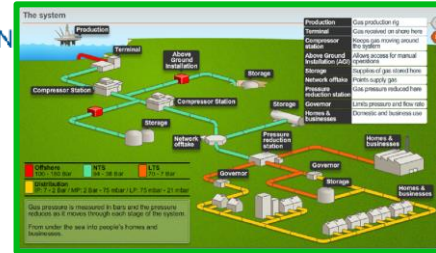
Secure Phased Approach

- 1: Run tram on biomethane from the grid
- 2: Build AD + use existing filling stations
3. Produced naturally from local resources using local labour, creating 30k new jobs and providing total security of supply

Food waste collection mandatory 2023

Waste also from hospitality, hospitals, schools

90m tonnes of animal manures produced each year in the UK only 3% is treated
170mT organic waste available

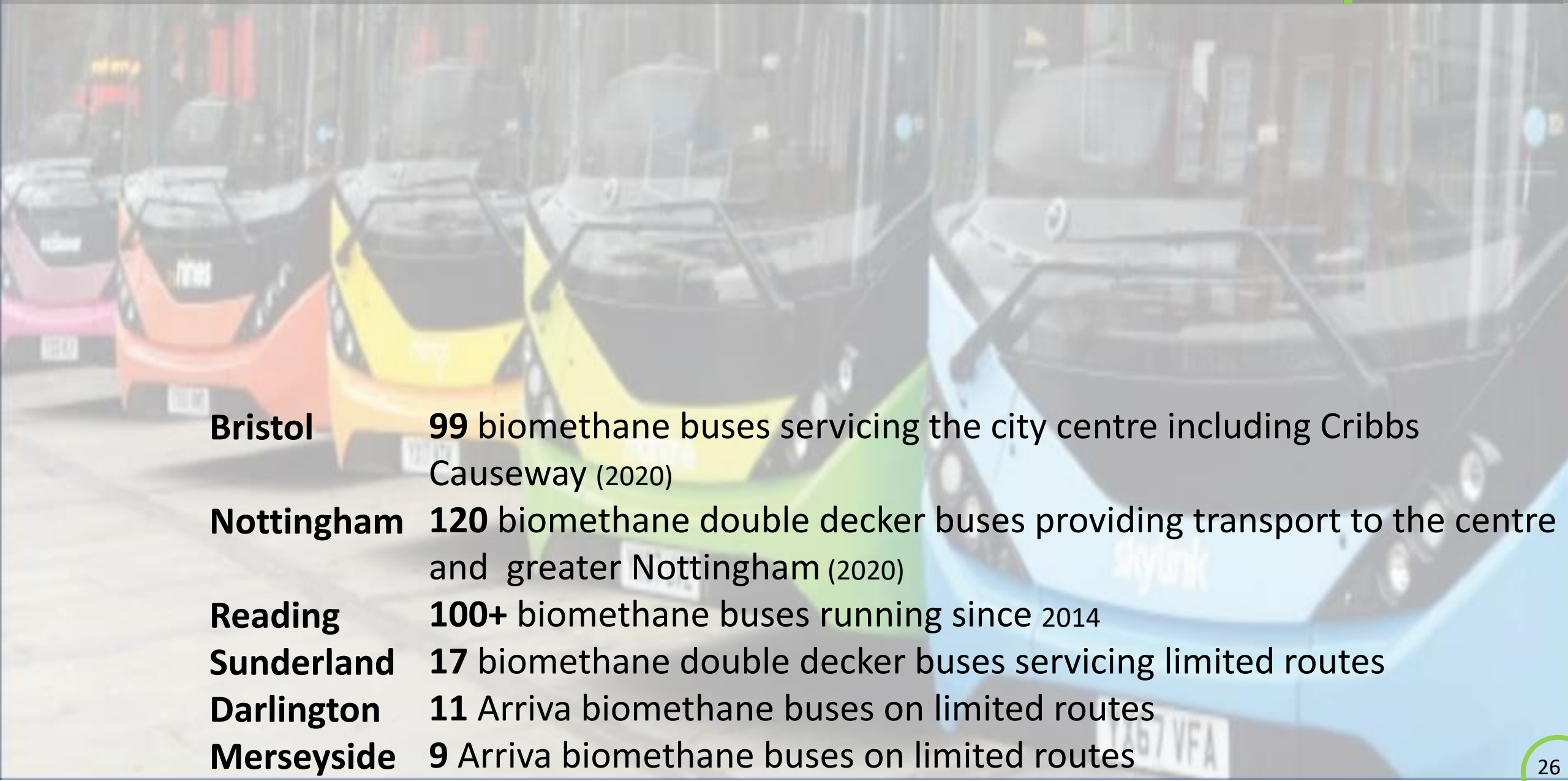


Other uses;
heating
generating electricity
2mTwh2 to 120mTwh2

Power for trains, HGV, cement lorries, refuse trucks, trams and coaches




Current Biomethane Services




| | |
|-------------------|---|
| Bristol | 99 biomethane buses servicing the city centre including Cribbs Causeway (2020) |
| Nottingham | 120 biomethane double decker buses providing transport to the centre and greater Nottingham (2020) |
| Reading | 100+ biomethane buses running since 2014 |
| Sunderland | 17 biomethane double decker buses servicing limited routes |
| Darlington | 11 Arriva biomethane buses on limited routes |
| Merseyside | 9 Arriva biomethane buses on limited routes |

Fuel availability

 Operational CNG
Fuels Station

 CNG Fuels Station
in construction

 Planned CNG
Fuels Station

 300miles returning
range

Biomethane refuelling stations

AD plants

- Severn Trent Water has **27 Anaerobic Digestion facilities** servicing **1008 sewage treatment works**

- If Severn Trent converted all its biogas to biomethane, they could heat **c50k homes** or power around **1,200 HGVs**

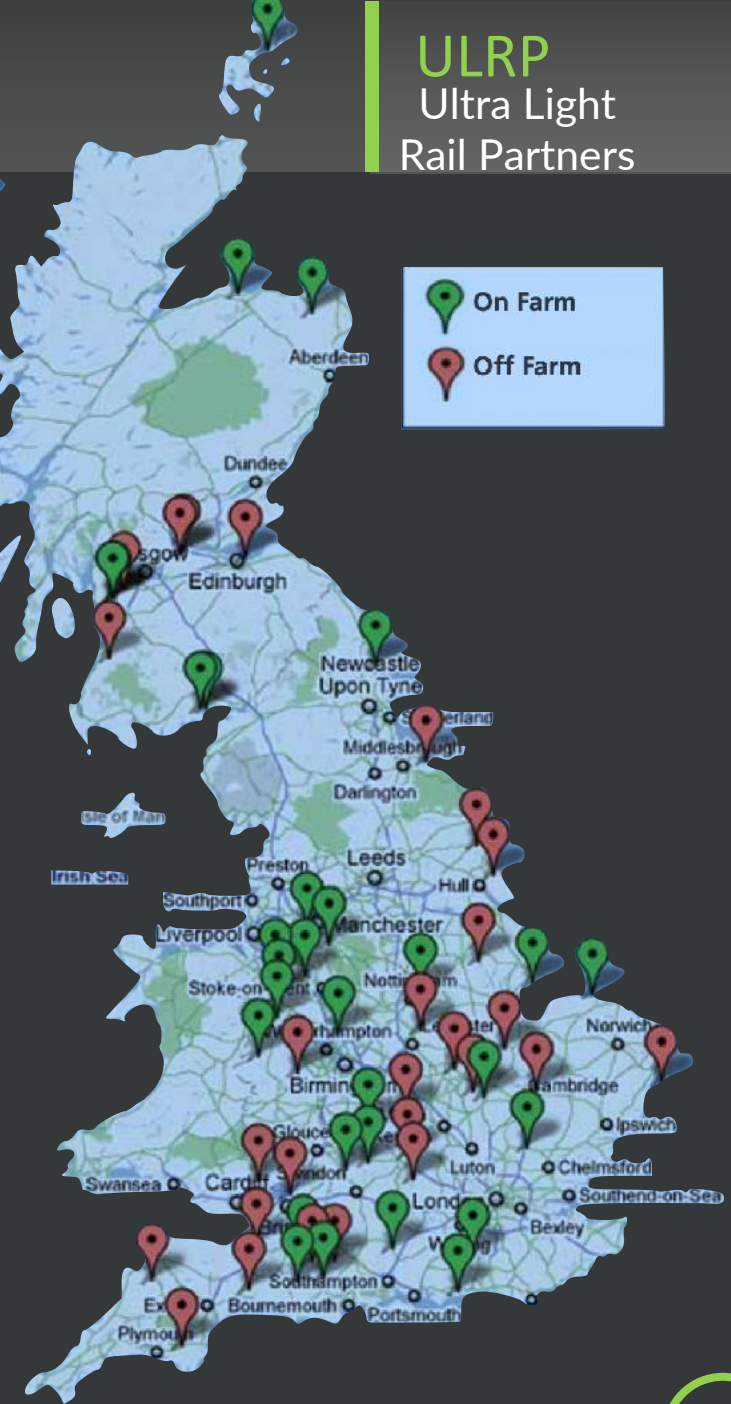
- **11mT food waste** produced annually; **170mT organic waste** available

- **3% animal manures** treated pa






890,000 tonnes
of food is thrown away in London each year

 On Farm
 Off Farm

Coaches can also run on CNG available everywhere in the UK from the national gas grid



With Net Zero, the transport landscape has changed with greater future roles for biomethane and hydrogen

| | | Potential demand in 2050 ¹ |
|--|--|--|
|  | Industry: Hydrogen is the most technically and economically feasible low-carbon feedstock and source of high-temperature heat for many industrial processes | 50 – 200 TWh |
|  | Heavy transport: Hydrogen is expected to be the primary low-carbon fuel for large vehicles such as HGVs, buses, trains and tankers | 50 – 100 TWh |
|  | Buildings: Hydrogen is one of the leading options for decarbonising heat in buildings, alongside heat pumps and district heating networks | 50 – 200 TWh |
|  | Power: Hydrogen is increasingly seen as the most viable low-carbon alternative to natural gas for peak dispatchable power generation | 50 – 100 TWh |
|  | Flexibility: Hydrogen can provide energy system flexibility in the form of storage (including inter-seasonal) and sector coupling | TBC |
| <div style="background-color: #f44336; color: white; padding: 10px; display: inline-block; border-radius: 15px;"> Total potential demand in 2050 </div> | | 200 – 600 TWh (c. 25 – 50% of the UK's total energy demand in 2050) ² |

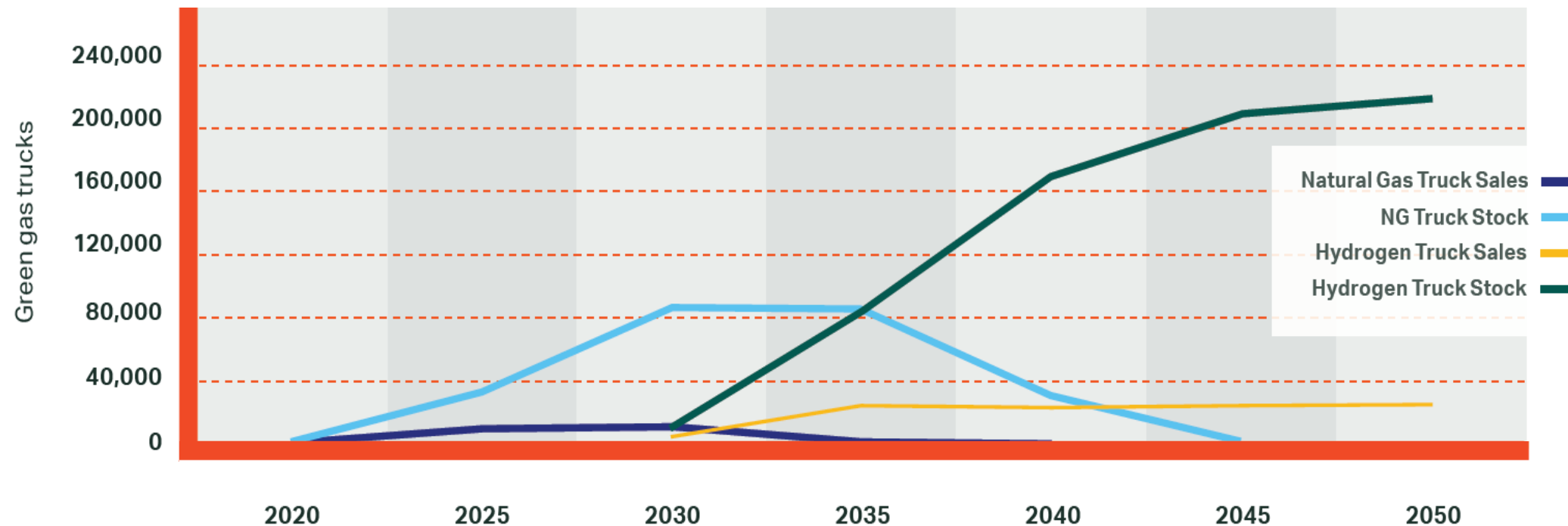
Source: Navigant, Element Energy, CCC, Aurora, Imperial College, National Grid

1. Ranges are directional

2. Based on National Grid's FES 2020 scenarios

A transition to a Net Zero future through green gases is possible by 2050

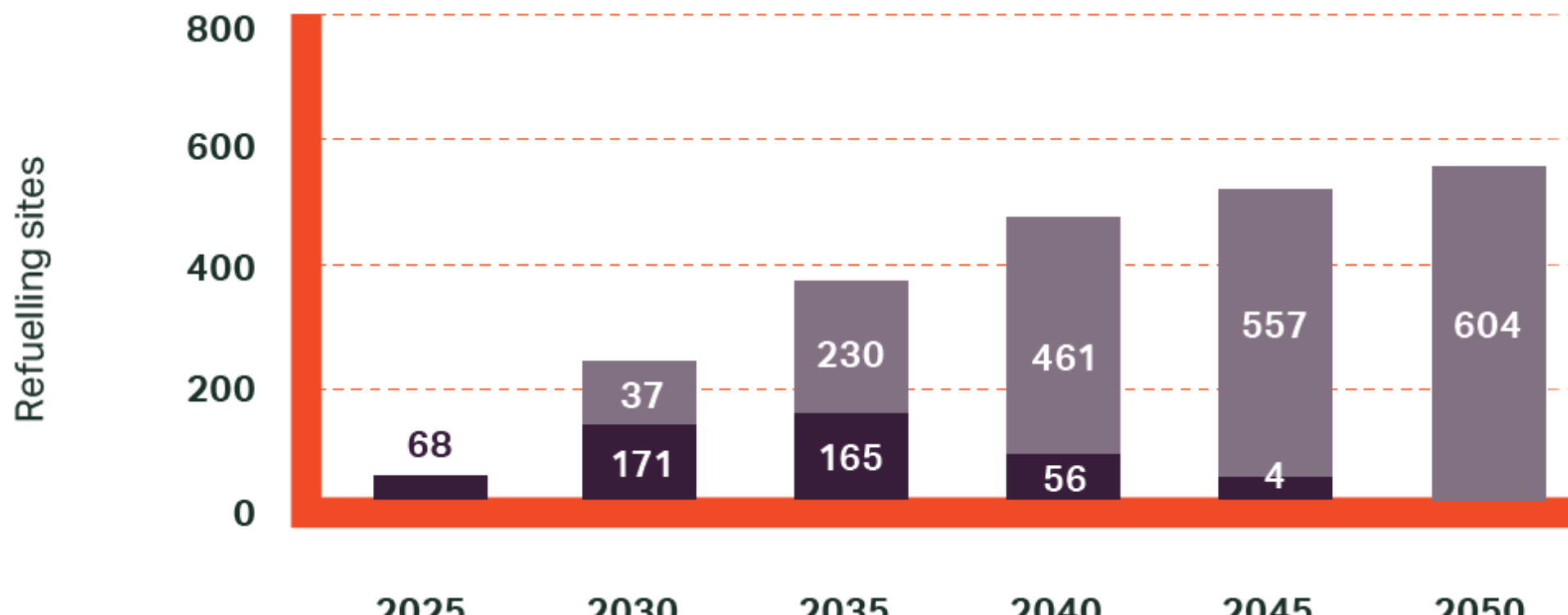
- Significant momentum is building behind zero-emission HGVs - but it takes time to scale up
- Need successful demonstrations & rapid sales growth to facilitate large numbers of vehicles
- This leaves a 10-15 year window where Biomethane HGVs can support decarbonisation, building off its more advanced technology/infrastructure readiness level



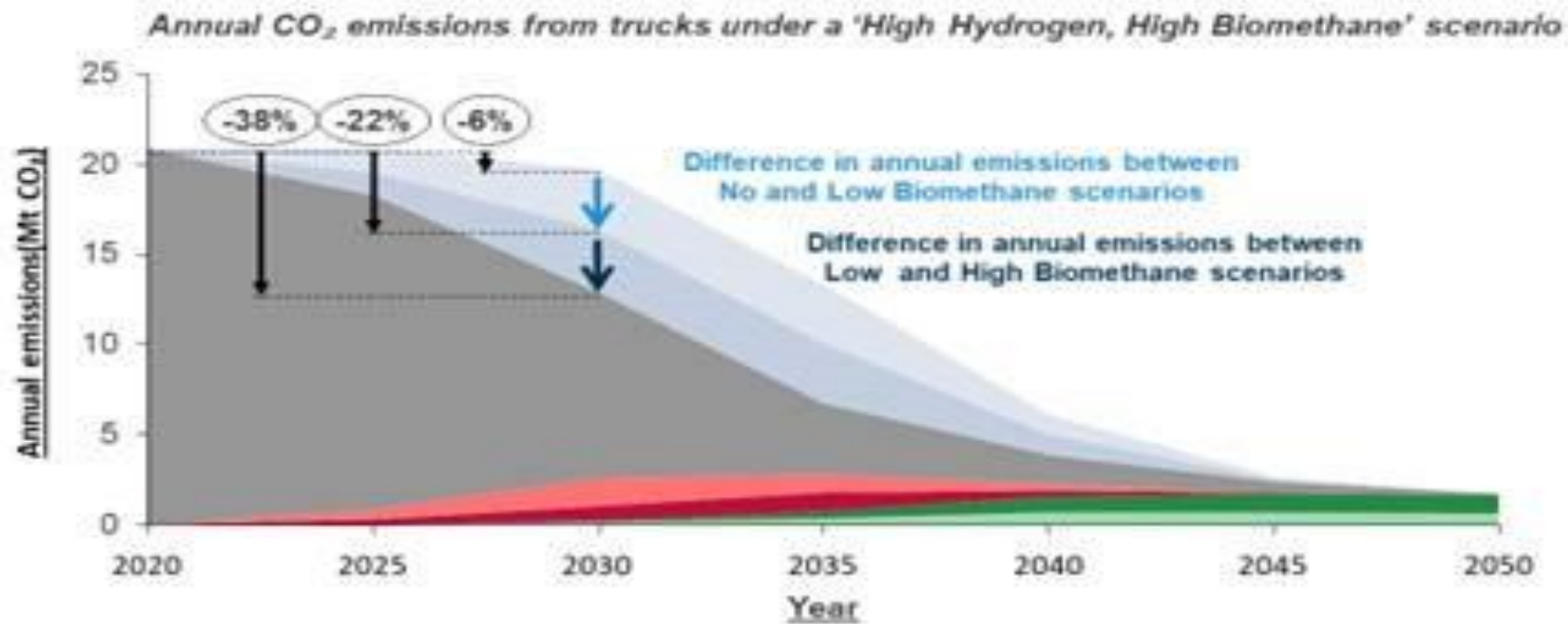
The transition pathway through green gases reduces, rather than increases, the risk to infrastructure

Some argue that building CNG/LNG infrastructure will lead to stranded infrastructure assets. However Cadent see the CNG/LNG network as:

- A transition in HGV operator refuelling behaviour
- Support for early HRS business case
- Building blocks for developing a hydrogen refuelling network
- Upskilling in station building in UK



The green gas transition pathway significantly reduces the overall emissions



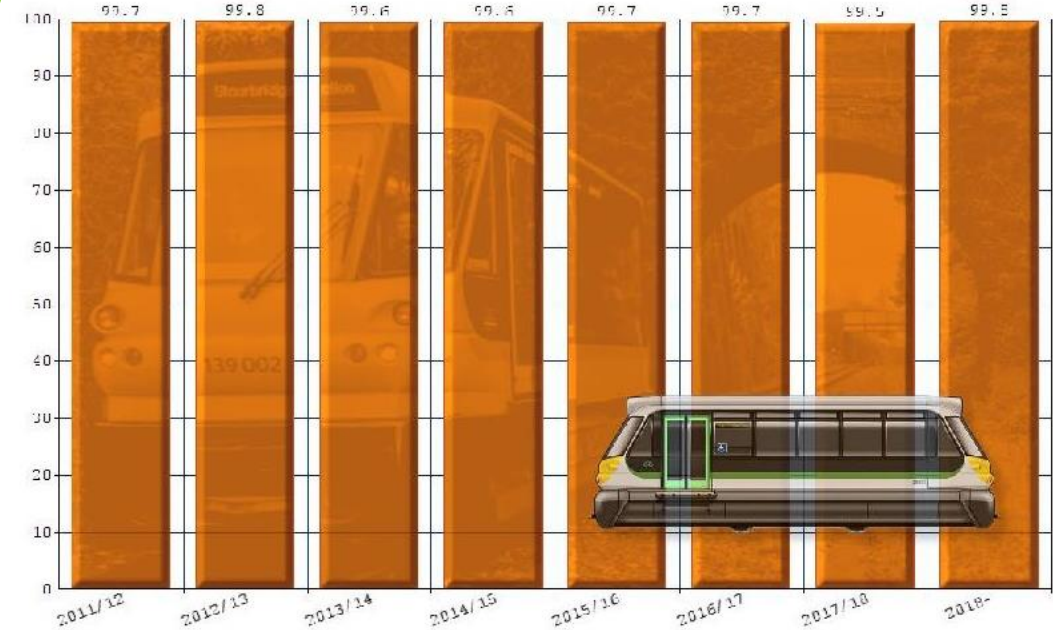
| | | |
|---------------------------------|----------------------------|----------------|
| Total No Bio-CH ₄ | Bio-CH ₄ - High | Electricity |
| Total Low Bio-CH ₄ | Bio-CH ₄ - Low | H ₂ |
| Diesel High Bio-CH ₄ | | |

Cadent
Your Gas Network

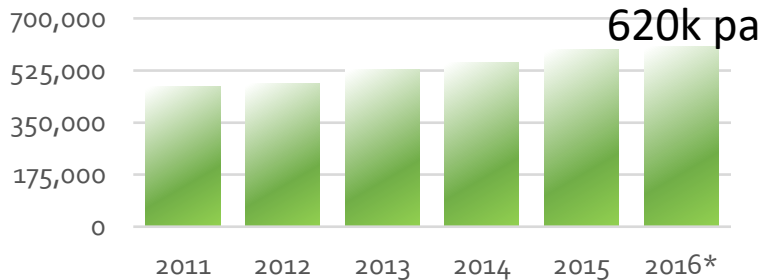
Stourbridge Shuttle Performance

- 25 year history promoting ultra light rail and modal shift
- 12 years in operation in West Midlands operated by Pre Metro Operations
- LPG – 70% cleaner than diesel
- 6 million + safe, reliable passenger journeys
- Highest passenger satisfaction levels in Stourbridge Bristol trials
- Operating 1300 trips each week
- 184 miles drivetime without refuelling

**99% +
RELIABILITY**



Passenger Numbers



Achievements to date



Pilot Biomethane train at Long Marston July 2020

Successful UK *first-of-a-kind* build and trial of Biomethane/Bio-CNG train **on time and to budget** in Project STEAMUltra with practical refuelling options **Completed August 2020**



Refuelling demonstration: Tank filled in under three minutes

Viral coverage of BioUltra train
January 2021



Successful production of technical design specifications on time and to budget for 120 passenger BioUltra train **Completed January 2021**



Biomethane/Bio-CNG and H2 BioTrams



Low cost Metro extension

- Operating biomethane trams in Birmingham and other cities
- Seeking local authority collaboration
- Health, energy, durability

1. Passenger Cabin CCTV Monitor
2. Vehicle Speed and Brake Control
3. Vehicle Display
4. Drivetrain Display
5. Horn
6. Headlights
7. Windscreen Wipers Controls
8. Comms + Passenger Intercom
9. Adjustable Armrest
10. Vehicle Data Recorder
11. Interlocking / RETB Control
12. Master Control Key
13. Door Control
14. Vigilance System Pedal
15. Stop Request Indication
16. Programmable Passenger Information Screen
17. Driver Power Outlets
18. FF Camera + Data Storage
19. FF Camera Monitor



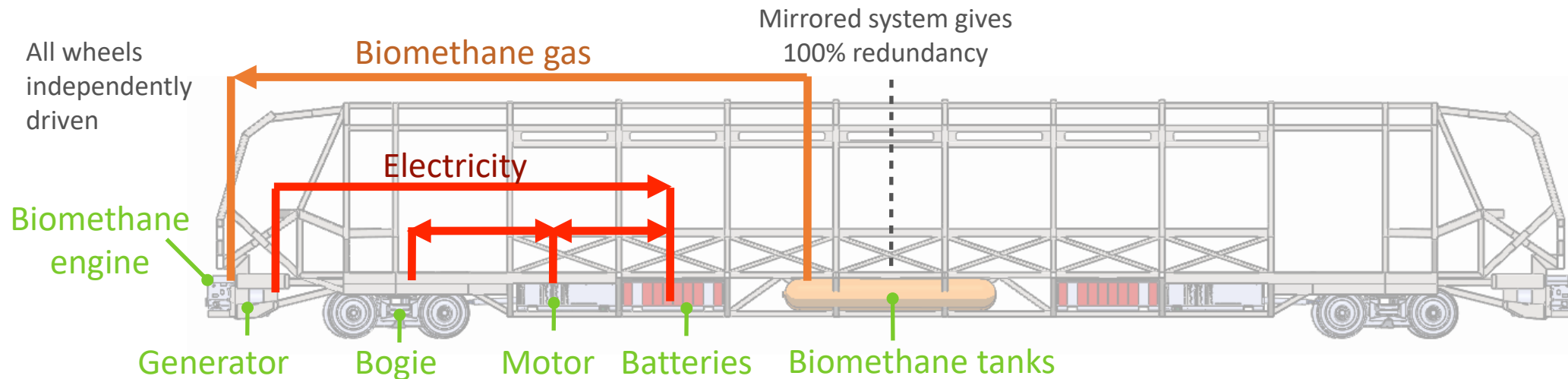


Open Data Institute measurements show Birmingham productivity falls at peak times due to bus dependency
40m real journey time and bus departures were recorded in the city by ODI
If we assume agglomeration benefits in the UK were as significant as in France, would deliver an increase in GDP/capita of 7%

Why Hybrids?

Trend is for pure battery or pure hydrogen - why the hybrid:

- Increased range 1000km
- No interruption to service during the day
- Lower vehicle investment
- Lower refuelling / recharging station costs
- Lower infrastructure costs 30% weight saving
- Small engine (0.9L) using less fuel than a family car
- Performance and efficiency



Developments in progress



BioUltra: PAX 120 Mainline Train

BioTram: PAX 120 Tram

