H21:
Meeting UK Climate Change Obligations

(Climate Change Act 2008)

UK 2050 Emissions Targets

2018 UK Energy, Carbon Emissions

456

Million tonnes (Mtpa) of carbon per annum

Reduction in current emissions required to meet 2050 targets

65%

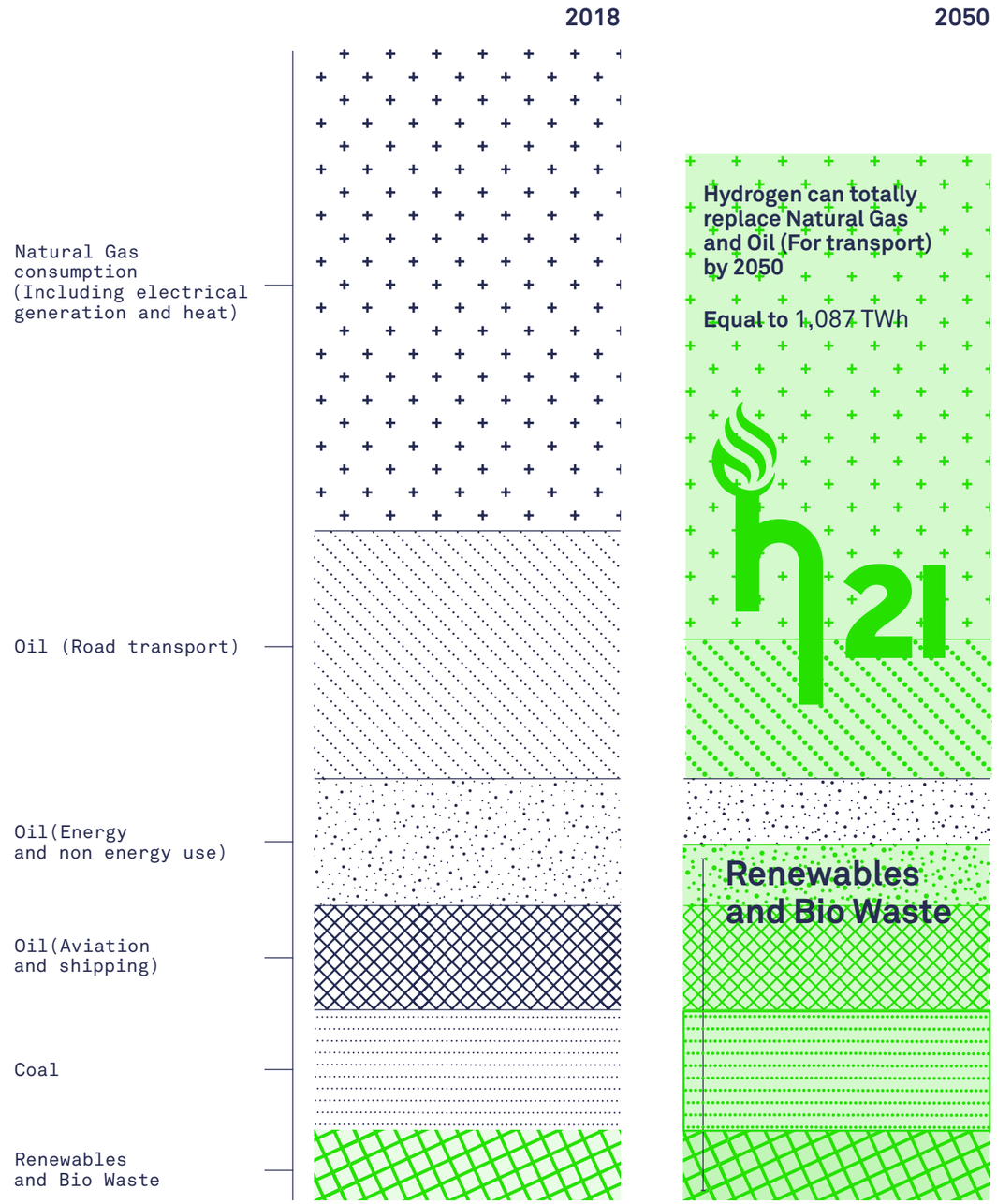
2050 UK Energy, Carbon Emissions Target

160

Million tonnes of carbon per annum

2018 UK Energy Mix

The chart below shows UK energy mix 2018 and potential mix in 2050.



H21 North of England (NoE) The fundamental building block for the UK to meet its 2050 target.

UK delivers on 2050 climate change act obligations.

Establishing a Hydrogen economy ultimately trading renewables globally.

H21 NoE

Front End Engineering and Design (FEED) 2019-2023

Urgent

Requirement for the UK to progress.

£250 Million required.

Potential Government Policy Decision 2023

H21 NoE Engineering and construction

2023-2026

Commission 1st Hydrogen Production and Storage 2026

H21 NoE Commissioning

2026-2028

Commence NoE Conversion 2028

H21 NoE Conversion

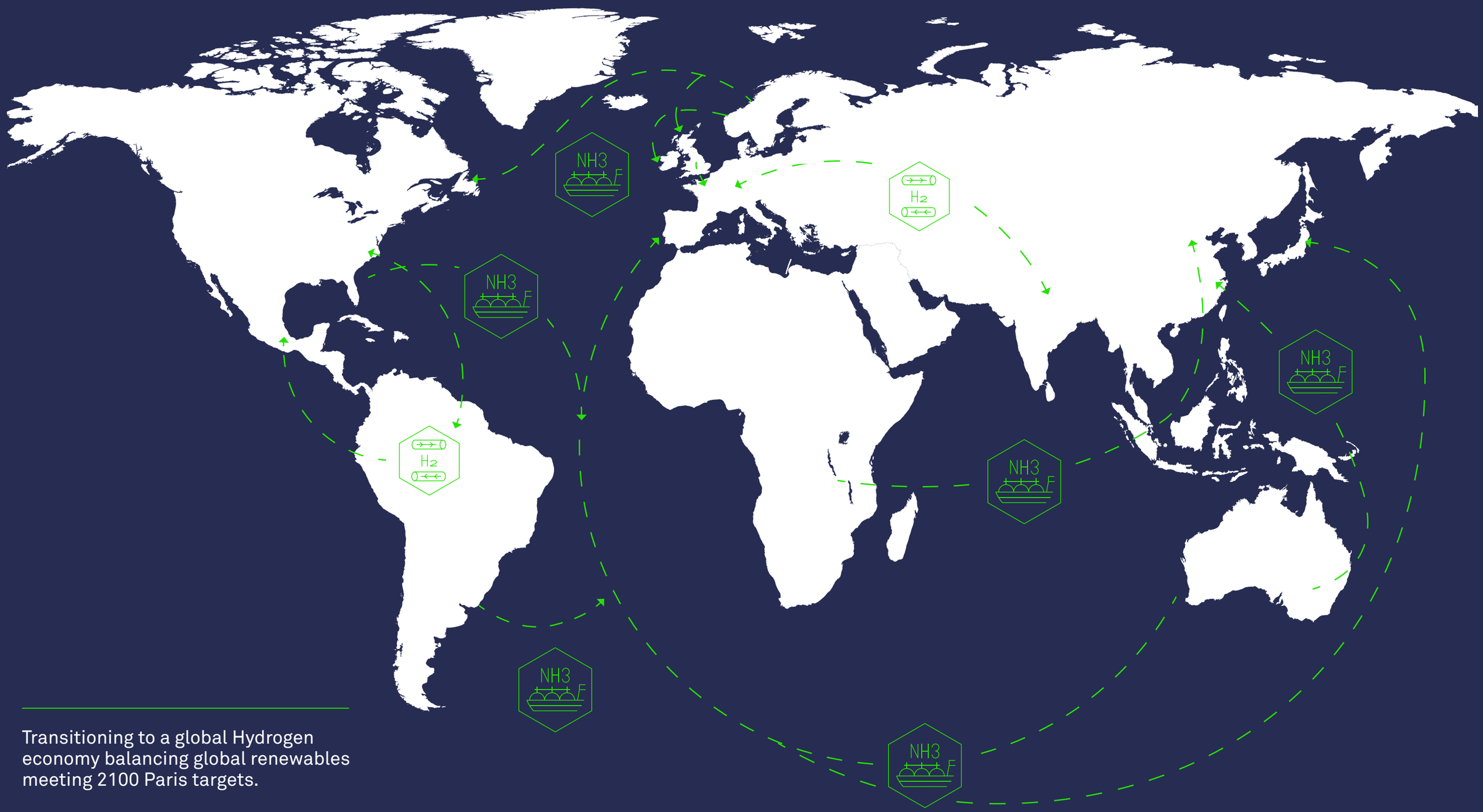
2028-2034

Completion NoE Conversion

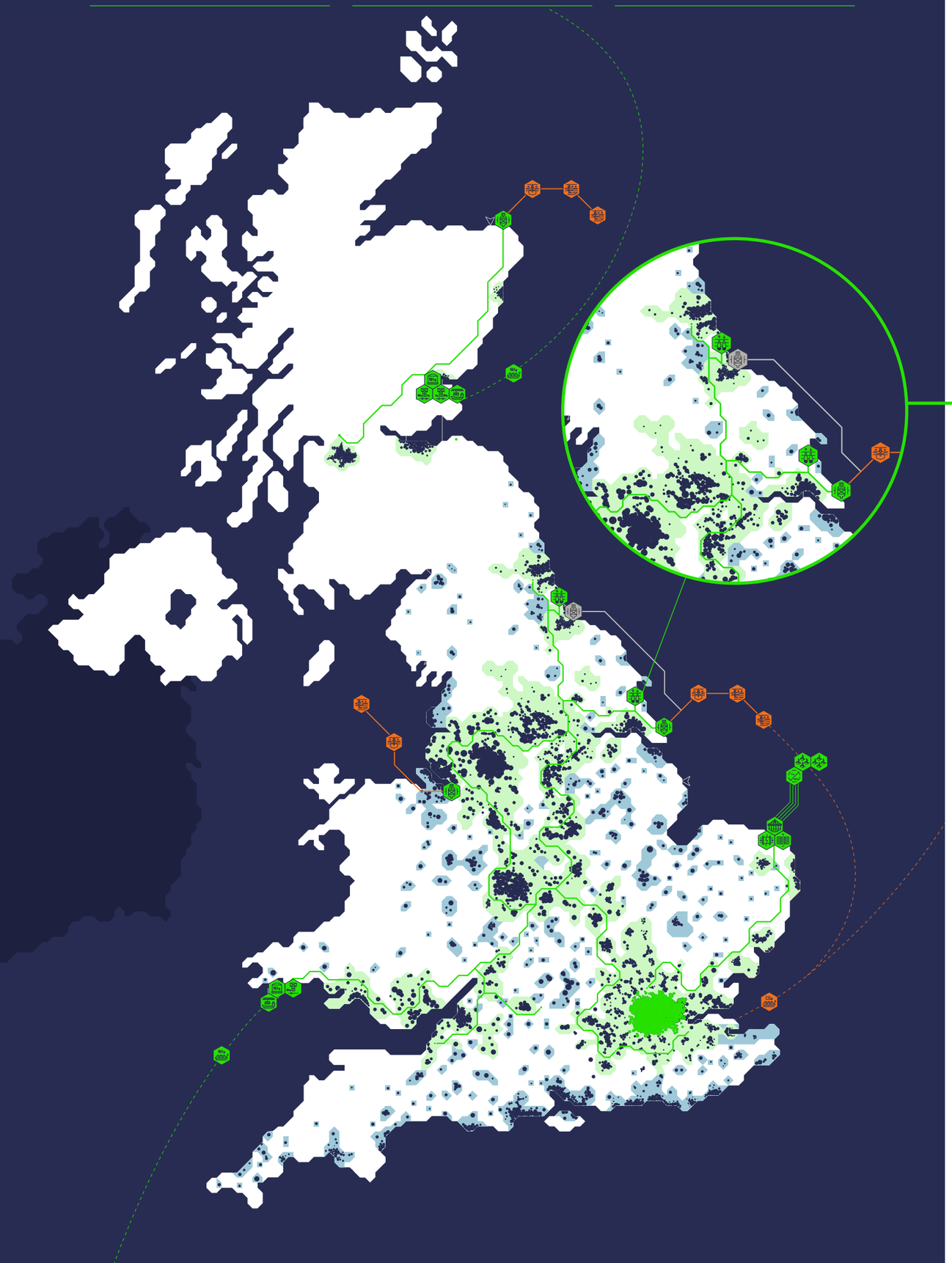
2034

2019 2023 2026 2028 2034

A New Global Hydrogen Economy



Transitioning to a global Hydrogen economy balancing global renewables meeting 2100 Paris targets.



UK Hydrogen Conversion Position in 2050

Phase 1
H21 NoE
Conversion 2028 - 2034
14% UK heat
30% Power (H21 XL) for North of England

Phase 2
H21 South Yorkshire & East/ West Midlands
2033-2038

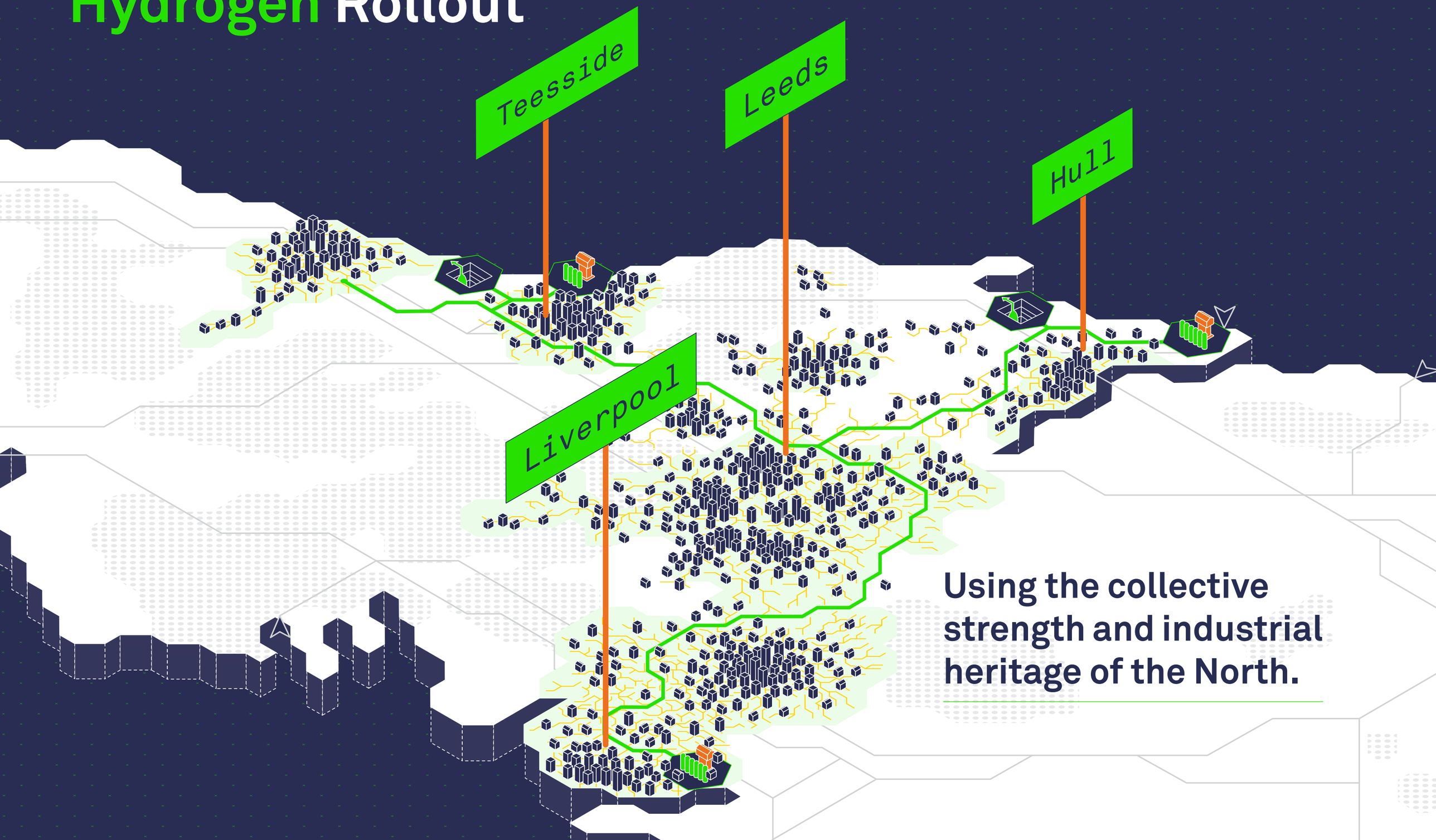
Phase 3
H21 Scotland
2030-2032

Phase 4
H21 South Wales & South West
2036-2037

Phase 5
H21 East Anglia & Home Counties
2040-2045

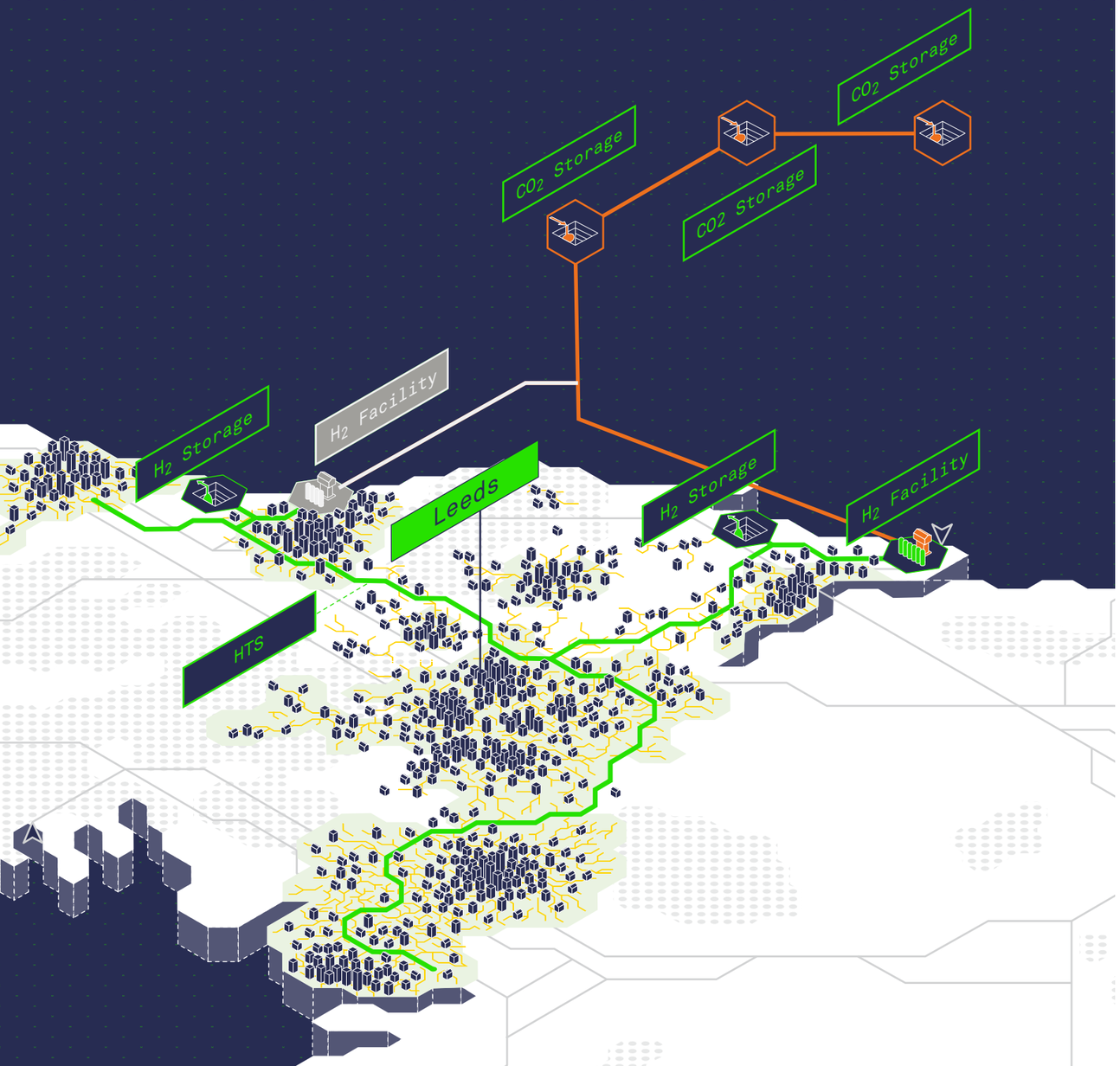
Phase 6
H21 London
2045-2050

Incremental UK Hydrogen Rollout



Using the collective strength and industrial heritage of the North.

H21 NoE Project Details



Key Technical Parameters

H_2 Facility

Hydrogen production

12.15 GW

(12,150 times larger than 1 MW)

Carbon capture and storage scaling

20 Mtpa

by 2035

H_2 Storage

Hydrogen storage

8,052 GWh ≡62,000

Australian mega batteries

HTS

Hydrogen Transmission System

125 GW capacity

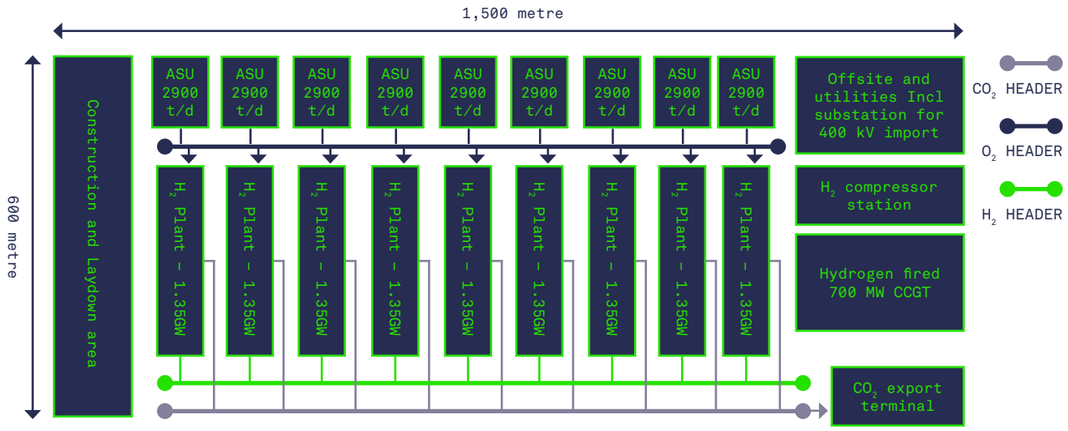
+25 GWh

Intraday storage
(≡200 Australian mega batteries)

This one project single-handedly meets the recommendations of the committee on climate change.

Meeting The Energy Demands of The North

Modular construction allows commissioning and conversion to align with demand. Based on proven, referenced technology.



Hydrogen production facility modular construction as pictured above.

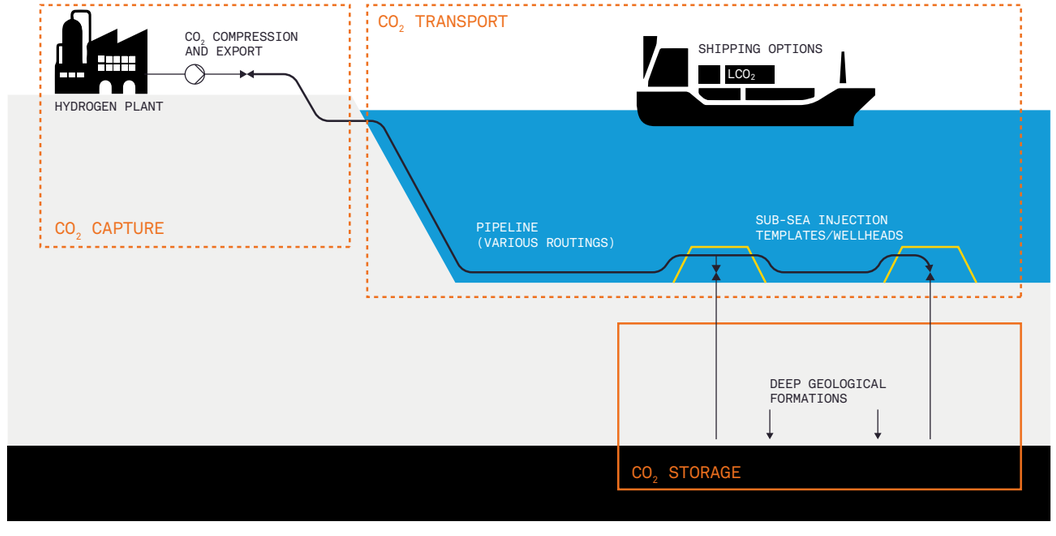
12.15 GW (9x1.35 GW)
74.4% efficiency
94.2% CO_2 capture

↖ **Combined ATR and SMR plant at Tjeldbergodden.**

Carbon Capture Utilisation and Storage

In the journey to zero–carbon energy, Hydrogen should be considered the world's destination fuel. The Carbon Capture and Storage (CCS) part of this journey is the essential transitional step to facilitate a longer term, sustainable Hydrogen economy.

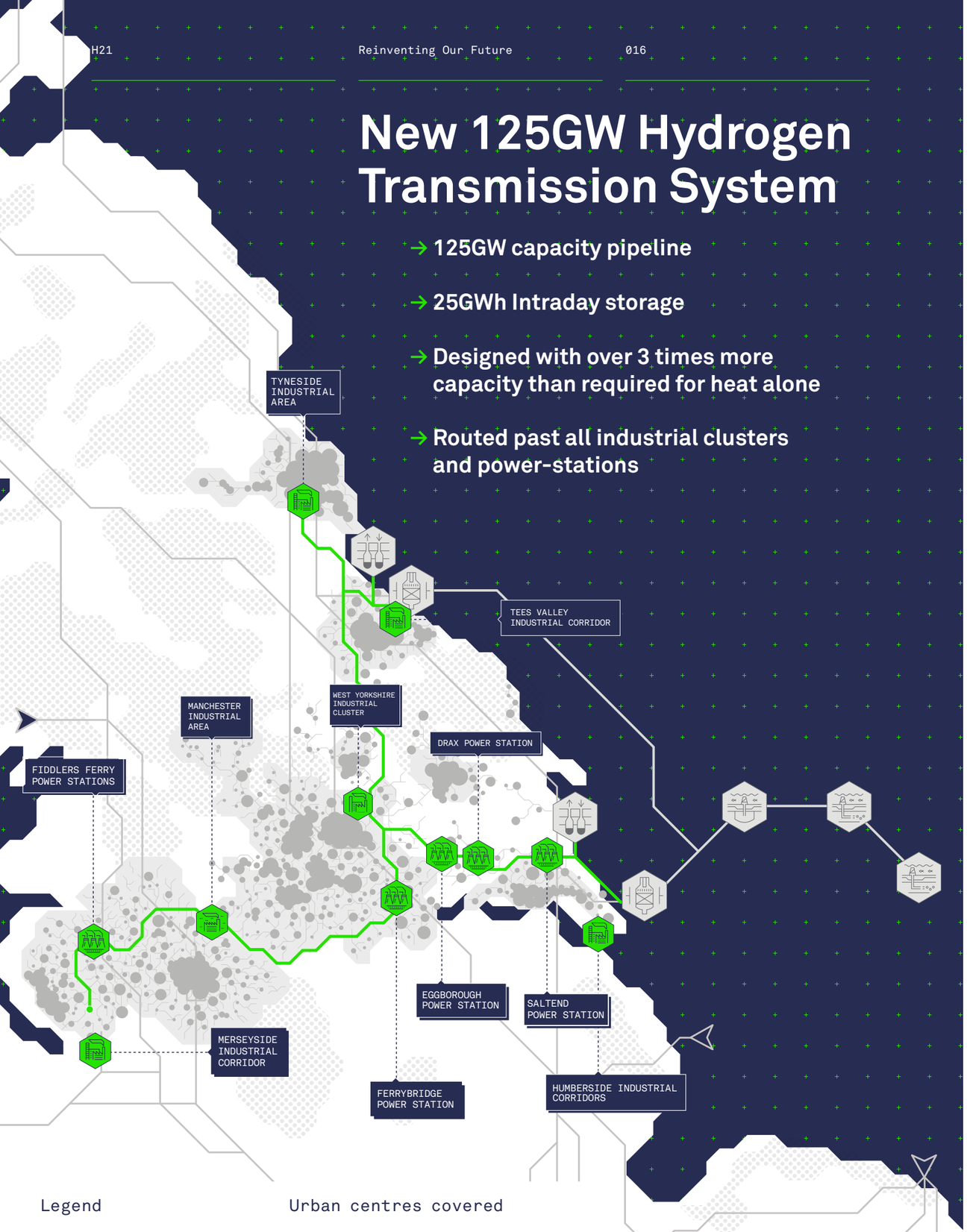
- → Less than £6 per tonne (Max advantage of economies of scale).
- → Allows future trade to Europe with strategic position close to Netherlands and Germany.
- → 20Mtpa by 2035.
- → Biggest CCS scheme in the world but still within the realms of technical confidence.



↑ Carbon capture, storage and transport method.

New 125GW Hydrogen Transmission System

- → 125GW capacity pipeline
- → 25GWh Intraday storage
- → Designed with over 3 times more capacity than required for heat alone
- → Routed past all industrial clusters and power-stations



Legend

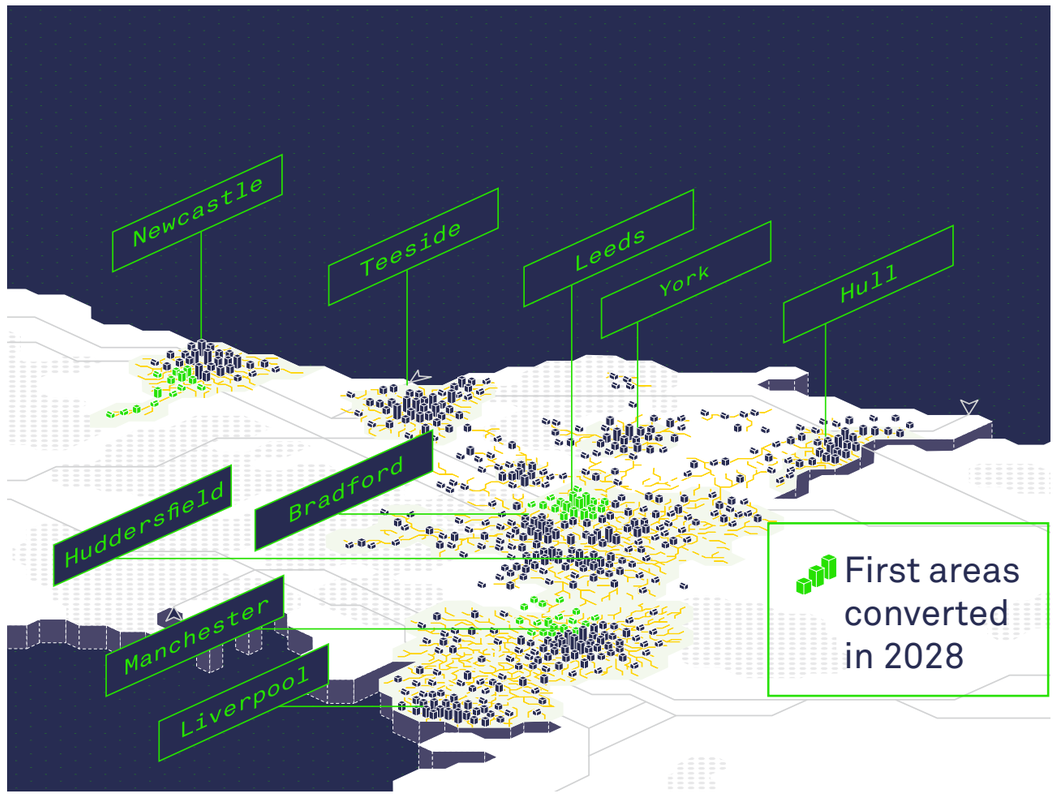
- NTS
- Hydrogen transmission line
- Gas Terminal

Urban centres covered

- → Bradford
- → Halifax
- → Huddersfield
- → Hull
- → Leeds
- → Liverpool
- → Manchester
- → Teesside (Middlesbrough)
- → Tyneside (Newcastle/Gateshead)
- → Wakefield
- → York

Conversion of The North of England

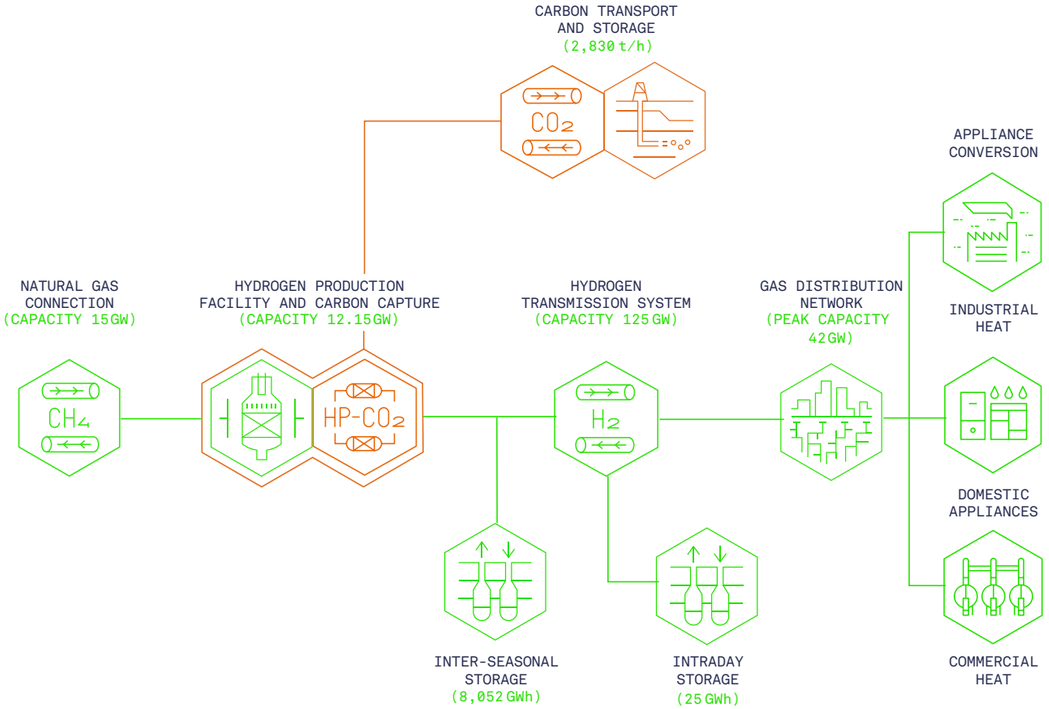
- → Conversion 2028 – 2034
- → Max time off gas 1-5 days
- → Vulnerable customers less than 1 day off gas
- → Supply and demand managed through engineering design.



↑ Conversion areas, 2028 year one position

Project Costs

ITEM	CAPEX (£M)	OPEX (£MPA) POST 2035 (ONCE CONVERSION AND COMMISSIONING IS COMPLETE)
Natural Gas connection	0 (included in HPF)	0
Hydrogen Production Facility (HPF)	8,520	285
Inter-seasonal hydrogen storage	1,991	63
Carbon transport and storage	1,340	24
Hydrogen transportation system	3,427	3
Appliance conversion	7,500	0
SUB TOTAL	22,778	375
Additional energy cost for Hydrogen Production Facility (see section 08 of full report)	N/A	580
TOTAL	22,778	955

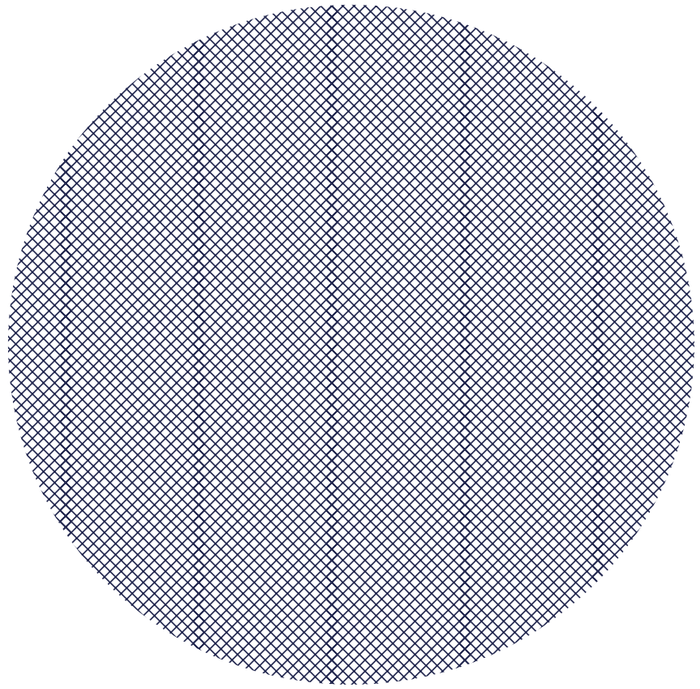


Gas Bill Impact

H21 NoE will only increase gas bills by 7% in 2035 (including all infrastructure and appliances).

Projected average domestic gas bill 2035 (£780 per year)

The increase Hydrogen will have on the projected 2035 gas bill (£57)



H21 Carbon Footprint

Based on proven referenced technology

50 g/kWh

2050 UK government electric grid target

UK heat by 2050 would be

1/3

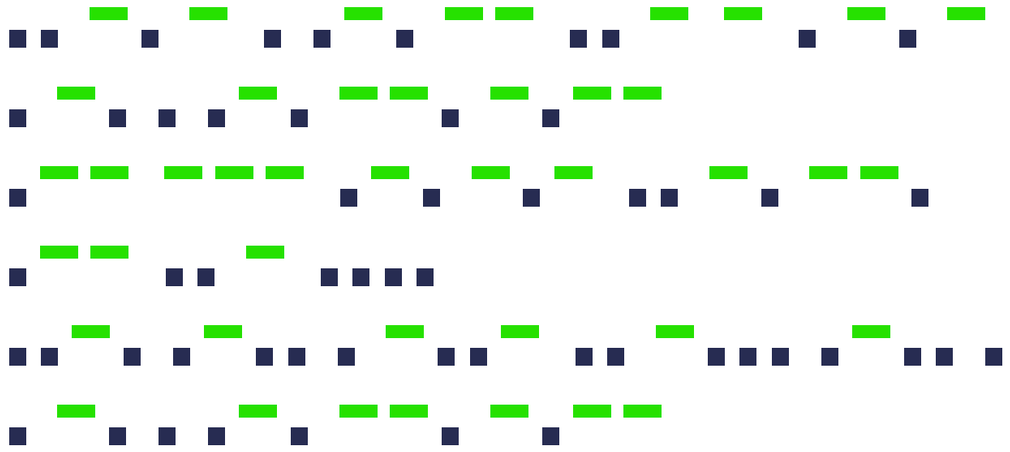
UK electric grid targets

14.47 g/kWh

guaranteed UK heat in 2050

H21 - XL

Decarbonising UK heat and Power



Intermittent energy working with flexible energy

Circa 20% CAPEX saving per unit of energy.

Divert surplus Hydrogen in summer to power generation.

Decarbonise 50% of UK Power using same system.

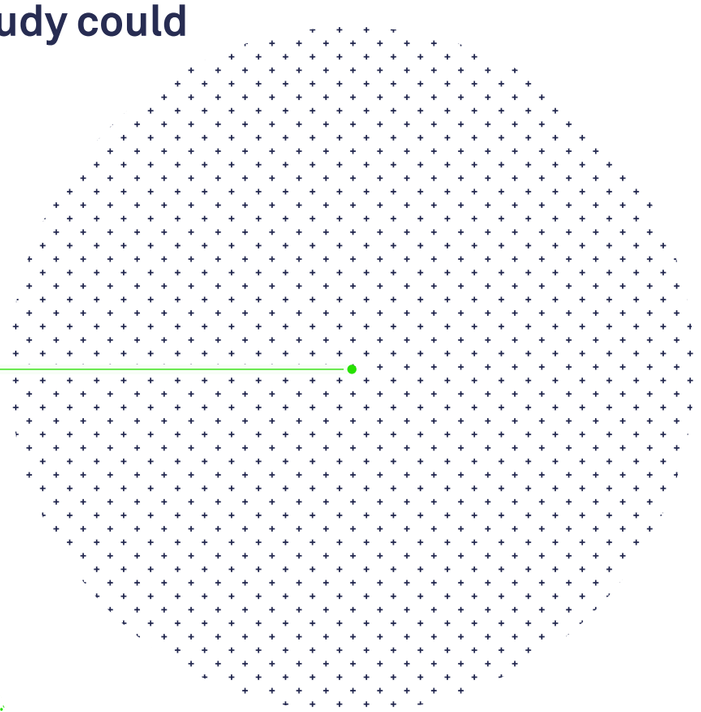
A potential reduction of inter-seasonal Hydrogen storage capacity requirement of 75%.

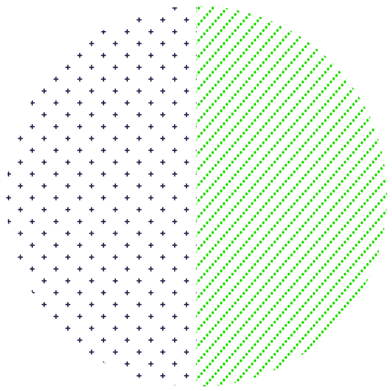
Maintaining UK Leadership Advantage

Low regret next steps.

For <1% of the overall project costs, a £250 million FEED Study could be undertaken.

£250 million =
<1% Project cost

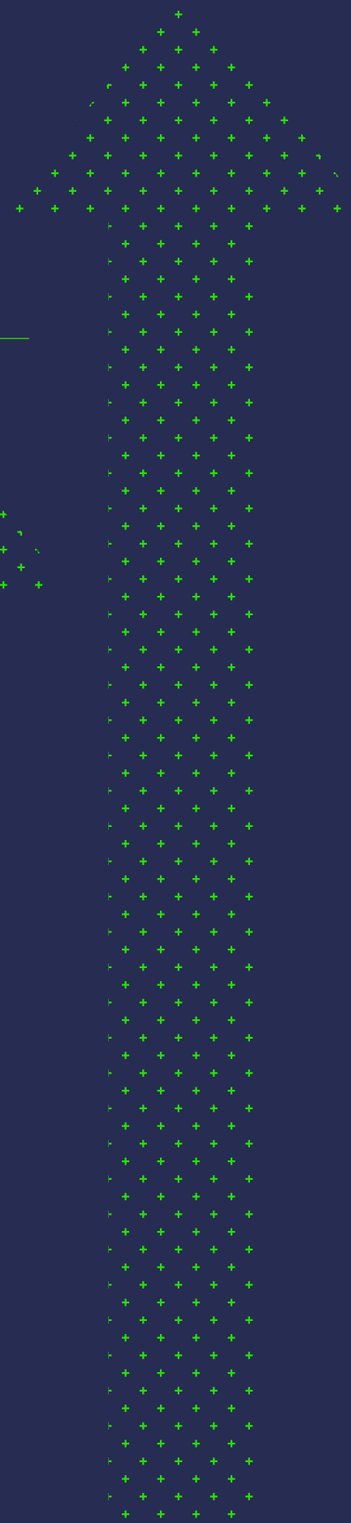




50/50 split could be available with private sector should the UK government commit to the H21 NoE FEED Study.

Creating Huge UK Economic Benefit

10s of thousands of UK jobs for decade after decade.

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