SCOTTISH Hydrogen & Fuel Cell ASSOCIATION

INFORM
CONNECT
GROW

Hydrogen in Scotland

Scaling up Hydrogen for Net Zero by 2045

Nigel Holmes

CEO, Scottish Hydrogen & Fuel Cell Association

www.shfca.org.uk

Opportunity: Scaling up Hydrogen

Scotland has a target for Net Zero by 2045, and annual electricity demand is now almost all met by renewables. Orkney BIG HIT established one of the first Hydrogen Valleys, with others now developing:

- **Mobility & Logistics**: Aberdeen H_2 fleets with Aberdeen H_2 Hub
- **Industry**: Cromarty Green Port, Aberdeen's Energy Transition Zone
- **Heat**: key evidence to deploy 100% H_2 for heat with H100 Fife trials

Scotland is now scaling up hydrogen production and demand, with the ambitious target for 5GW low carbon hydrogen production by 2030.

Further scale-up will support the Just Transition from fossil fuels to low carbon energy, with opportunities for partnerships and sharing experience.

Our Contribution to Stopping Global Warming

Scotland's target: Net Zero by 2045

Year	Scottish CO_2 Reduction
2030	75%
2035	80%
2040	90%
2045	100%

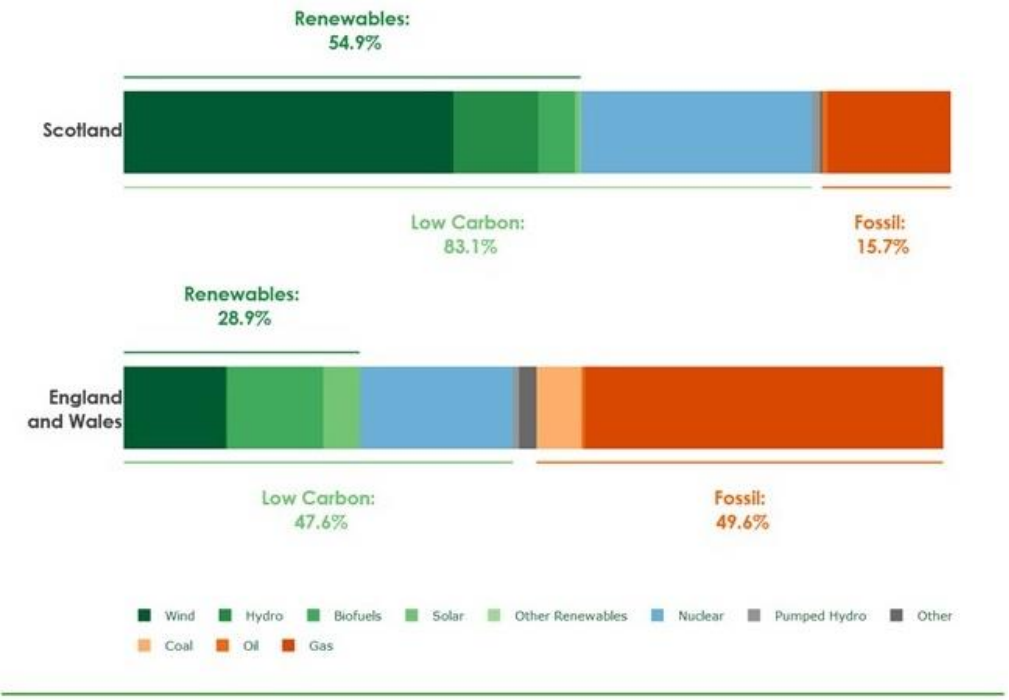
2009 Climate Change (Scotland) Act set an ambitious stretch target for 42% GHG reduction by 2020

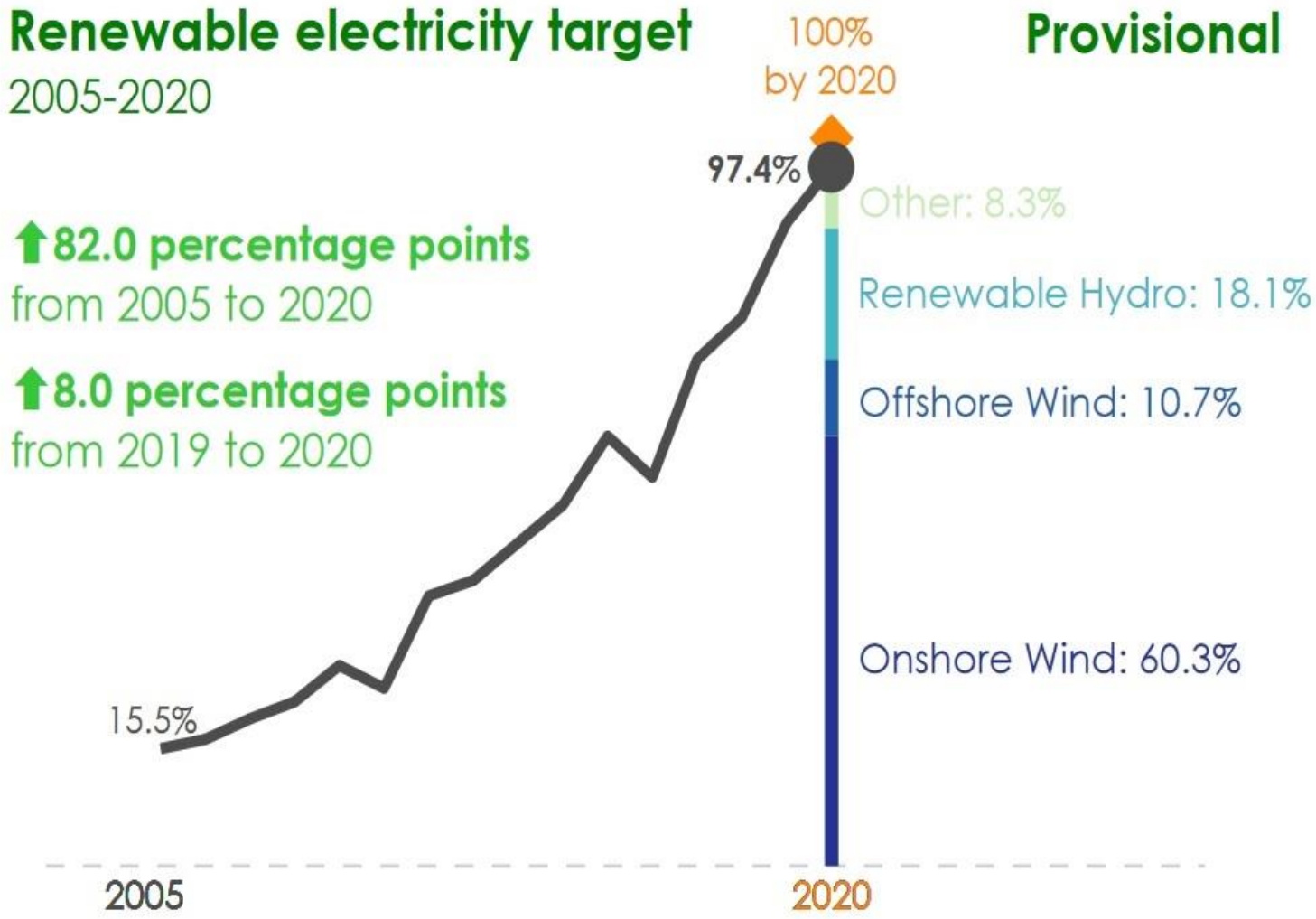
Climate Change (Scotland) Act 2009

AN INCLUSIVE ENERGY TRANSITION

Scotland's Transition to Low Carbon Electricity

Proportion of electricity generation by fuel type in 2018 (BEIS data)



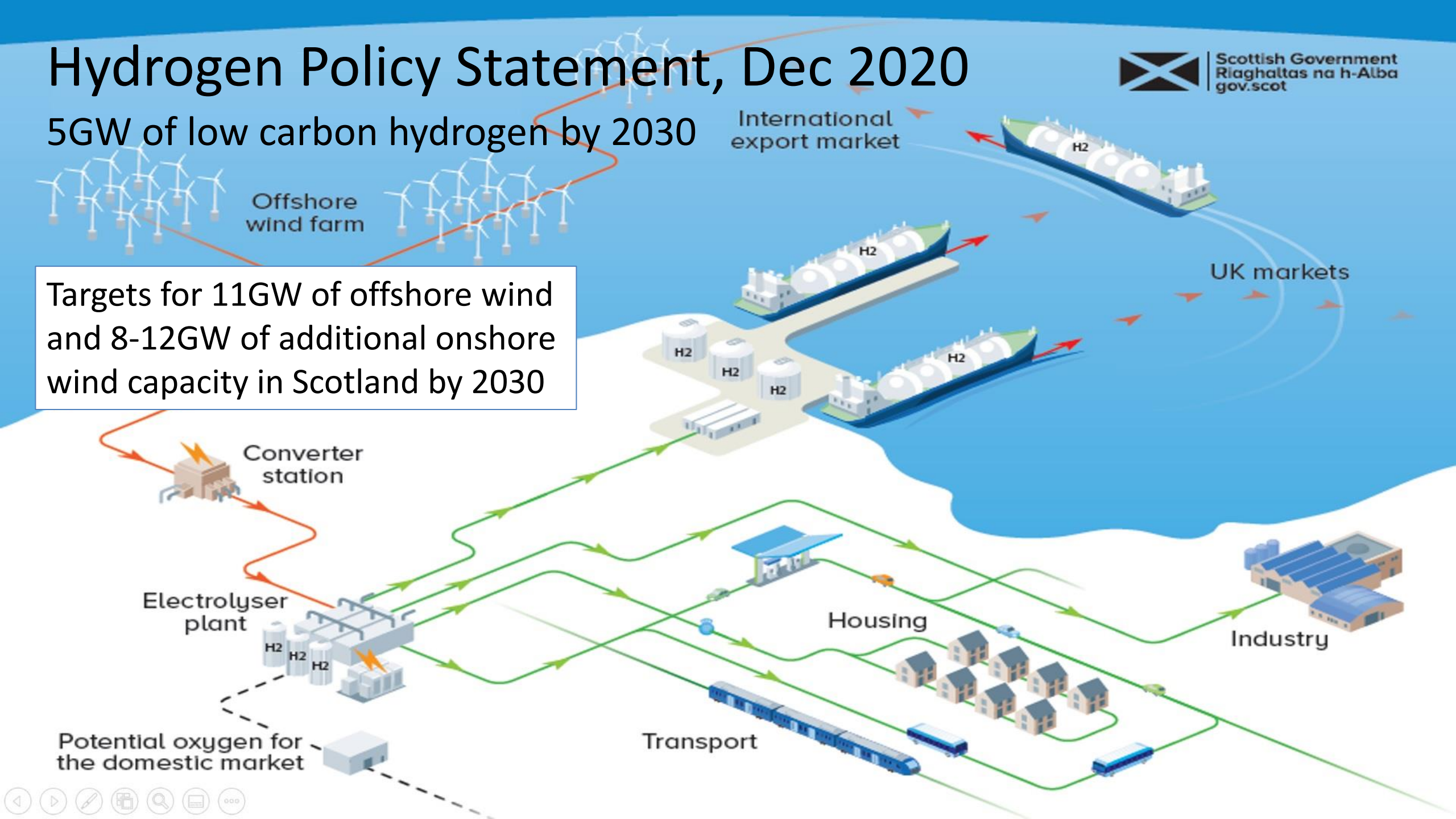


Energy Statistics for Scotland: Q4 2020 Figures (March 2021)

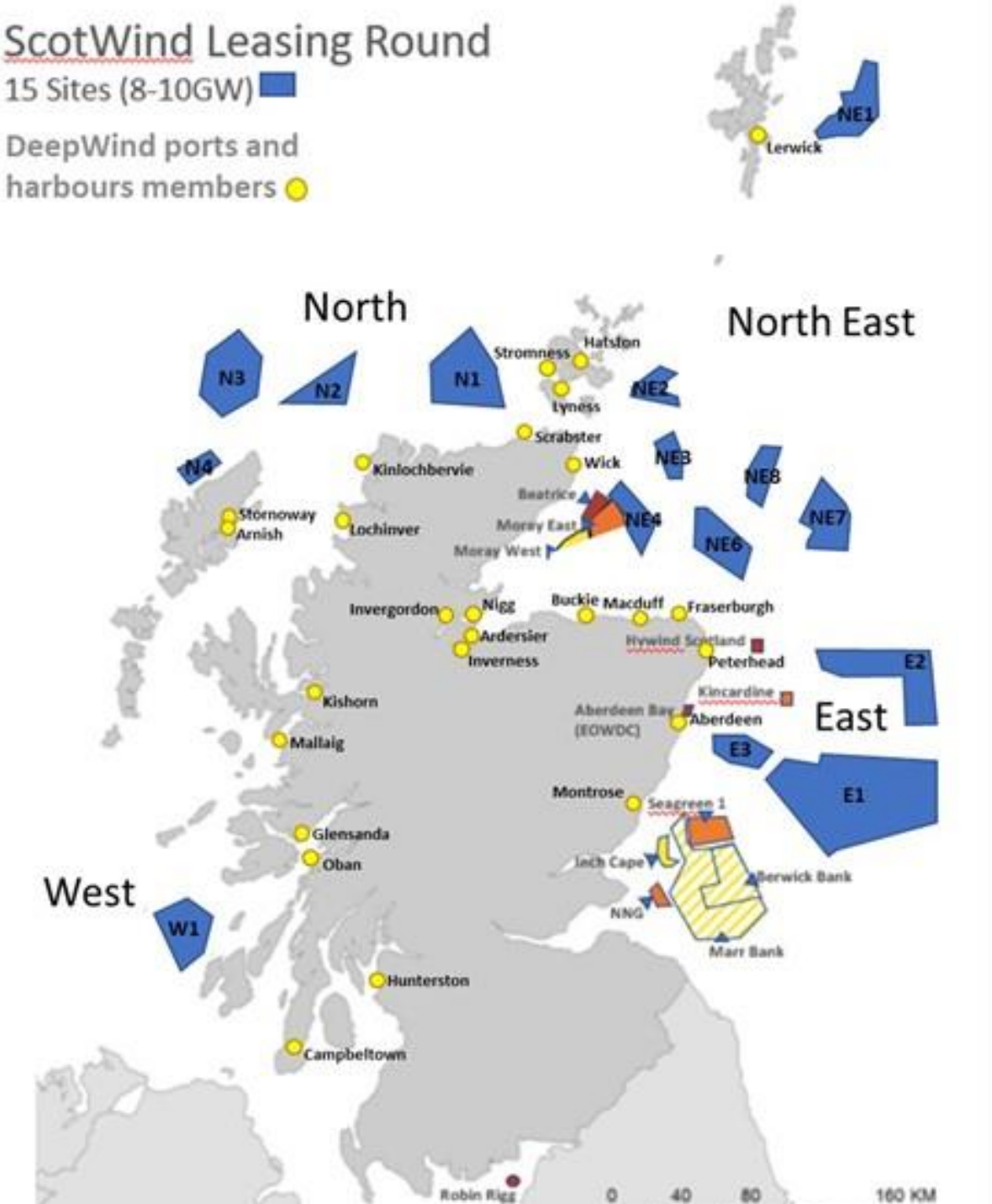
Hydrogen Policy Statement, Dec 2020

5GW of low carbon hydrogen by 2030

Scottish Government
Riaghaltas na h-Alba
gov.scot

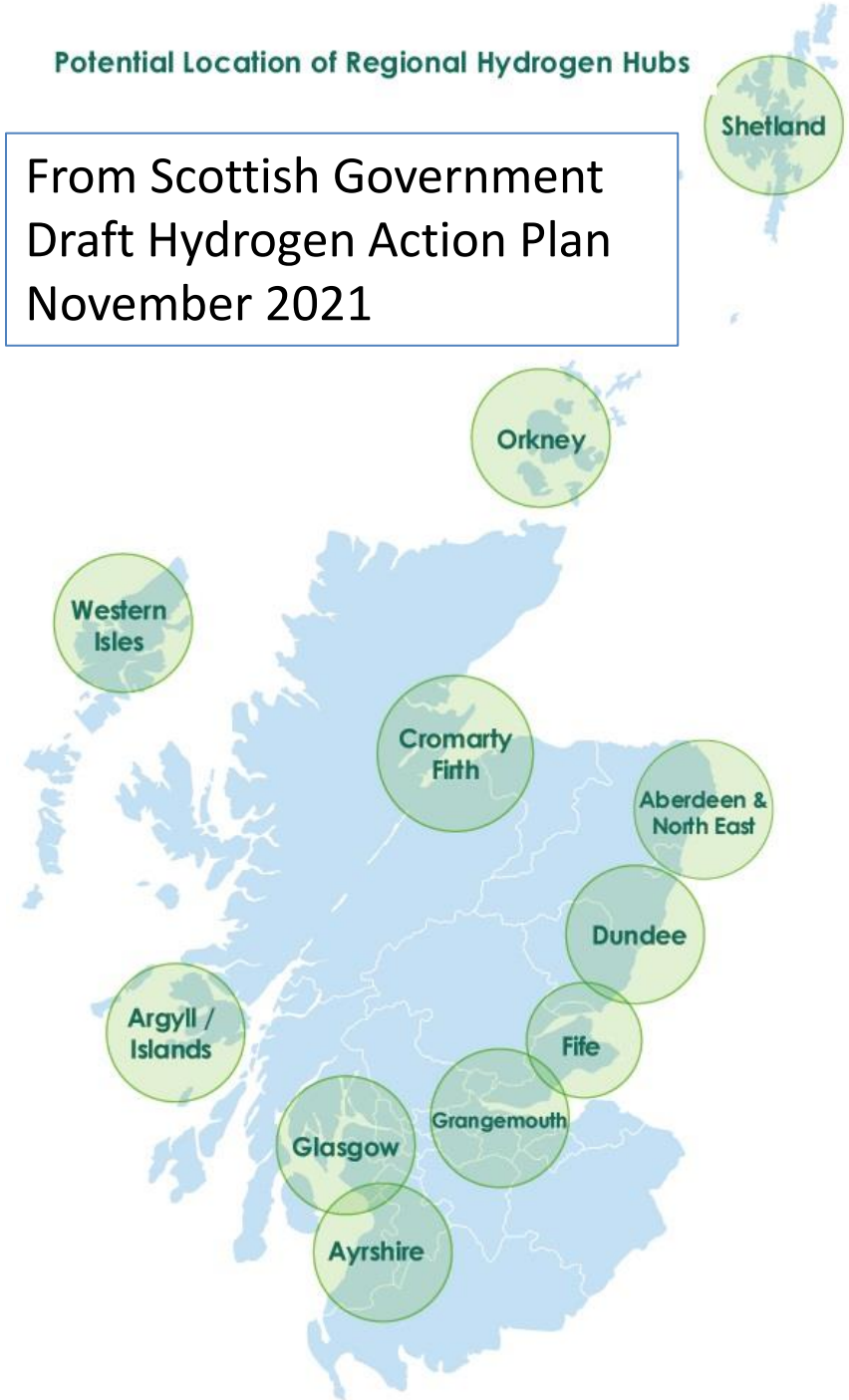


Targets for 11GW of offshore wind and 8-12GW of additional onshore wind capacity in Scotland by 2030



Potential Location of Regional Hydrogen Hubs

From Scottish Government
Draft Hydrogen Action Plan
November 2021



Some of Scotland's Current Hydrogen Projects

End User

01 Cloverhill's Aberdeen Hydrogen First
02 Eden Mill distillery
03 Glasgow Hydrogen Gritters
04 HECTOR project
05 HyDIME
06 HyFlyer
07 HySeas III
08 HySpirits
09 Hytransit Project - Aberdeen Hydrogen Busses
10 Hytrec
11 JIVE 2 - Dundee Hydrogen Transport
12 Kirkwall Airport Decarbonisation
13 Liquid Organic Hydrogen Carriers (LOHC) for the transportation of hydrogen
14 Project HyLaddie
15 Scottish Hydrogen Train project
16 TimberLINK
17 Uist Distilling Company

Multi-vector

18 Aberdeen Hydrogen Hub
19 Aberdeen Vision
20 BIG HIT
21 East Neuk Power to Hydrogen
22 GENCOMM - AD
23 ITEG - Integrating Tidal Energy into the European Grid
24 North of Scotland Hydrogen Programme
25 OHLEH - Outer Hebrides Local Energy Hub
26 Orion Project
27 PITCHES
28 ReFLEX (Responsive Flexibility) Project
29 SWIFTH2
30 PURE Energy Centre
31 Flotta Hydrogen Hub

Production

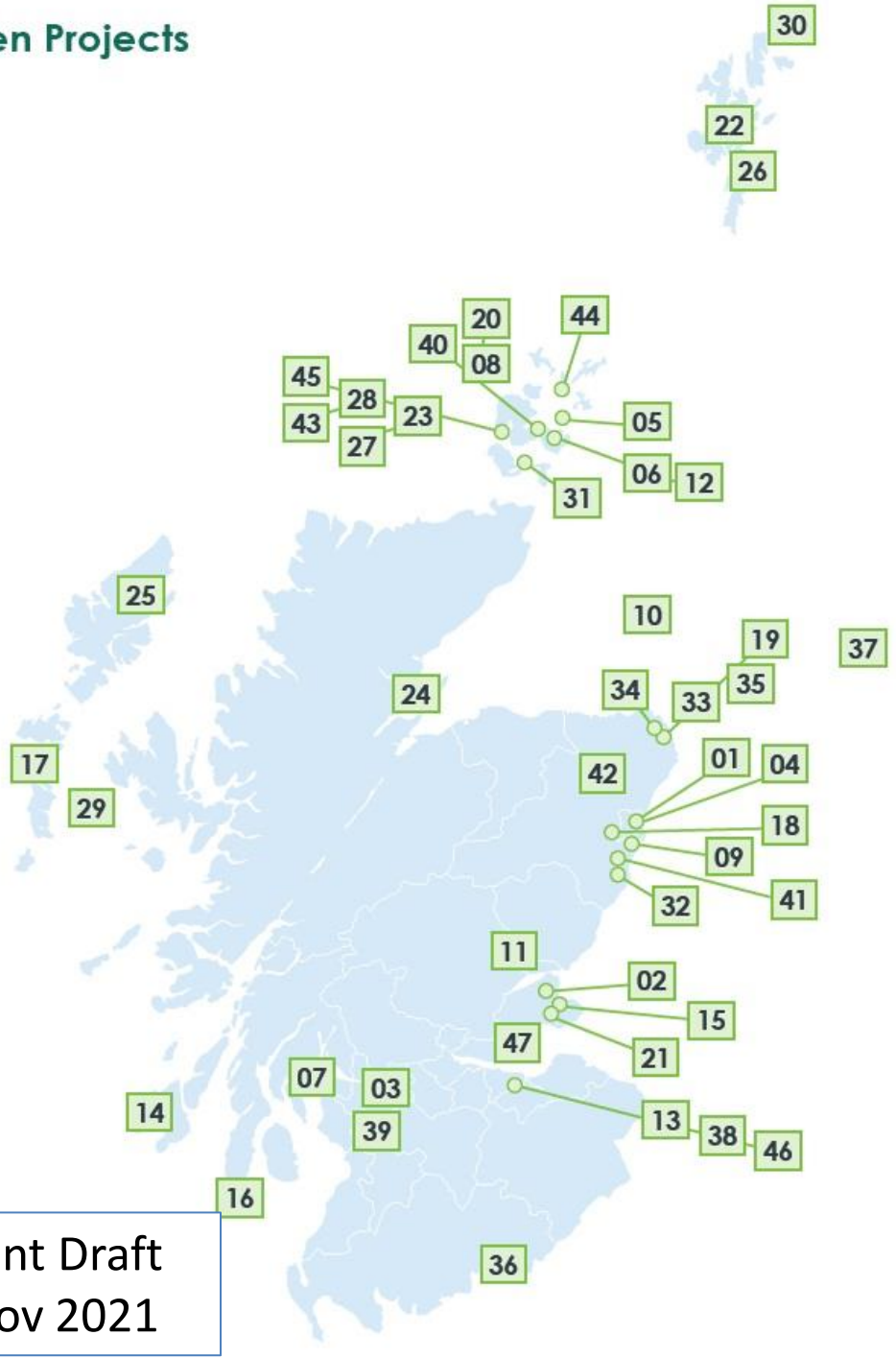
32 Aberdeen Hydrogen Centre (ACHES)
33 Acorn CCS
34 Acorn Hydrogen
35 Caledonia Clean Energy Project
36 Chapelcross Initiative
37 Dolphyn Project
38 Edinburgh International Festival decarbonisation project
39 Green Hydrogen for Glasgow
40 Hammars Hill Green Ammonia project
41 Kittybrewster Refuelling Station
42 Skelmonae Green Hydrogen
43 'Surf 'n' Turf'

Storage

44 Eday Flow Cell Battery Project
45 HyAI
46 HyStorPor Project

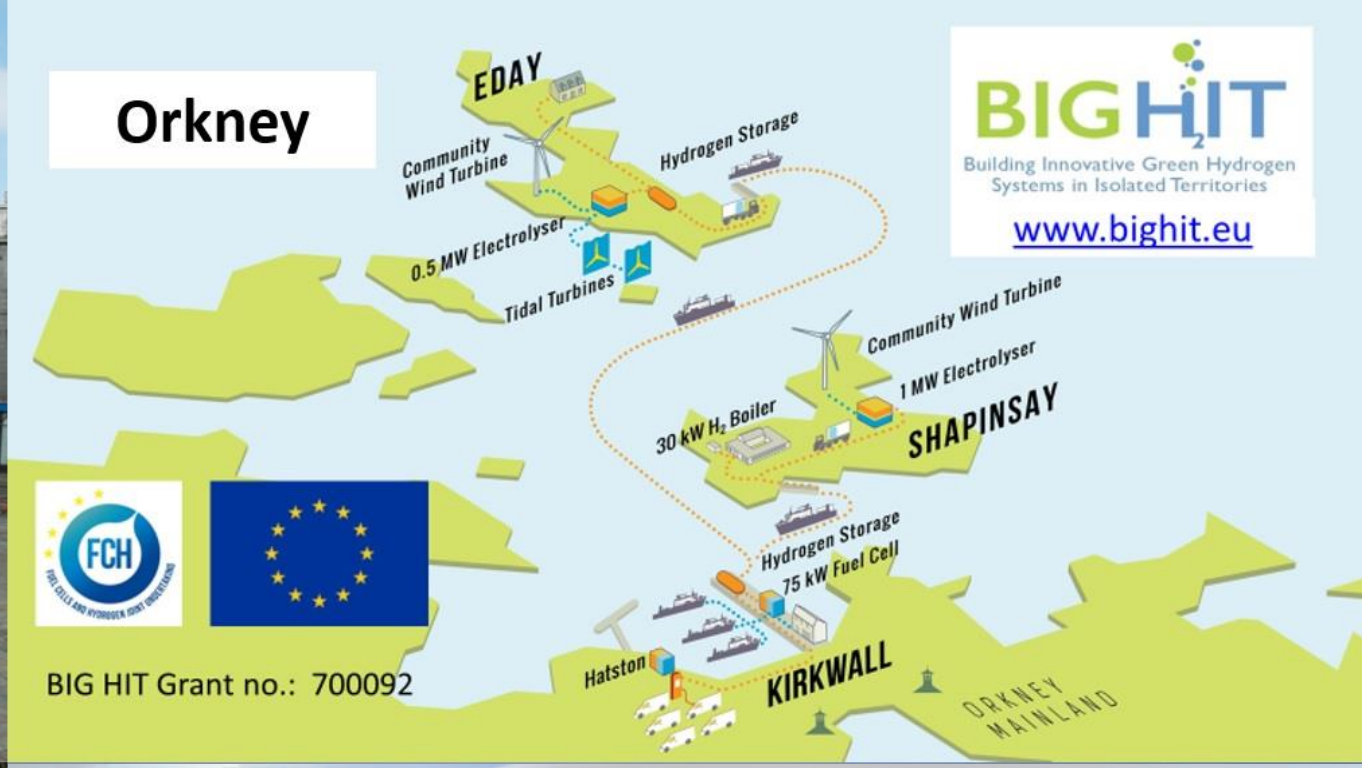
Transmission/distribution

47 H100 Fife project

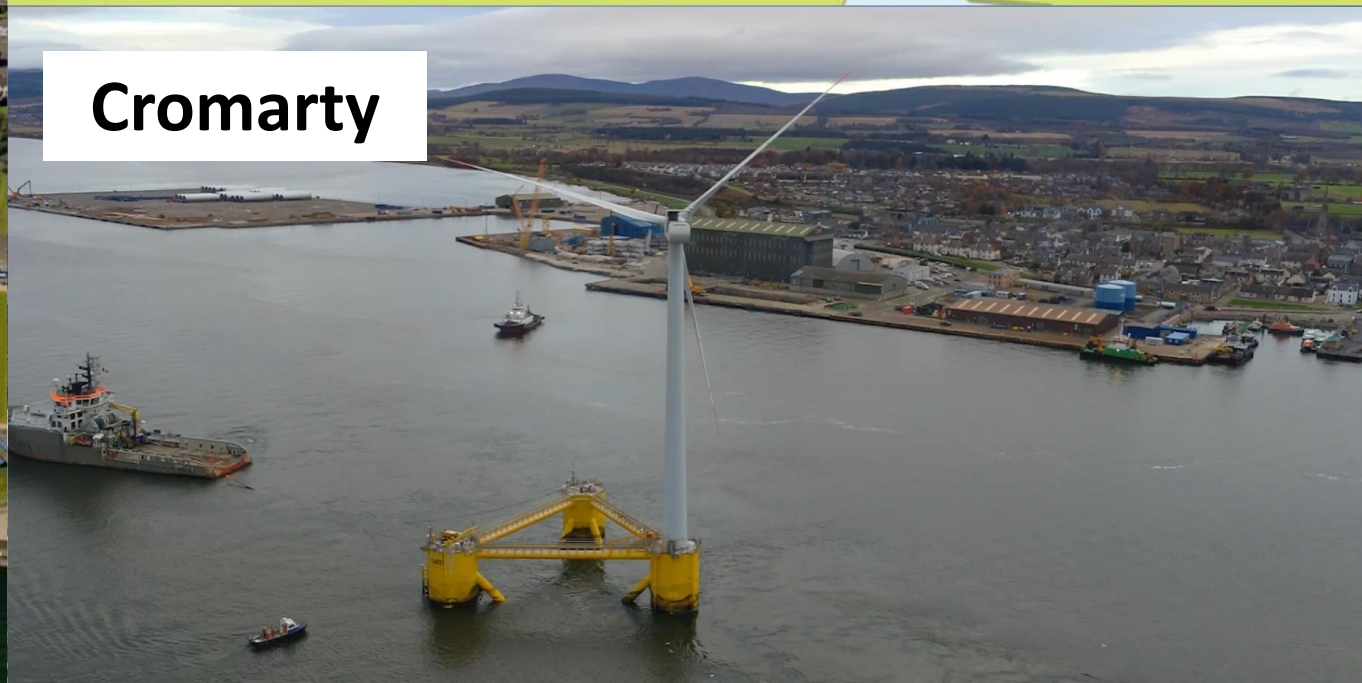


From Scottish Government Draft Hydrogen Action Plan, Nov 2021


Aberdeen
H2
Aberdeen
FCH


Orkney
BIG H2IT
Building Innovative Green Hydrogen Systems in Isolated Territories
www.bighit.eu
EDAY
Community Wind Turbine
Hydrogen Storage
0.5 MW Electrolyser
Tidal Turbines
Community Wind Turbine
1 MW Electrolyser
30 kW H2 Boiler
SHAPINSAY
Hydrogen Storage
75 kW Fuel Cell
Hatston
KIRKWALL
ORKNEY MAINLAND
FCH
BIG HIT Grant no.: 700092

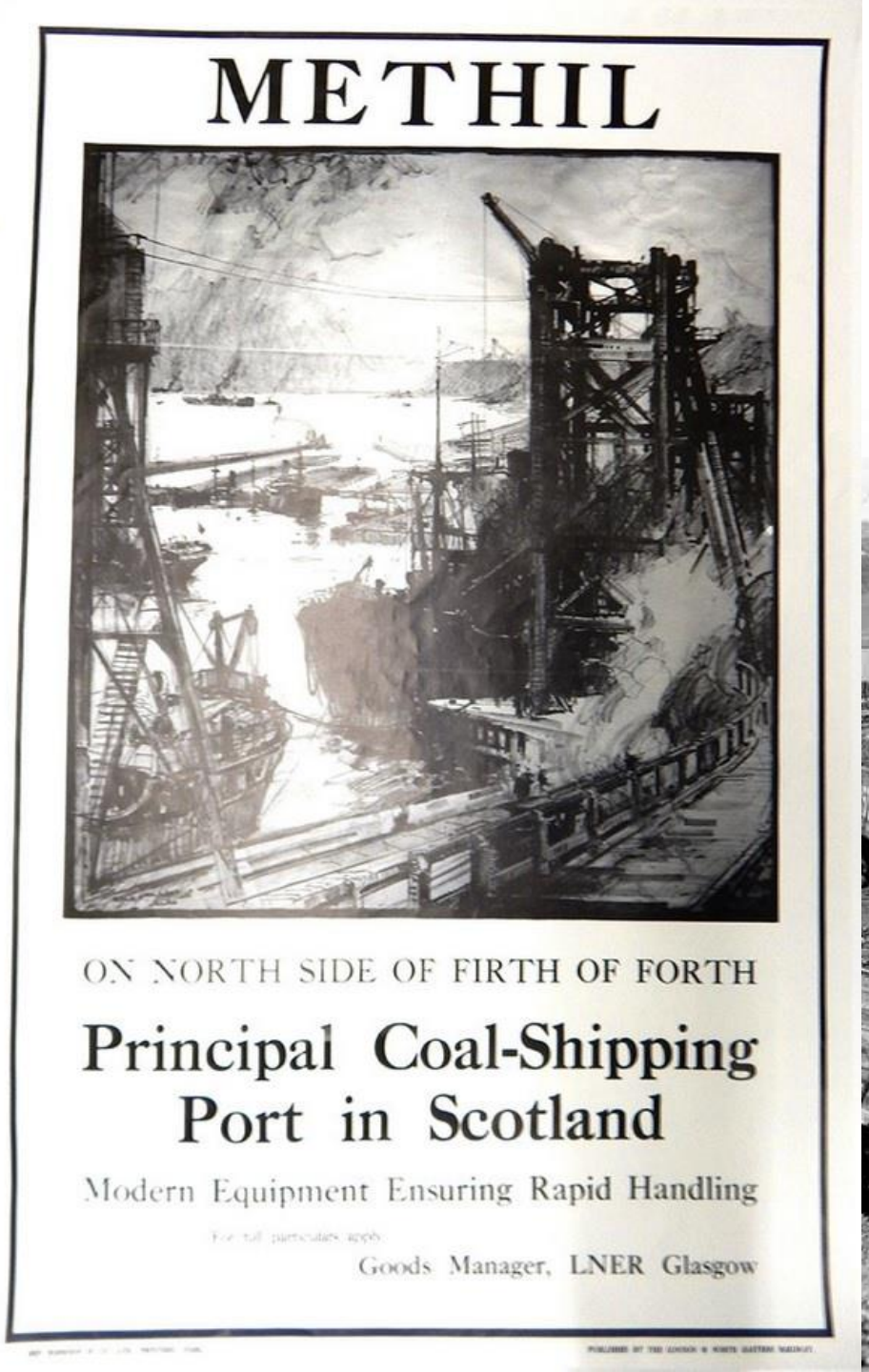

Levenmouth
THE CHALLENGE FUND

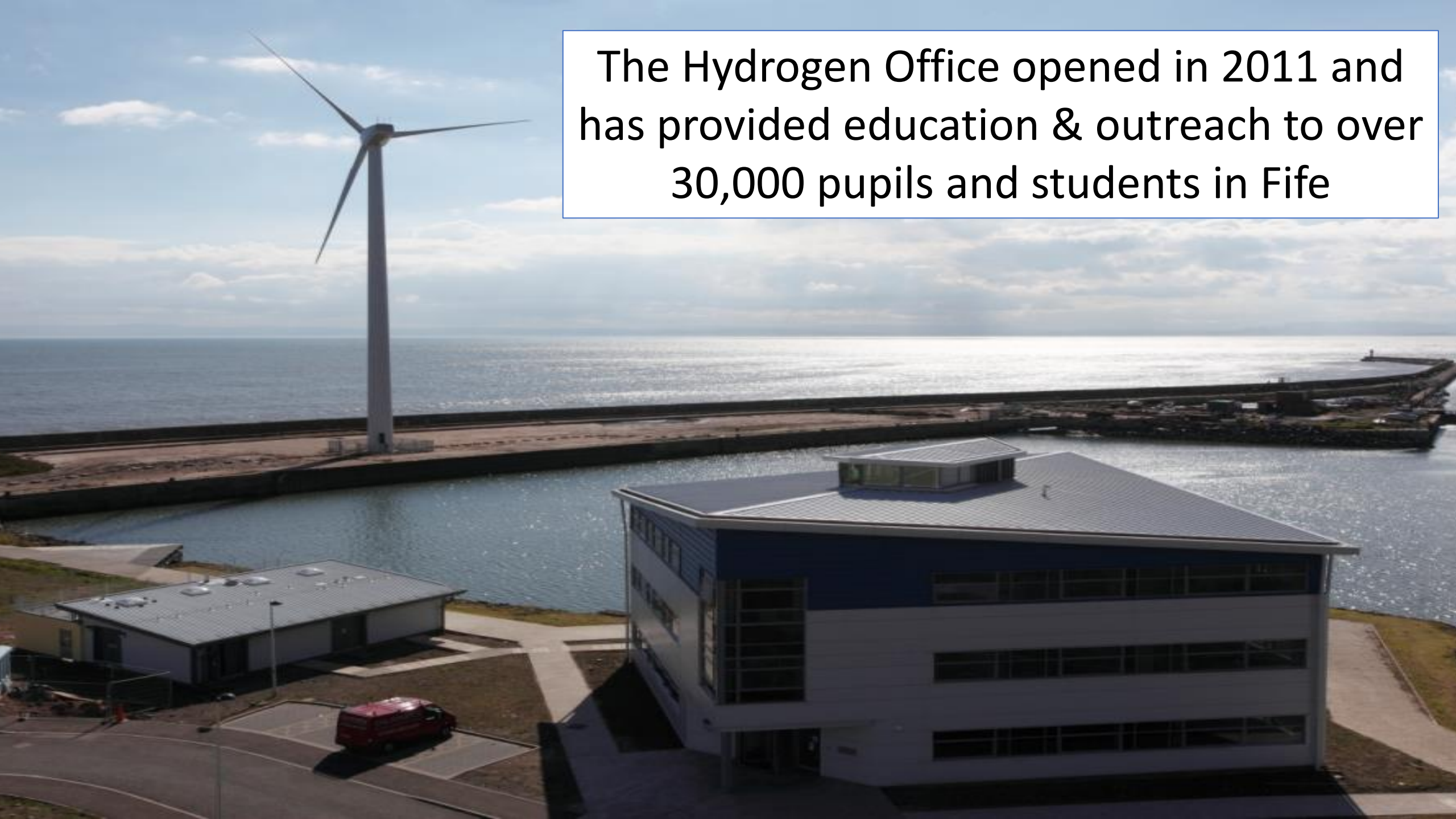

Cromarty

The Hydrogen Office at Levenmouth

Levenmouth Smart Energy System at the Hydrogen Office & FRIC

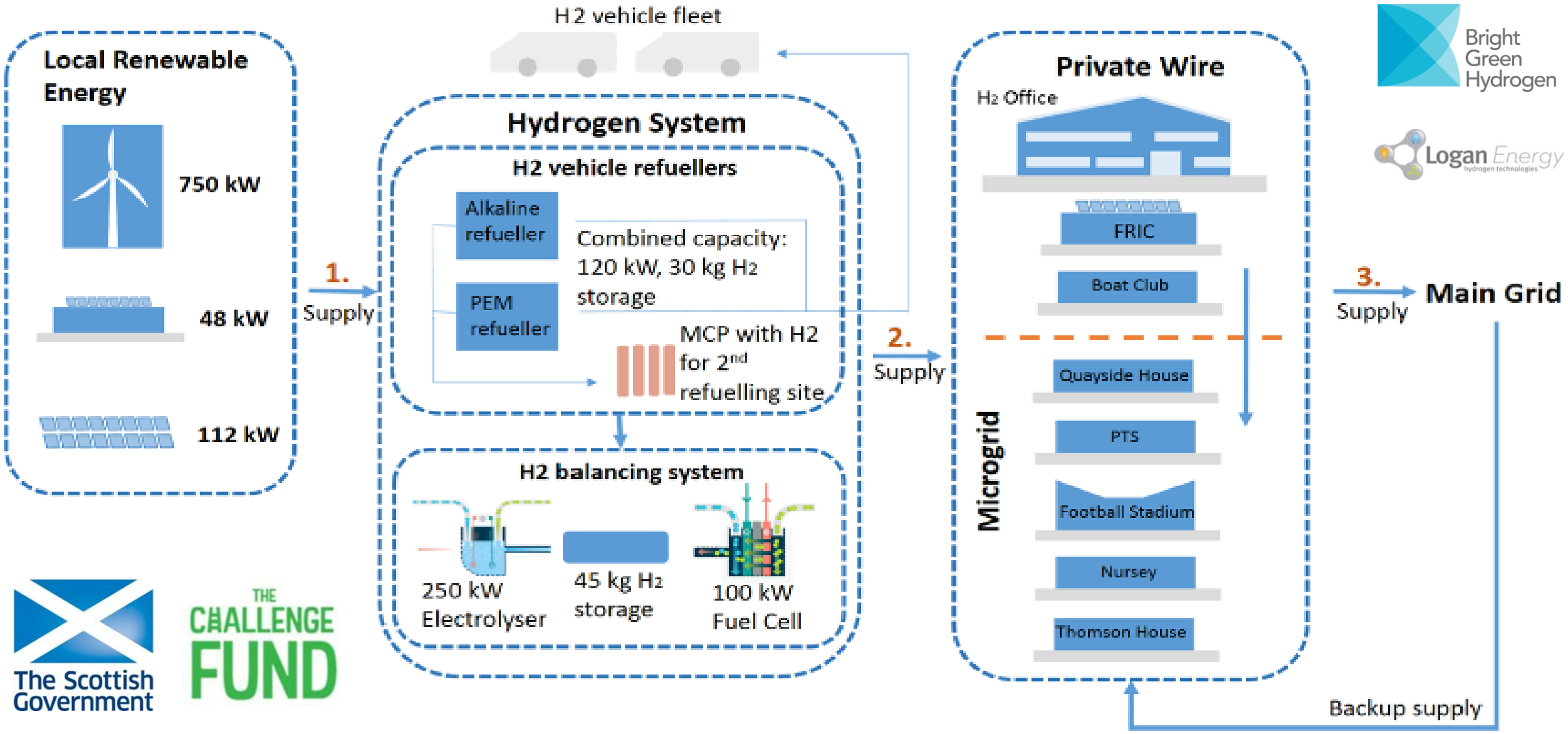
Methil Docks – Exporting Coal





The Hydrogen Office opened in 2011 and has provided education & outreach to over 30,000 pupils and students in Fife

2017: Levenmouth Smart Energy System



TOSHIBA
Leading Innovation

Bright Green Hydrogen

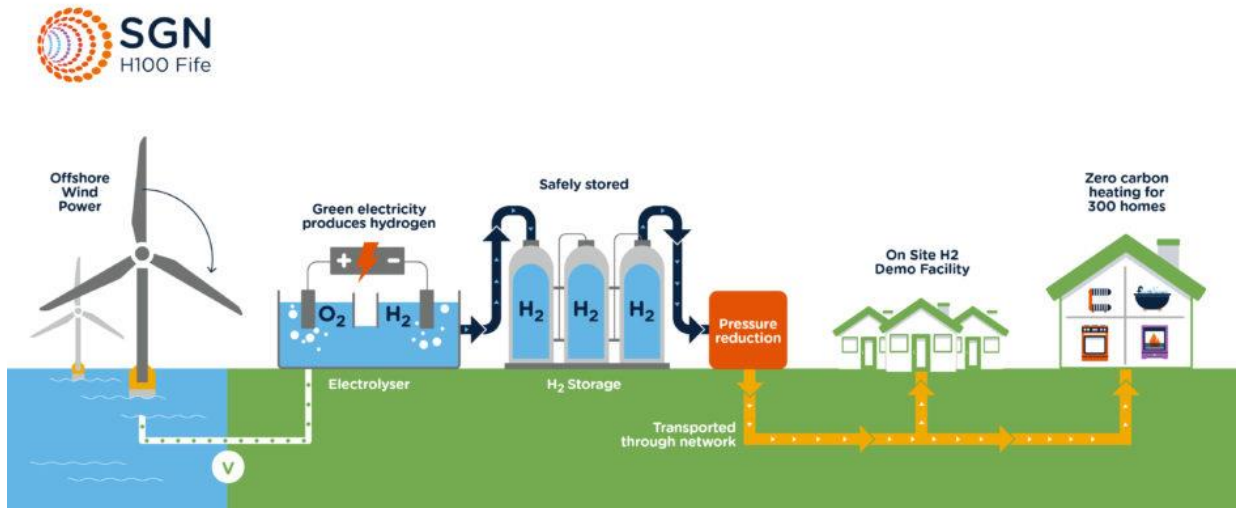
Logan Energy
hydrogen technologies

The Scottish Government

THE CHALLENGE FUND

Next steps: Consumer Acceptance with H100 Fife

Energy Park Fife



100% Green H_2 for household heat

- Use locally produced green H2 for heating & cooking
- Demonstration of reliability and technical R&D
- Households opt-in: positive choice to join the H100 trial
- Match supply/demand in representative and scalable network
- Quantified risk to inform household conversions
- Market creation and key learning of customer acceptance

SGN Your gas. Our network. ARUP kiwa

H100 Fife in Levenmouth

Proving safe use of 100% H_2 for heat

Aberdeen & Energy Transition Zone

BON ACCORD
ABERDEEN
CITY COUNCIL

FCH
FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

Scottish Enterprise

Clean Hydrogen for Fuel Cell Bus Fleet

Some of Aberdeen's 65+ Hydrogen Vehicle Fleet in 2019 including fuel cell and H2 internal combustion power

€22m FCH-JU project

- Started March 2015
- 10 x Van Hool FC buses
- 2 million passengers
- 1.1 million kilometres
- 89% bus availability
- 200+ tonnes H2 used
- 10-12 mins refuel time
- >98% HRS availability

New Hydrogen Double-deckers in operation January 2021

Building the Ambition with Aberdeen H2 Hub

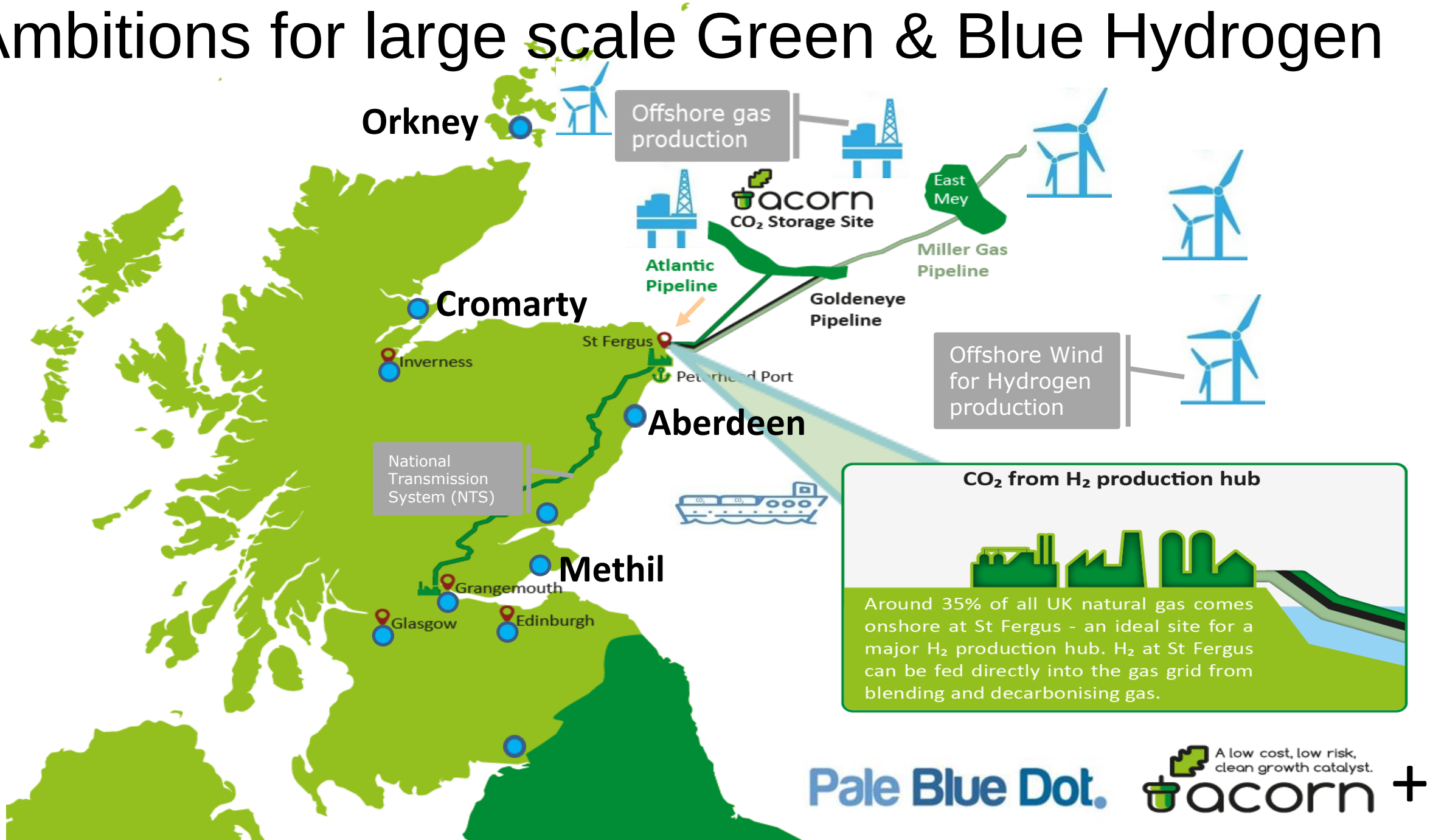
3 February 2022: Aberdeen City Council announces bp as strategic partner for the H2 Hub to accelerate the city's ambitions to become a world-class hydrogen hub with estimated £700M GVA.

A key part of the programme will involve the creation of Scotland's first scalable green hydrogen production facility.

This hydrogen hub will enable supply & export of renewable hydrogen, creating up to 700 skilled jobs in the regional hydrogen economy by 2030.

Louise Kingham OBE of bp with Aberdeen City Council Leader Laing

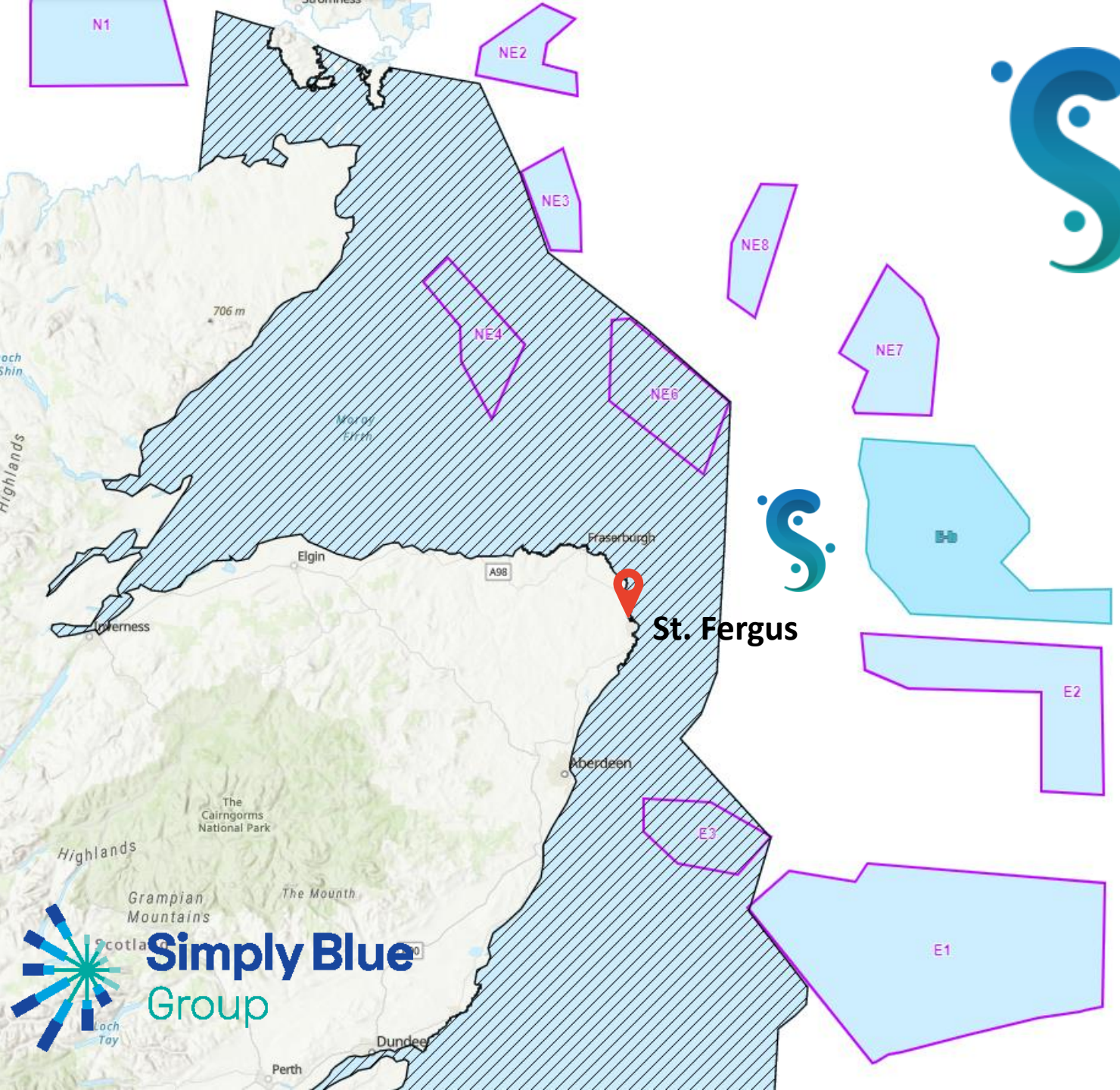
Ambitions for large scale Green & Blue Hydrogen



Pale Blue Dot.

A low cost, low risk, clean growth catalyst.

acorn +



SALAMANDER

200 MW pre-commercial ‘stepping-stone’ floating offshore wind project

Just east of St Fergus, Aberdeen

Exploring multiple potential routes to market including green hydrogen production

MoU with ERM, for ERM Dolphyn

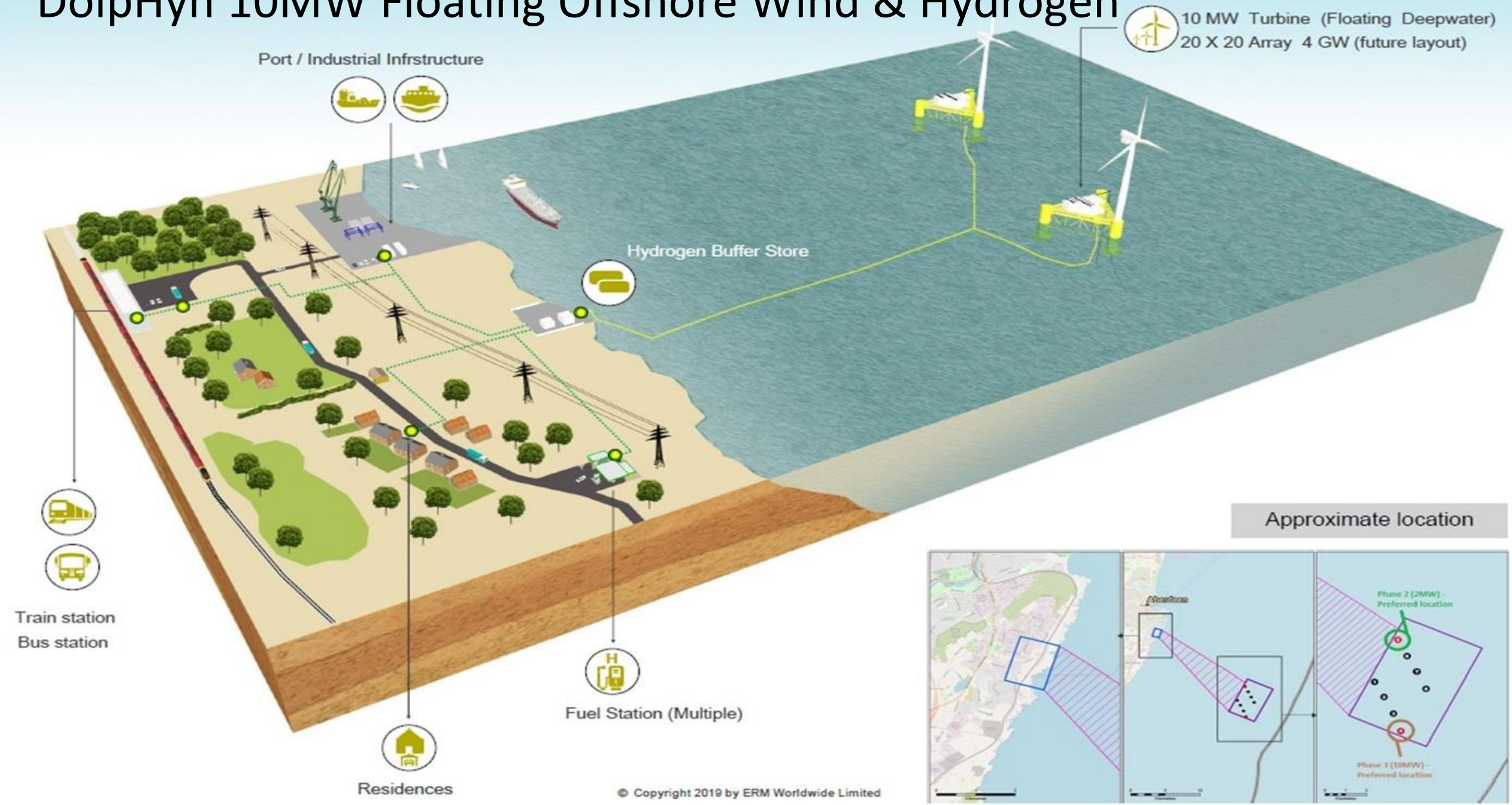
Exploring options with SGN

Links into Aberdeen ETZ

Simply Blue Group

https://salamanderfloatingwind.com/

DolpHyn 10MW Floating Offshore Wind & Hydrogen



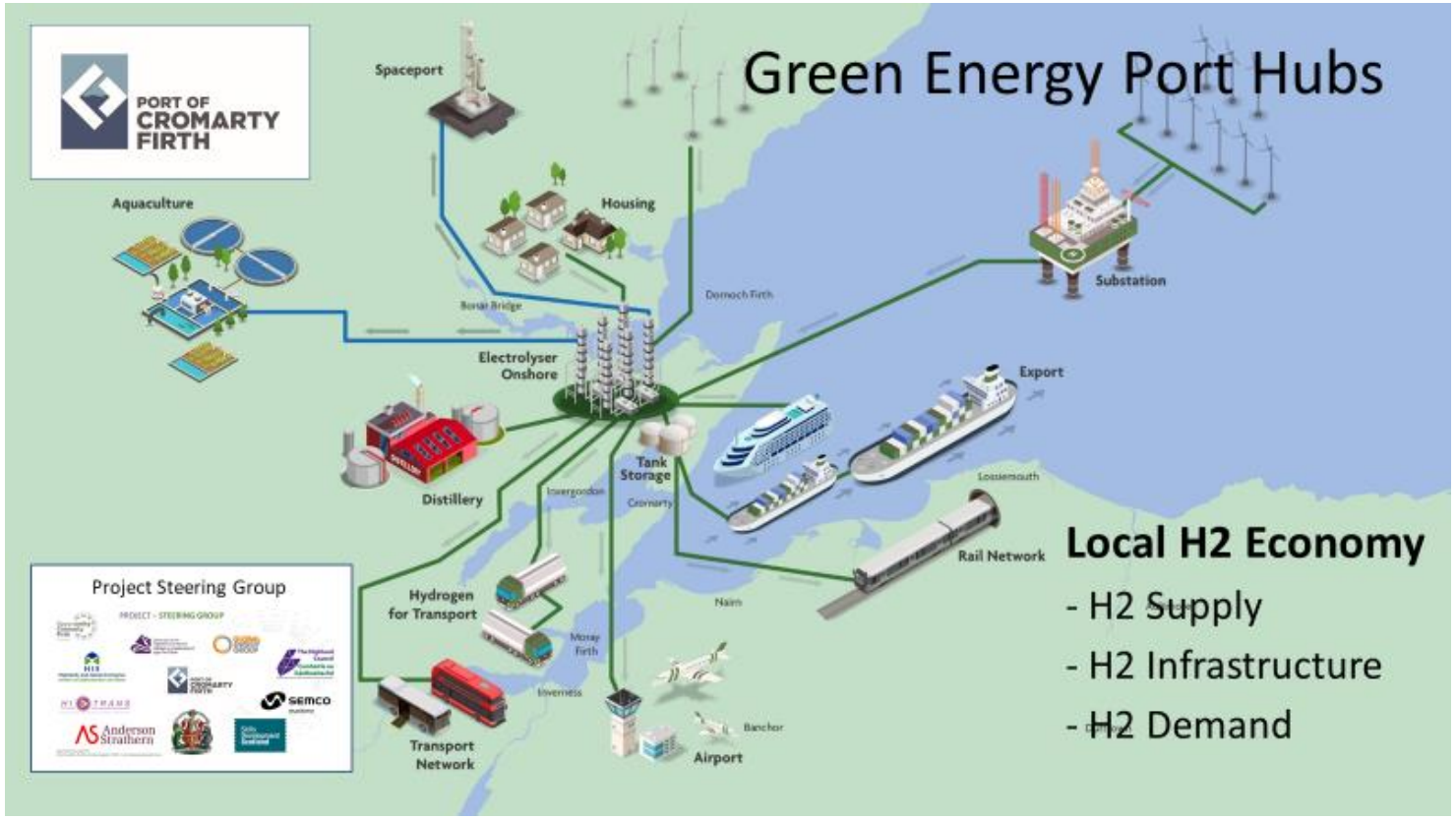
Energy Transition Zone - Hydrogen Campus Concept

Green Hydrogen Test & Demonstration Facilities

- Business incubation & Technology acceleration
- Electrolyser Manufacturing
- Clean Fuels Metrology Centre

Cromarty: Green Hydrogen Hub

One of Scotland's largest natural harbours and connection point to offshore wind power



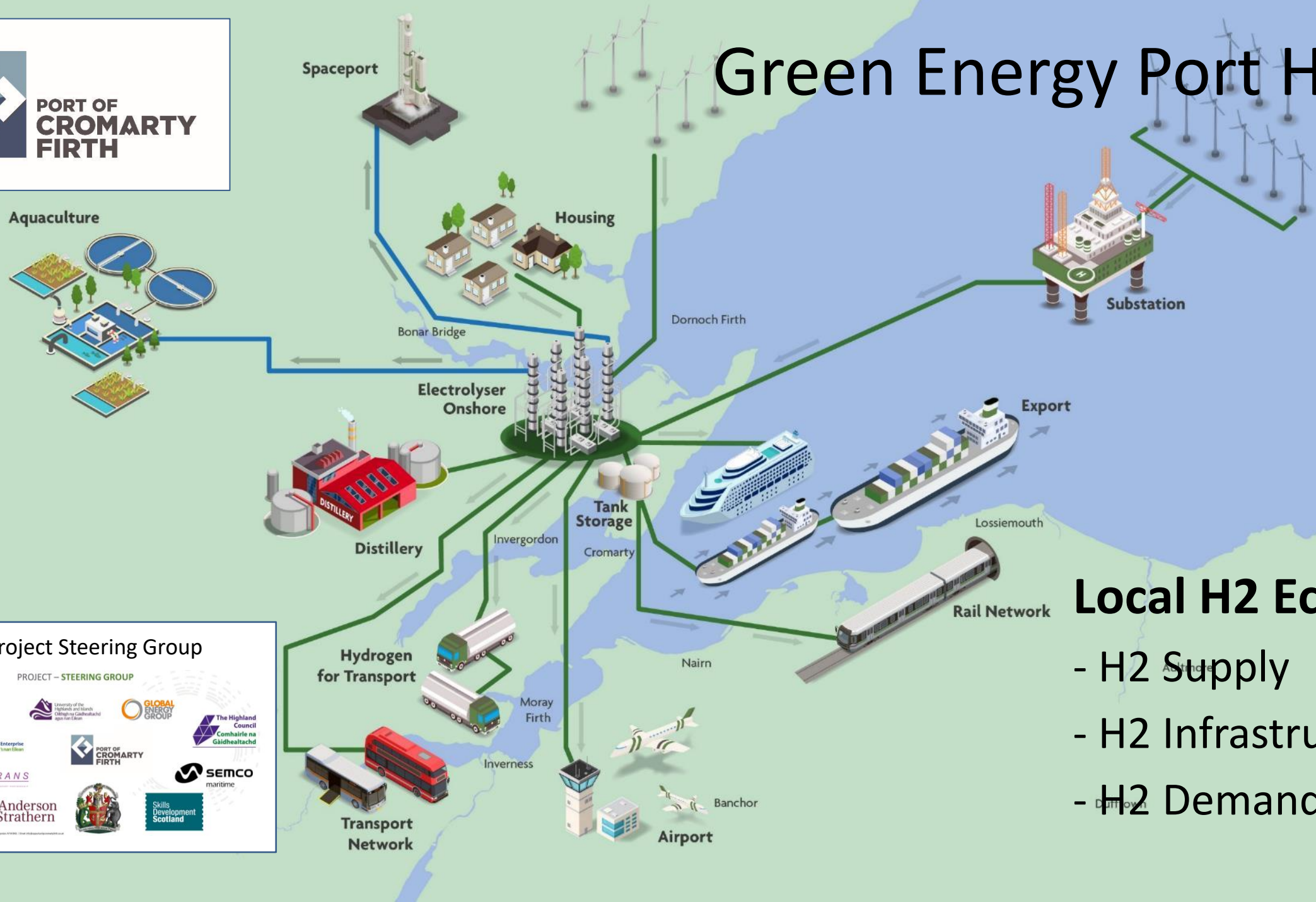
Building local industry demand for green H2

5 March 2021: Port of Cromarty Firth and ScottishPower launch the North of Scotland H2 Hub with 35MW electrolysis capacity

24 May 2021: Port of Cromarty Firth signs MoU for import and transhipment into Europe of green hydrogen from Norway

PORT OF CROMARTY FIRTH

Green Energy Port Hubs



Local H2 Economy

- H2 Supply
- H2 Infrastructure
- H2 Demand

Project Steering Group

PROJECT – STEERING GROUP

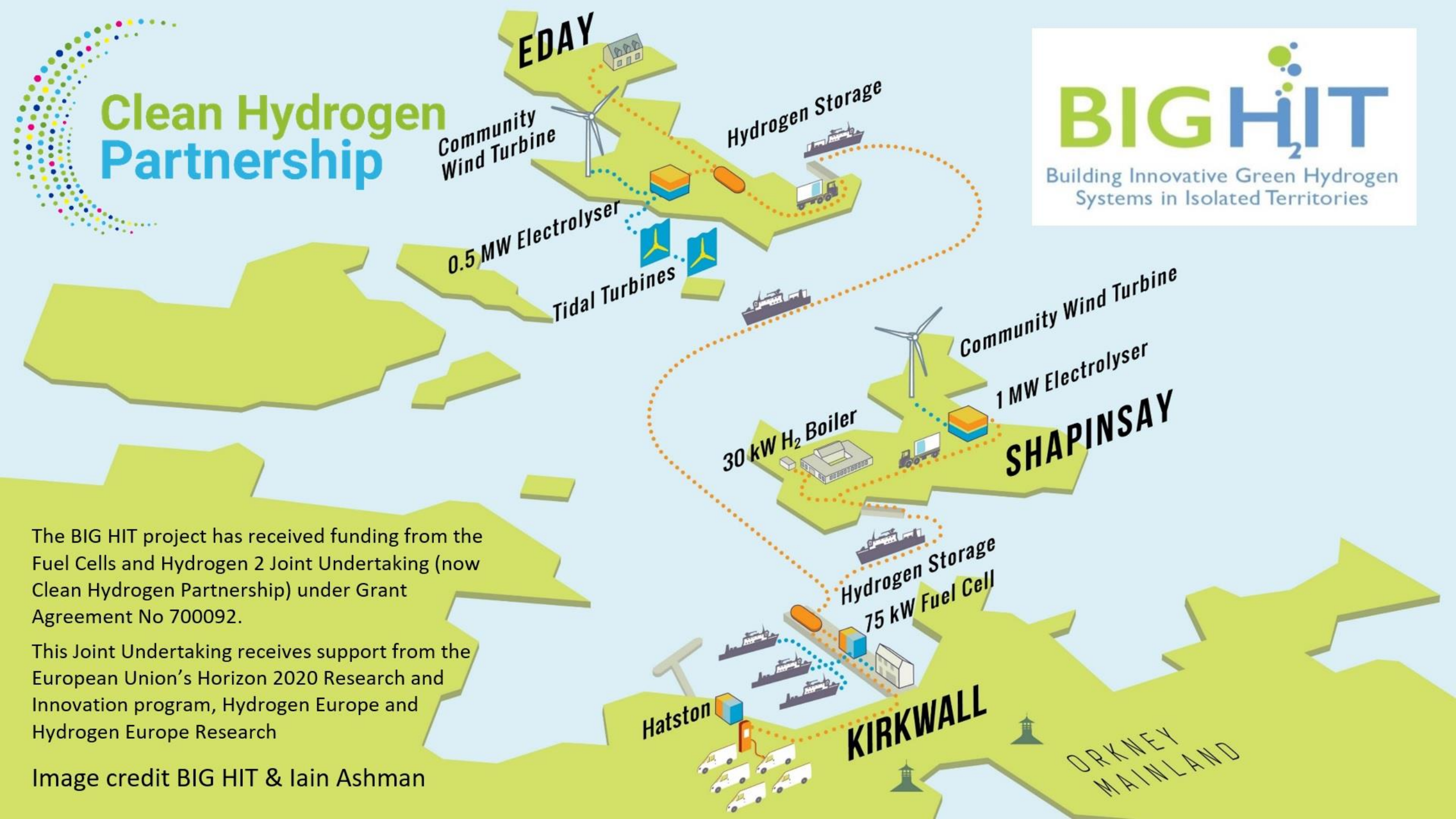
Orkney: >100% Green Electricity

Renewables generate > 100% of Orkney's electricity

Over 50MW of installed renewable capacity

>1000 renewable installations for 10,000 households

By 2014 Orkney was generating 120% of its annual electrical demand from Renewables



The BIG HIT project has received funding from the Fuel Cells and Hydrogen 2 Joint Undertaking (now Clean Hydrogen Partnership) under Grant Agreement No 700092.

This Joint Undertaking receives support from the European Union's Horizon 2020 Research and Innovation program, Hydrogen Europe and Hydrogen Europe Research

Image credit BIG HIT & Iain Ashman

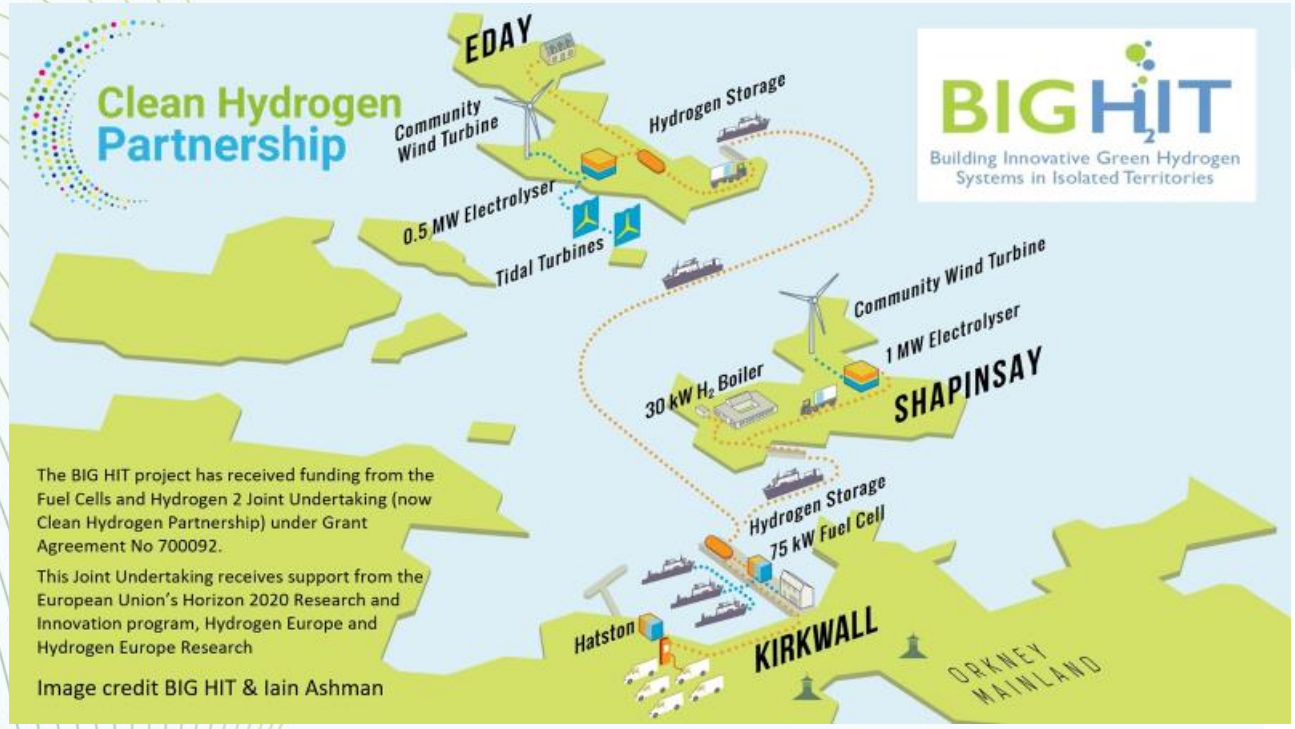
BIGH2IT
Building Innovative Green Hydrogen Systems in Isolated Territories

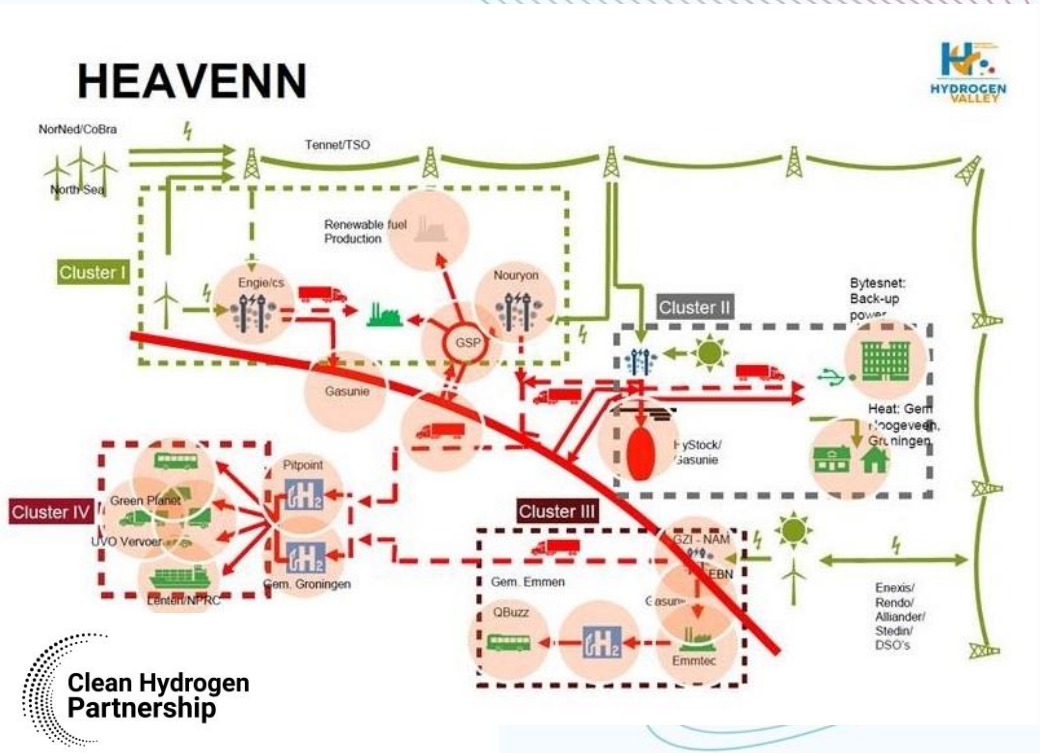
Green Hydrogen for heat, power, & transport

Orkney: Growing the H_2 Portfolio

Next steps with H_2 for marine, aviation, and industry

Scaling up Hydrogen Valleys





Experience and learning from the Clean Hydrogen Partnership supported BIG HIT project in Orkney

Shared with the CH2P's first Hydrogen Valley project in the North Netherlands

HYDROGEN TERRITORIES PLATFORM

http://h2territory.eu/about-the-htp/#become-a-member

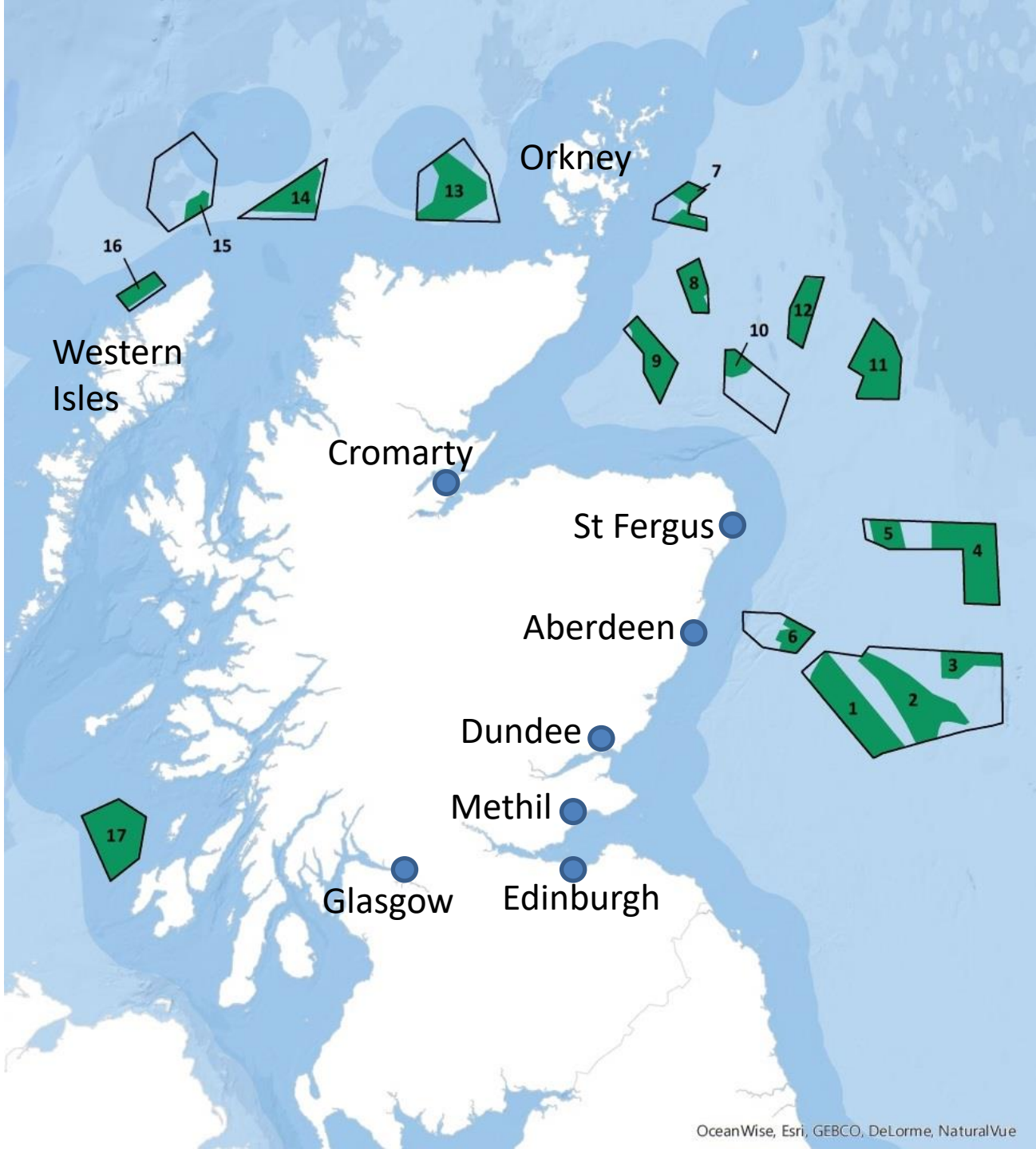
H2TP

Where Next?
Scaling Up Green Hydrogen…

Scaling up Hydrogen for 2030 with Offshore Wind

Scotwind announcement 17 Jan 2022

- successful bidders been offered option agreements for rights to specific areas of seabed around Scotland.
- 17 projects with a total of 24.8 GW of proposed offshore wind capacity have been selected
- £700m will be paid by the successful applicants in option fees
- The area of seabed covered by the 17 projects is just over 7,000km^2



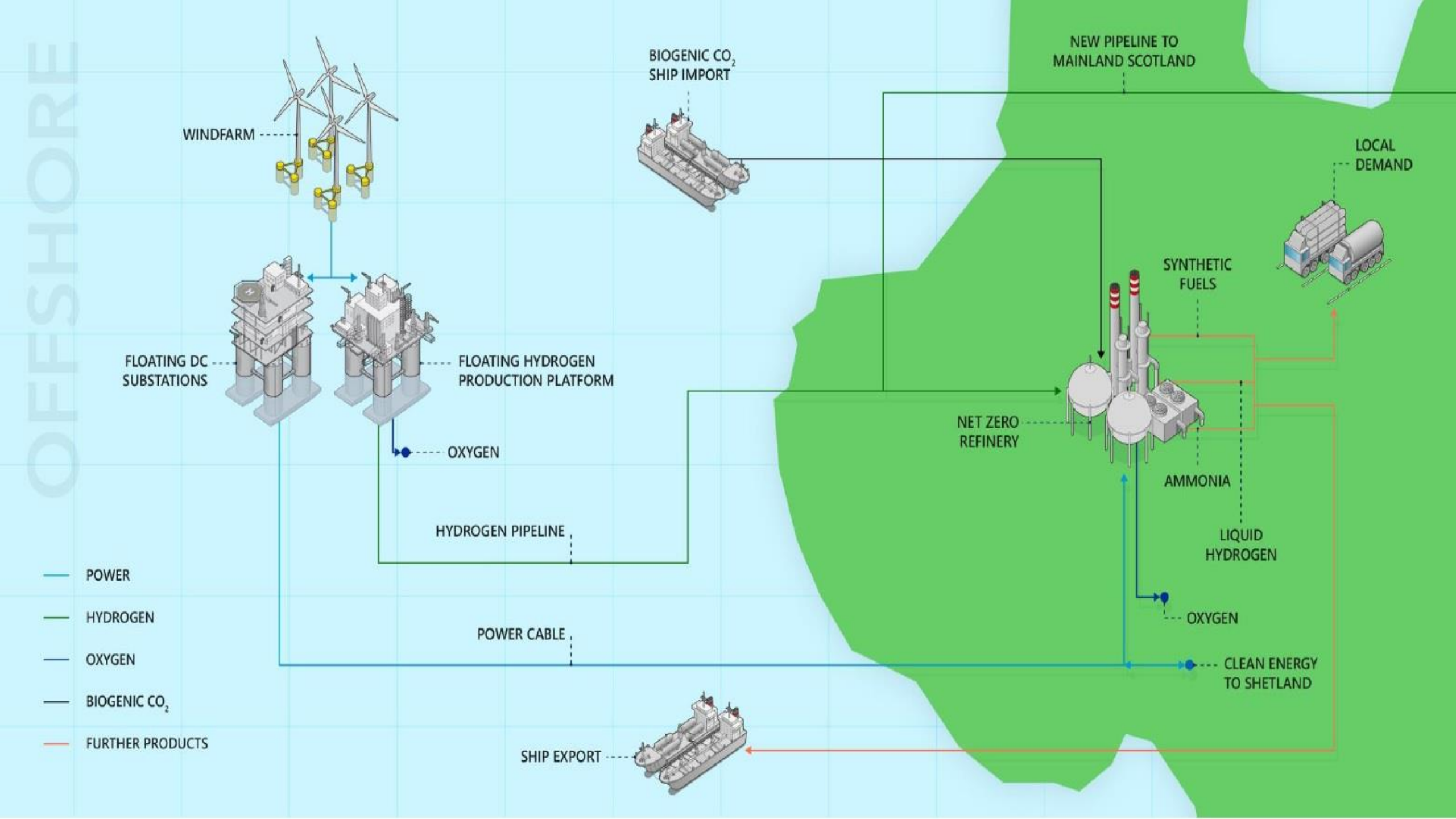

Flotta Hydrogen Hub
Orkney
Orkney proposed Flotta Hydrogen Hub
Using up to 2GW offshore wind from N1
Green H2 production by late 2020’s
New Hydrogen Infrastructure
Existing Facility
New Electrical Substation for Offshore Windfarm
https://www.flottahydrogenhub.com/

Shetland ORION Clean Energy Project

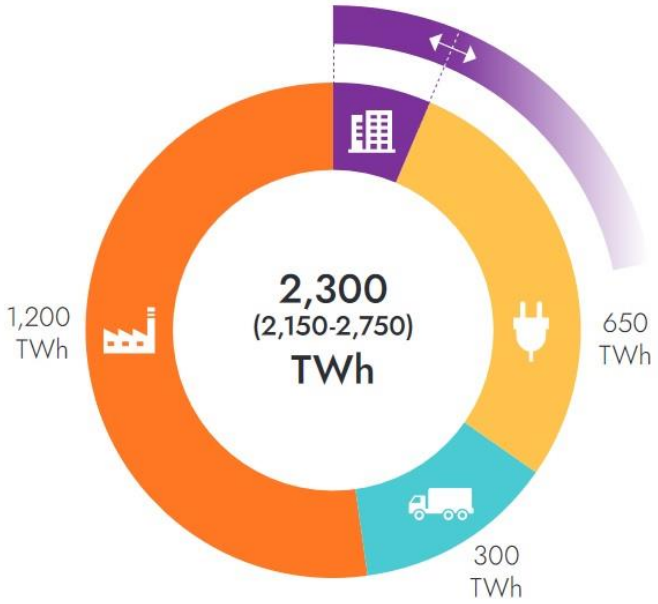
Green H_2 from onshore & offshore wind

Repurpose Sullom Voe oil & gas terminal

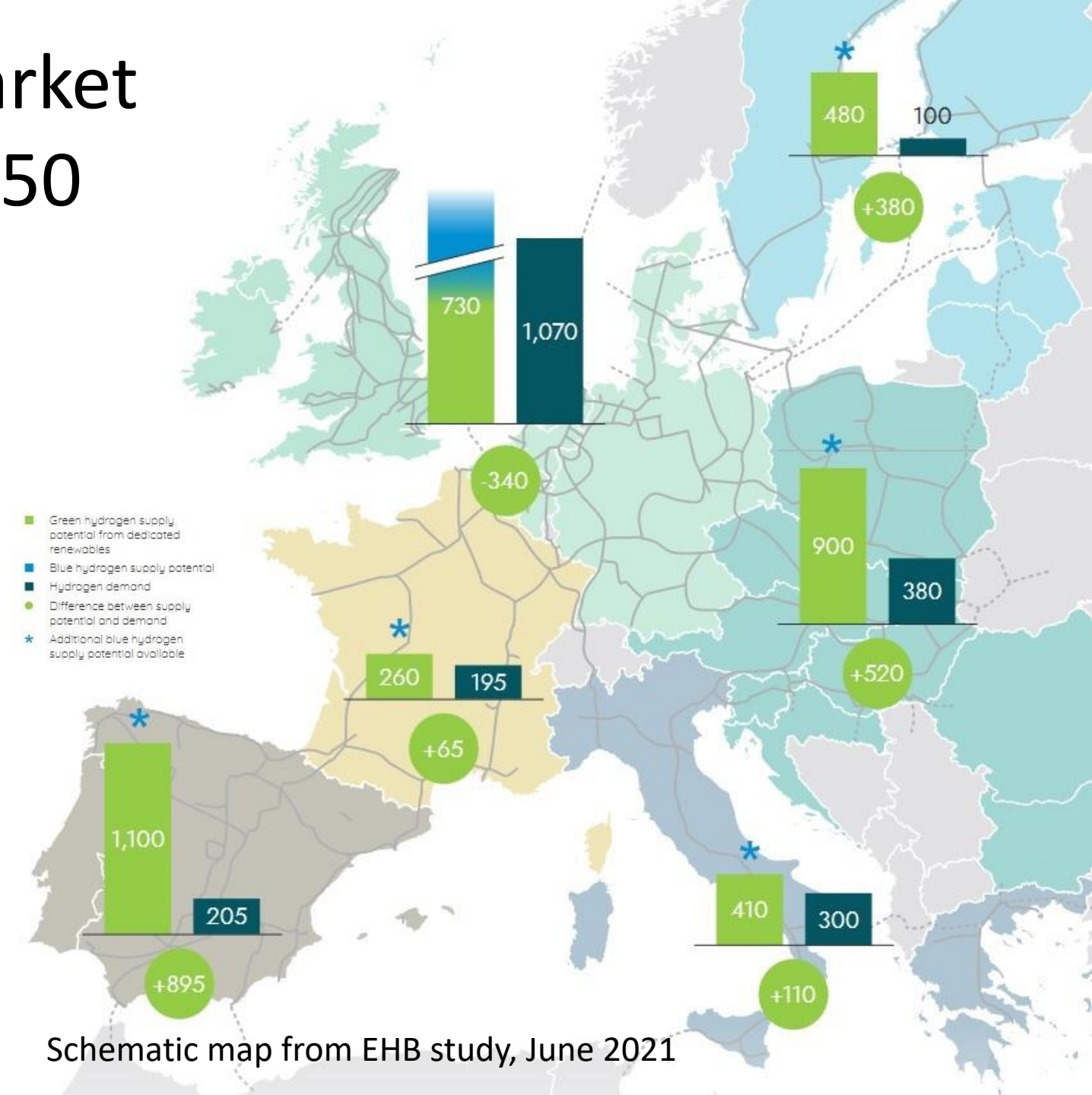
https://www.orioncleanenergy.com/


OFFSHORE
WINDFARM
BIOGENIC CO_2 SHIP IMPORT
NEW PIPELINE TO MAINLAND SCOTLAND
LOCAL DEMAND
SYNTHETIC FUELS
FLOATING DC SUBSTATIONS
FLOATING HYDROGEN PRODUCTION PLATFORM
OXYGEN
NET ZERO REFINERY
AMMONIA
LIQUID HYDROGEN
HYDROGEN PIPELINE
OXYGEN
POWER CABLE
CLEAN ENERGY TO SHETLAND
SHIP EXPORT
POWER
HYDROGEN
OXYGEN
BIOGENIC CO_2
FURTHER PRODUCTS

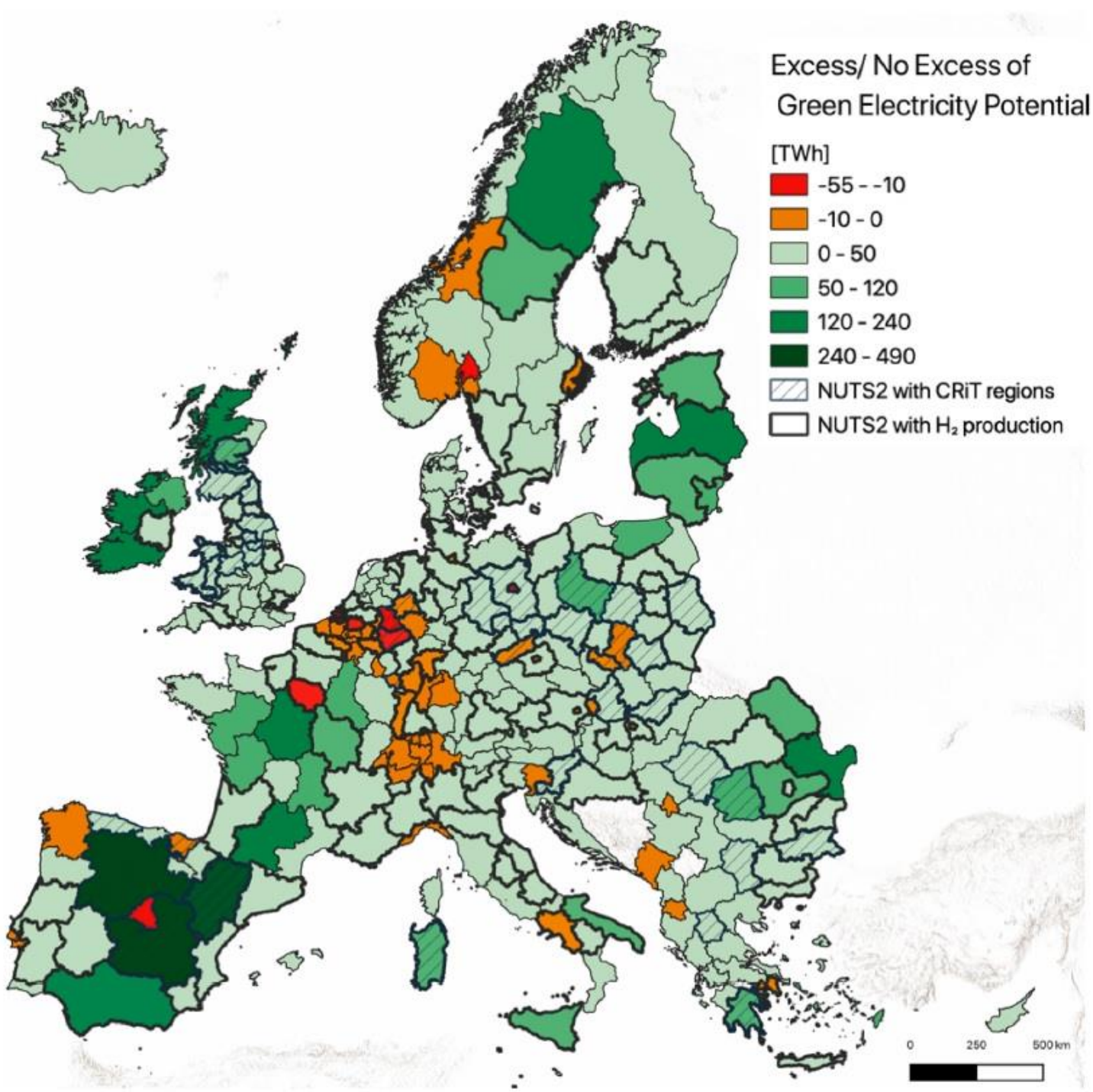
European Hydrogen Market Supply & Demand in 2050

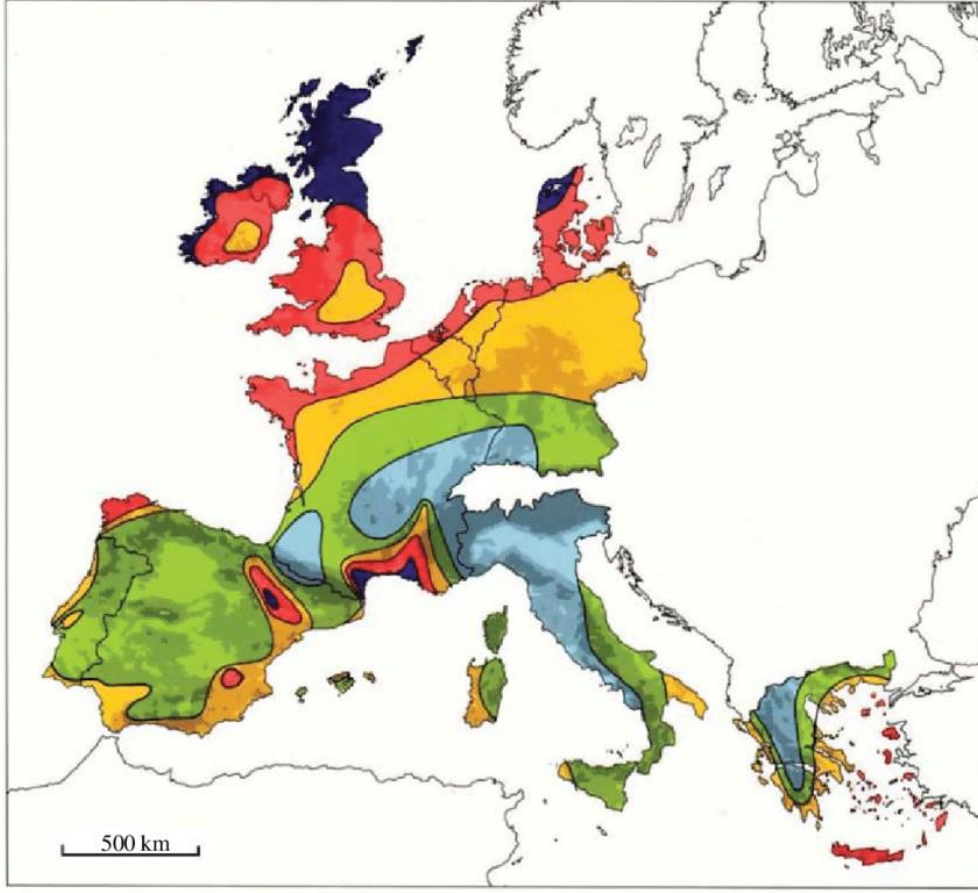


Hydrogen will be crucial to ensure that Europe becomes a climate-neutral continent (EHB study, June 2021



Schematic map from EHB study, June 2021





wind resources at 50 m above ground level for five different topographic conditions

	sheltered terrain		open plain		at a sea coast		open sea		hills and ridges	
	ms^{-1}	Wm^{-2}	ms^{-1}	Wm^{-2}	ms^{-1}	Wm^{-2}	ms^{-1}	Wm^{-2}	ms^{-1}	Wm^{-2}
	>6.0	>250	>7.5	>500	>8.5	>700	>9.0	>800	>11.5	>1800
	5.0–6.0	150–250	6.5–7.5	300–500	7.0–8.5	400–700	8.0–9.0	600–800	10.0–11.5	1200–180
	4.5–5.0	100–150	5.5–6.5	200–300	6.0–7.0	250–400	7.0–8.0	400–600	8.5–10.0	700–120
	3.5–4.5	50–100	4.5–5.5	100–200	5.0–6.0	150–250	5.5–7.0	200–400	7.0 – 8.5	400 – 70
	<3.5	<50	<4.5	<100	<5.0	<150	<5.5	<200	<7.0	<400

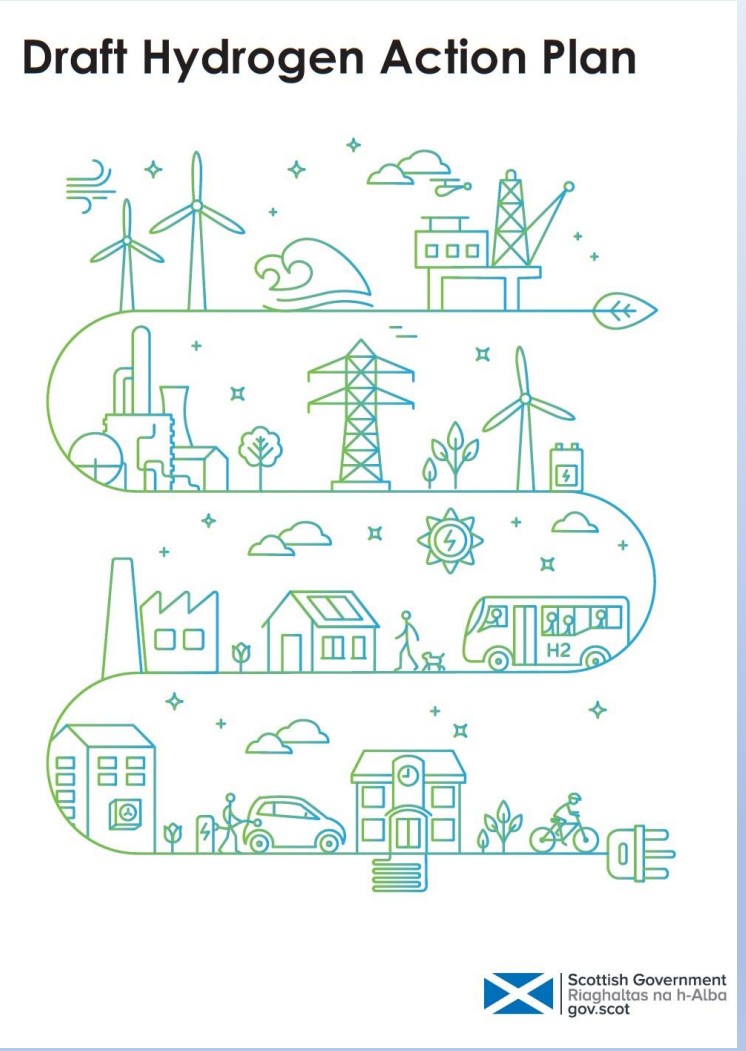
European onshore wind potential (above):
https://www.hindawi.com/journals/jwe/2014/415898/

Green H2 in Europe – a regional assessment (left):
https://www.sciencedirect.com/science/article/pii/S0196890420311766

Turning Scotland's Hydrogen Policy into Actions

Scotland's Draft Hydrogen Action Plan outlines actions to enable delivery of key targets for the hydrogen economy in Scotland, with areas for partnerships on innovation and trade:

- **Action 31**: inward and outbound trade missions
- **Action 33**: strengthen existing relationships and develop bilateral partnerships, with MoUs to help build H2 markets and shared H2 economies
- **Action 36**: support multi-national collaboration on H2 R&D challenges, including Mission Innovation and the Clean Hydrogen Partnership
- **Action 37**: support calls for joint academic and applied research proposals on key H2 challenges



https://www.gov.scot/news/making-scotland-a-leading-hydrogen-producer/

Opportunities - Scaling up Hydrogen

Scotland has target for Net Zero by 2045, and annual electricity demand is now almost all met by renewables. Hydrogen Valleys are developing in Aberdeen, Fife, Orkney, and the port of Cromarty region.

Scotland's Draft Hydrogen Action Plan outlines the actions to enable delivery of key targets for the hydrogen economy in Scotland, with areas for partnerships on innovation and trade.

Scaling up green hydrogen production and demand, with much of Scotland's 5GW low carbon hydrogen by 2030 likely to be from offshore wind.

Partnerships for scaling up Hydrogen will support the Just Transition from fossil fuels to low carbon energy, with opportunities for sharing experience.

SHFCA Members: Building the Hydrogen Economy

Some of our 200+ SHFCA members… contact info@shfca.org.uk for membership details

SCOTTISH Hydrogen & Fuel Cell ASSOCIATION

INFORM
CONNECT
GROW

Hydrogen in Scotland

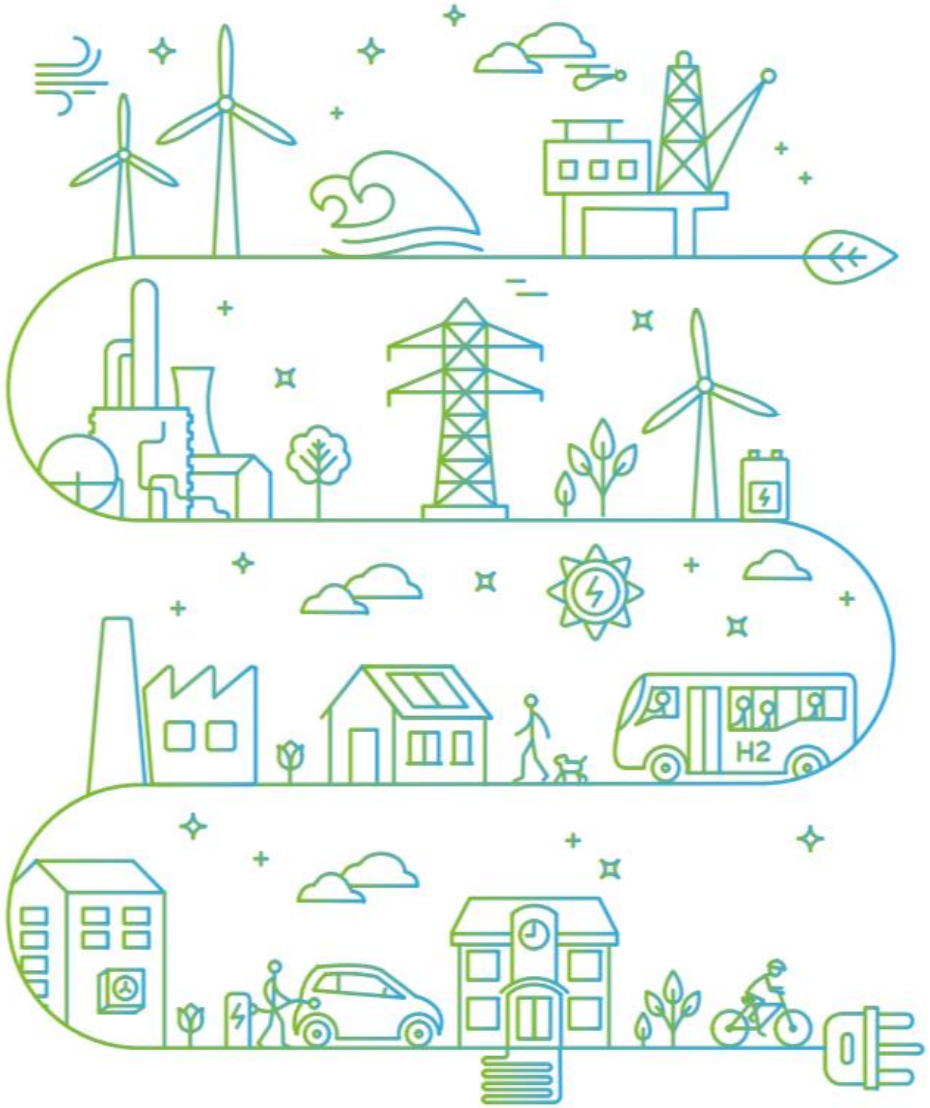
Scaling up Hydrogen for Net Zero by 2045

Nigel Holmes, SHFCA

info@shfca.org.uk

Hydrogen Action Plan for Scotland

Stuart McKay
Head of Hydrogen Policy

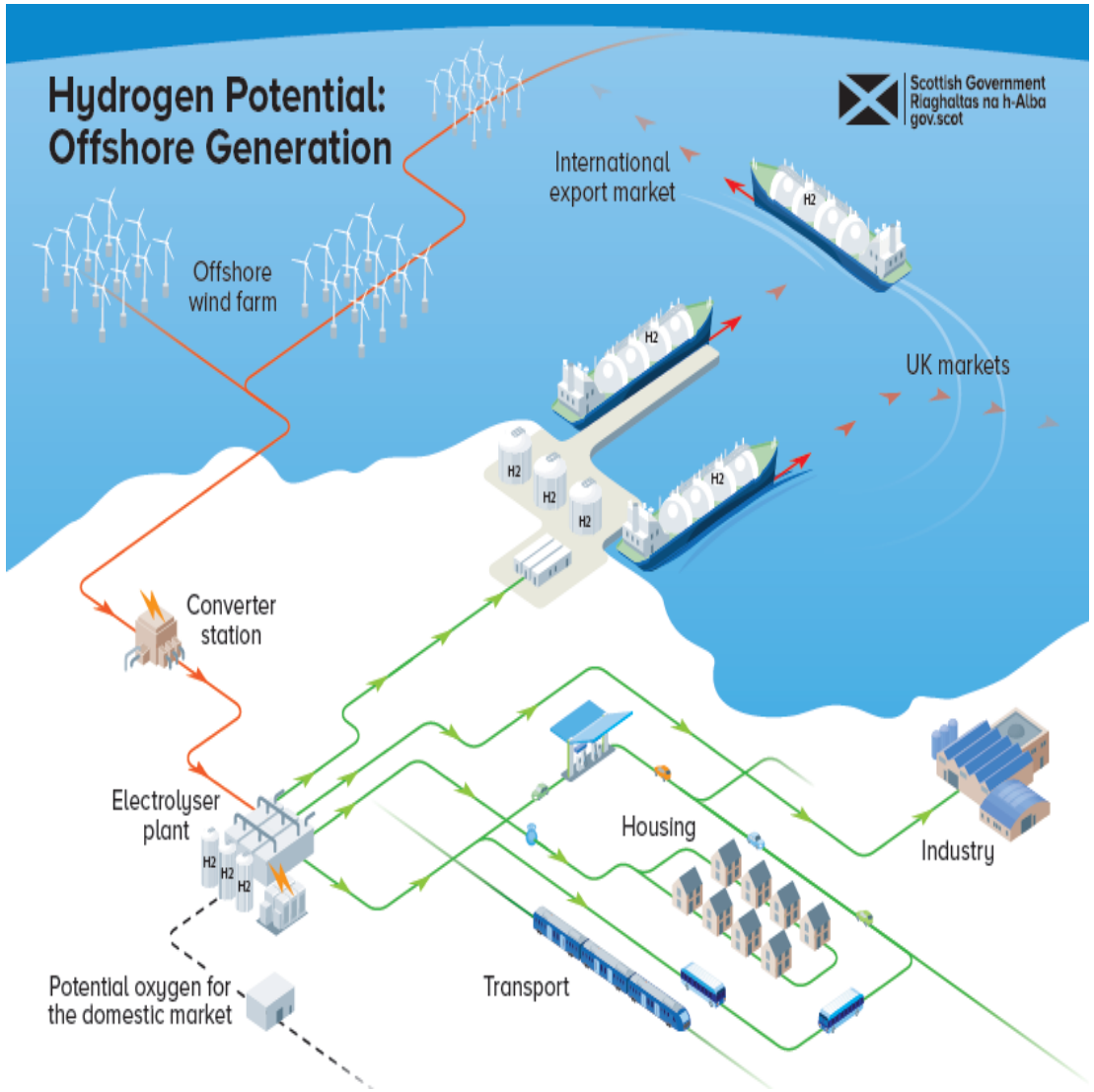


Scottish Government
Riaghaltas na h-Alba
gov.scot

Policy Background

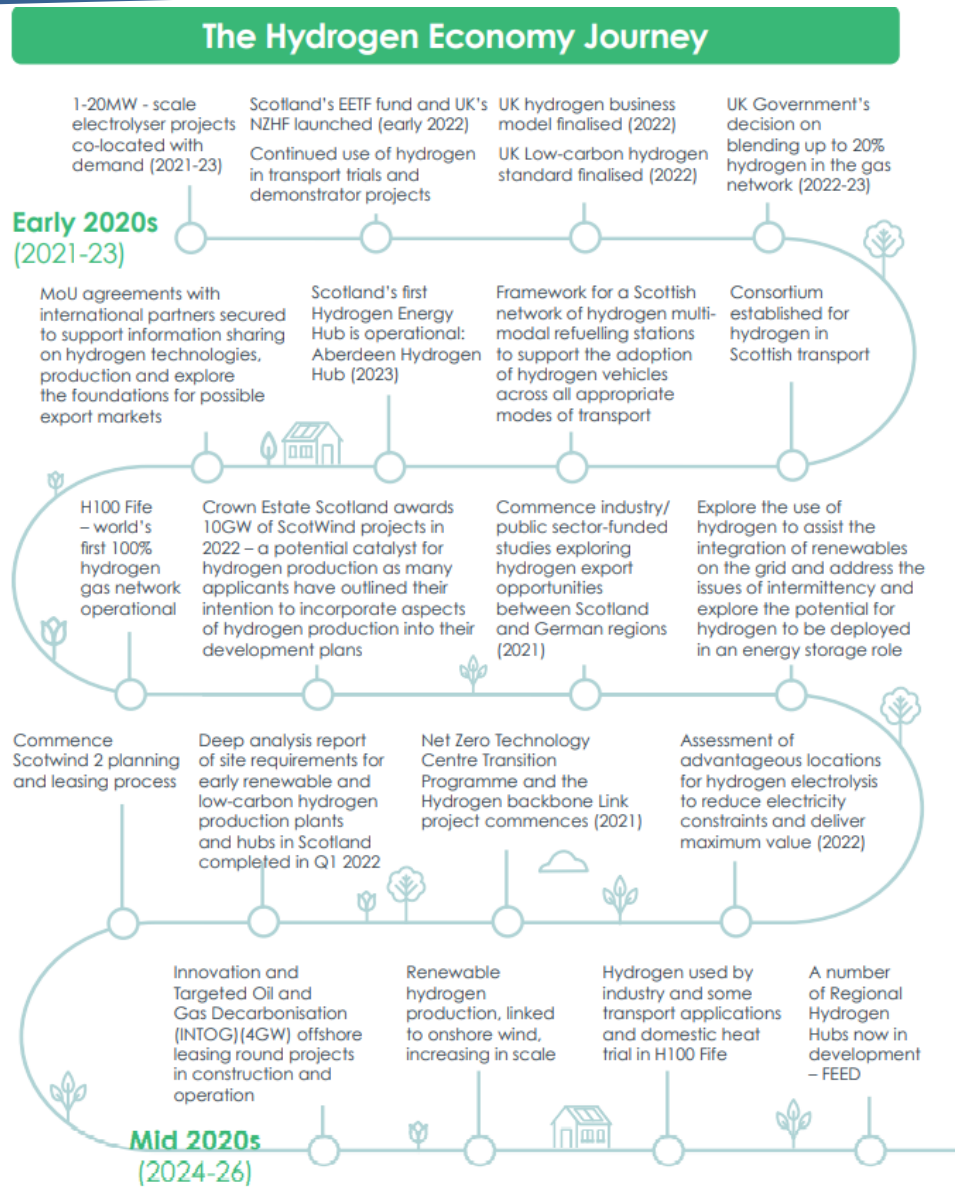
Hydrogen Assessment Project → Hydrogen Policy Statement → Draft Hydrogen Action Plan

- Scotland's abundant offshore wind resources offer the potential for large scale production of renewable hydrogen
- Hydrogen is not just an energy and emissions reduction opportunity, it could also have an important role in generating new economic opportunities in Scotland
- Both renewable and low-carbon hydrogen will play an important role in our transition to net zero in 2045
- **Ambition of 5GW installed hydrogen production capacity by 2030 and 25GW by 2045**



Hydrogen Action Plan

- Companion document to Hydrogen Policy Statement
- Defines some of the key, short-term actions necessary to achieve aims, ambitions and commitments
- Outlines a route map to 2030 and 2045
- Provides detail of supportive funding landscape

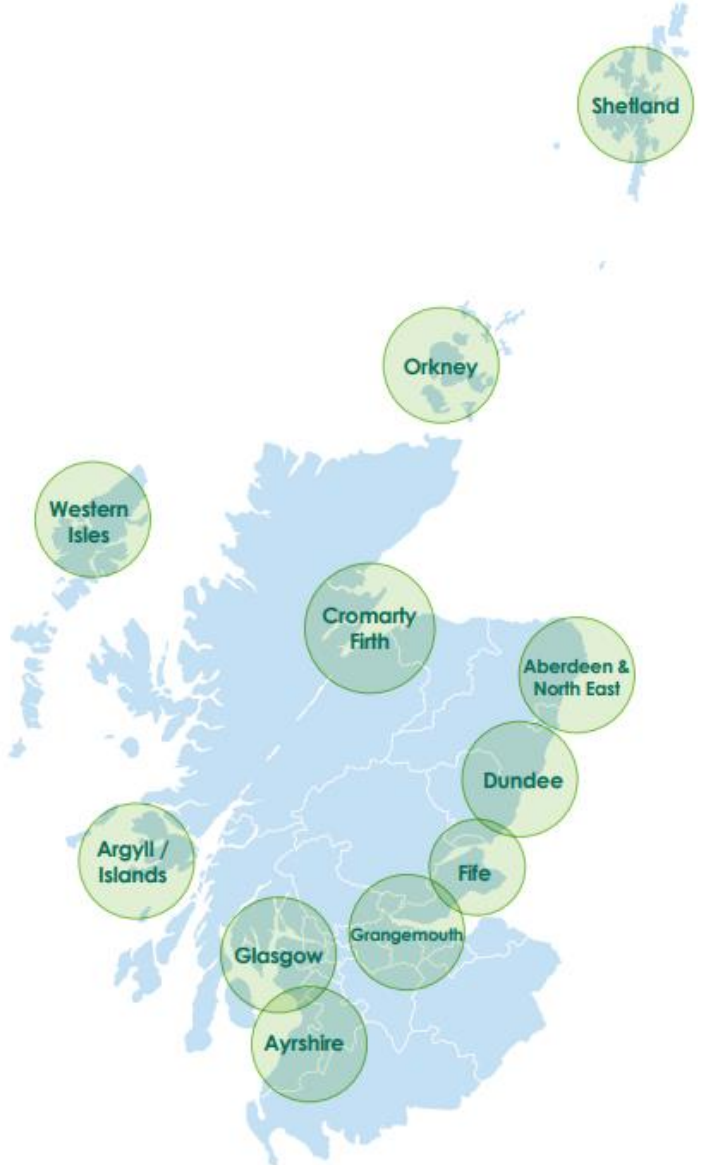


Regional Approach

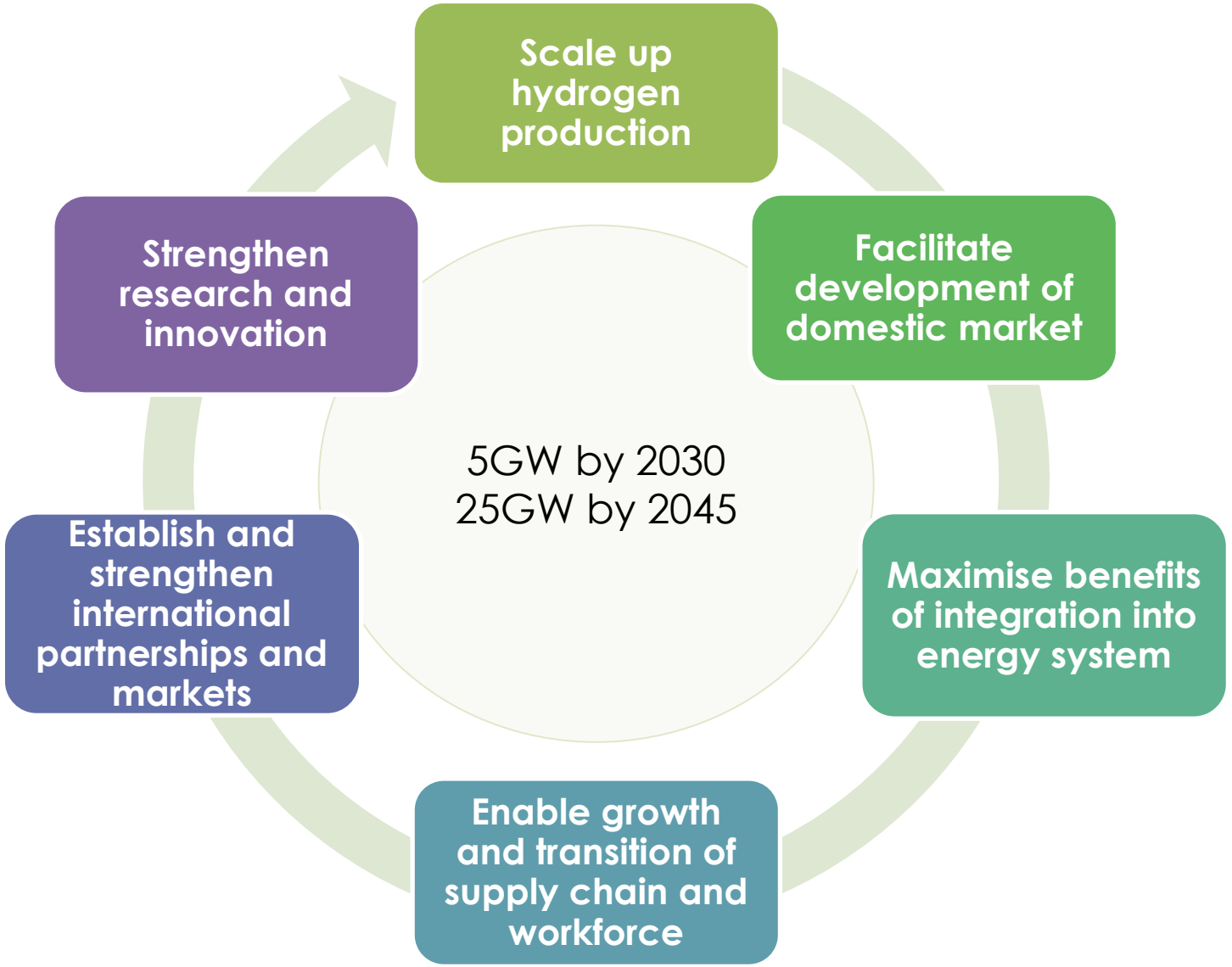
The draft Hydrogen Action Plan commits to:

- A regional approach to development of the Hydrogen Economy in Scotland
- Support for the development of Regional Hydrogen Energy Hubs

A **Regional Hydrogen Energy Hub** is a geographic location (region, city, island, industrial cluster) that is host to the entire hydrogen value chain, from production, storage and distribution to end-use. Regional Hydrogen Hubs will include multiple end-users with applications ideally covering more than one sector.



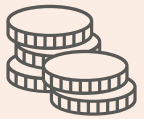
Key Action Themes



Key Themes (1/3)

1. Scaling up hydrogen production

- **£100m** renewable hydrogen development fund (EETF) to support hydrogen pathfinder projects in the next five years
- Ensure the regulatory, planning and consenting framework for renewable energy and hydrogen developments supports the scale-up of hydrogen production at pace.
- Work with the electricity system operators to accelerate hydrogen from constrained wind and address curtailment payments.



2. Facilitating the development of a domestic market

- Support Regional Hydrogen Hubs, coupling hydrogen production with multiple end-use applications to help aggregate demand
- Use of hydrogen in industrial decarbonisation supported by match-funded grants from SIETF
- Establish a consortium for hydrogen in Scottish transport to co-design technology and infrastructure pathways for the application of hydrogen in transport
- Work with SGN and National Grid to generate evidence of H2's role in decarbonsing heat

Key Actions (2/3)

3. Maximising the benefits of integration into the energy system

- Work with electricity and gas network operators to realise system benefits of hydrogen
  - Identify integration challenges and service opportunities
  - Evaluate optimal locations for electrolysis
- Support development of hydrogen distribution network to support export to UK and Europe
  - Fund the NZTC Transition Programme and Hydrogen Backbone Link
- Explore the use of hydrogen as an energy storage and balancing asset to the national grid.

4. Enabling the growth and transition of Scotland's supply chain and workforce

- Develop a Hydrogen Economy Cluster to help companies realise opportunities in hydrogen markets
- Establish the skills to underpin our energy transition
  - Support for programmes such as National Energy Skills Accelerator in Aberdeen
- Fund a Hydrogen Business Development service, through the Energy Technology Partnership, to accelerate knowledge exchange between academia and enterprise
  - £100k engagement fund to support collaboration

Key Actions (3/3)

5. Establishing and strengthening international partnerships and markets

- Work with industry to develop a sector export plan
- Support development of international supply chains
  - Scot2Ger project
- Develop new bilateral partnerships, such as recent hydrogen MOU with Hamburg
- Develop a Hydrogen Outreach Programme
  - SDI to engage >280 international firms as targets for foreign direct investment

6. Strengthening research and innovation

- Launch **£10m** Scottish Hydrogen Innovation Fund
- Establish Scottish Innovation Network in 2022, providing an overarching framework for Scottish hydrogen innovation portfolio
- Support Scottish applications to Clean Hydrogen for Europe partnership
- Provide funding for bilateral and multilateral research projects
  - £150k Scotland-Germany research fund
  - 3-year MultiHyFuelproject, deploying HRS across UK and Europe.

Funding Programme

- **£100m** Emerging Energy Technologies Fund to support renewable hydrogen projects *(Complementary to UK Gov Net Zero H2 fund)*
- Launch **£10m** Scottish Hydrogen Innovation Fund
- A call for projects will be launched in early 2022

Funds	Target Group	£
Emerging Energy Technologies Fund (Hydrogen/CCUS/NETs)	Business/Industry	£180m (2021-26) £180m breakdown: £100m hydrogen £80m CCUS/NETS
Energy Transition Fund	Business	£62m (2020-25)
Energy Investment Fund	Third Sector	£60m
Community & Renewable Energy Scheme (CARES)	Community/Third Sector	£8.25m (2021-22)
Successor to the Low-Carbon Infrastructure Transition Programme (LCITP)	Public and Private Sector	£400m (2021-26)
Low-Carbon Manufacturing Challenge Fund	Business	£50m
Scottish Industrial Energy Transition Fund (SIETF)	Business/Industry	£34m (2021-26)
Green Supply Chain Development Fund	Business	£50
Green Jobs Fund	Enterprise Agencies	£100m (2021-26)
Green Business Support Fund	Business	£50m
Green Growth Accelerator Programme – unlocking £200 million of public and private investment in low-carbon infrastructure projects across Scotland, underpinned by Scottish Government funding.	Local Authorities	£200m +
Switched-On Fleets	Public Sector	£12m
Scottish Zero Emission Bus Challenge Fund – support for the cost of zero-emission buses and the associated charging or refuelling infrastructure.	Public and Private sector	£50m

Policy Documents and Guidance

The Hydrogen Action Plan can be viewed here:
Hydrogen action plan: draft - gov.scot (www.gov.scot)

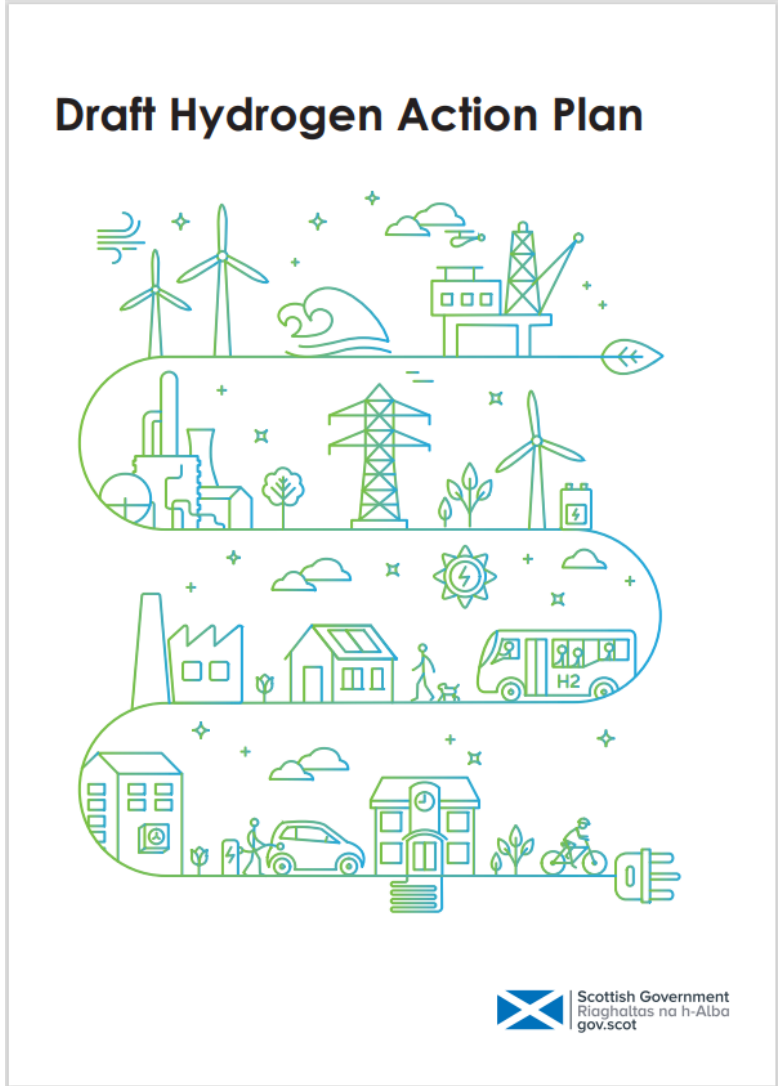
The Hydrogen Policy Statement can be viewed at:
https://www.gov.scot/isbn/9781800045033

The Hydrogen Assessment report can be viewed at:
https://www.gov.scot/isbn/9781800045057

The Wind to Green Hydrogen Supply Chain Study can be viewed at:
https://www.gov.scot/isbn/9781800045040

The Deep Decarbonisation report can be viewed at:
https://www.gov.scot/isbn/978180004411

•



Thank You

Stuart Mckay
Head of Hydrogen Policy