Hydrogen:
A Business Opportunity for Scotland

Session three Chair: Kirsty Lynch, Pale Blue Dot

Energy for Transport Heat Power

ERM Pale Blue Dot. Scottish Enterprise ABERDEEN CITY COUNCIL Interreg North Sea Region HyTrEc2 European Regional Development Fund EUROPEAN UNION ONE OPPORTUNITY NORTH EAST Oil, Gas & Energy H2 Aberdeen

Session 3:
Hydrogen Projects

H2 Aberdeen – Andrew Win, Aberdeen City Council

Orkney: The Catalyst for Hydrogen Projects - Adele Lidderdale, Orkney and Islands Council

H100; a Domestic Supply Hydrogen Pilot Project - Angus McIntosh, SGN

Acorn Hydrogen - Hazel Robertson, Pale Blue Dot

Hydrogen as a Business Opportunity - Nick Stapley, Logan Energy

H2 Aberdeen

Speaker: Andrew Win, Programme and Projects Manager

Andrew Win
Programmes and Project Manager
Aberdeen City Council

H2 - the international market

Hyundai Motor to supply 1,000 hydrogen trucks to Switzerland

2018.09.20 15:12:08 | 2018.09.20 15:12:41

Germany launches world's first hydrogen-powered train

Two trains built by the French train maker Alstom are now operating on a 62 mile stretch of line in northern Germany

▲ The world's first hydrogen fuel cell passenger train is now running in northern Germany. Photograph: David Hecker/EPA

Signs $163M 50th hydrogen station opens in Germany

The latest investment and partnership activity in the fuel cell sector.

Hydrogenics to Provide Fu... Cells for Hea... Europe ...ruck

Toyota to supply its hydrogen technology to Caetanobus SA (Portugal) Europe

Toyota today took another important step towards a broader hydrogen society by announcing that it will provide its hydrogen fuel cell technology to Caetanobus SA in Portugal

September 27 2018

...rogen Contract to Support 30 Fueling Stations

Nikola's hydrogen-electric Class 8 tractor. Nikola partnered with Nel Hydrogen as it prepares to roll out a U.S. fueling network. (Nikola Motor Co.)

...japan to be 1st country to reach 100 hydrogen filling station milestone

KYODO NEWS | Mar 23, 2018, 19:34 | All Life

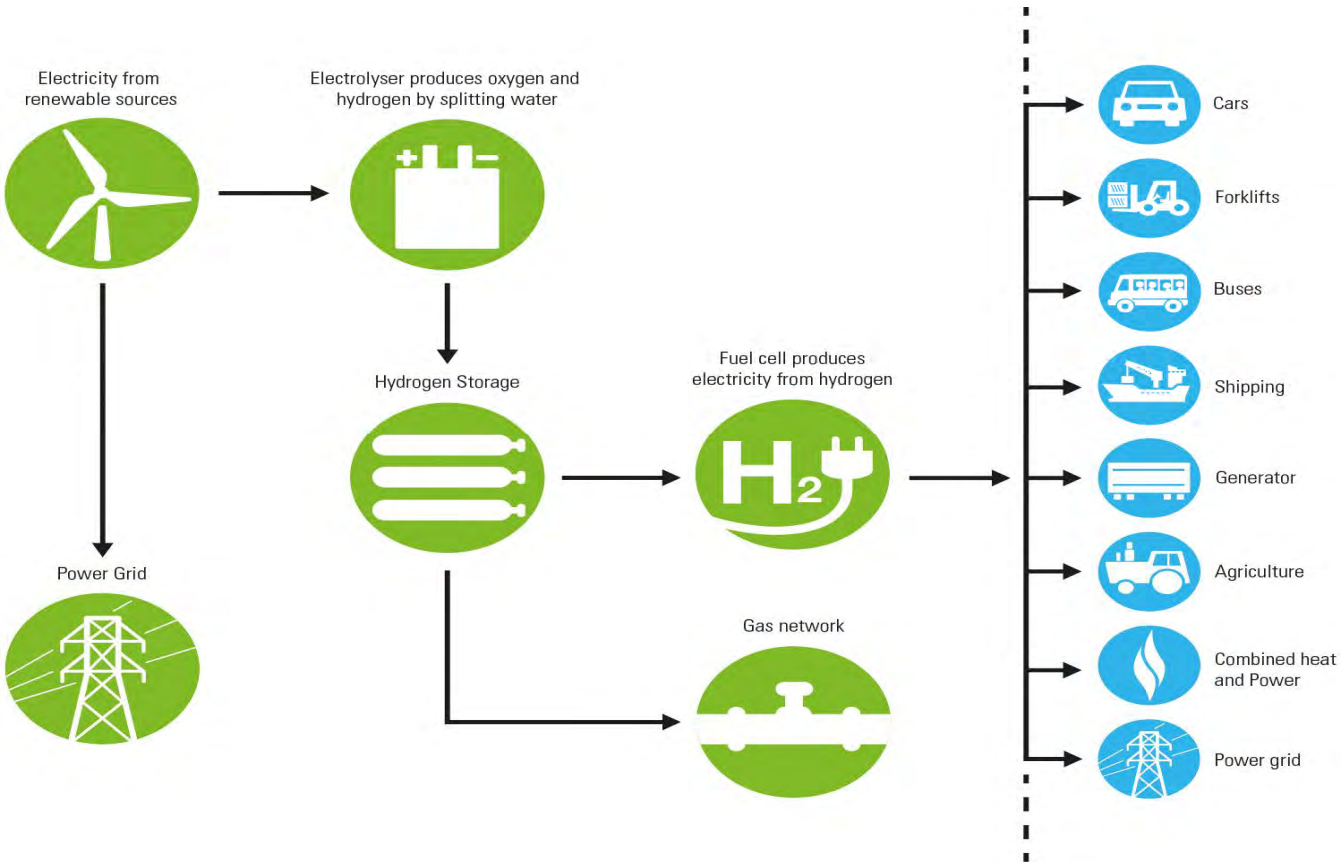
Nel ASA: EU awards funding for large scale hydrogen bus project

THU, SEP 27, 2018 14:29 CET

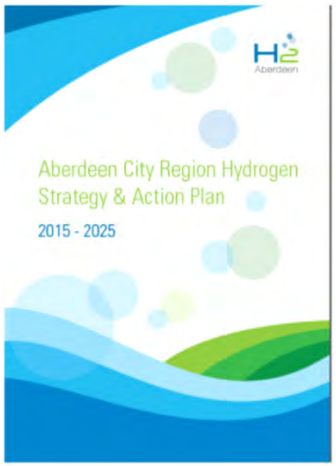
Plans rolled out to deploy 2,000 hydrogen buses in China

Shandong Heavy Industry has announced it aims to promote hydrogen mobility across the Shandong Province

Hydrogen and Energy



H2 Aberdeen


Aberdeen City Region Hydrogen
Strategy & Action Plan
2015 - 2025

Policy Framework

Developing a hydrogen economy

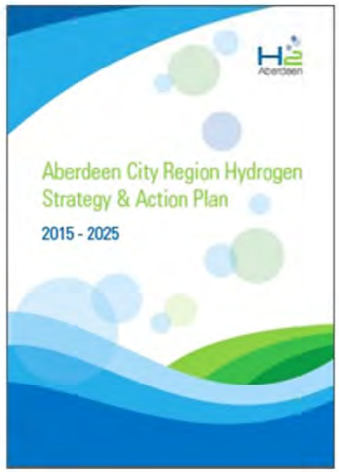
Strategic aim : to become *'a world-class energy hub leading a low carbon economy and at the forefront of hydrogen technology in Europe'*

Local drivers

- Highly skilled workforce in energy sector (oil and gas industry)
- Accustomed to the use of hydrogen in industrial processes
- Production of excess renewable energy (wind)

Policy drivers

- Reduce cross-sector greenhouse gas emissions by 42% by 2020 and 80% by 2050 (Scotland)
- Phase out of all petrol and diesel vehicles by 2032 (Scotland)
- Aberdeen City and Region Hydrogen Strategy 2015-2015



The Aberdeen Bus Project

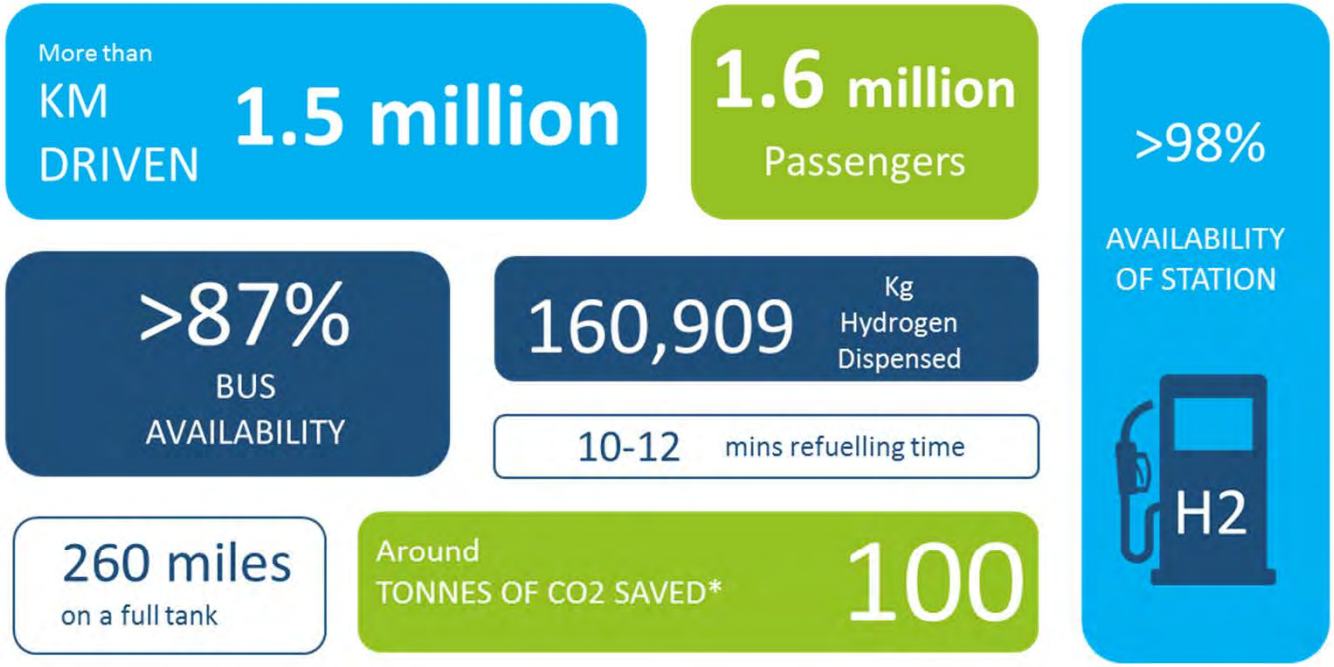
An innovative public-private partnership

Was Europe's largest fuel cell electric bus fleet: 10 buses in total

- 4 buses First
- 6 buses Stagecoach
- 1 production & refuelling station
- Dedicated bus maintenance facility

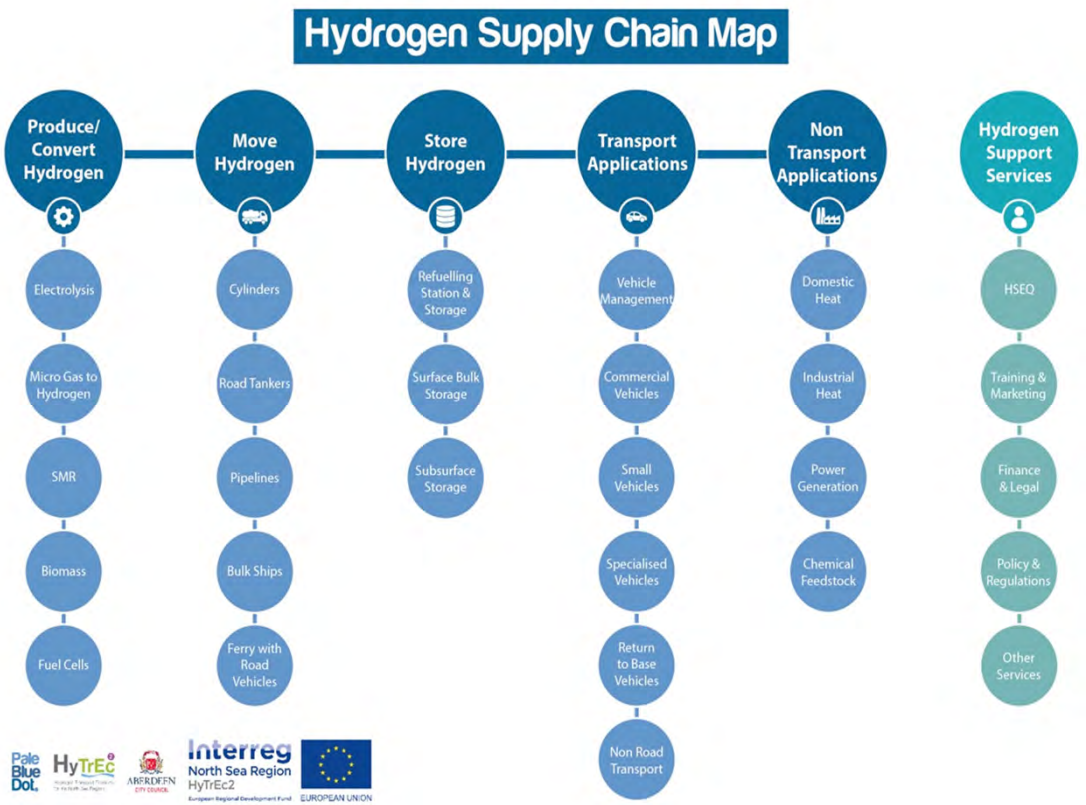
PROJECT DEVELOPMENT	NEGOTIATION	PREPARATION	LAUNCH	OPERATION	AND BEYOND?
2010-2011	2011	2012-2013	June 2014	March 2015-March 2019	

Achievements for far



*COMPARED TO EURO VI VEHICLES

H2 Supply Chain



The Aberdeen Bus Project

Design & Construction – 12 businesses/companies

Design Services

Construction – Civil, Mechanical, Electrical Engineering

Installation and commissioning

Support Services– 8 businesses/companies

Risk Assessments, Hazard ID & Procedures

Legal and Financial Services

Project Management

Operation & Maintenance – 7 businesses/companies

Parts & consumables

Technicians - maintenance and servicing

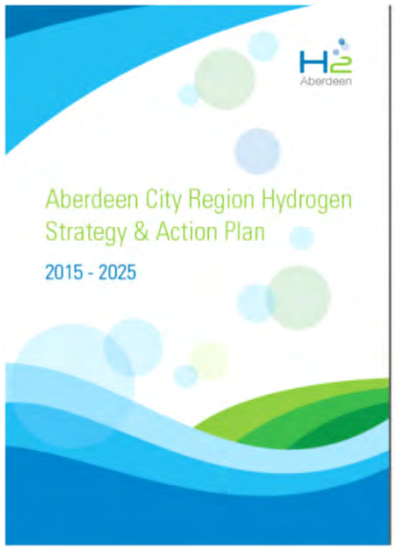
Supply Chain Constraints

- Volume and Demand
  - Vehicles and Infrastructure
- Component and Servicing Costs
  - Buses – components, fuel cells, parts
  - Hydrogen – components and consumables
- Servicing Supply Chain
  - Parts supply chain maturity
  - Cost and availability
  - Expertise
- Maintenance & Technicians
  - Bus maintenance expertise
  - People – skills and knowledge
- Hydrogen production & infrastructure costs
  - hydrogen price
  - electricity price

Supply Chain Opportunities

- Vehicle and bus deployments across UK and Europe are happening!
  - Bus OEM – Scottish and UK OEMs entering the market
  - SME's – hydrogen range extenders
- Commercial hydrogen production and supply tenders are coming to the market
  - Two tenders published in 2019 (London and Brighton)
- ACC facilitating a tender for a commercial supply for North East Scotland- late 2019
  - 1300kg per day (expected increase in demand in 2020-2023)
  - 10-15 year supply period

The opportunity is real!



Andrew Win
Programmes and Project Manager
Aberdeen City Council

Orkney: The Catalyst for Hydrogen Projects

Speaker: Adele Lidderdale, Orkney and Islands Council

Energy of ORKNEY

ORKNEY ISLANDS COUNCIL

Adele Lidderdale

Hydrogen Project Officer

Orkney Islands Council

"The Orcadian is an intelligent fellow who looks well after his farm and fish and anything else he can lay hands on."

- R Menzies Fergusson, 1892

Energy of ORKNEY

ORKNEY ISLANDS COUNCIL

Energy of ORKNEY

ORKNEY ISLANDS COUNCIL

In Orkney…

- ~120% local electricity demand generated from renewable sources
- > 50MW of installed renewable capacity
- > 200 electric vehicles and counting

But…

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Curtailment

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Orkney's hydrogen future

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Projects:

Surf ‘n’ Turf	HySeas I, II & III
BIG HIT	NORA – North Atlantic Hydrogen
Dual Ports	Learning Network
HyDime	ITEG

Orkney's hydrogen future

Eday:

- Curtailed wind and tidal turbines
- 0.5 MW of electrolysis
- 30kW catalytic boilers
- 500kg storage

Shapinsay:

- Curtailed wind
- 1MW of electrolysis
- 30kW catalytic boilers
- 110kg storage

Mainland:

- 75 kW FC: heat and power to harbour
- 350bar H_2 refuelling station
- 5 x FC vans
- 110kg storage

Transport:

- 5 x 250 kg tube trailers

Orkney's hydrogen future

BIG H2IT

Building Innovative Green Hydrogen Systems in Isolated Territories

- Building on Surf 'n' Turf
- **12 partners from 6 Countries across Europe**

FOUNDATION FOR THE DEVOLOPMENT OF NEW HYDROGEN TECHNOLOGIES IN ARAGON

GIACOMINI WATER E-MOTION

ITM POWER Energy Storage | Clean Fuel

Symbio FCell

EMEC ORKNEY The European Marine Energy Centre Ltd

CALVERA

ORKNEY ISLANDS COUNCIL

DTU Technical University of Denmark

Community Energy Scotland

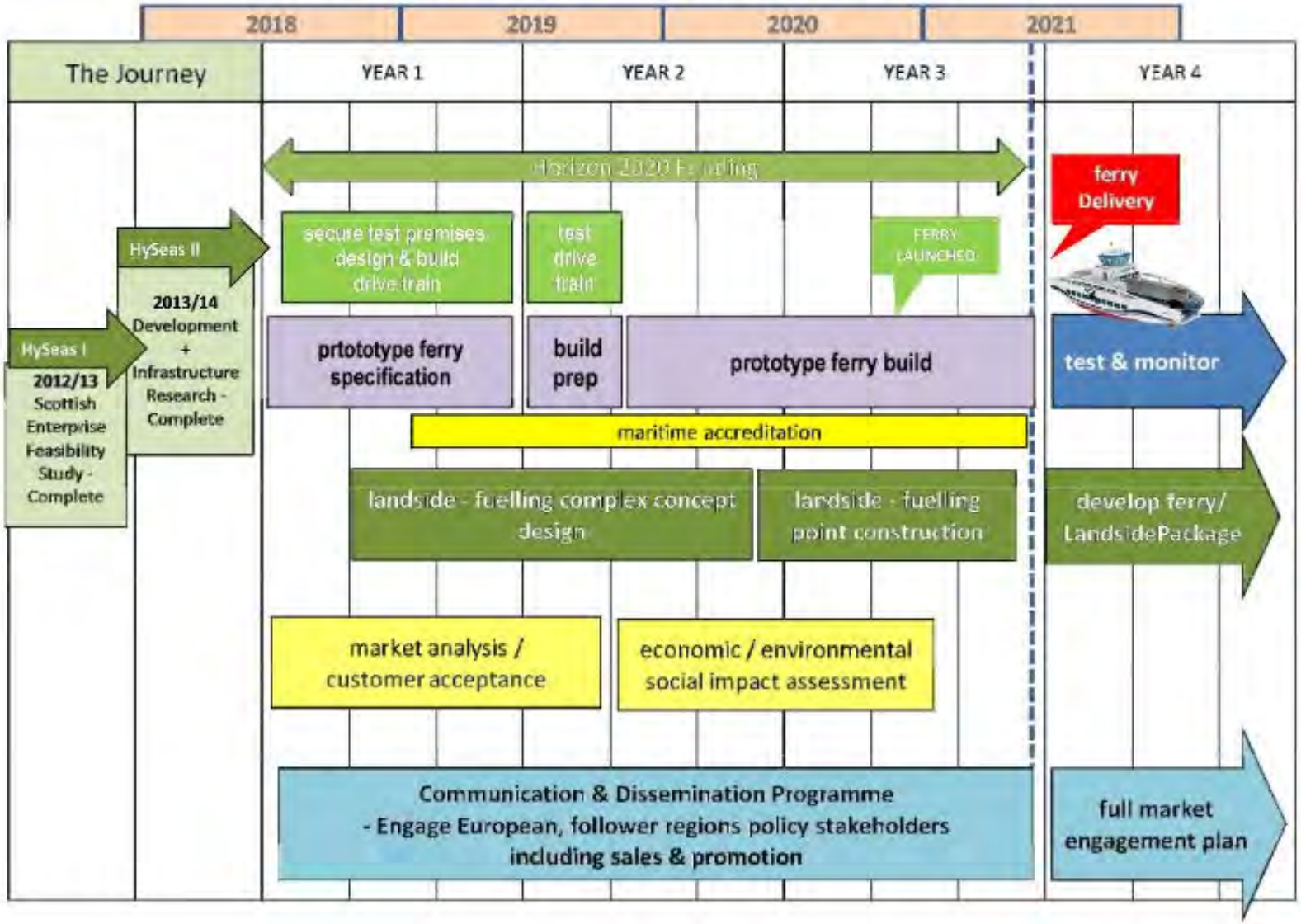
SCOTTISH Hydrogen & Fuel Cell ASSOCIATION

MINISTRY FOR TRANSPORT AND INFRASTRUCTURE

Orkney's hydrogen future

(Grant Agreement nº 700092)

HySeas III - The Last Step in Taking the Hydrogen Ferry to Market



Energy of ORKNEY

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What's next?

Orkney's hydrogen future

Energy of ORKNEY

ORKNEY ISLANDS COUNCIL

Orkney Hydrogen Roadmap:

- Address curtailment
- Support hydrogen development projects
- Facilitate infrastructure required for future integrated if hydrogen into the local economy and beyond

Orkney's hydrogen future

Adele Lidderdale
Hydrogen Project Officer
Orkney Islands Council

adele.Lidderdale@Orkney.gov.uk

Orkney's hydrogen future

H100; a Domestic Supply Hydrogen Pilot Project

Speaker: Angus McIntosh, SGN

A reminder of SGN

Upgrade

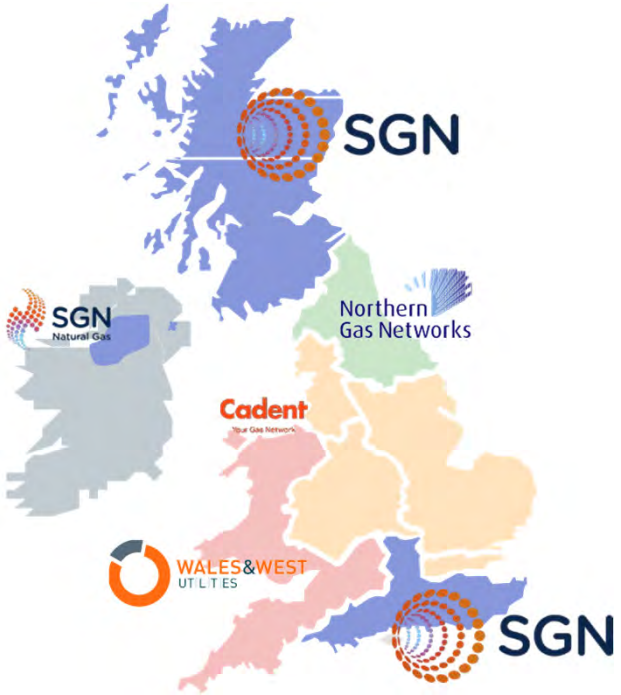
1,000km mains
replaced per year

Connect

20,000 connections
(5,000 fuel poor) per year

Emergency

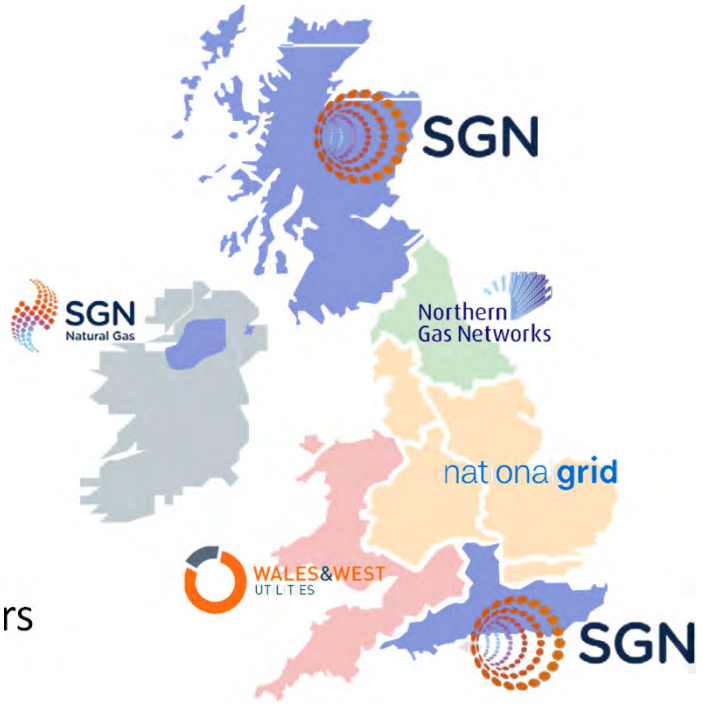
230,000 calls
50,000 repairs per year



SGN

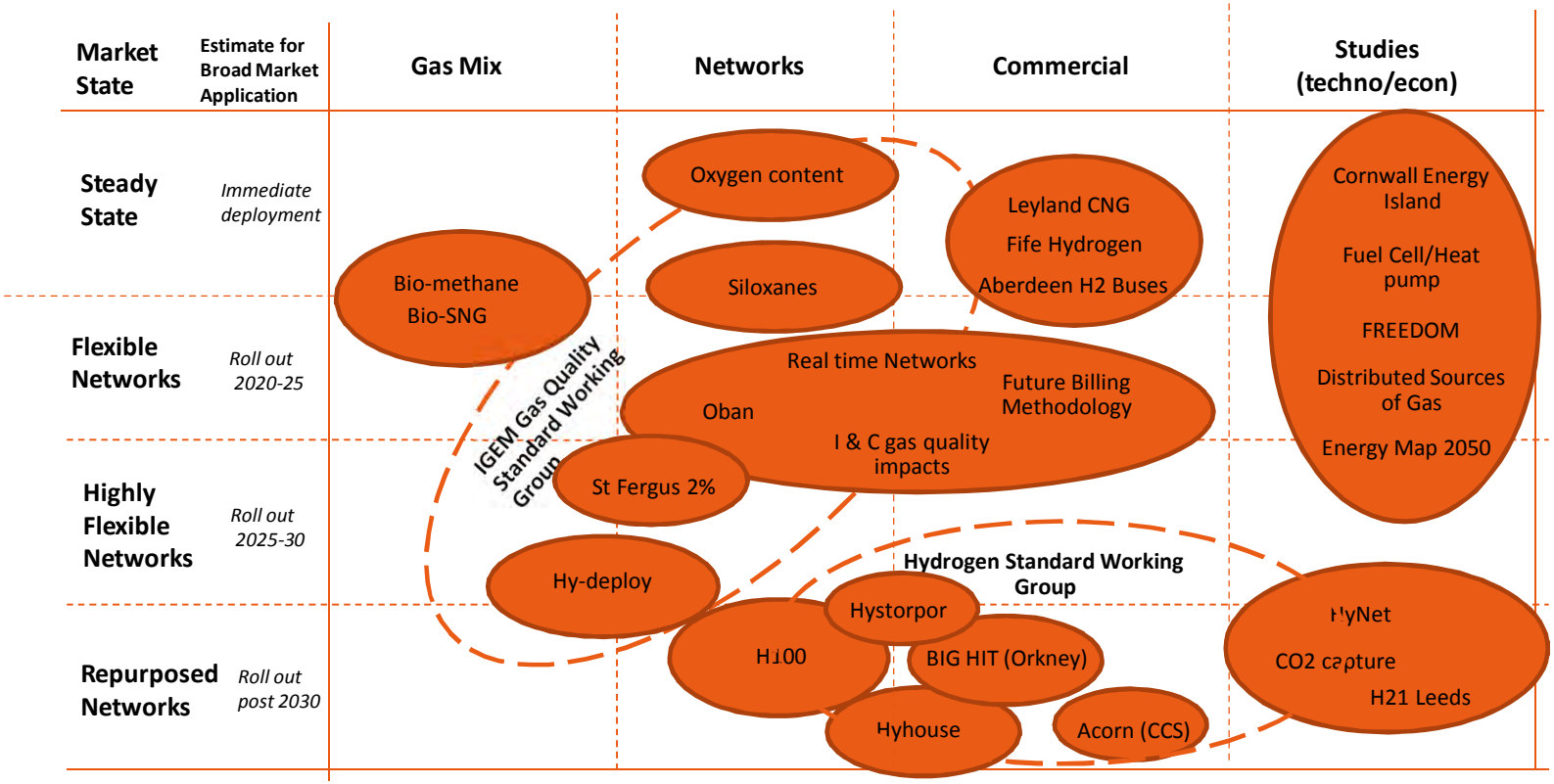
SGN in Scotland

- 25,000km of pipeline
- 1.8m meter points, 4.5m people
- 15 biomethane plants connected
- 300km metal mains replaced with plastic pipe each year
- Connections - 12,000 p.a.
  (3,000 fuel poor p.a.)
- 1,400 employees plus 400 contractors



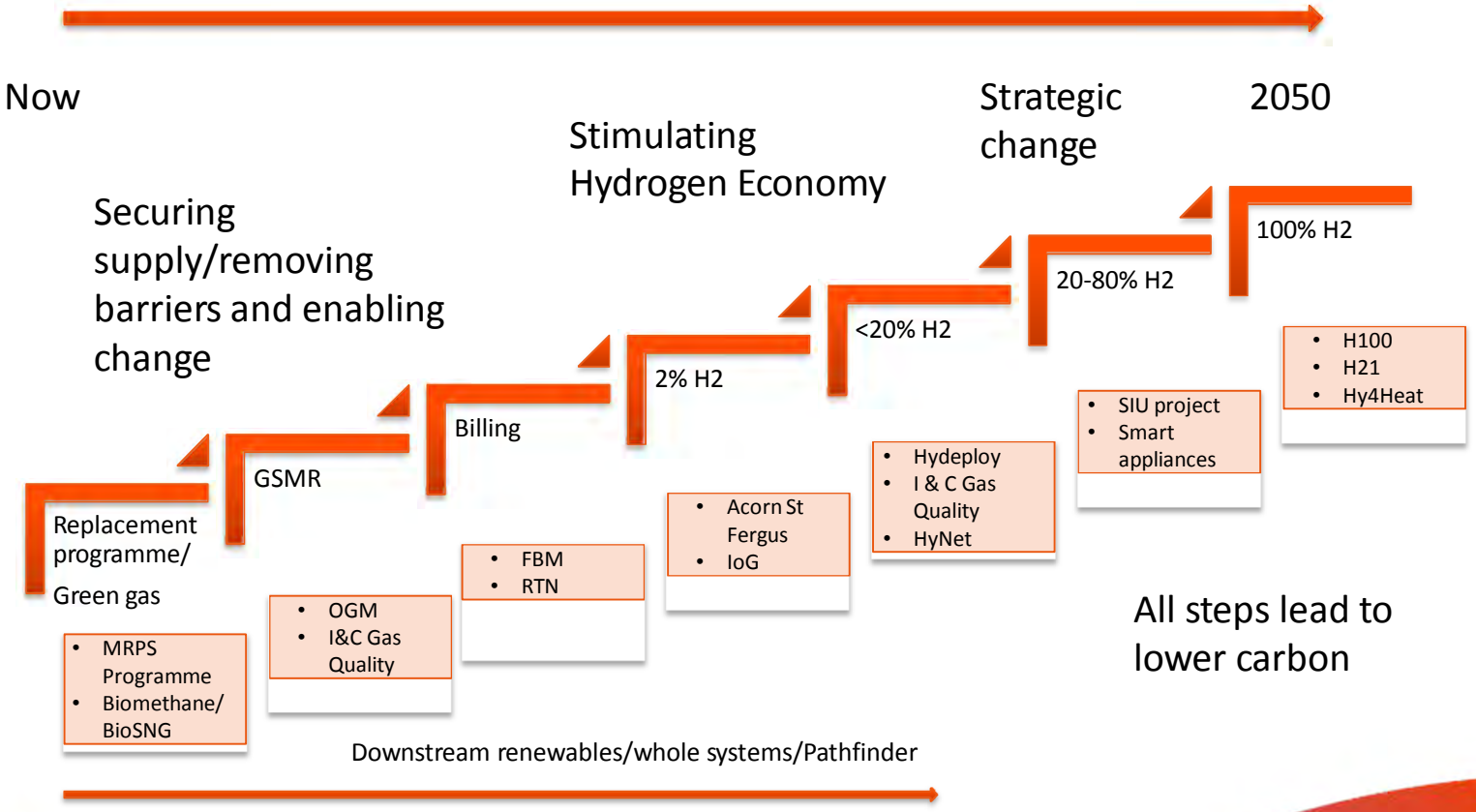
SGN

Future Energy Scenarios - Gas



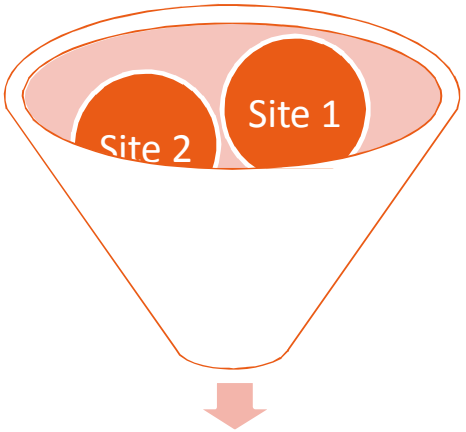
*Not exhaustive

Future Energy Scenarios – Networks Gas quality decarbonisation pathway



H_2 Projects

HYDROGEN

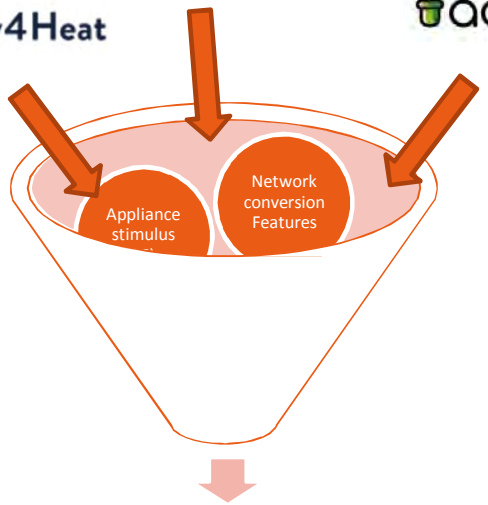


Construction Demonstration

100% H_2

Hy4Heat

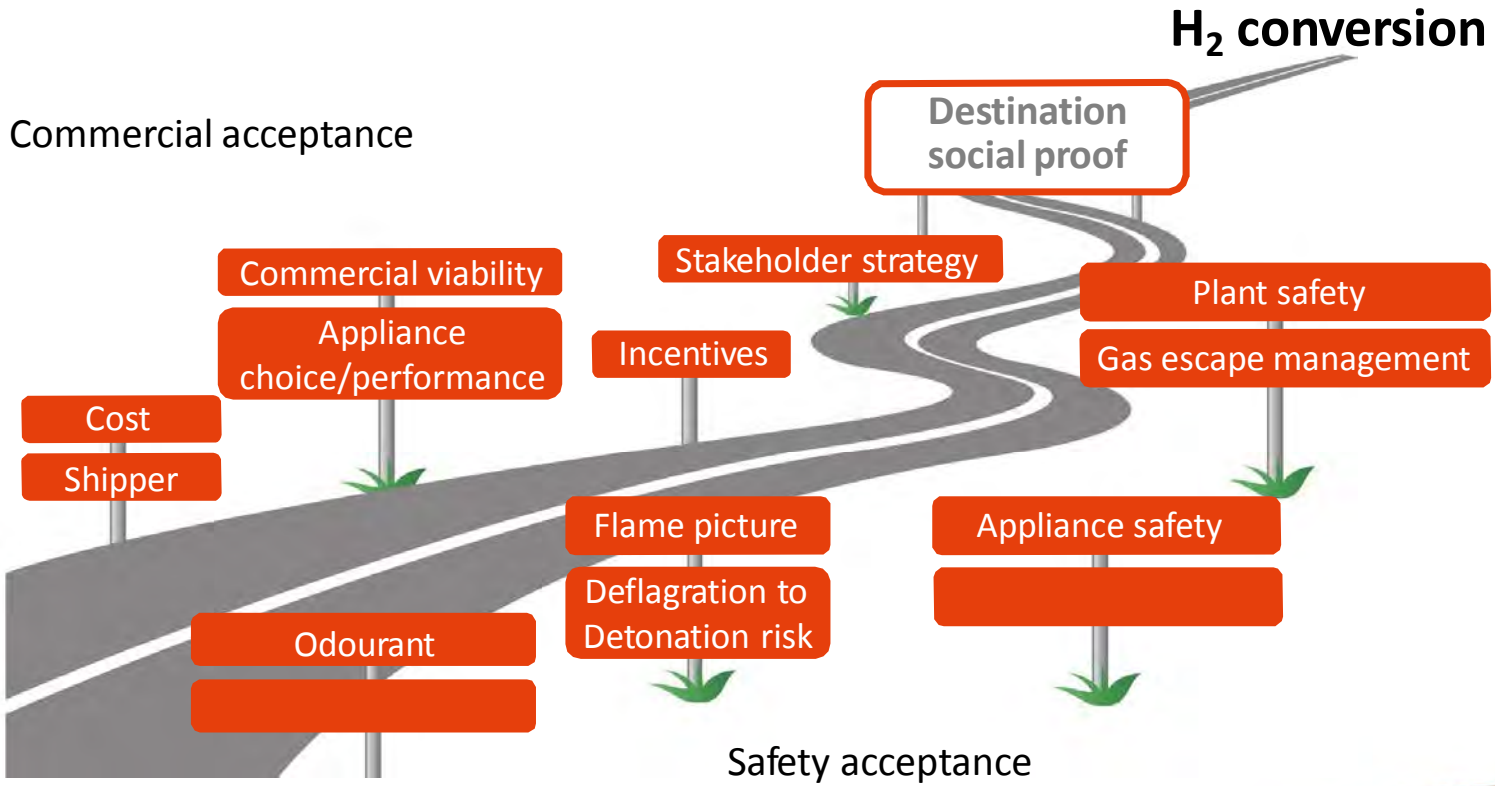
acorn



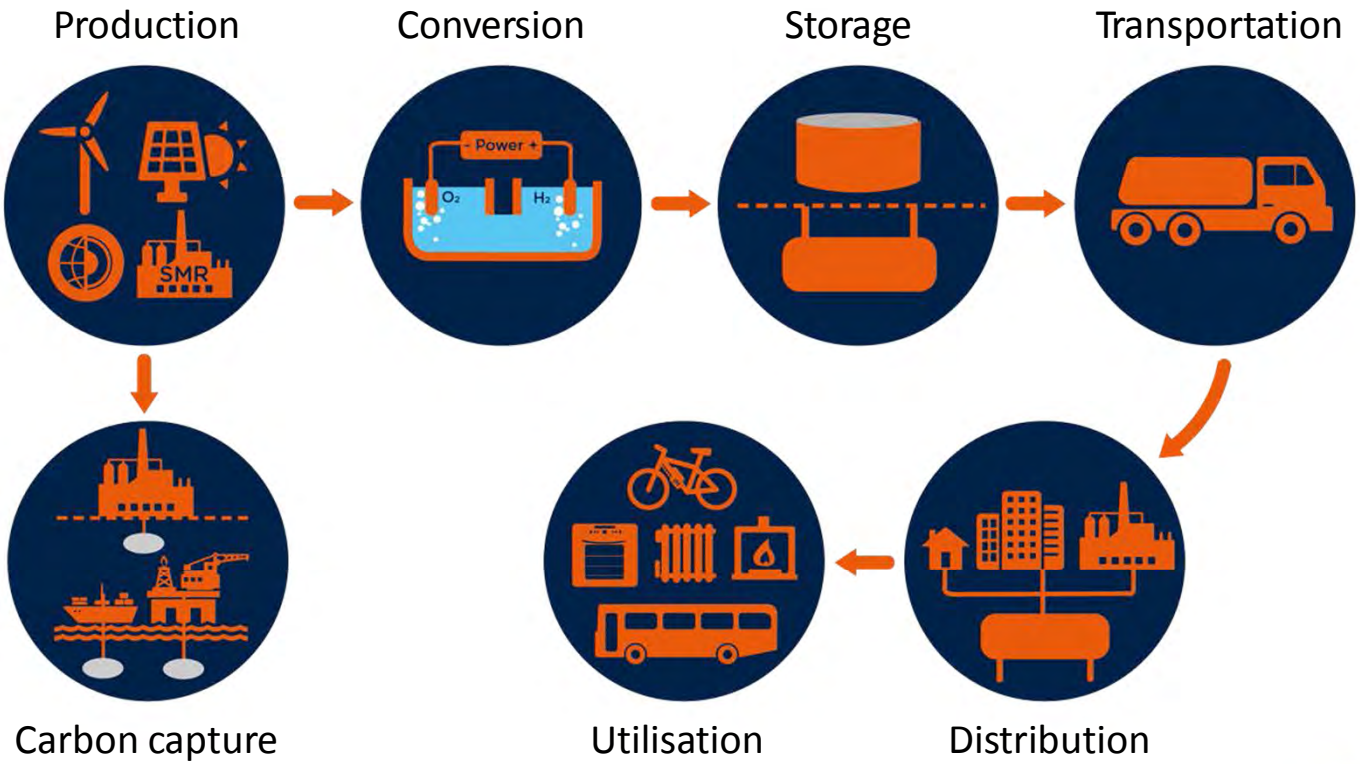
Collaborative Parallel evidence toward conversion

SGN

H_2 Road to social proof



Hydrogen network



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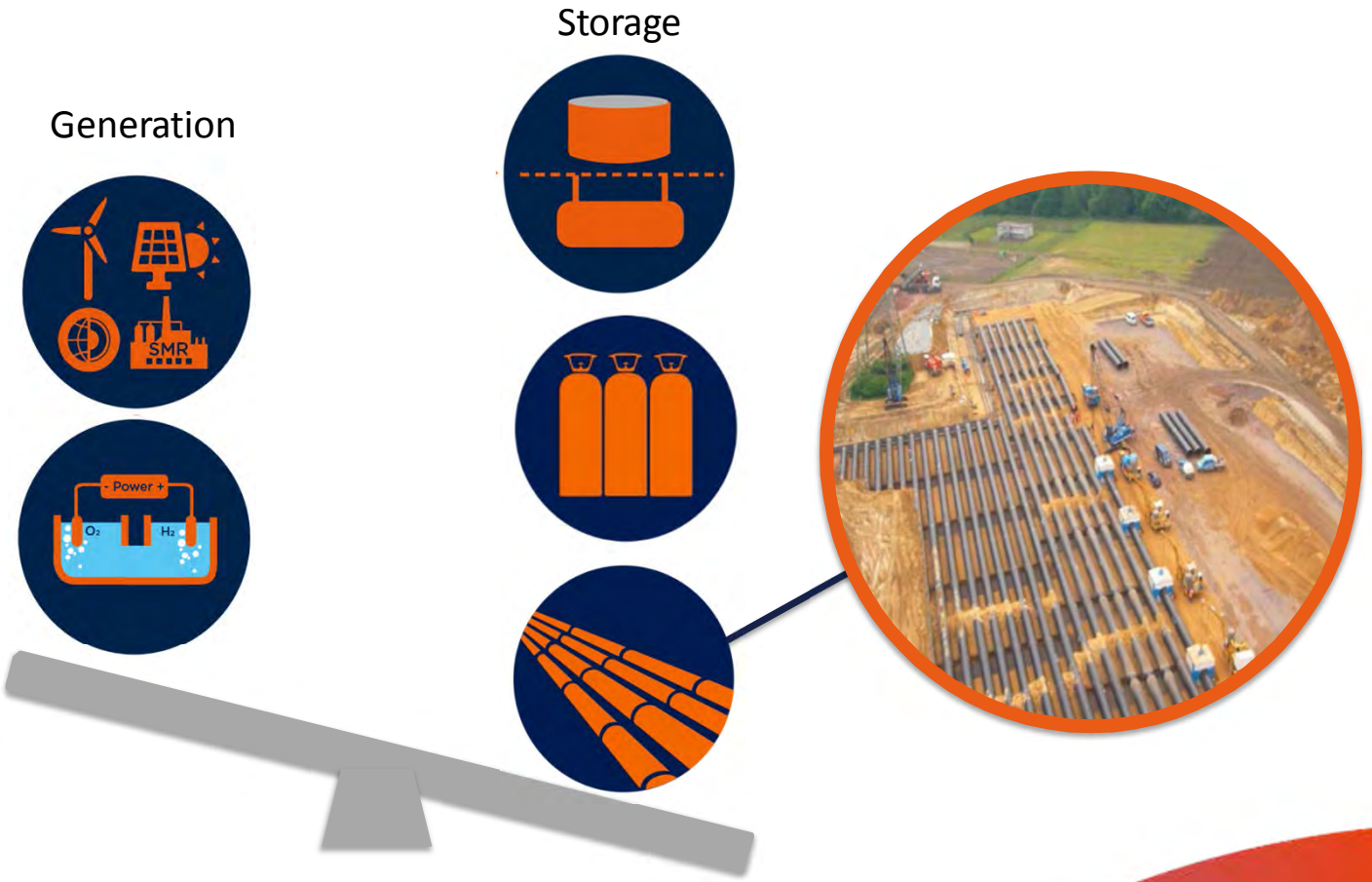
Hydrogen Generation/Storage



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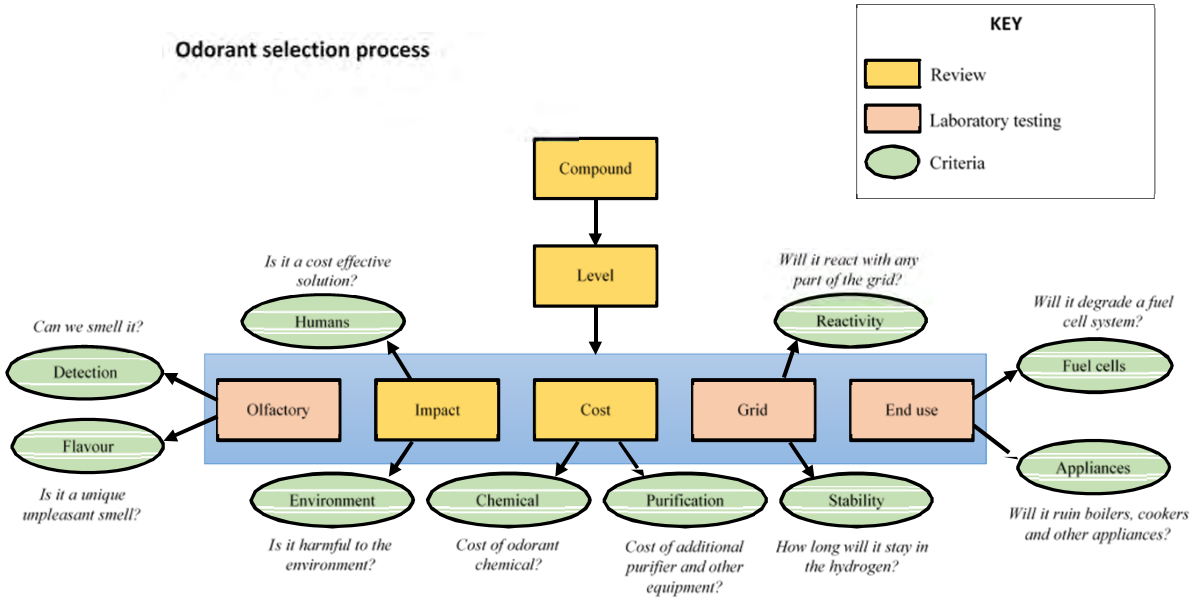
Odorant selection process

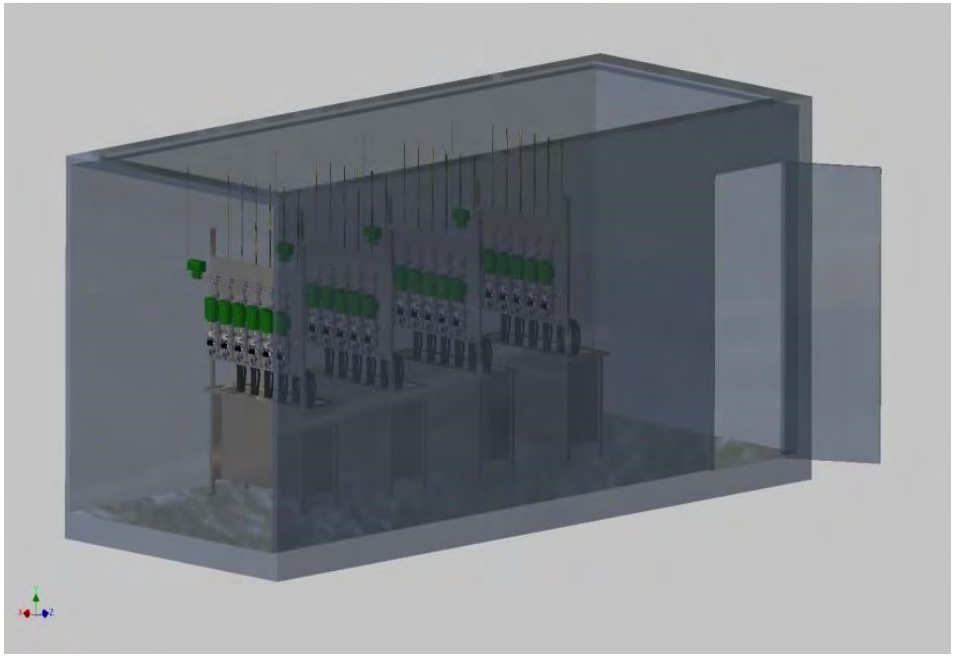


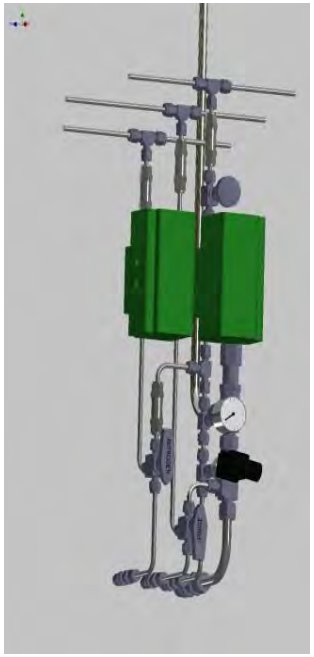
Candidate odorants to be tested

	Odorant compound	Rationale
1	Odorant NB (78% TBM, 22% DMS)	In use by SGN and UK
2	Standby odorant 2 (34 % Odorant NB, 64 % Hexane)	In use by SGN
3	Odorant THT (100 % THT)	In use by SGN and Europe
4	GASODOR-S-FREE (34% MA, 601% EA, 2.5% EMP)	Sulphur-free odorant in use in Germany
5	5-ethylidene-2-norbornene	Suitable for fuel cells with unpleasant odour

PE Materials - pipe and fittings

10,000 hr H^2 accelerated ageing test rig





Materials

Excess flow valve test rig

Hydrogen Characteristics

Hydrogen Flux measurement

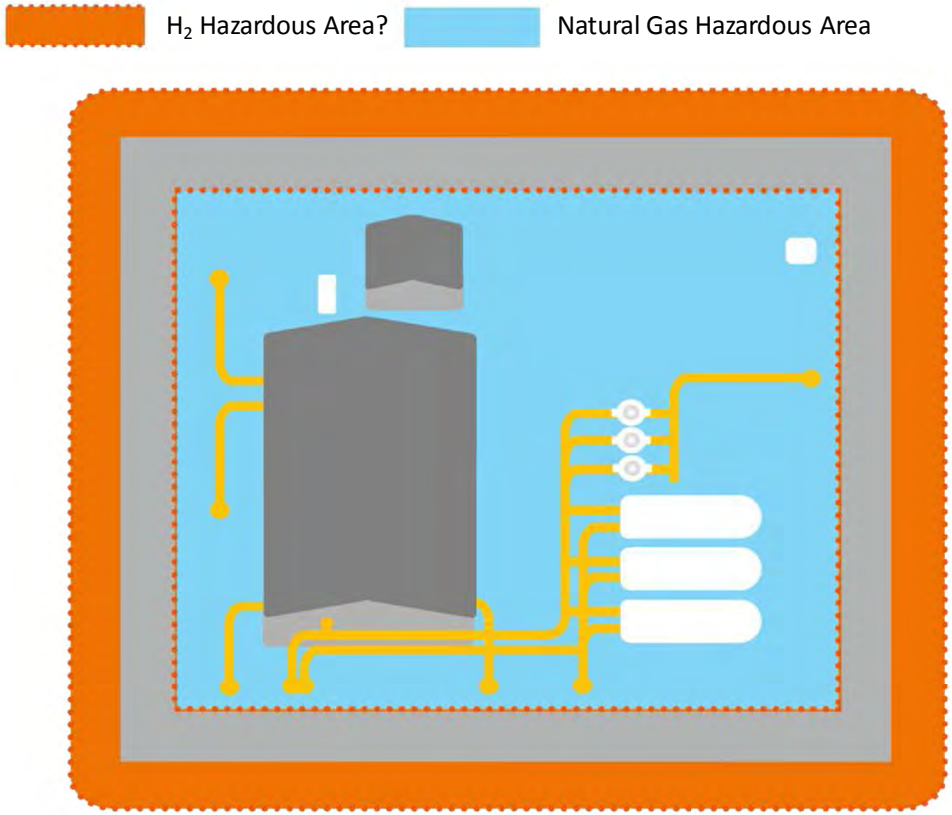
Start

30 seconds

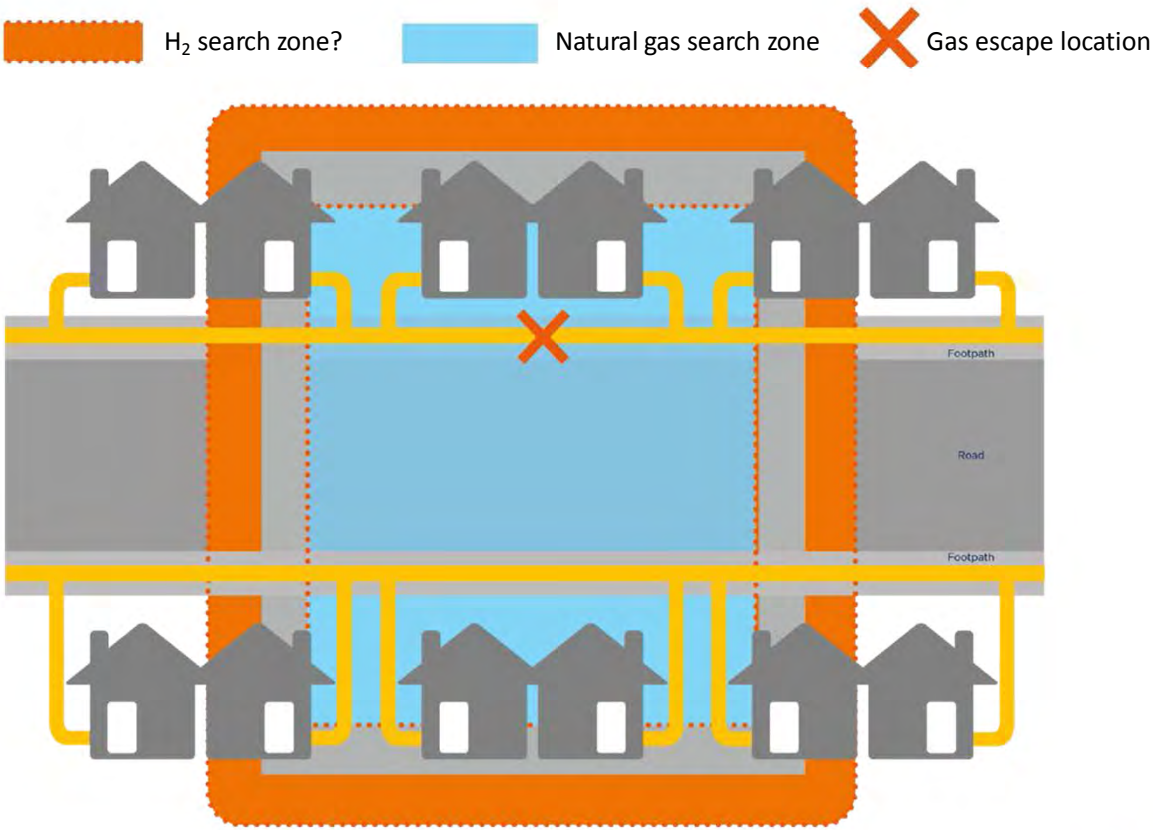
120 Seconds

180 seconds

PRS Hazardous Area



Search zone for gas escape



Relative risks to the home

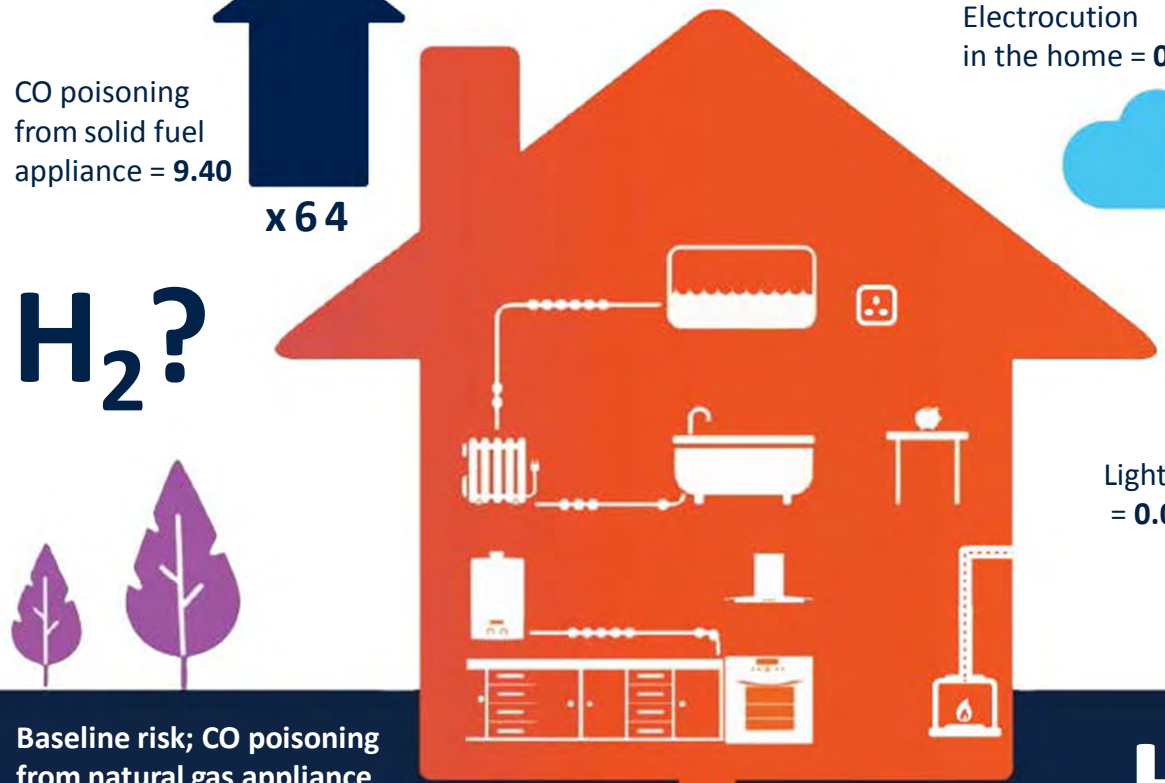
Risk = number of fatalities per million people per year

CO poisoning from solid fuel appliance = **9.40**

x 6 4

Electrocution in the home = **0.364**

x 2



H_2?

Lighting strike = **0.0012**

x 1 2 3

Baseline risk; CO poisoning from natural gas appliance at Wobbe Index (WI) of 51.4 MJ/m³ = 0.147

H_2?

Levenmouth Innovation Zone

SGN

Fife H_2 vehicles

Levenmouth Turbine

Features

Wind class
IEC Class I_A / S_B

Rotor dia.
171.2m

Capacity
7MW at grid side

Hub height
110.6m

Blade length
83.5m

Total height
196m blade tip to sea level

Generator
Medium voltage PMG (3.3kV)

Converter
Full power conversion

Drive train
Medium speed (400rpm)

Rated frequency
50Hz

Rotor speed
5.9 ~ 10.6rpm

Wind speed
3.5 ~ 25m/s

Temp. range
Survival
-20°C to +50°C
Operating
-10°C to +25°C

Lightning protection level
Level 1 (IEC 62305-1)

Corrosion category (ISO 12944-5)
Inside : C4
Outside : C5-M

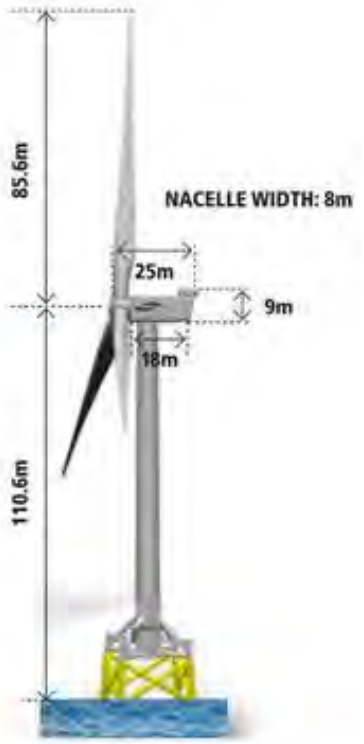
Design life
25 years

Control system features

- Independent and collective pitch control modes
- Active drivetrain damping
- Active load control
- Blade load monitoring

Complementary measurement opportunities

- Access hatches on roof
- Land-side flat locations for lidar installation (including 1 pad with electrical connections)
- On-site IEC met mast with cup anemometry currently installed
- Deck space on transition piece for small instruments



Levenmouth example future vision

- Wind farm expansion
- Neart Na Gaoithe (NNG) wind farm array
- Industrial byproduct expansion (Mossmorran Ethylene Plant, circa 50000 tonnes p/a)
- Hydrogen vehicle fuel (Fife Council)

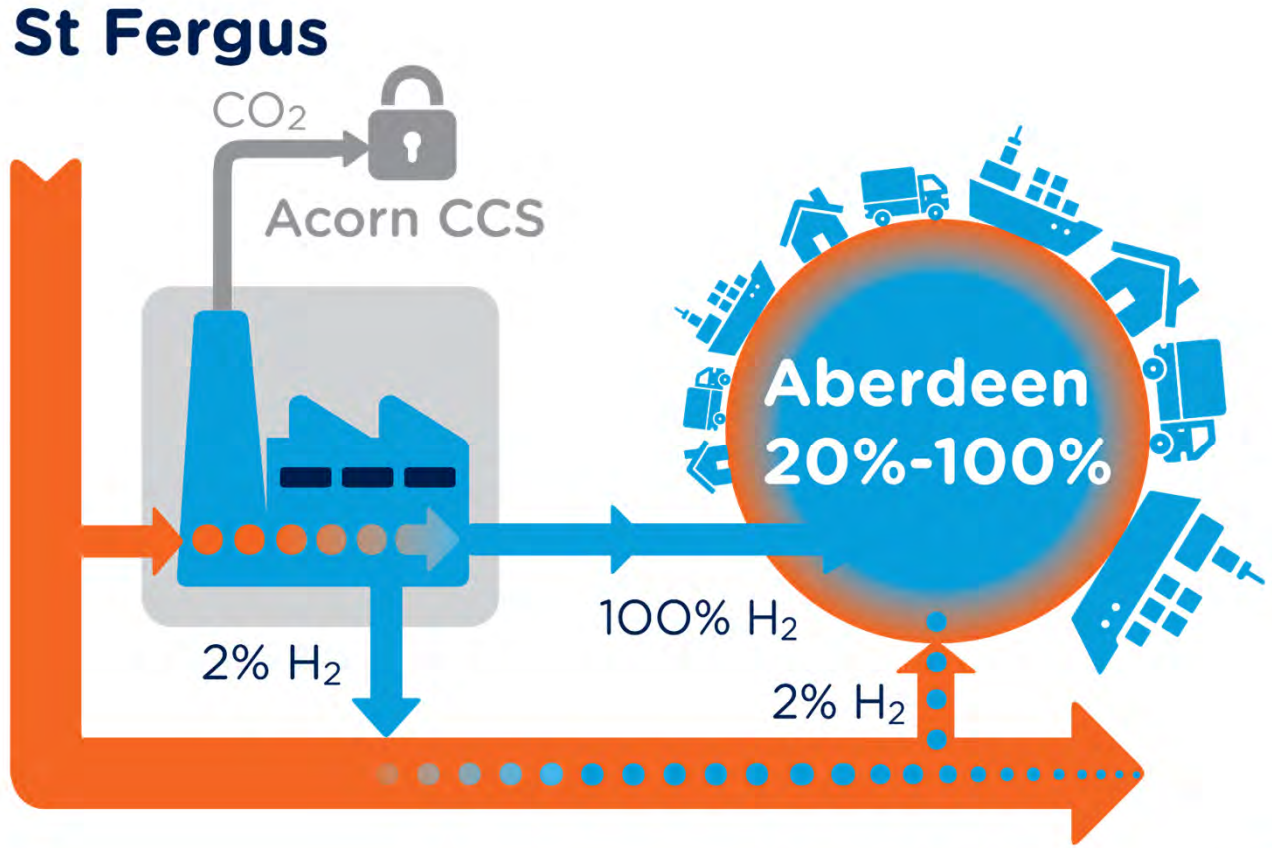
MACC Business Park and Airport

MACC Business Park and Airport

Aberdeen – Bridge of Don

Aberdeen H_2 Buses

Aberdeen Vision example



SGN

Thanks

Angus.mcintosh@sgn.co.uk

SGN
Your gas. Our network.

Acorn Hydrogen

Speaker: Hazel Robertson, Pale Blue Dot

Pale Blue Dot.

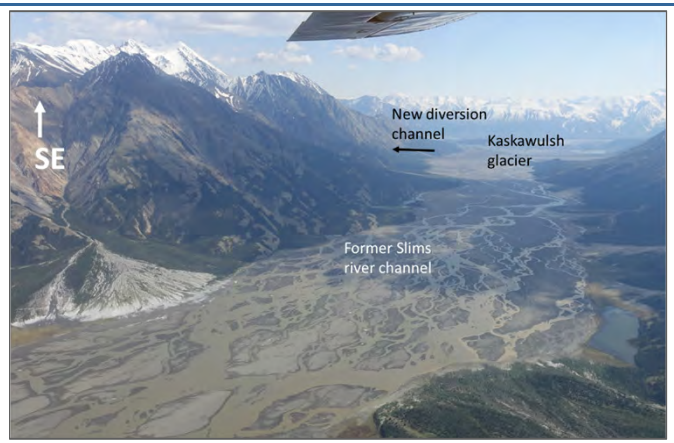
Acorn Hydrogen Project

Hydrogen: A Business Opportunity for Scotland

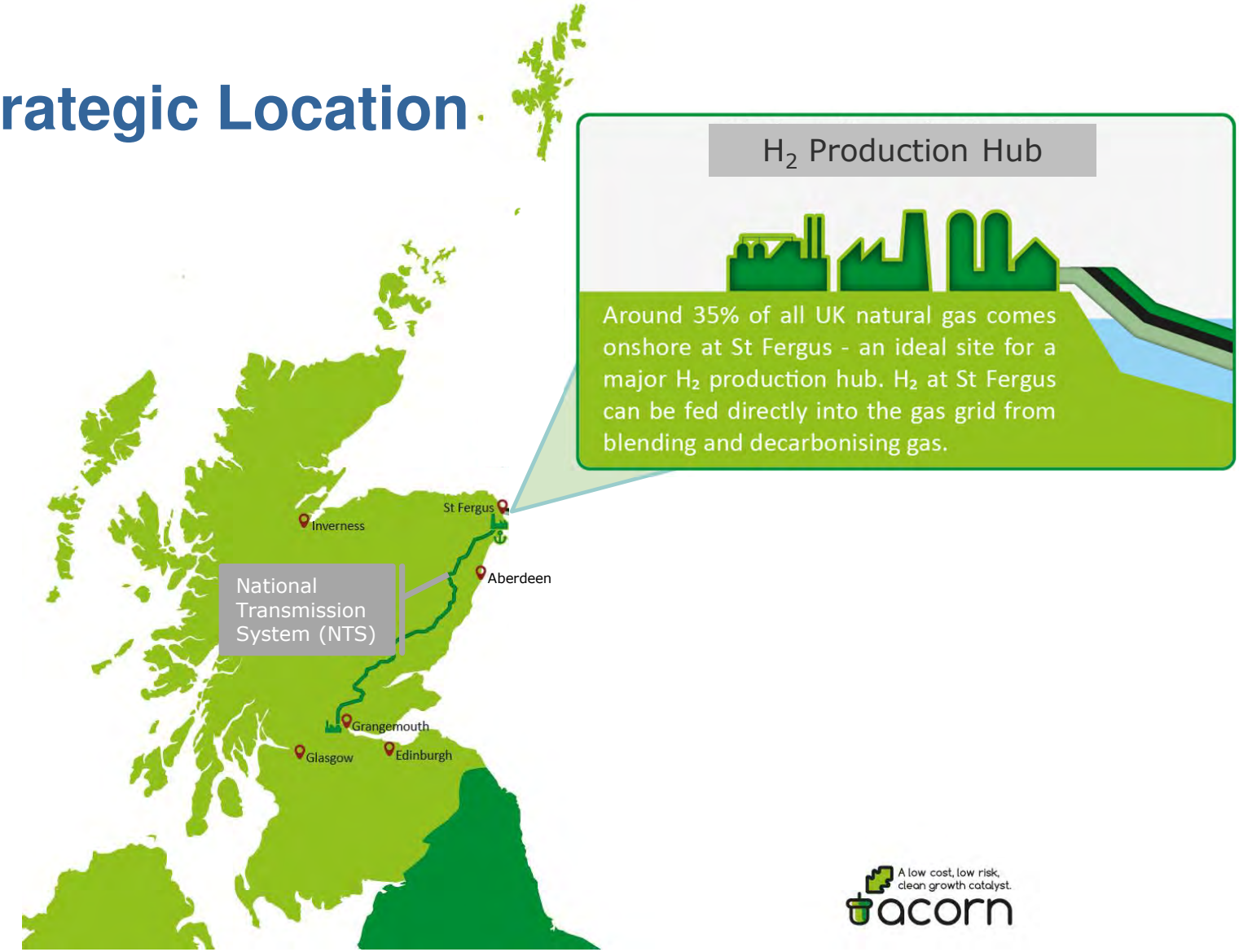
9th October 2018

Hazel Robertson
@hazelerobertson
hazel.robertson@pale-blu.com

A bit of background...

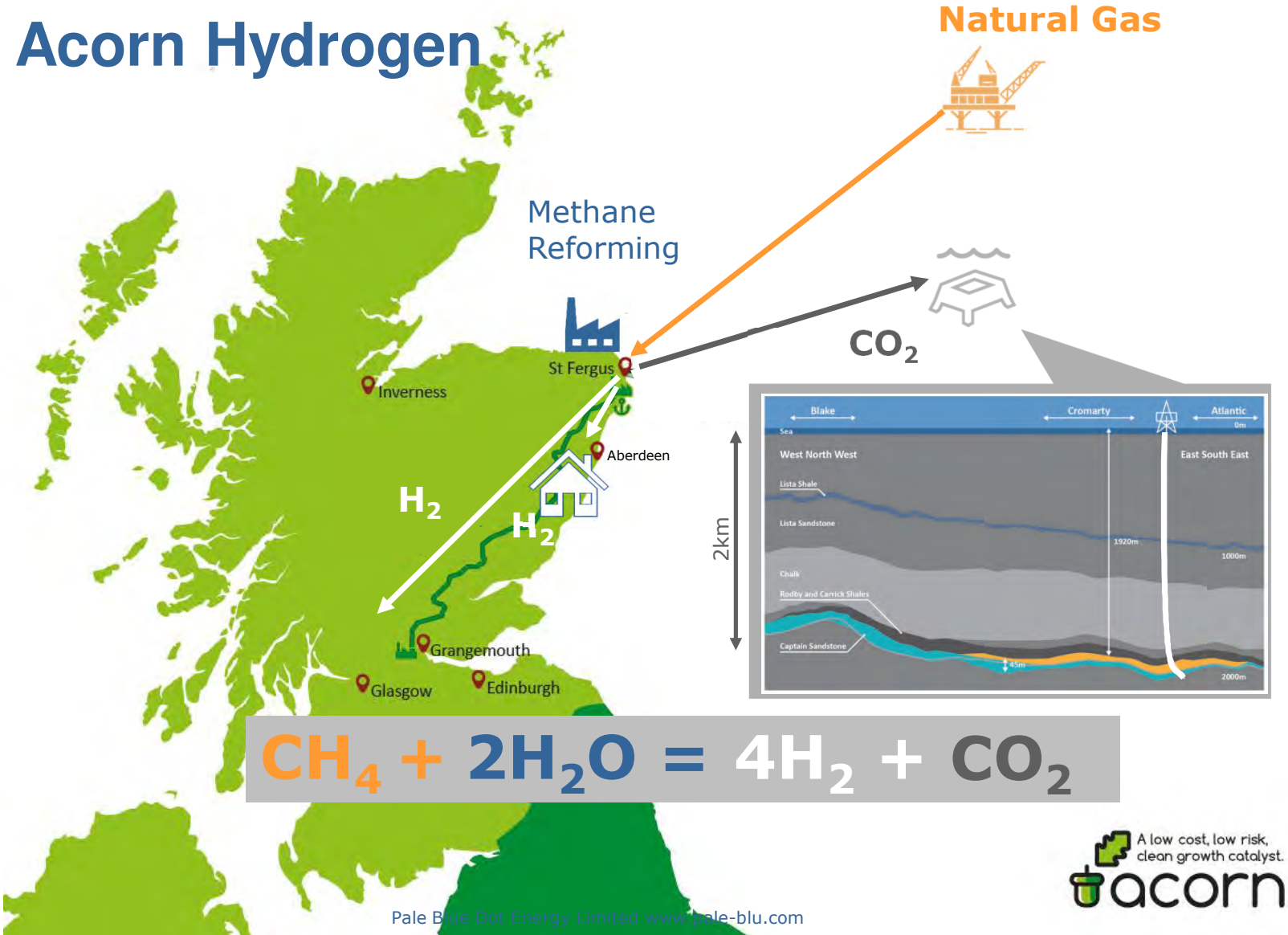


Strategic Location



A low cost, low risk, clean growth catalyst.
acorn

Acorn Hydrogen

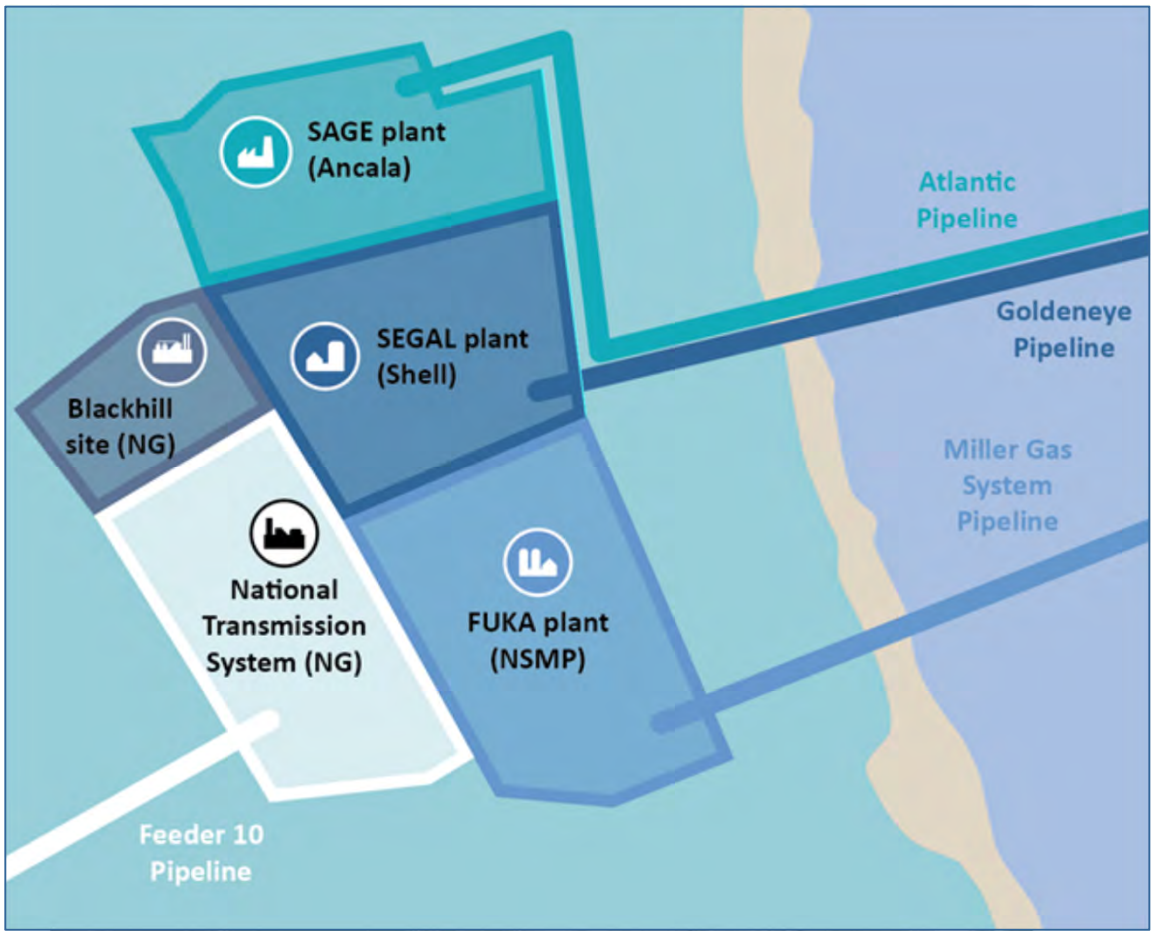


$$CH_4 + 2H_2O = 4H_2 + CO_2$$

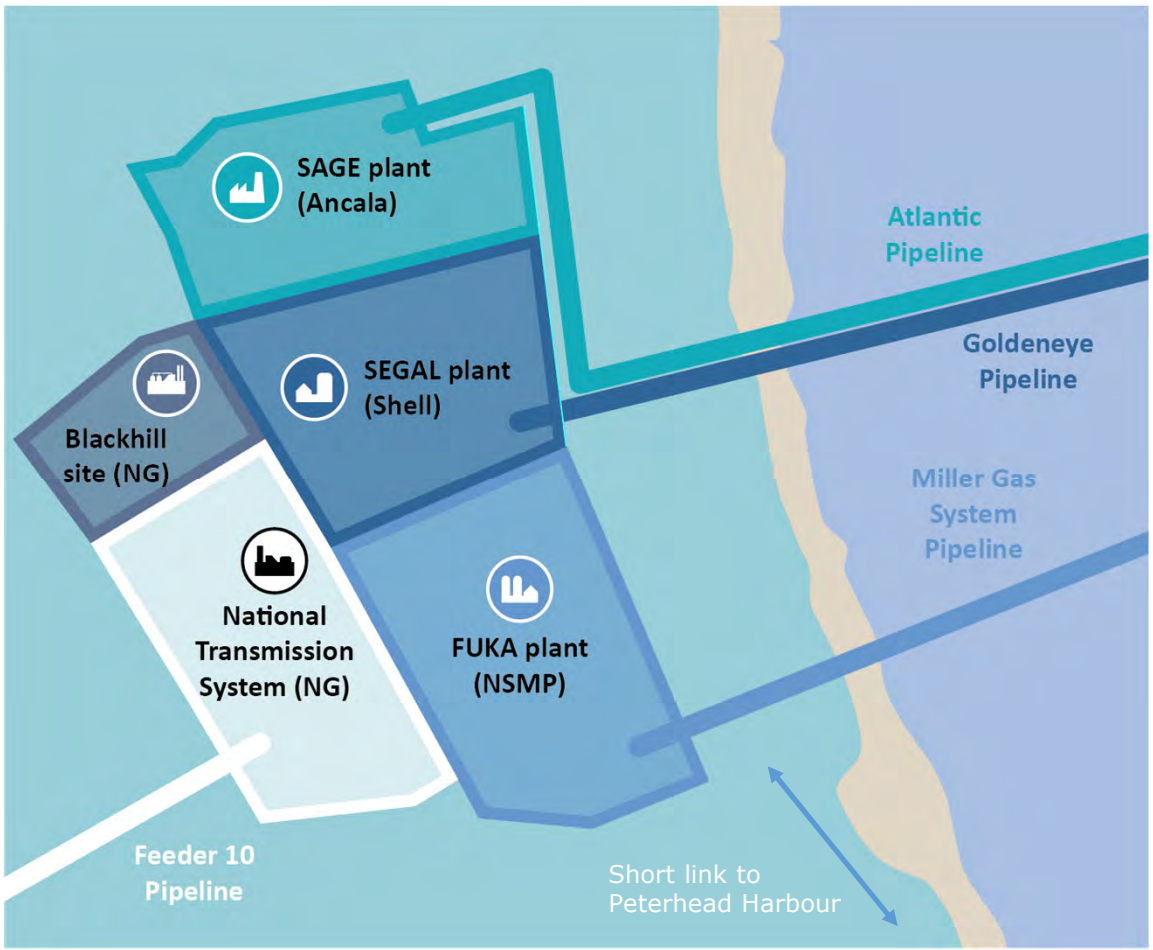
A low cost, low risk, clean growth catalyst.

acorn

Acorn - St Fergus Gas Terminal



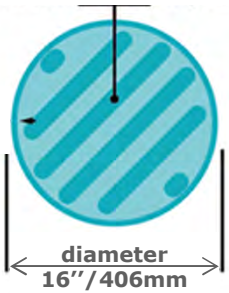
Acorn – St Fergus Gas Terminal



Acorn - CO_2 Transport and Storage

Atlantic Pipeline

Throughput: 5 million tonnes CO_2 per year

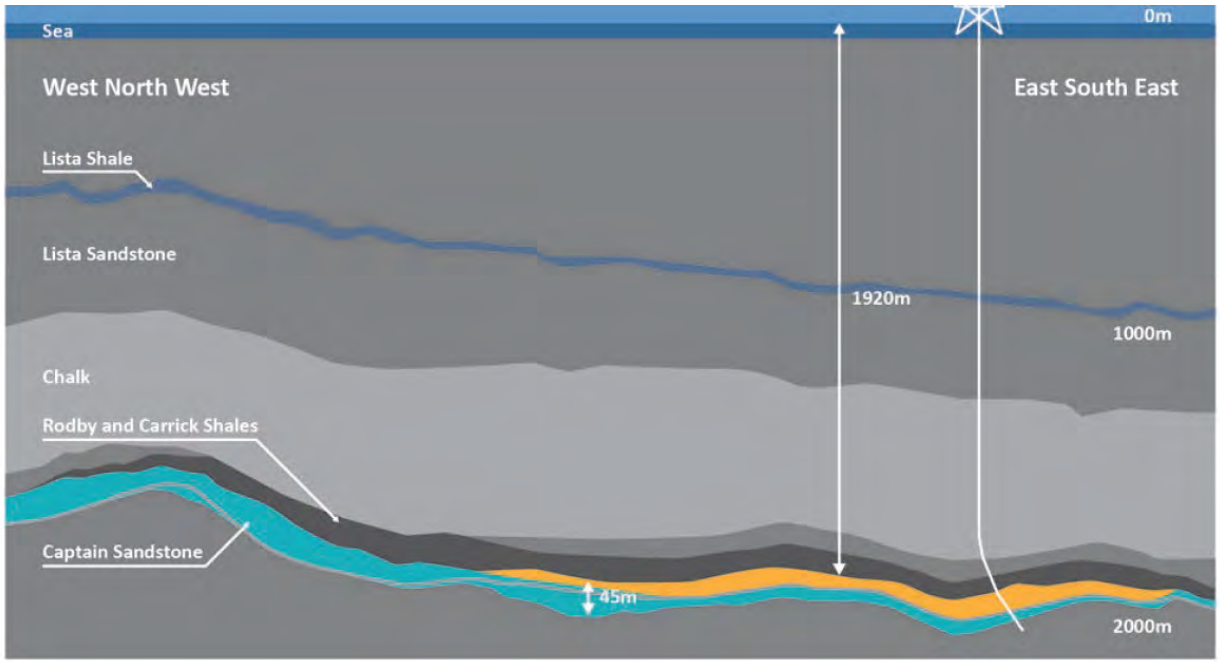


Pressure: 170barg

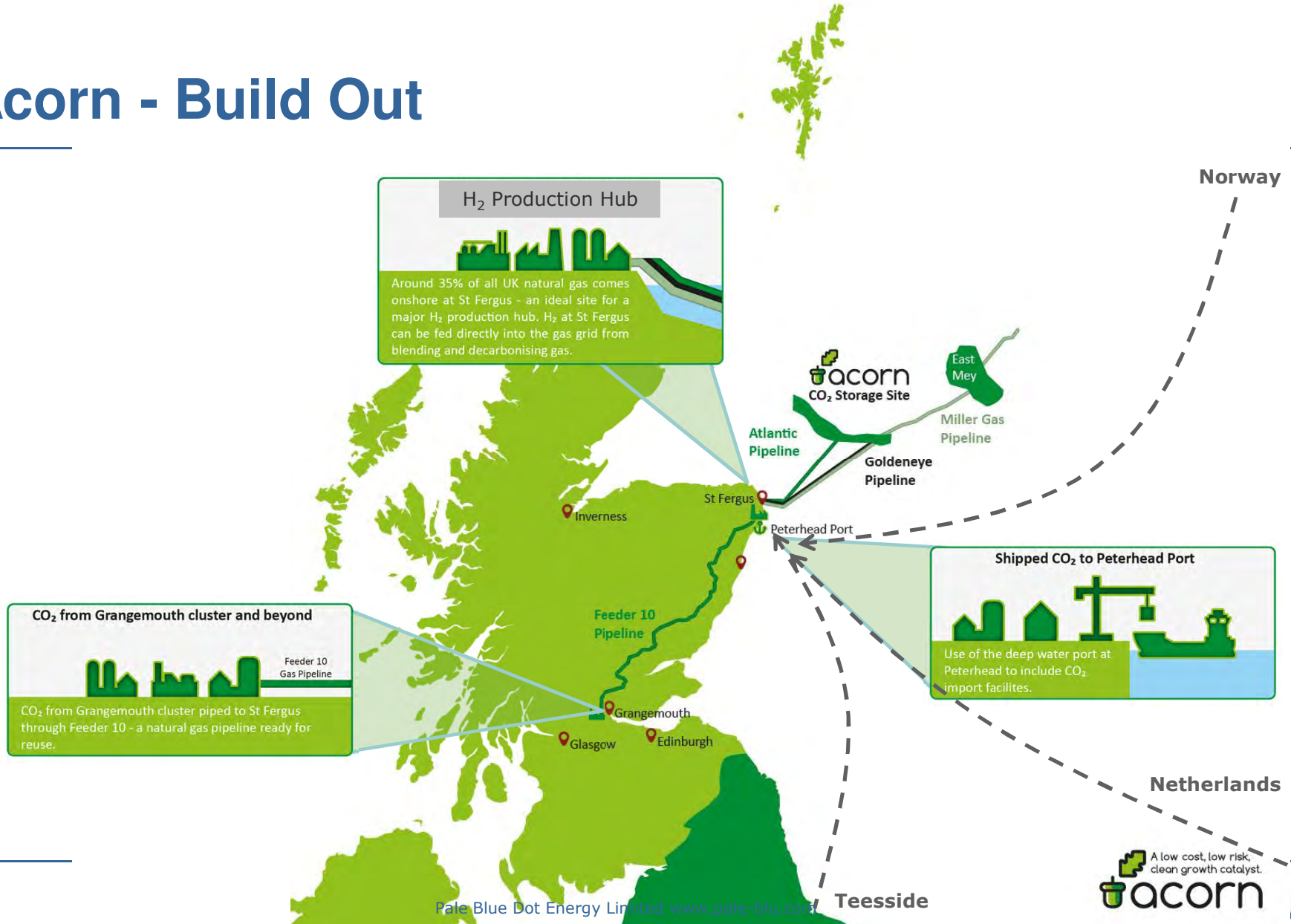
Design life: 20 years

Operated for: 4 years

Acorn CO_2 Storage Site



Acorn - Build Out



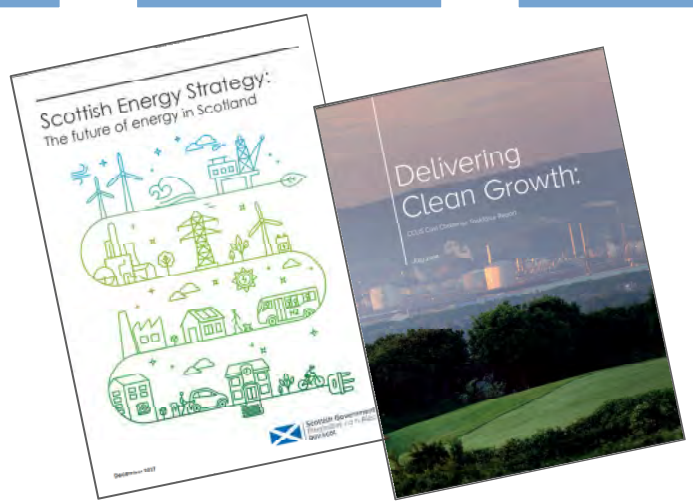
Acorn Hydrogen Project Status

Acorn CCS

Feasibility Engineering Underway

£2.3m BEIS grant through Horizon2020

£100k grant from Scottish Government



Acorn Hydrogen Project Status

Acorn CCS

Feasibility Engineering Underway

£2.3m BEIS grant through Horizon2020

£100k grant from Scottish Government

Lease Option

CO_2 Storage Licence

PCI 3rd List and First CCS project to be awarded CEF funding

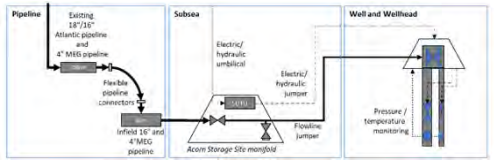
H_2 Blending Feasibility

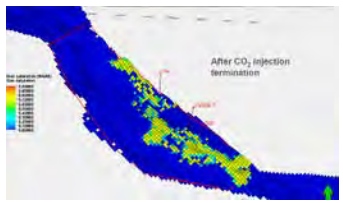
Next up…Front End Engineering and Design…

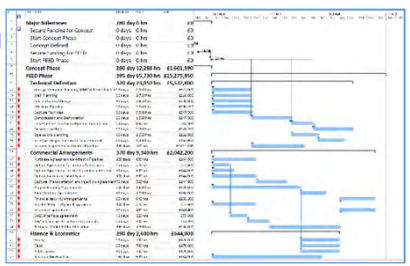
Acorn – Supply Chain Opportunity

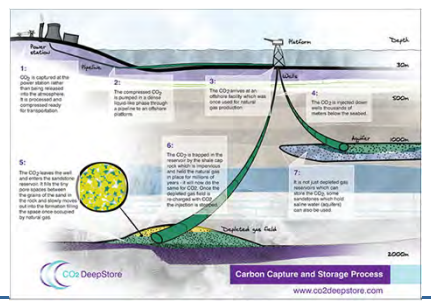
Climate Change Act 2008

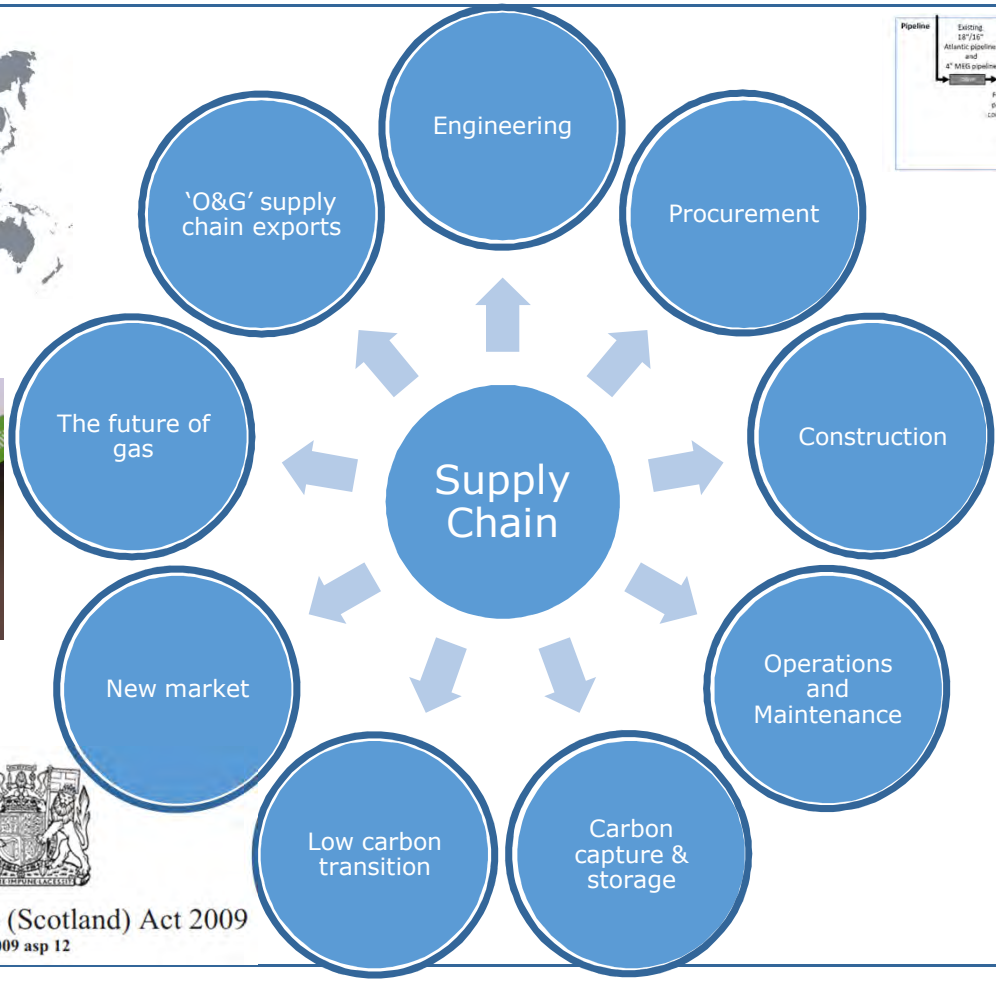
Climate Change (Scotland) Act 2009
2009 asp 12











Pale Blue Dot.

…mighty oaks from little acorn grow…

Thank you!

Hydrogen as a Business Opportunity

Speaker: Nick Stapley, Logan Energy

Renewable Hydrogen and Sector Shifting

Nick Stapley - BD

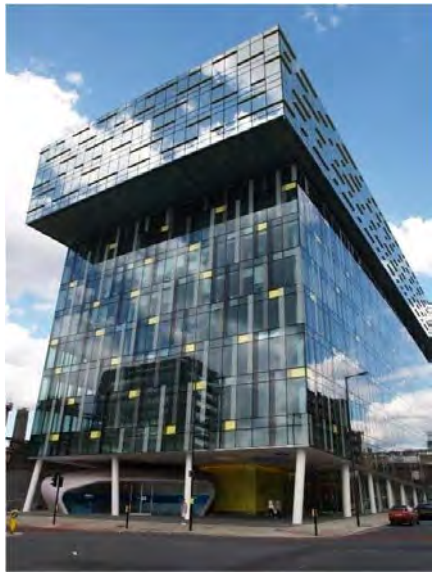
Logan Energy Limited

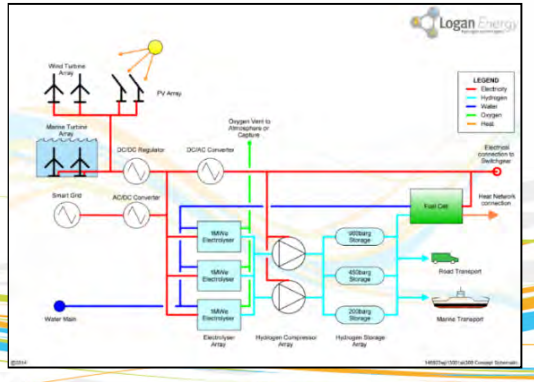
Company Background

- 1995: Logan Energy Corp. established in USA
- 2005: Logan Energy Ltd registered in UK as spin off from LEC
- 2008: SSE and Scottish Enterprise invested & become shareholders
- 2016: Dunelm Energy acquires SSE Shares
- 2017: **n-tropy Group** is created
  - Logan Energy Ltd remains the group's engineering consulting business
  - 4 wholly owned subsidiaries by industry segment or activity:
    - **H2Tec Ltd** Hydrogen Energy Systems Manufacturing
    - **EneTec Ltd** Hydrogen Equipment Distribution
    - **FuelCellUK Ltd** Hydrogen Vehicle Systems
    - **ProtonPower Ltd** Hydrogen Facility Operation and Maintenance
  - Manufacturing facility created in Wallyford, East Lothian
- 2018: **H2Tec BV** established in Gröningen, Netherlands

Company Projects

- Over 1.1MWe of fuel cell CHP, CCHP installed >98% installed capacity
- 2008 – TfL Palestra
- 2012 – Quadrant 3
- 2014 – 20 Fenchurch Street
- 2013/5 – Hyseas
  - Onshore H_2 production, storage, dispensing
  - On-board H_2 refuelling, storage, distribution
- 2015 – DECC H_2 Town
- 2017 – Levenmouth
  - Mobile refuellers
  - Energy storage systems
- 2018 – HyTIME
- 2018/19 – SEAFUEL / IZES

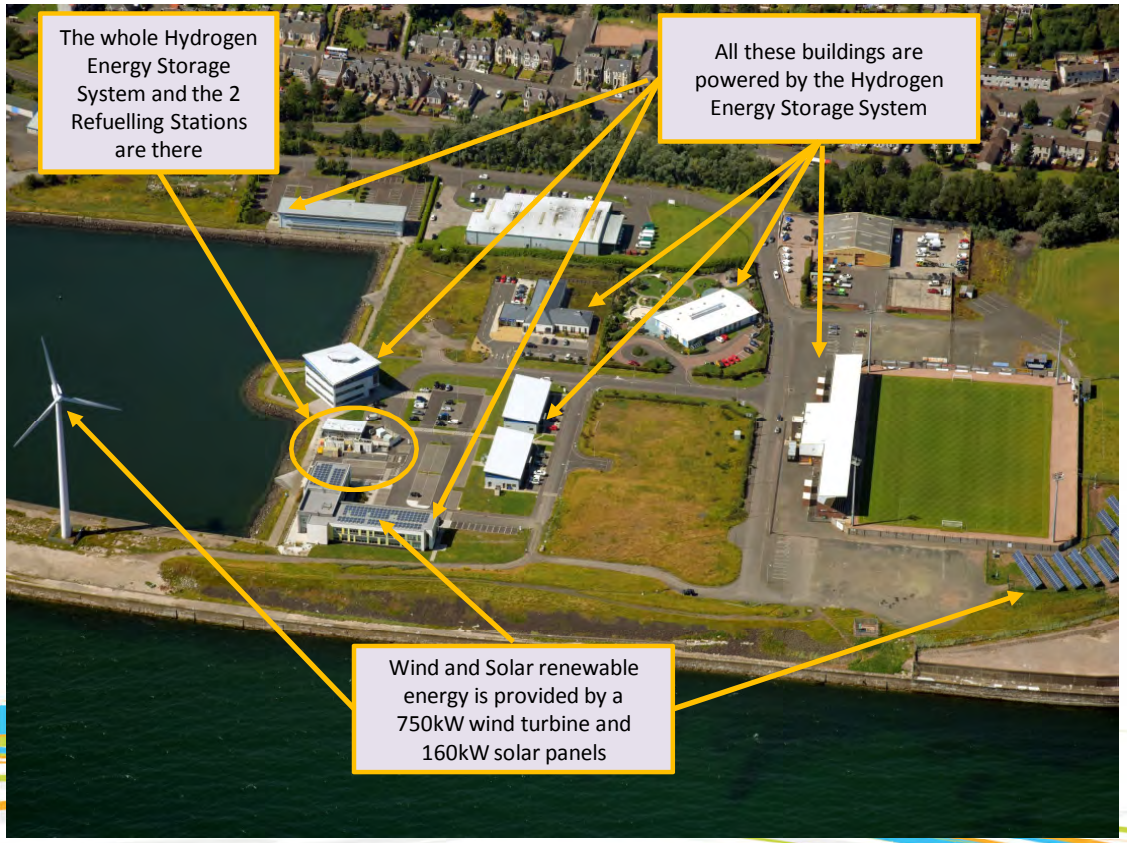




Company Offering

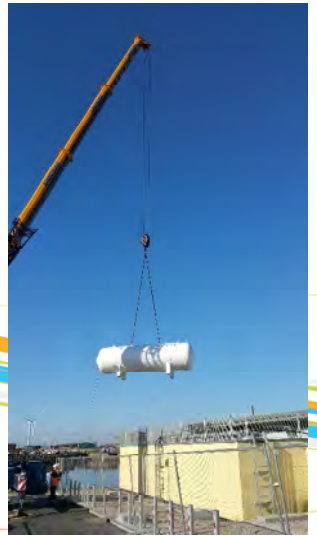
- Manufacturer-independent integration of hydrogen energy systems
- Edinburgh based Energy Solutions Provider
- Integrated Energy Systems
  - Energy Centres
  - Energy Storage
- Hydrogen Production and Refuelling Stations
- Product Development
- Governmental Policy Adviser

Levenmouth Community Energy Project



- Increase generation to 910kW
- Increase microgrid network
- Hydrogen energy storage system
- Two hydrogen refuelling stations – PEM and Alkaline
- Energy management system
- Fleet of 17 vehicles
- Investigation into Rural hydrogen
- Fully operational since April 2017

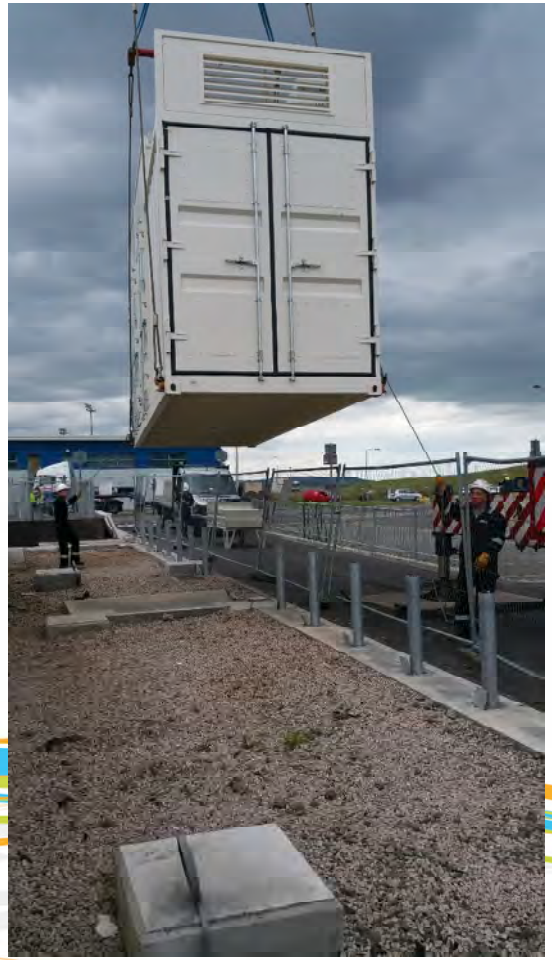
Energy Storage System



Logan Energy
hydrogen technologies

Mobile concept

Vehicle and MCP refuelling



Transport

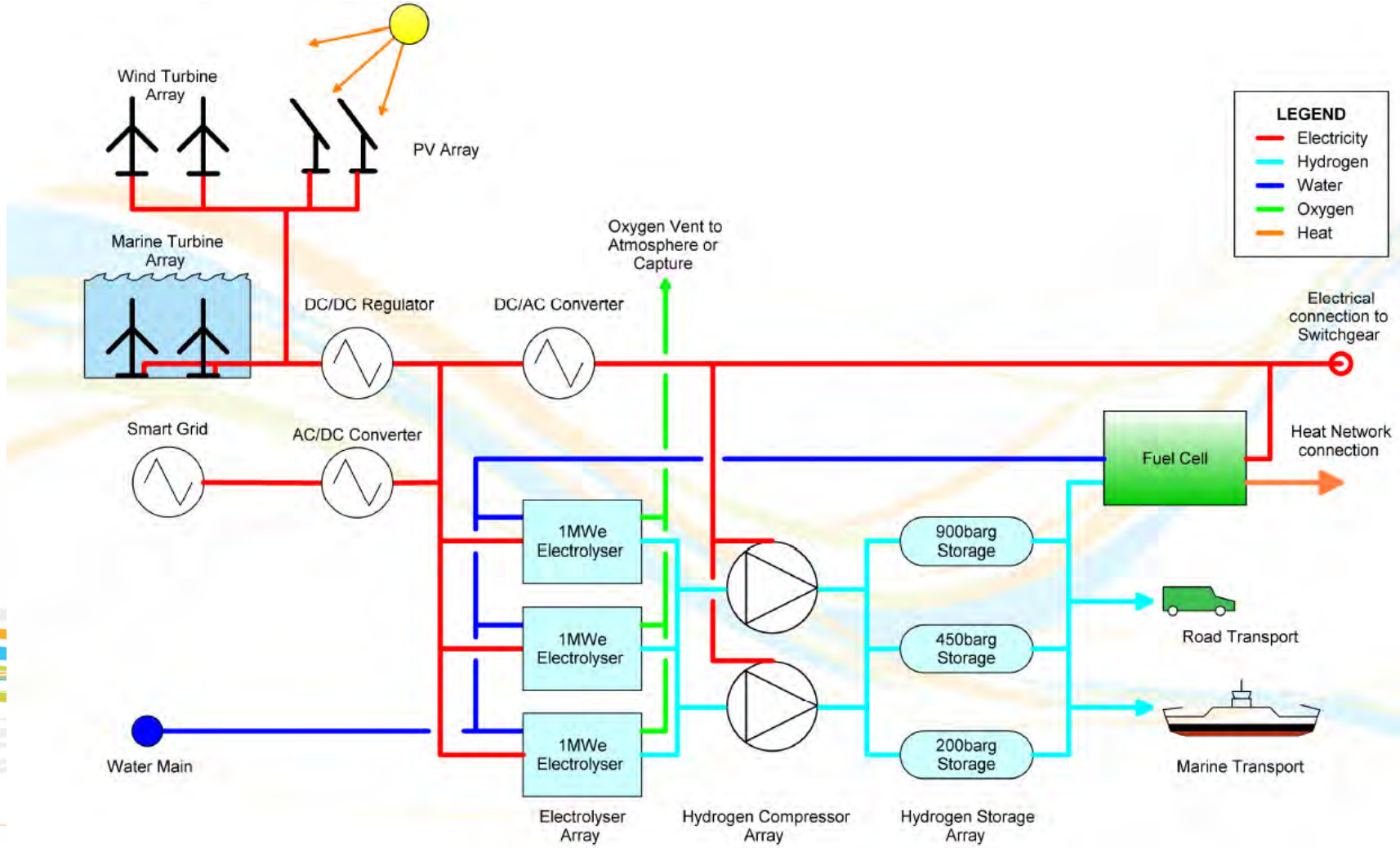
Logan Energy
hydrogen technologies

Utility vehicles

HyTIME: Economic HRS

- HRS for Veolia operating 2 RCVs Westminster City Council
- 350 bar; >10kg/day
- Compact and Economic design
- Fully assembled in factory
- Easy installation on site

Large Hydrogen Community



What's holding up H_2 deployment?

- No incentive framework
- Very few FCEV passenger vehicles
- BEV seen as “easy win”
- Demanding HRS requirements set by car manufacturers
- No fuel cell HGV and LGVs (in the UK)

➢ Provide some long term security

➢ Is this the right priority?

➢ Review true cost of deployment

➢ Define less costly standards

➢ Upskill and develop them in Scotland - H_2CoE

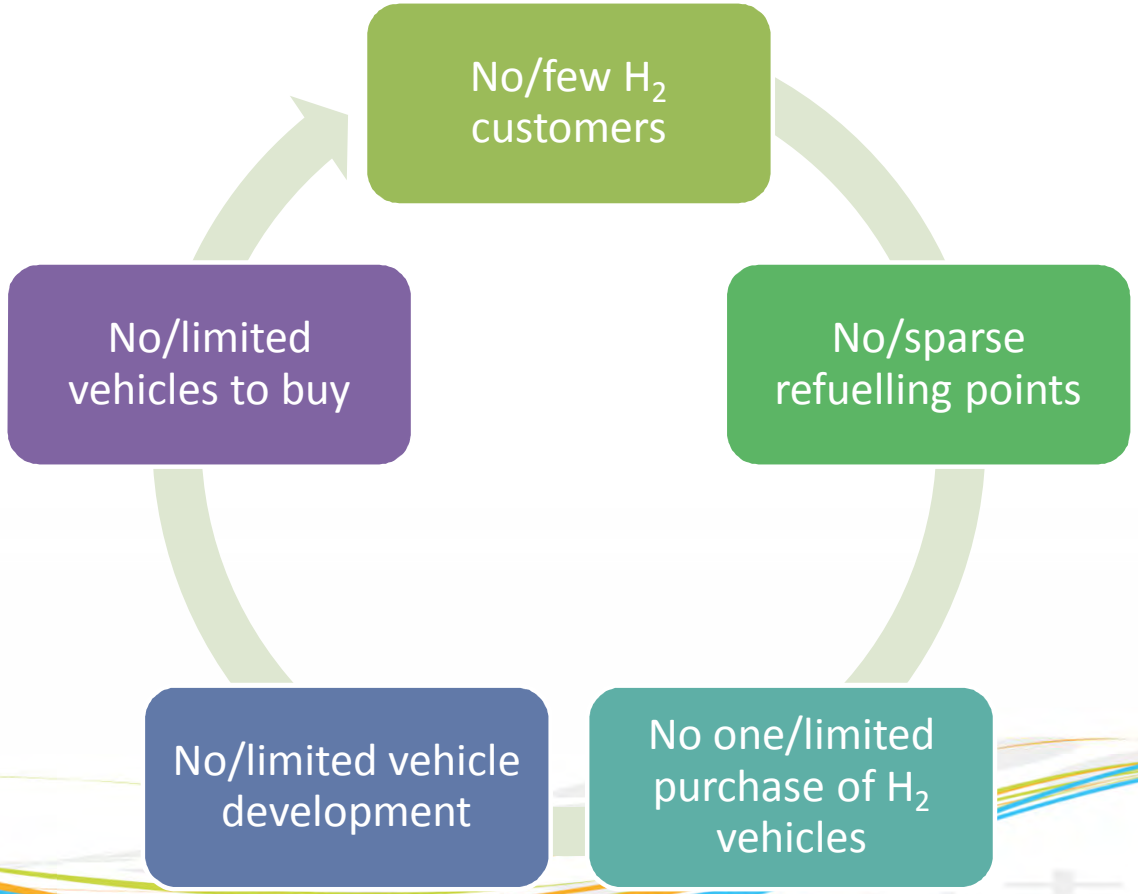
What's holding up H_2 deployment?

- High CAPEX
- Ban pollution emitters in poor air quality locations
- Commercially viable deployment
- H_2 Industry Paranoia

- ➢ Provide low cost loan facility supporting perceived higher risk projects
- ➢ A solution will be found
  eg mixture of FCEVs and BEVs
- ➢ Availability of Data
  Curtailed wind, Off gas grid consumers
- ➢ Partnerships

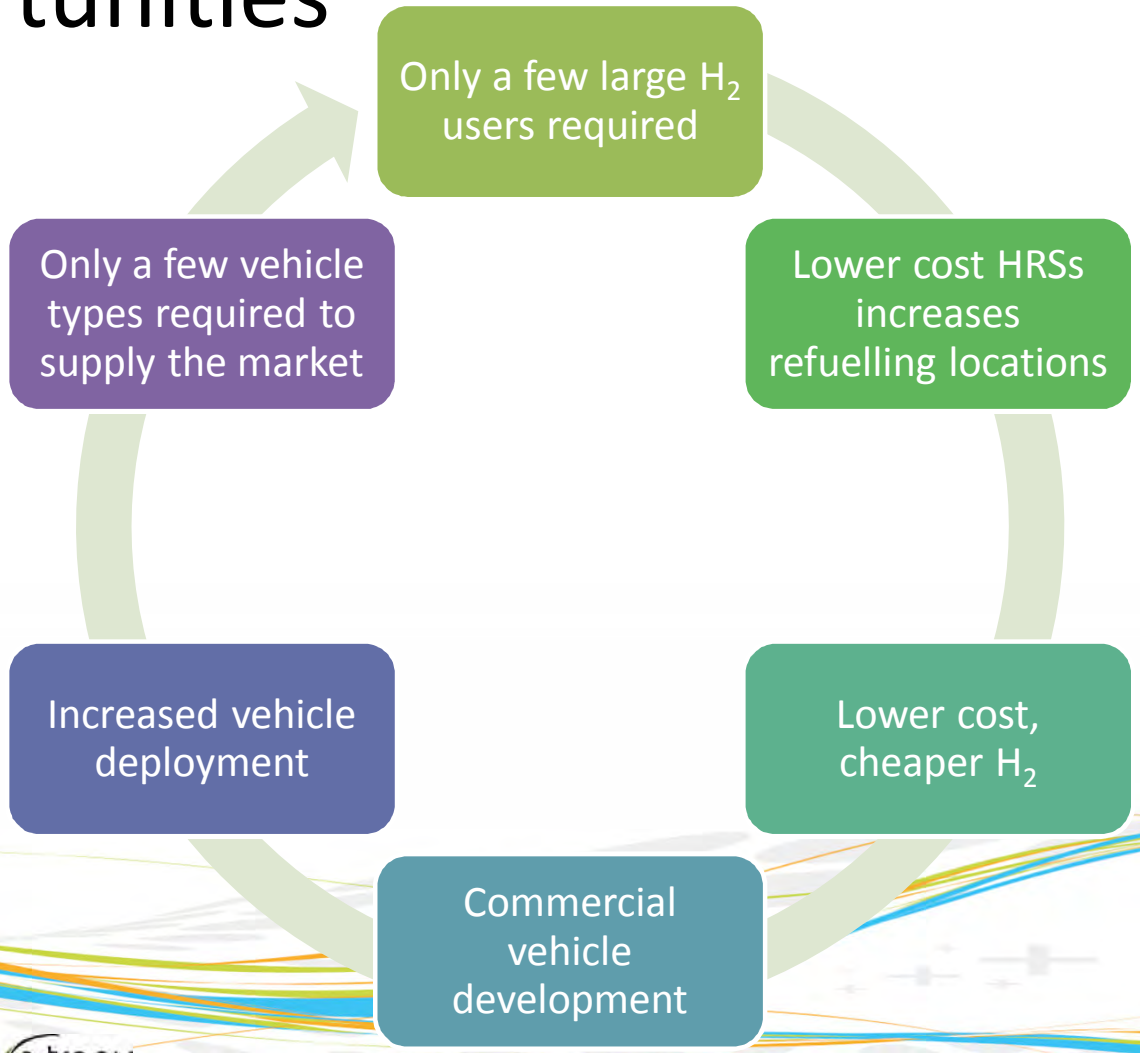
Chicken & Egg Road Block

- 700bar T40 HRS's high cost preventing deployment
- Restricted vehicle availability
- Lack of expertise in deployment
- Failure to deliver



Opportunities

- Reduce cost 350bar HRS's increased deployment
- Large user focus
- Commercial offering
- Increase deployment increases expertise
- Delivery success



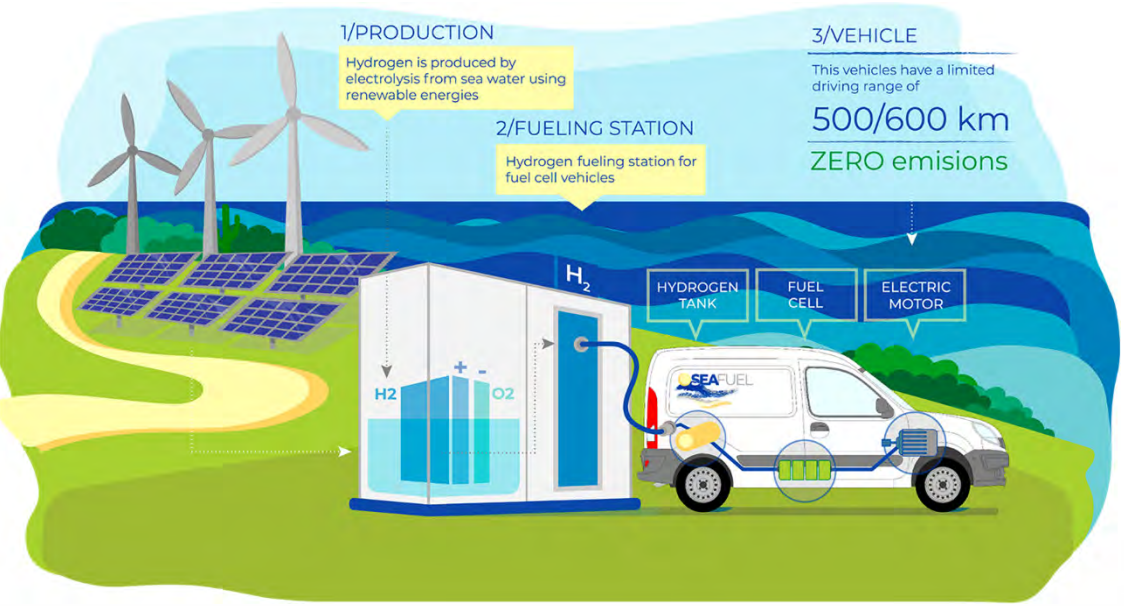
Opportunity

- Energy provision is changing
- Renewables percentage will increase further
- Energy storage is required
- Hydrogen is part of the mix
- Energy usage needs to change
- Sector shifting is an economic option **NOW**

Interreg - SEAFUEL

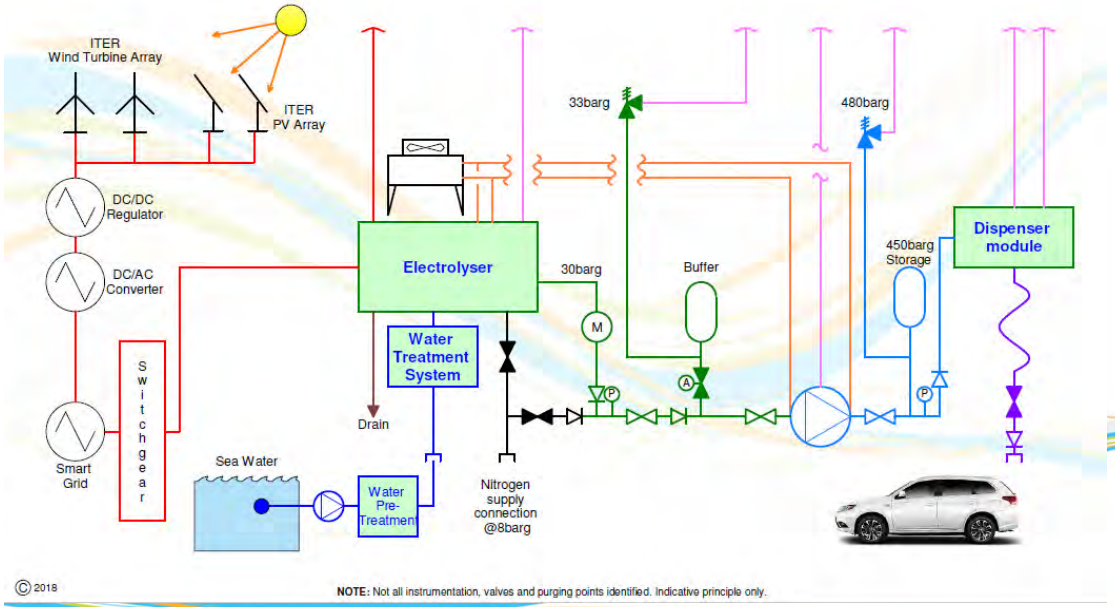
- Use renewable resources across the Atlantic Area to power local transport fleets
  - Expertise and infrastructure of partners in solar, wind and marine
  - Demonstrate viability of hydrogen as a fuel
- Support the shift to a low-carbon economy

SEAFUEL: Tenerife



- 350 bar HRS for local fleet of FCEVs
- Designed, built, commissioned in **Scotland**
  Installed and operated in Tenerife

- 51 MW installed renewable generation
- 125 m3/day desalination plant
- 25 kg H2/day 350 bar HRS



Interreg - GENCOMM

- GENCOMM: GENerating energy secure COMMunities through Smart Renewable Hydrogen
  - Provides a roadmap for communities to transition to renewable, hydrogen-based energy matrixes
- Aim is to technically and financially validate the renewable H2 value chain
  - Empower communities to implement hydrogen-based energy matrixes to sustainably satisfy their energy demand.
  - Stimulate the uptake of renewable hydrogen-based technologies by successfully running 3 demonstration facilities.
  - Establish a strong group of energy stakeholders devoted to, through the use of hydrogen, “sustainabilise” the energy matrix of the NWE region.

GENCOMM Project

- IZES (Saarbrucken, Germany)
  - SOLH2TRANSP
  - Solar → Hydrogen → Transport
- Tender to supply 700 bar HRS
  - Passenger vehicle refuelling
- 35 kW solar PVs

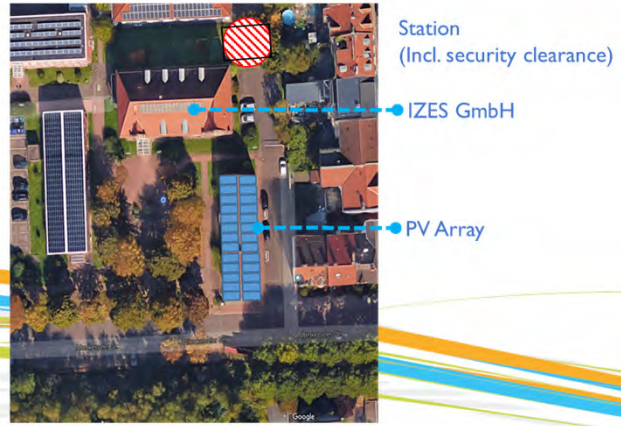


Fig1.H_2 Refueling Station Location
(Source Google Maps)

- Viridian (County Antrim, NI)
  - WINDH2STO
  - Wind → Hydrogen → Storage
- Tender to supply 3 hydrogen trailers
- 500 kW windfarm

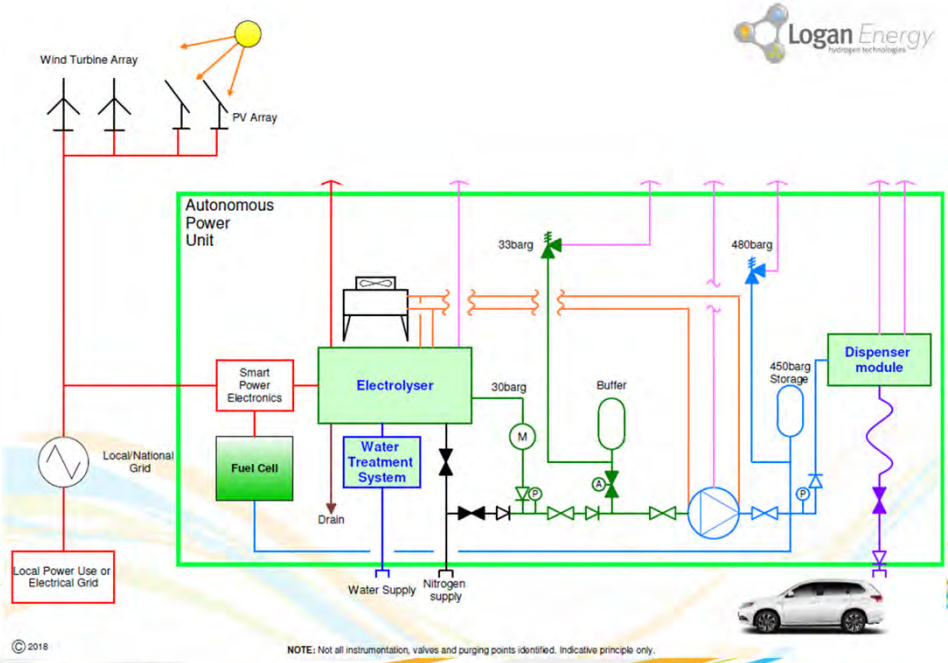
Mobile Fuel Cell Trailer

- Fuel Cell UPS
- John Radcliffe Hospital, Oxford
- 5kW alkaline UPS (Gencell G5)
- Demonstration/Trial
  - Having to trial
  - Lack of acceptance
  - Barrier to deployment
  - Need to break the mindset

R&D

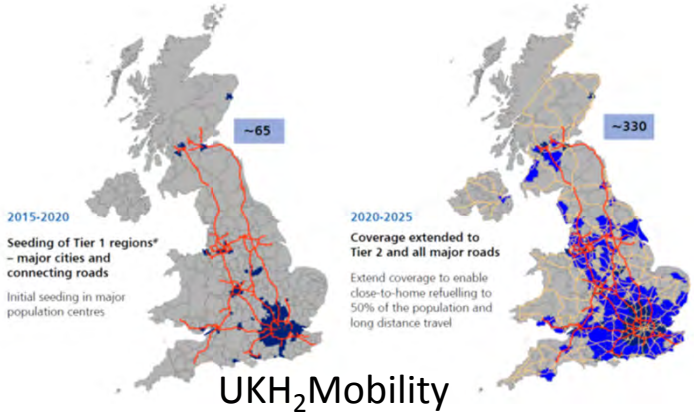
- Wallyford HRS
  - Cooling / Dispensing
  - £250,000 R&D Project

- Autonomous Power Unit

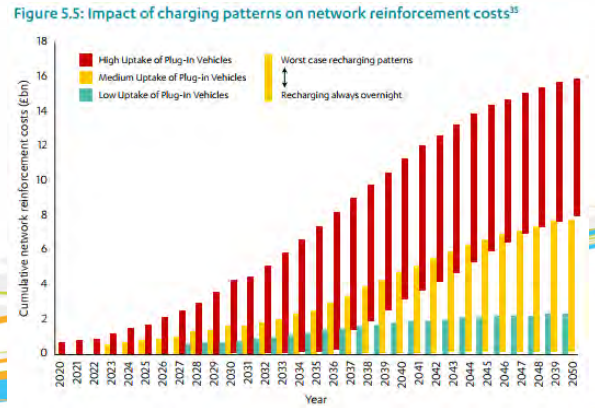


Policy, legislation and delivery

- Workable transport strategy
- Coordinated legislation
- Big Company Lobbying
- Level playing field??
  - Offshore wind – subsidy
  - Biofuel - subsidy
  - O&G no penalties for carbon emissions
  - EVs - £5000 subsidy/vehicle
  - H_2 – **nothing yet…**RTFO?
- Grid reinforcement costs £16bn for EVs alone?
- H_2 – recognised as a solution but no reliable support
- H_2 industry drive for 700bar - expensive vs 350bar
- Available vehicles ???



UKH_2Mobility



Thank you

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