



Hydrogen: A Business Opportunity for Scotland

Session two Chair: William Hazell, ERM





Session 2: Hydrogen Production and Applications

Hydrogen from Marine Renewables - Jon Clipsham, EMEC: The European Marine Energy Centre

Hydrogen from Natural Gas - Corin Taylor, UK Onshore Oil and Gas (UKOOG) and also DGA (Decarbonised Gas Alliance)

The Opportunity for Hydrogen in Scotland - Stuart Mckay, Scottish Government

HyDeploy - Catherine Spriggs, HSE

Managing the Risks and Perception of Hydrogen – David Caine, ERM



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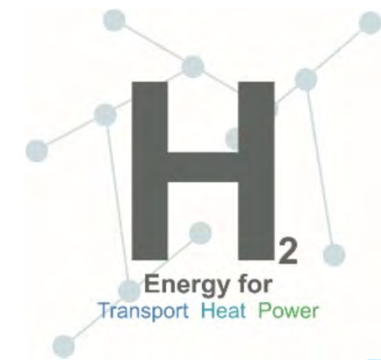
EUROPEAN UNION

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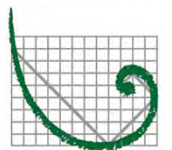
Oil, Gas & Energy

H₂
Aberdeen



Hydrogen from Marine Renewables

Speaker: Jon Clipsham, EMEC: The European Marine Energy Centre



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Hydrogen from Marine Renewables

Achievements

Generated >100%
of electricity from
renewables since
2013

Pioneers of new grid-
smart technologies and
local supply models

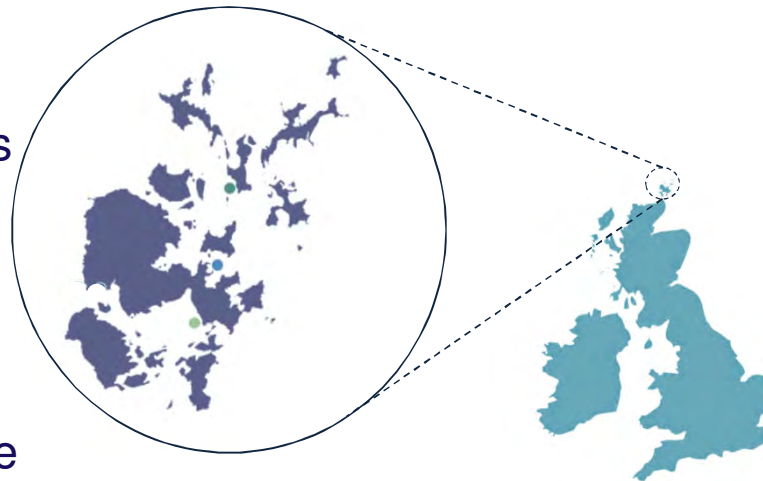
More wave and
tidal energy devices
than anywhere in
the world

1 in 10 of
households make
their own power

Highest uptake of
EVs in Scotland

Piloting powering
ferries with green
hydrogen

Highest levels of
'fuel poverty' in
Scotland



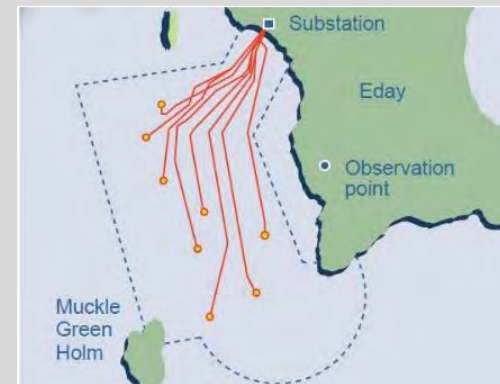
Grid-connected test sites for wave & tidal energy



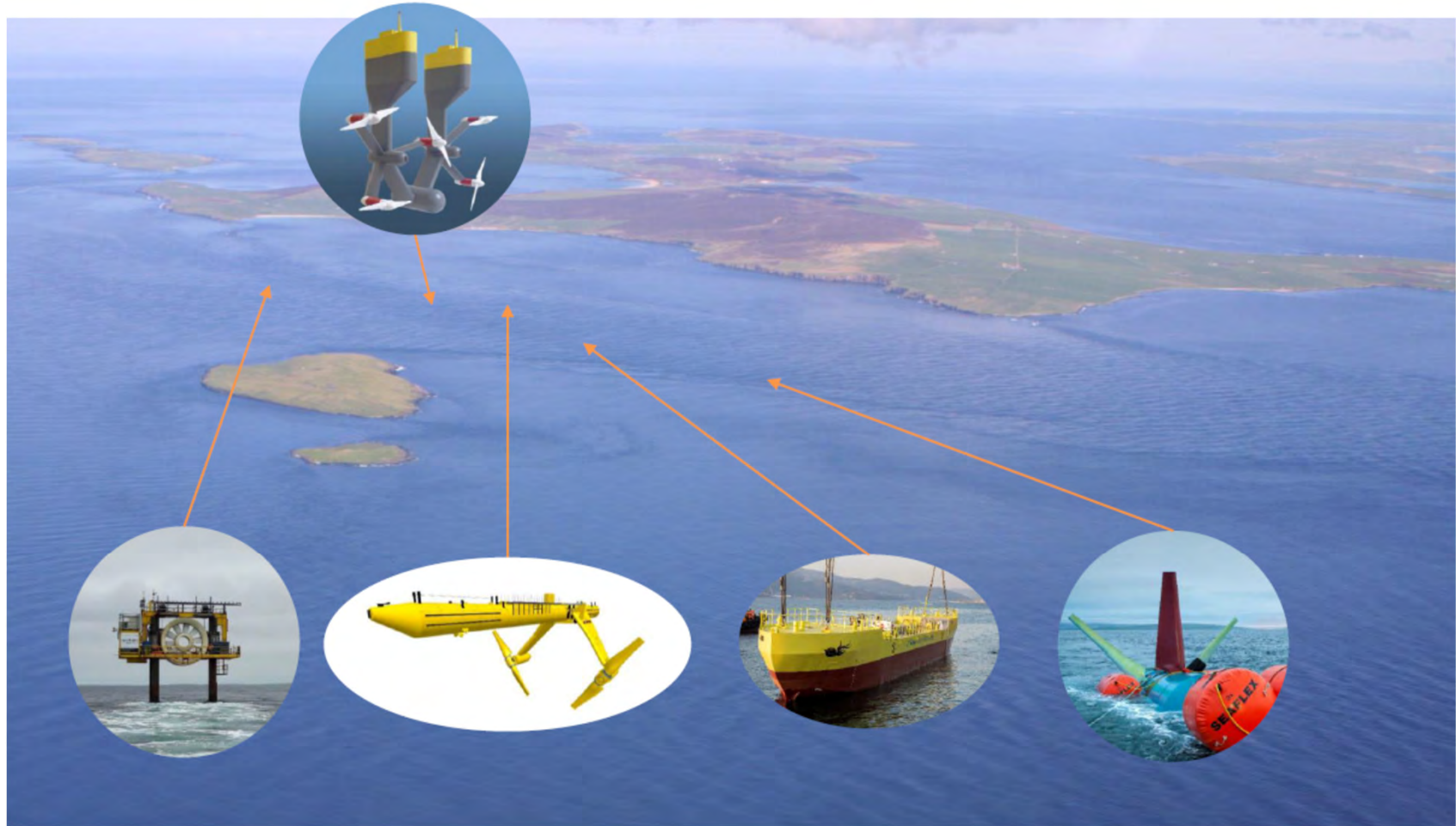
Wave: Billia Croo



Tidal: Fall of Warness



Falls of Warress



Orkney has....

- Big winds
 - Big waves
 - Big tides
- => Big, cheap electricity generation potential



Energy Storage and Hydrogen

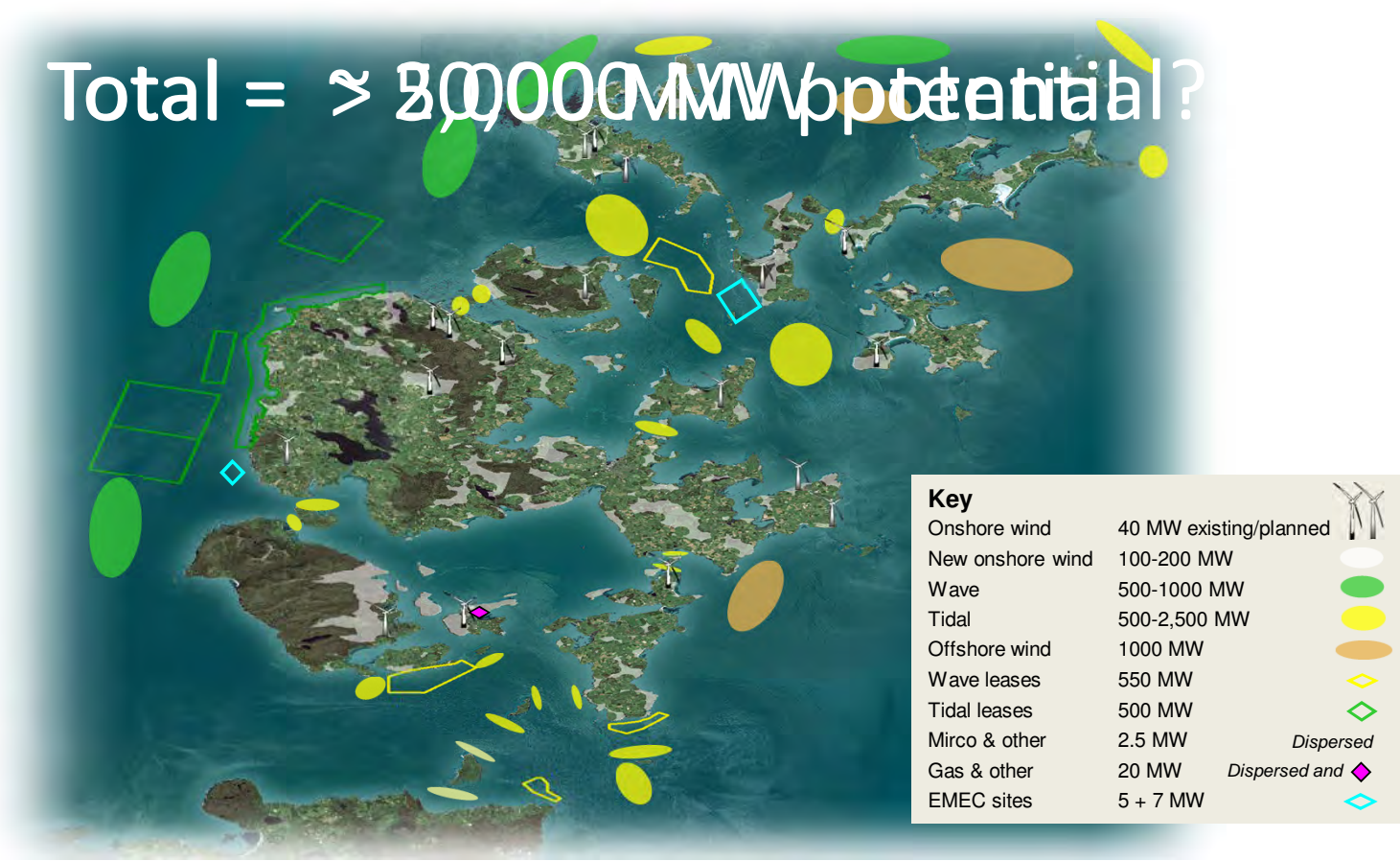


BUT....

- Constrained grid
- Remote & rural

Orkney's Energy Resources

Total = ≈ 200000 MW potential?



Hydrogen Projects



Hydrogen Enabling

Marine
energy



Hydrogen

Energy
System

Why Orkney Works

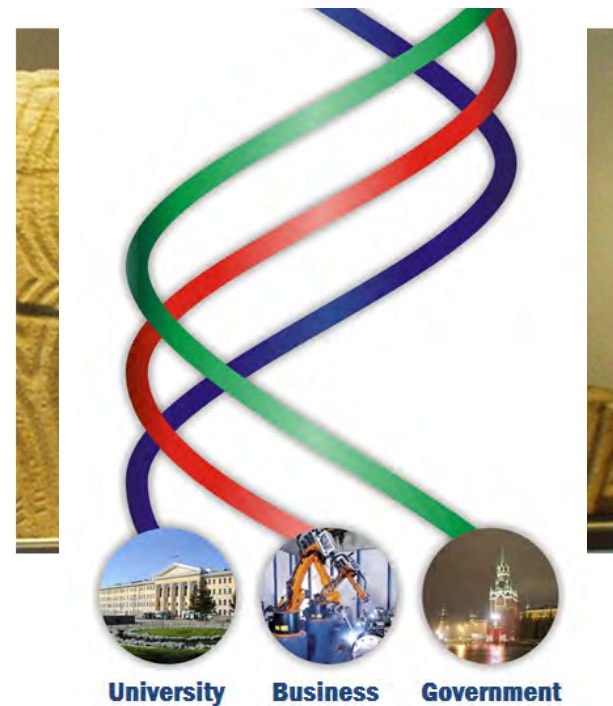


Triple helix

- Government
- Academia
- Industry

Quadruple helix

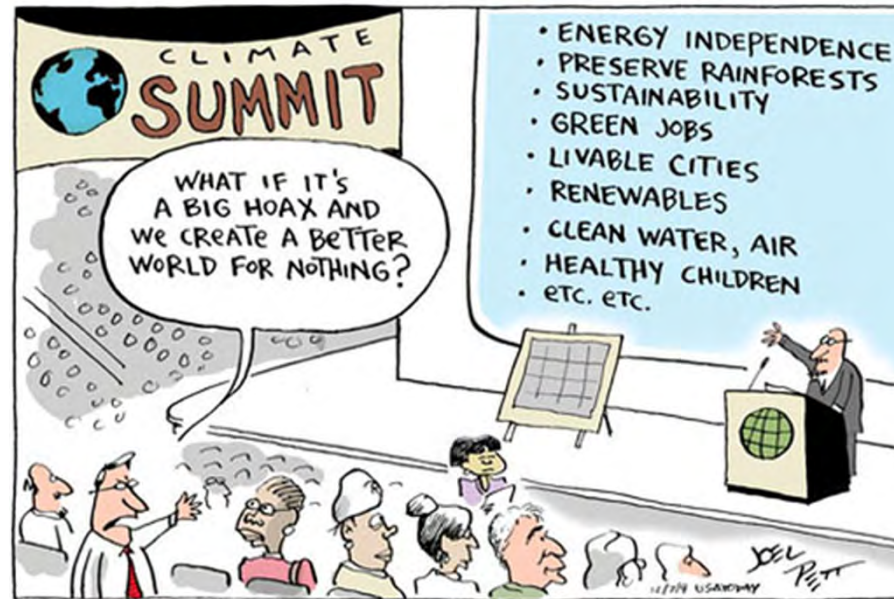
- Community and stakeholders



Community engagement is critical for success

Orkney is now positioned to transition from a historical mix of electricity and fossil fuels to a new energy future based on hydrogen and electricity derived from renewable energy

And finally...



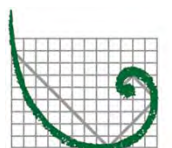
It's important

Orkney's hydrogen future



Hydrogen from Natural Gas

Speaker: Corin Taylor, UK Onshore Oil and Gas (UKOOG) and also DGA (Decarbonised Gas Alliance)



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Hydrogen from natural gas

Corin Taylor, Decarbonised Gas Alliance

Presentation to "Hydrogen: A business opportunity for Scotland" conference

9 October 2018



Pale Blue Dot.



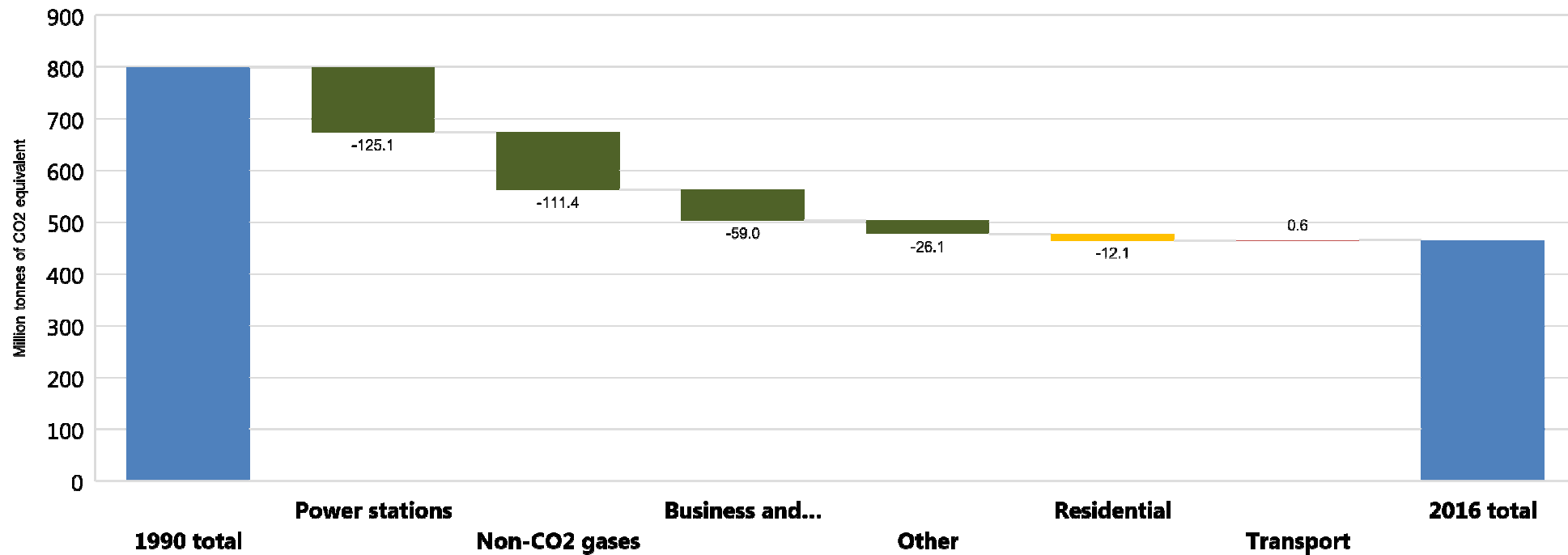
ARUP



UK decarbonisation context

- UK has cut emissions by 42% since 1990 baseline – halfway to 2050 target
- But little progress on heating and transport and air quality is a big problem

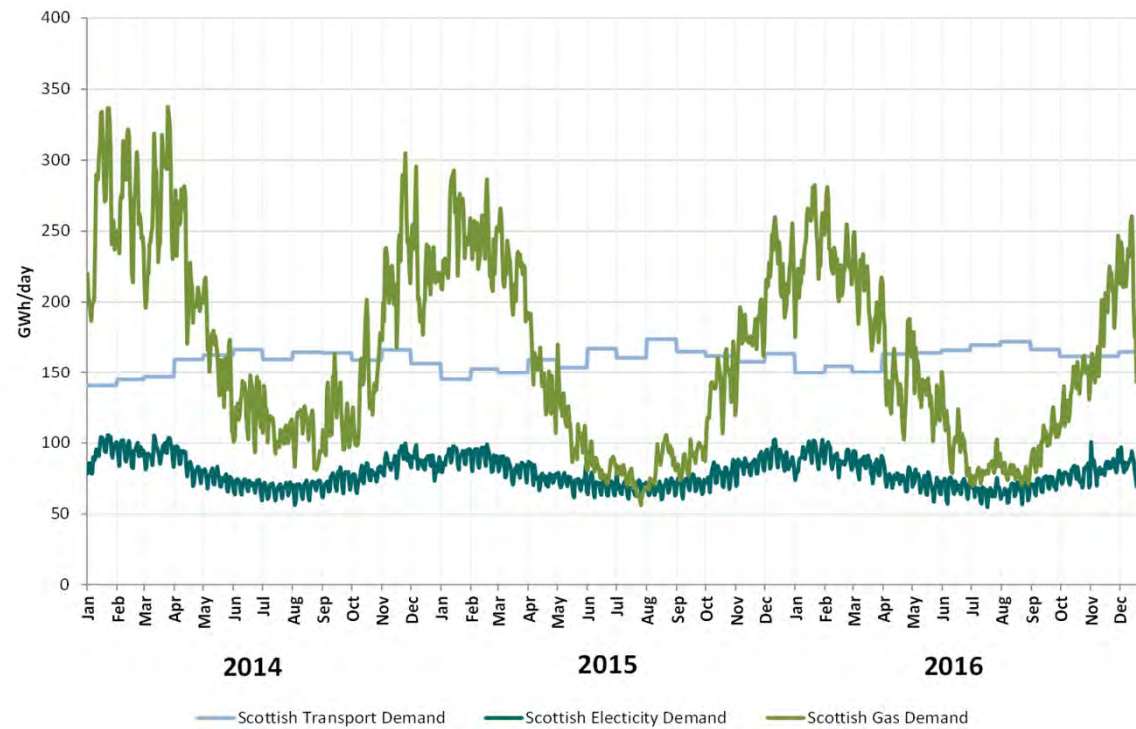
UK greenhouse gas emission progress: 1990-2016



Scottish heat system relies on gas



- 79% Scottish homes heated with gas (2017)
- Fuel poverty: gas heated – 23%; electric heated – 51% (2016)
- 22,000 new heat pumps; 1.6 million new gas boilers (2017, UK)





Advantages of hydrogen

100% hydrogen in the gas grid

- Iron Mains Replacement Programme already halfway through – programme for safety reasons but polyethylene pipes also able to transport hydrogen
- New boilers/cookers needed, but not wholesale changes to central heating system – far lower cost and disruption to consumers
- Town Gas was 50% hydrogen – wholesale conversion to natural gas in 1970s – we have done this before
- Hydrogen can be stored seasonally – batteries provide power for hours not months

Hydrogen blending

- Blending at up to 20-30% likely to be possible without conversions to appliances
- Can allow gas system to store excess renewable electricity through hydrogen



Key elements being demonstrated

Safety of hydrogen in the home:

- BEIS Hy4Heat programme – runs until 2021

100% hydrogen in the gas distribution network:

- Next phase of H21 project – runs until 2020

Industrial hydrogen with gas grid blending:

- HyNet project being developed in the North West of England
- Would take conclusions from HyDeploy project – runs until 2020

And a large number of Scottish projects...



Producing low carbon hydrogen from gas

Focus on gas today, but electrolysis and bio-hydrogen also important:

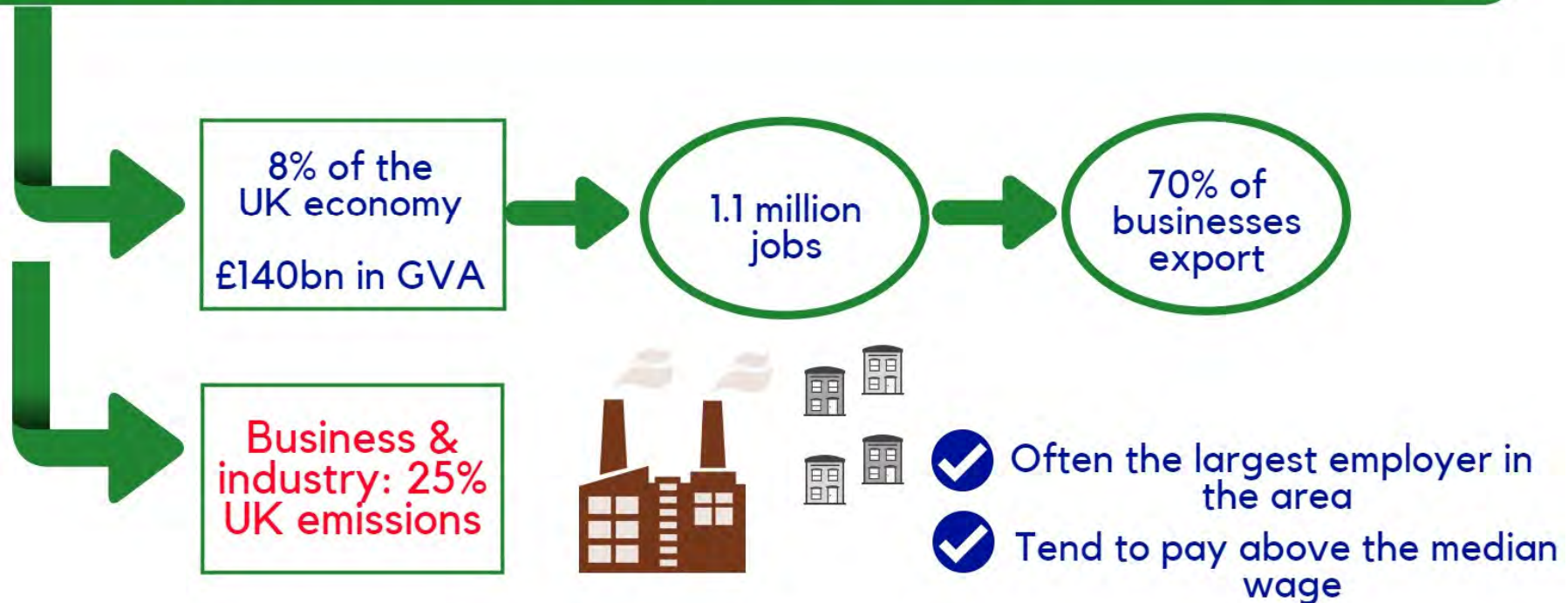
- Steam methane reformation produces half of global hydrogen – cheapest and most widely-used method
- SMRs in the UK e.g. Grangemouth, Teesside
- Hydrogen from methane with carbon capture essential:
 - Already proven in Texas, Canada and Japan
 - Permanent CO₂ storage in Norway offshore since 1996
- UK offshore has more than 100 years of CO₂ storage and fields ready for decommissioning or CCS are near to industrial clusters
- Committee on Climate Change: CCS is vital for meeting the 2050 target – costs could be twice as high without CCS

Tech. exists today: need to cut cost & increase CO₂ capture efficiency

Not just heat – industry too...



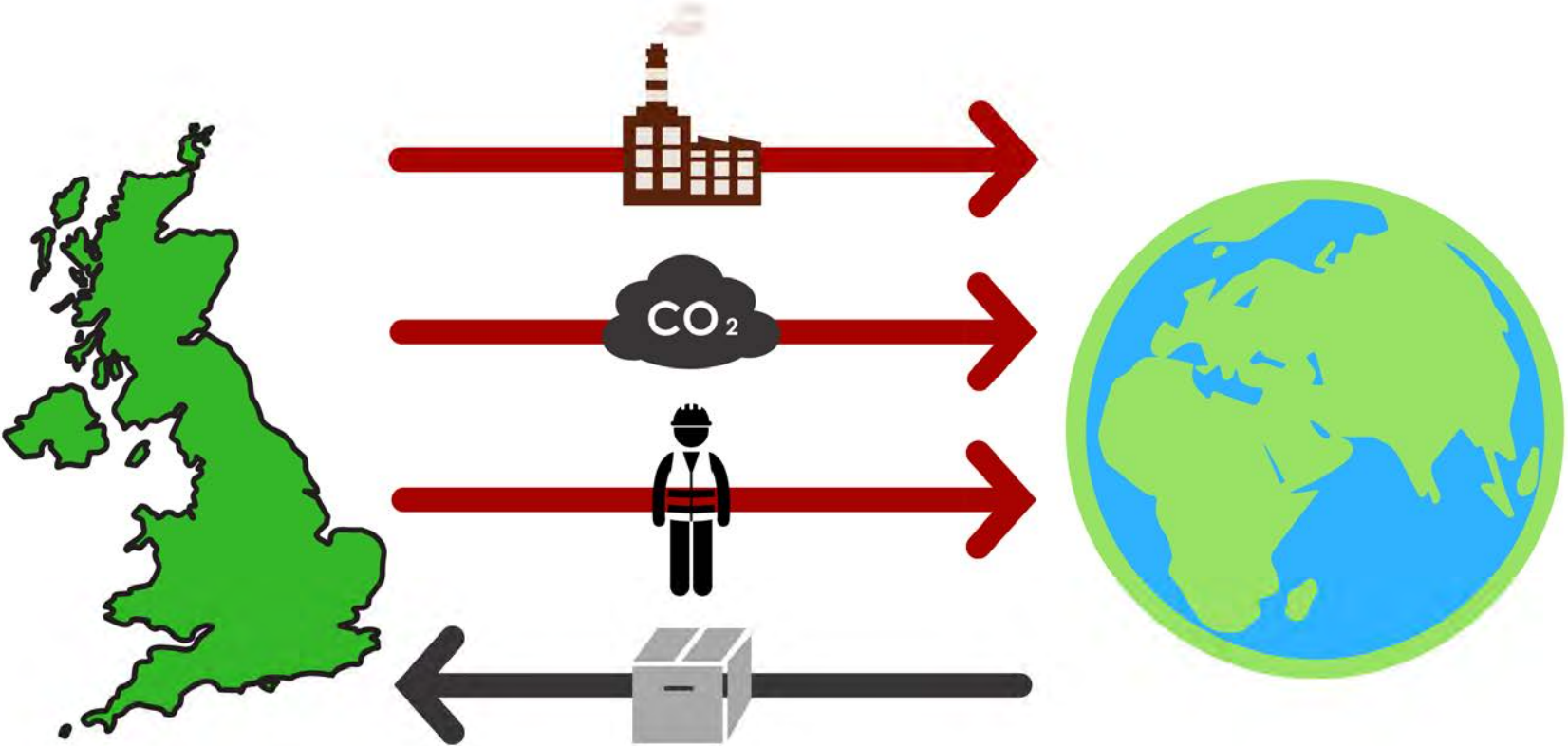
Energy intensive industries are vital



Our big industrial challenge



We have seen too much decarbonisation through offshoring in recent decades...



Off-shoring emissions

Between 1997 and 2015:

Greenhouse gas emissions

UK production: 33% ↓

UK consumption: 4% ↓

Carbon imports: 31% ↑

Manufacturing share of GVA

1997: 17%

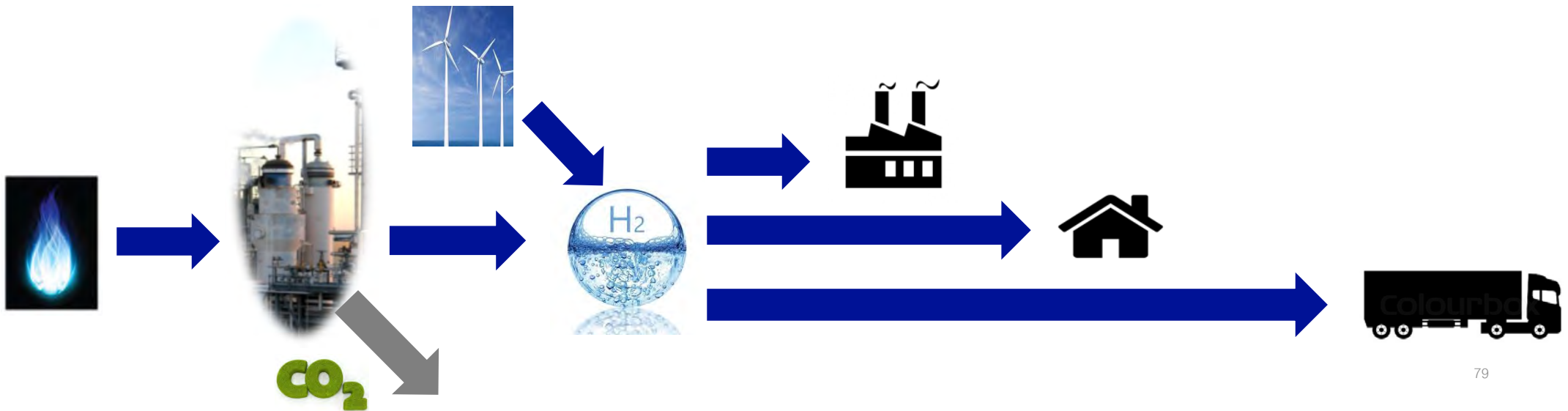
2015: 10%

Closure of Redcar steelworks in late 2015 caused nearly half the fall in industrial emissions in 2016 – but 2,000 jobs lost! If we do nothing this pattern continues...

Re-shoring responsibility



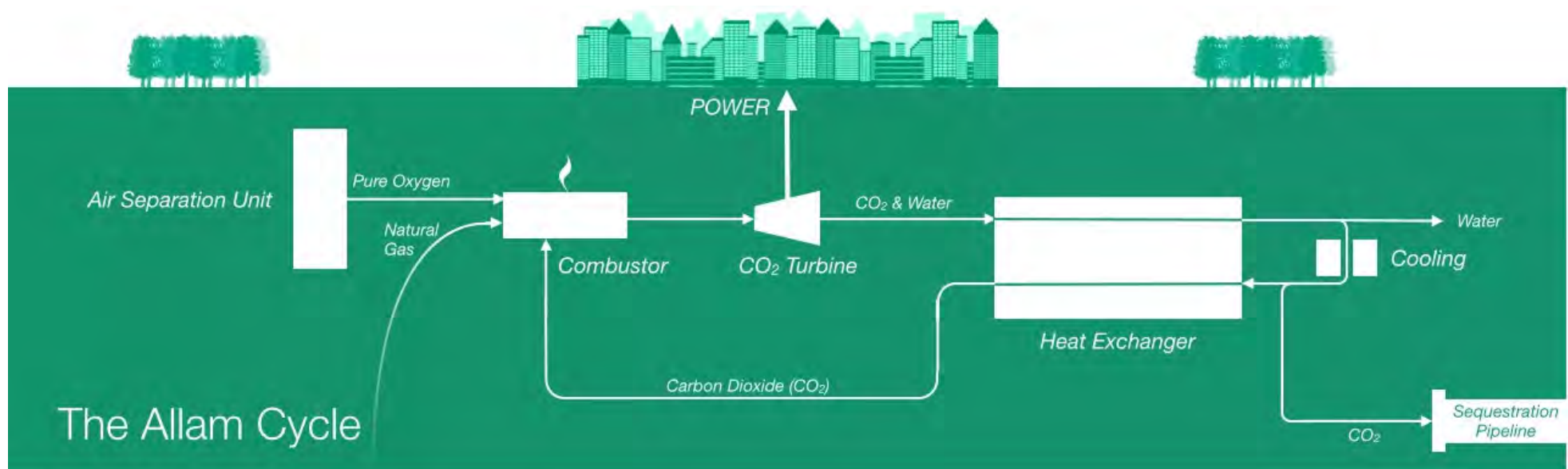
1. As domestic heat projects work through, opportunity to start using more hydrogen in industrial clusters
2. Tied into CCS development and linked to electricity system
3. With low carbon hydrogen production established, source of hydrogen for domestic heating and grid balancing
4. And source of hydrogen for transport – trains, ships, HGVs, fleet vehicles... and cars



And finally, let's not forget power!

- NetPower gas-fired power station with built-in CO₂ capture has just completed a 50MW demonstration in Texas.
- Short answer is – it works!

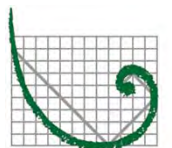
Could this be a route back for CCS in the power sector?





The Opportunity for Hydrogen in Scotland

Speaker: Stuart Mckay, Scottish Government



ERM Pale Blue Dot. Scottish Enterprise



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Scottish Government Energy Policy

Stuart Mckay : Hydrogen and CCUS Policy

Stuart.mckay@gov.scot



The Scottish Government

Energy and Climate Change

The Energy Challenge

Stuart Mckay
Hydrogen Policy



The Scottish Government

Energy and Climate Change

SYSTEM TRANSFORMATION

Decarbonising our energy system will require one of the most profound system transformations in history.

Success will depend on five connected changes;

- 1. Improved energy efficiency and smart network solutions**
- 2. Enhanced renewable energy capacity, that maximises system utility**
- 3. Fuel switching to low and zero carbon energy vectors (transport and heat).**
- 4. Integration of energy storage**
- 5. Distributed energy (electricity) system**

Carbon capture, storage and utilisation required to minimise transition costs.



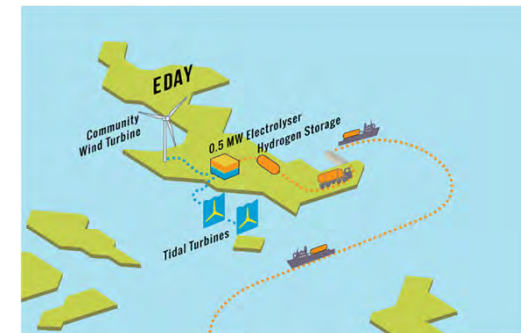
Transport

Hydrogen System - SCOTLAND

- Europe's largest hydrogen bus fleet (Aberdeen), with more proposals due.



- Levenmouth (Fife)
- Orkney Surf n' Turf – hydrogen system demonstrator
- BIGHIT – Orkney project
- Active trade body- SHIFCA



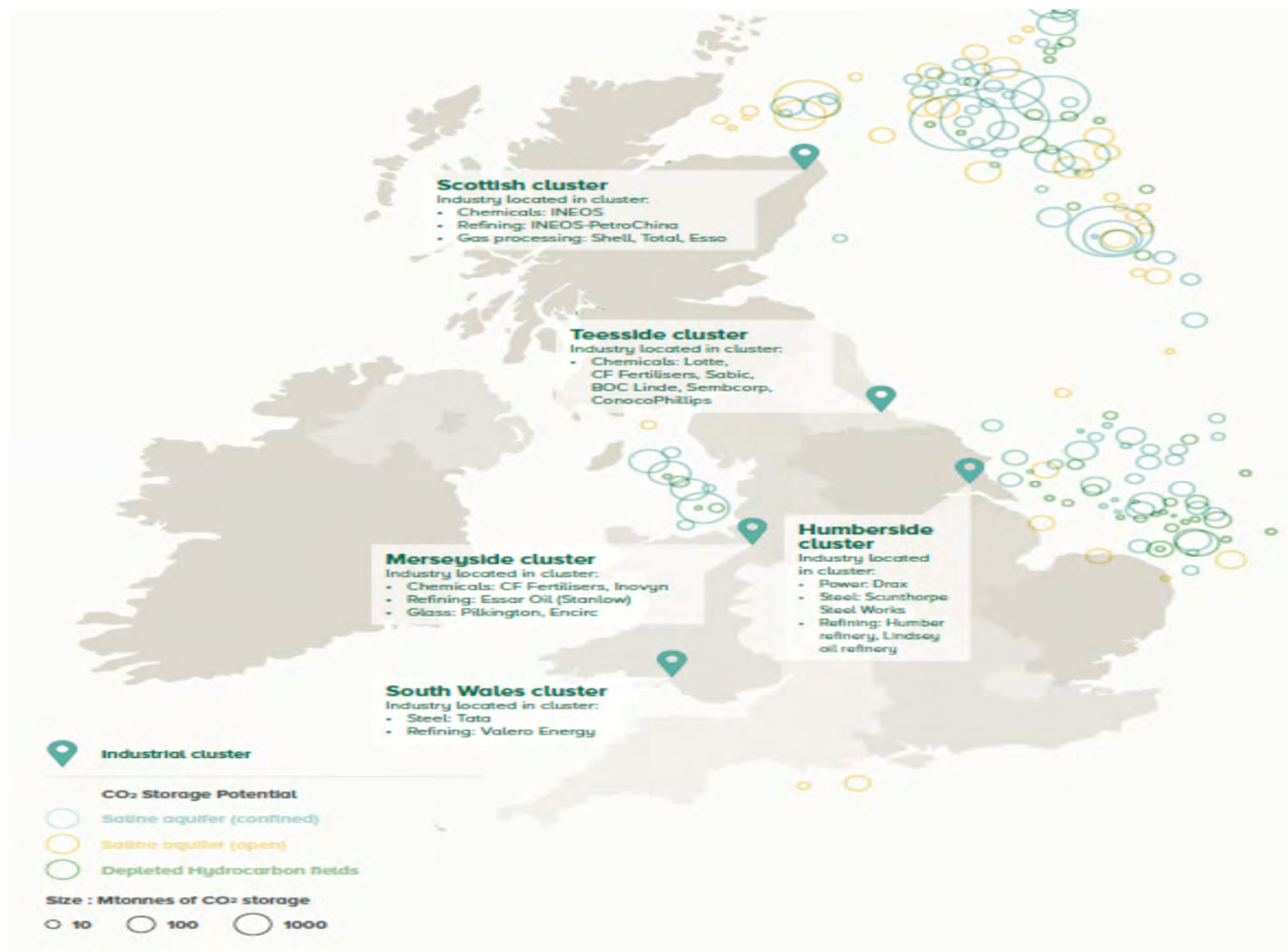
Heat

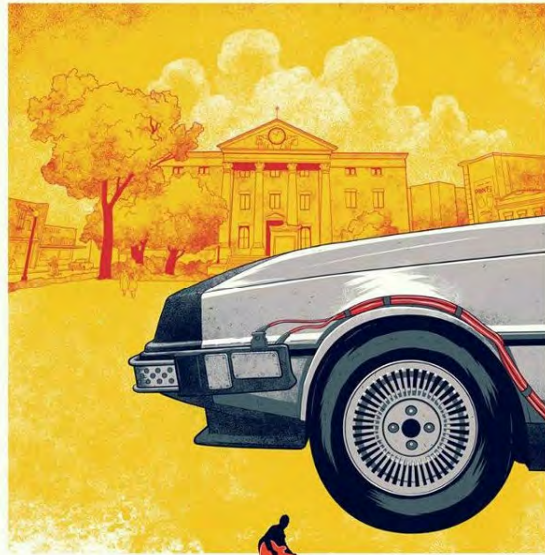
Decarbonising Heat : Hydrogen in the Gas Network

- **Scottish Gas Networks** – feasibility study into 100% hydrogen gas grid currently underway next stage is to construct demonstration scale hydrogen gas grid in Scotland.
- **National Grid HyDeploy Project (£6.8m)** – underway to demonstrate that natural gas containing levels of 10-20% of hydrogen can be distributed and utilised safely in the current gas grid.
- **UK Government BEIS - £25 million** funded programme announced in April 2017 to explore the potential use of hydrogen gas for heating UK homes and businesses.



Industry





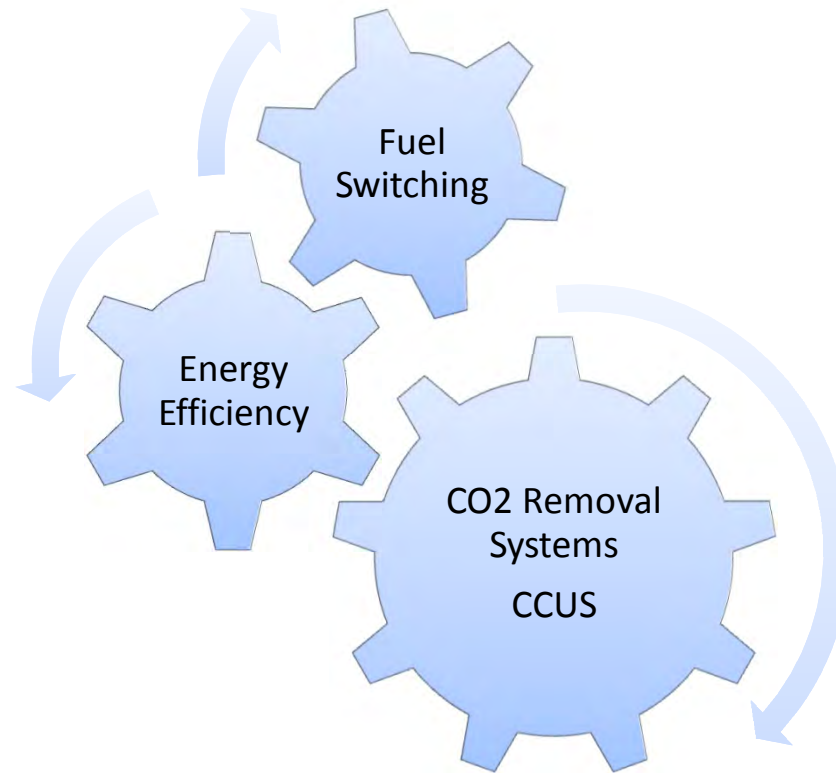
System Transformation



The Scottish Government

Energy and Climate Change

Systems Focus



THANK YOU

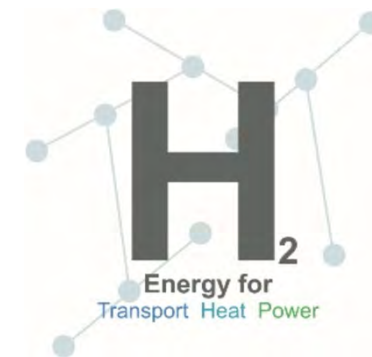
Stuart Mckay : Hydrogen and CCUS Policy

Stuart.mckay@gov.scot



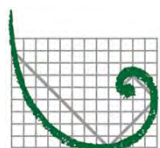
The Scottish Government

Energy and Climate Change



HyDeploy

Speaker: Catherine Spriggs, HSE



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Project Overview

Project Objective

To demonstrate for the first time that a blend of hydrogen and natural gas can be distributed and utilised safely & efficiently in the UK distribution network without disruptive changes for consumers.

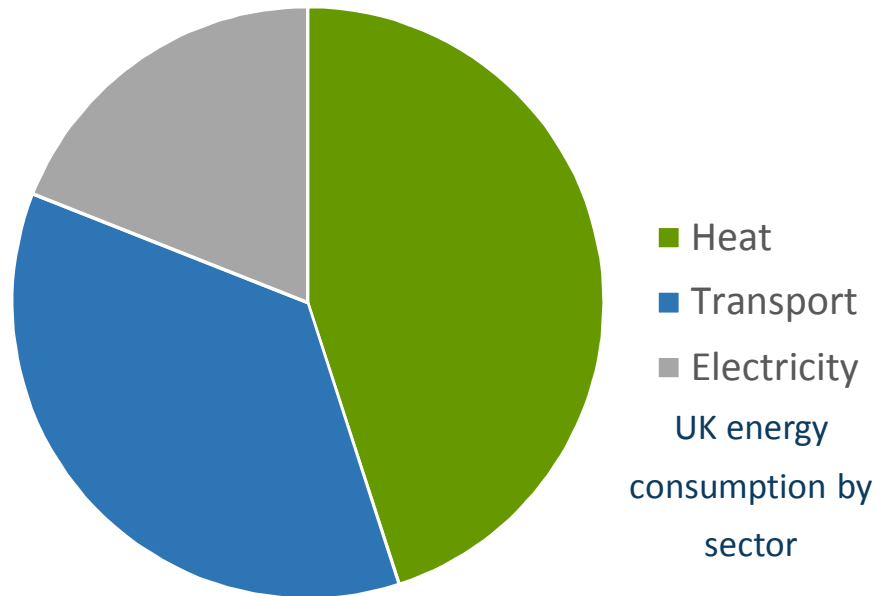
Potential to Deliver

29TWh of low carbon heat per annum equating to saving:
CO_{2e} of 120 million tonnes & £8 billion cumulatively by 2050

*Project Funded under OFGEM's
Network Innovation Programme*



Heat



Heat represents nearly half of UK energy consumption

We need to reduce the carbon impact of heat

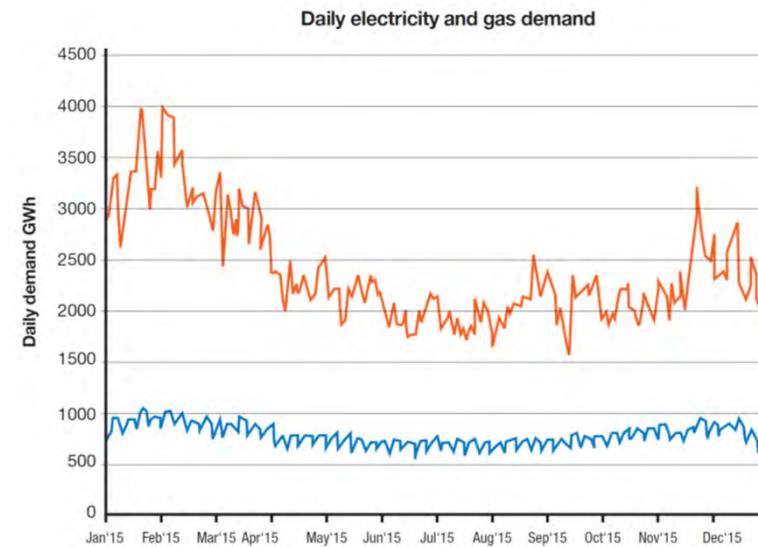
Gas: flexible & convenient delivery of heat



Gas provides 80% of heat at times of peak demand

320TWh per annum to domestic customers

Over 23 million gas UK customers through world class infrastructure

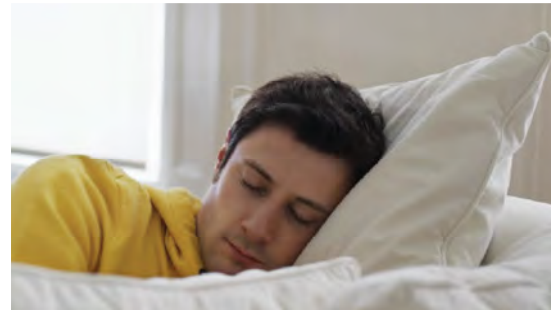


A Customer focused solution

'The majority of domestic consumers will not change their existing heating provision unless significant financial benefits will be accrued, and only then if they have funding available..... If their current system was operating well and providing heat for their homes they would not change their heating systems and spend money unnecessarily.'

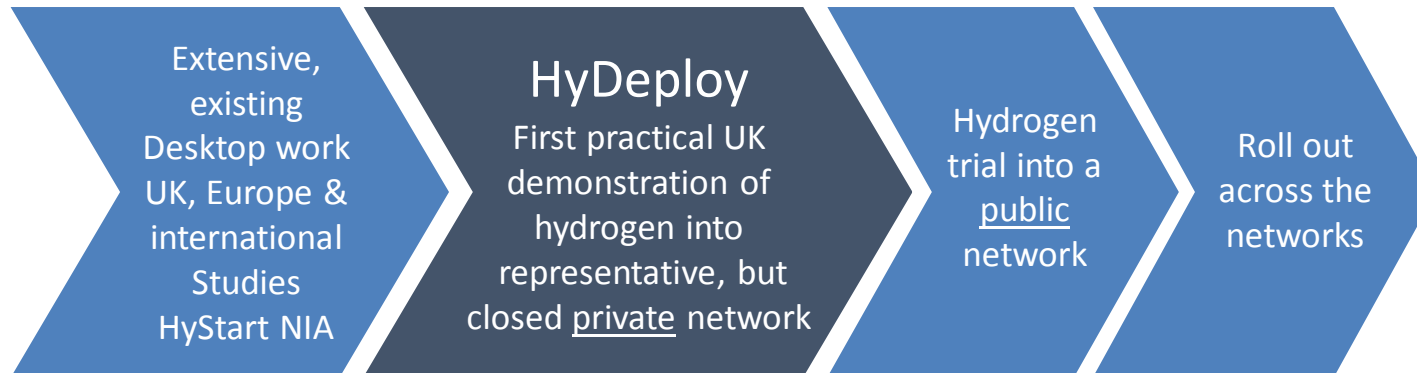
WWU NIA Funded Bridgend study, 2015

Blending hydrogen into the natural gas grid delivers low carbon heat to customers without requiring disruptive & expensive changes in their homes



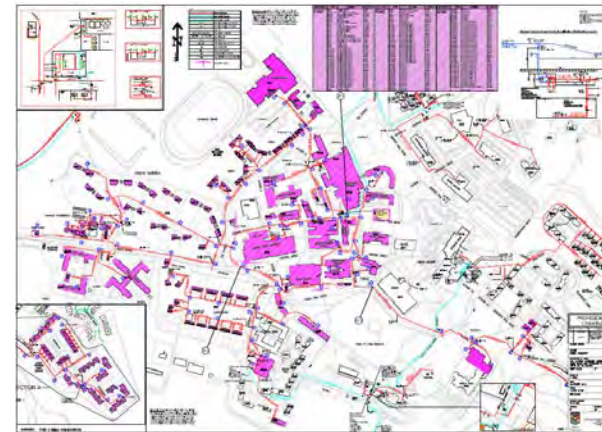
The HyDeploy Demonstration Project

- HyDeploy: A reference work to be used by the industry now & into future
- Build on existing work on the impact of H₂ on appliances & networks & best practice for running new gas trials
- A closed private network is ideal for the first UK trial



The Keele Campus - a small town on gas

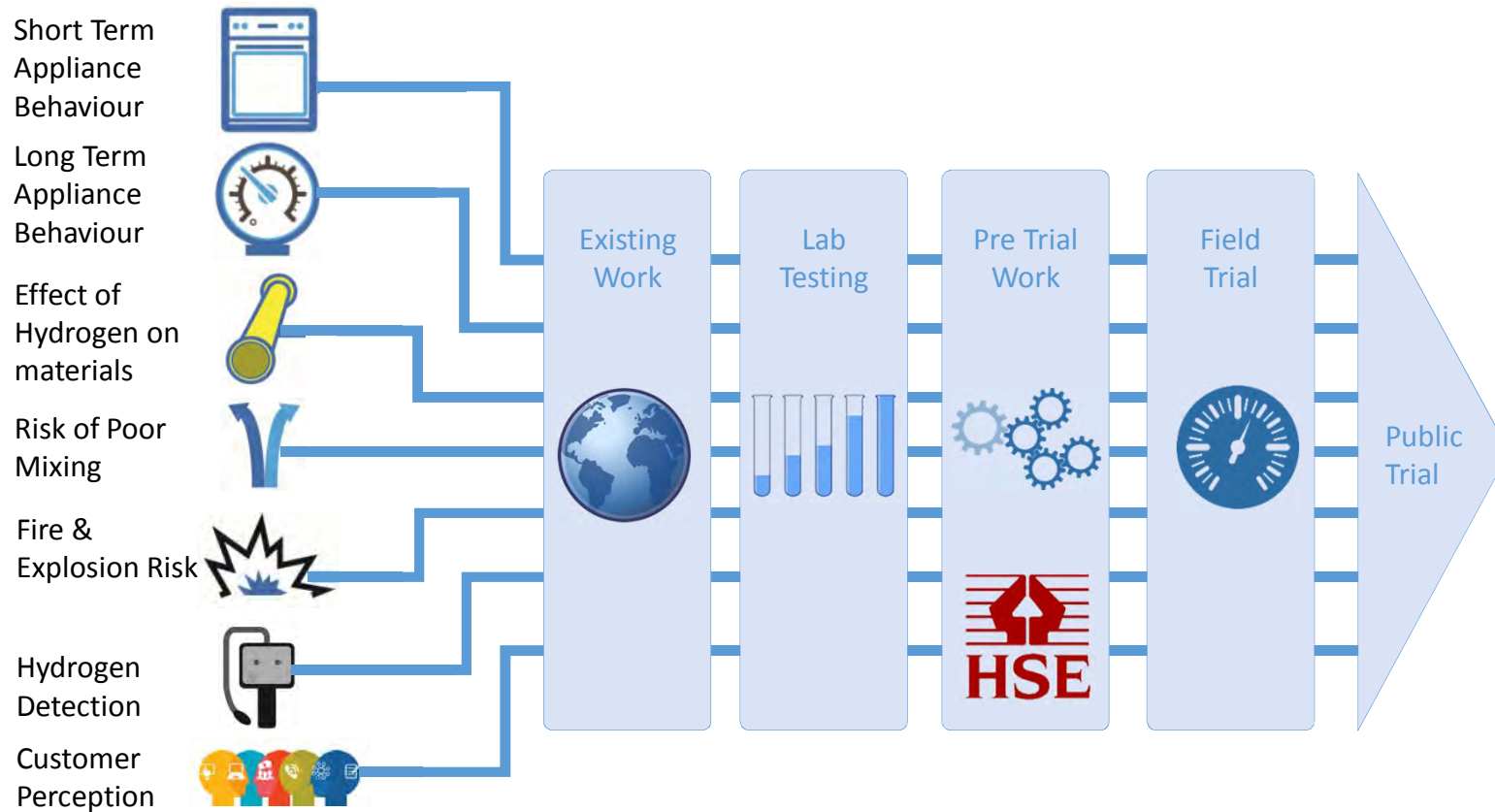
- The Campus the size of a small town
 - 101 residential houses
 - 8 multi-residential buildings
 - 17 extensive office blocks & laboratories
 - 7 recreational & service facilities
- Keele is licensed transporter & supplier
- Engaged with BEIS and HSE to use its energy network as a *'Living Laboratory'*



Programme Overview



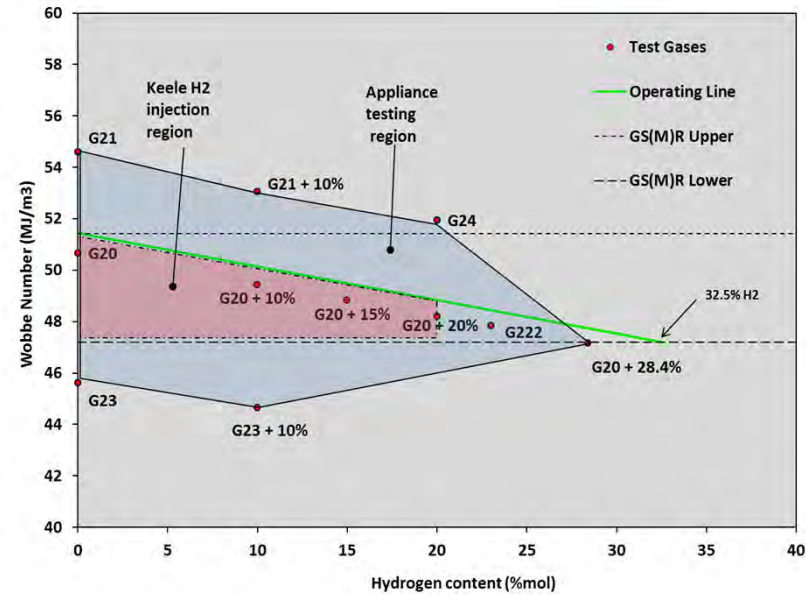
Key Issues to Address & Demonstrate



Appliance Performance



- Combustion gases
- Efficiency
- Light back
- Noise
- Temperatures
- Sooting
- Appearance
- Delayed Ignition
- Safety devices
- Ionisation Current



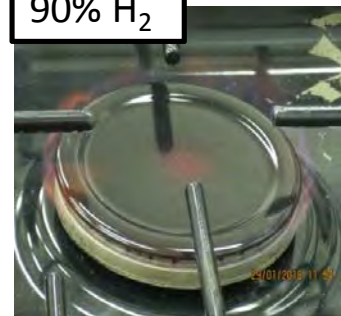
0% H₂



20% H₂



90% H₂



Limit of Operation
 ➤ Up to 80 vol% hydrogen

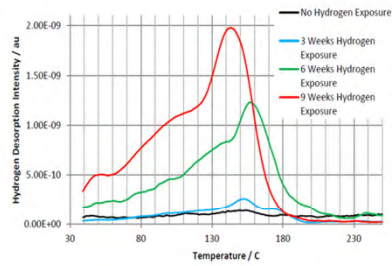
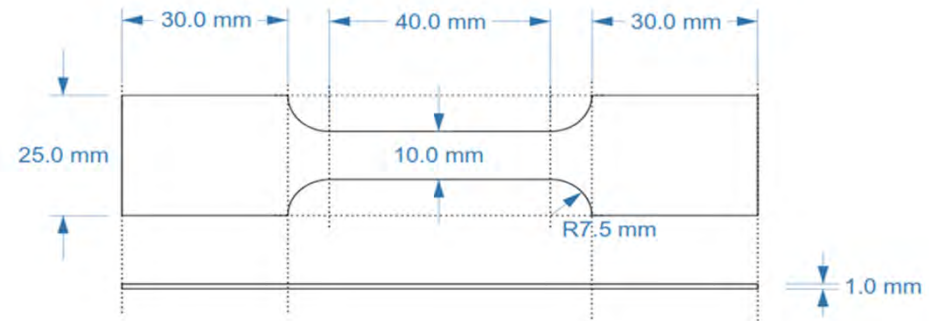
Onsite Appliance Assessment



- Test every appliance on site
- Ensure installations are well maintained
- Ensure appliances are functioning correctly
- Cross check field trial appliances with lab testing results









Materials




Gas Detection & Procedures



Expert Consortium

 <p>Cadent Your Gas Network</p>	<p>Delivers gas to 11 million customers. Project Sponsor</p>
 <p>Northern Gas Networks</p>	<p>Delivers gas to Yorkshire, NE and N Cumbria. Collaborating GDN</p>
 <p>Keele University</p>	<p>Largest UK university campus. Site sponsor & host network</p>
 <p>HEALTH & SAFETY LABORATORY</p>	<p>UK's foremost H&S research establishment. Technical lead & oversight</p>
 <p>ITM POWER Energy Storage Clean Fuel</p>	<p>UK's leading electrolyser provider. Hydrogen production & operation</p>
 <p>Progressive energy</p>	<p>Clean energy development & innovation coordinator. Project management</p>

Key Stakeholder

	<p>GSMR Regulatory Permissive Stakeholder</p>
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Key Suppliers and Contractors

	<p>Trial & Lab. programme execution</p>
	<p>Technical & regulatory gases expert</p>
	<p>Engineering construction management</p>

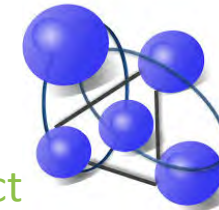
Customer Impact



- Customer engagement is a priority for the project team. Safeguarded by Keele's Ethics Committee and OFGEM
- Trial designed for minimal disruption, learning from 'Opening up the Gas Networks' NIC at Oban
- Safety is paramount. Programme managed by Health & Safety Laboratory, and injection trials can only commence if the HSE is satisfied with the scientific evidence base
- Trial customers will be protected by conservative declared billing arrangements

Stakeholder Engagement & Support

- Wide interest and support from across the industry
- Key stakeholders will contribute through the Advisory Board
- Dissemination of findings will be ongoing throughout the project



Outcome

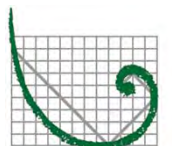
- A customer focused solution to deliver non-disruptive low carbon heat cost effectively
- An expert consortium engaged with key stakeholders supportive of the project
- A detailed demonstration programme designed to deliver expert knowledge and best practice to unlock low carbon heat delivery via the gas grid





Managing the Risks and Perception of Hydrogen

Speaker: Dave Caine, ERM



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Managing the Risks and Perceptions of Hydrogen

ERM, Aberdeen

October 2018

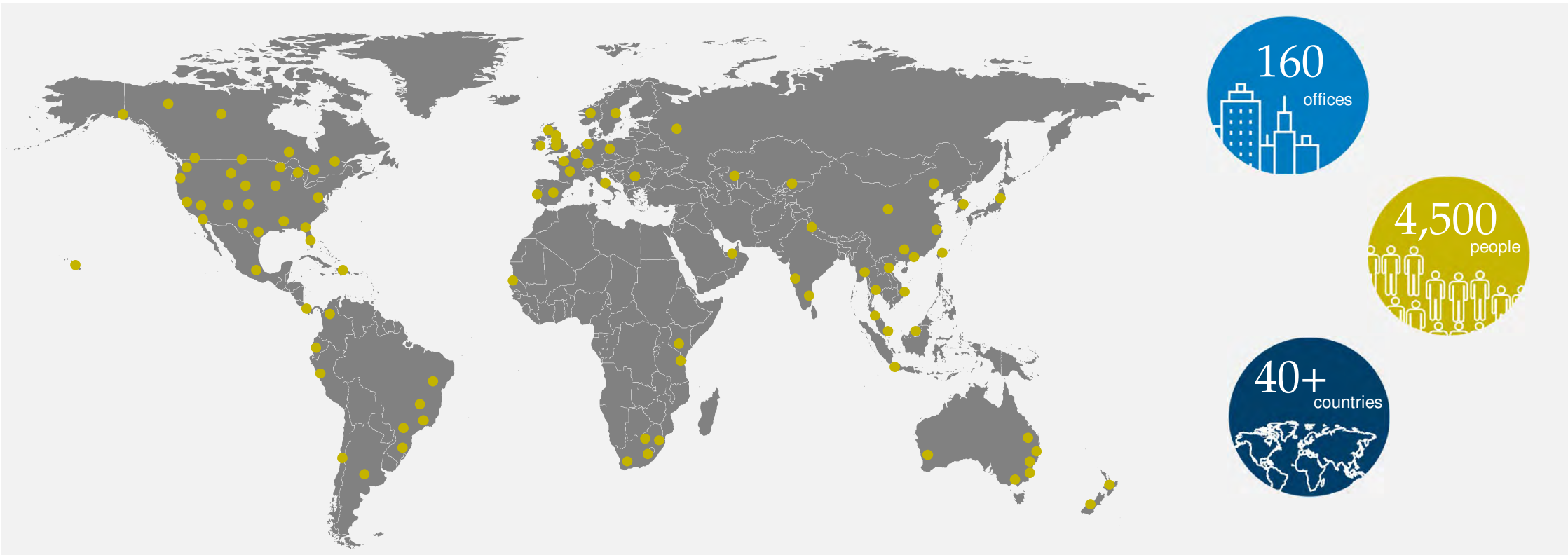
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The business of sustainability



About ERM

Environmental Resources Management (ERM) is a leading global provider of **environmental, health, safety, risk, social** consulting services and **sustainability** related services. ERM is committed to providing a service that is consistent, professional and of the highest quality to create value for our clients. We have worked with many of the Global Fortune 500 companies delivering innovative solutions for business and selected government clients helping them understand and manage the sustainability challenges that the world is increasingly facing.



Gas is a low contributor to domestic risk

All values in # of fatalities per year in UK

Fires (caused by electric) – 40

Electrocution – 22

Carbon Monoxide Poisoning - 16

Fires and explosions
(caused by gas) - 2



Climate change - ?

Air pollution linked ~ 40,000

Road accidents – 1,700

Rail (excl. suicide) – 40

Lightening Strikes - 3

Sources (Approx. values shown)
UK fire service
ONS
CO-Gas Safety

Work is ongoing to understand practical issues associated with hydrogen economy

1 How likely is it to leak?

2 If it leaks where can it go?

3 How likely is it to ignite?

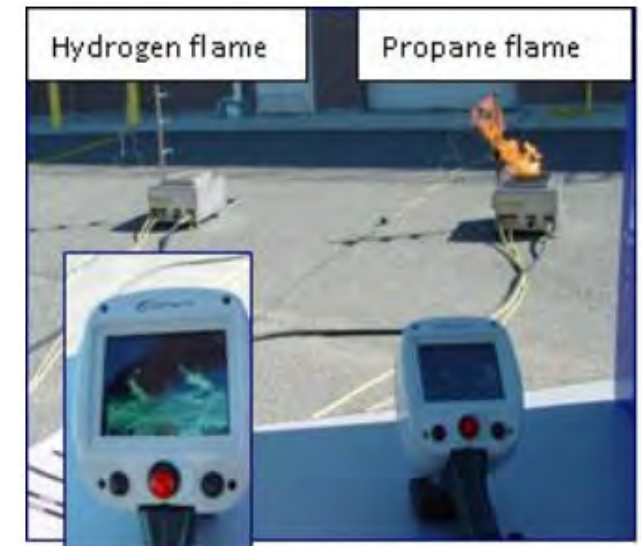
4 What happens if it ignites?

5 What more do we need to do?



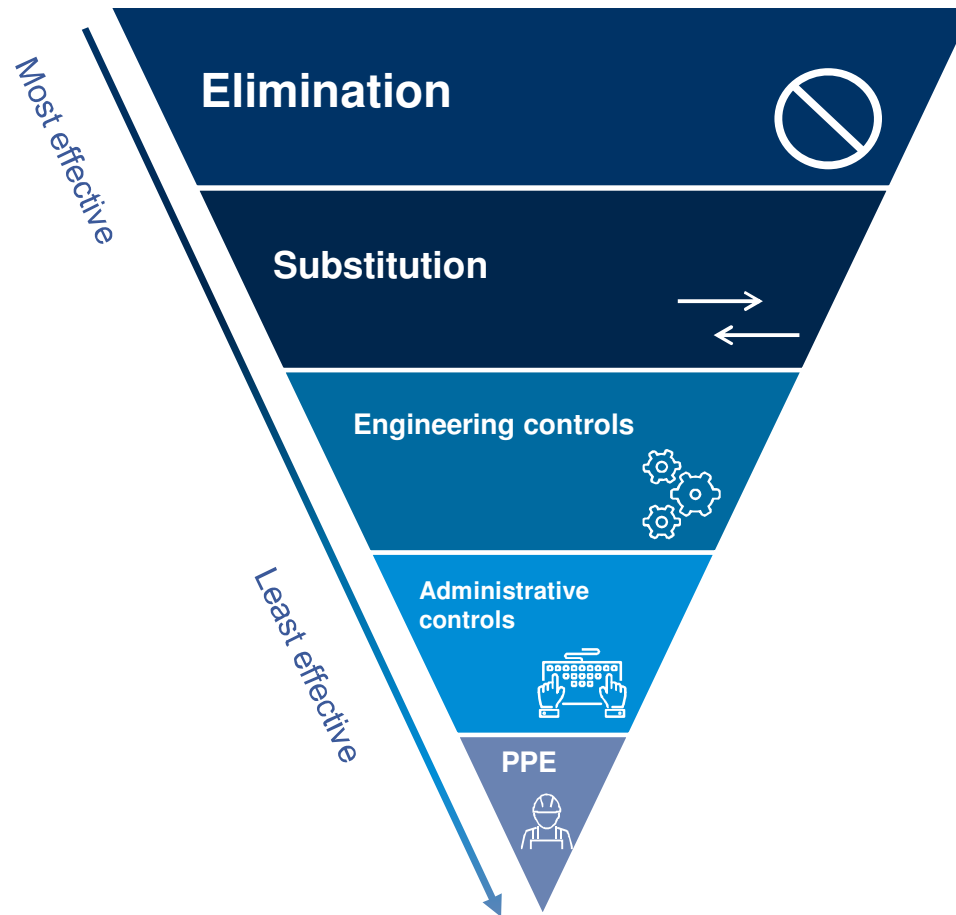
Understood for some industrial uses but room for improvement

Ongoing work to understand factors for potential use in the gas network and for domestic, commercial and industrial end users



Sources
SGN H100 Project (HSL)
US DoE (h2tools.org)

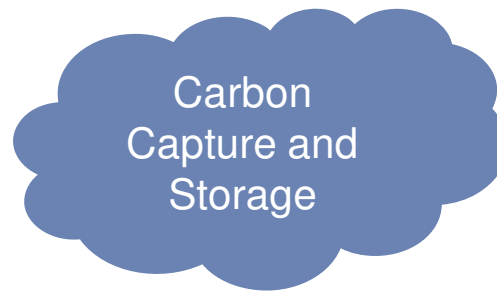
Engineering for safety is key



Sources
Hierarchy of Controls, HSE

Which way will public discussion go?

- Consistent Message
- Big-name Organisations and Government
- Pro-active Engagement
- Factually Grounded
- On-the-ground Engagement
- Objective Discussion



Sources
ERM Photo of Shell Public Display
IMechE photo of Aberdeen H₂ bus

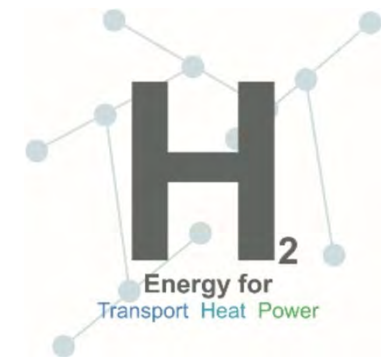


Thank you

David Caine
Principal Consultant:
Energy Transition
david.caine@erm.com
+44 (0)161 958 8834
Manchester, UK

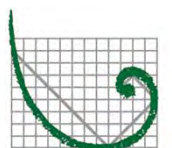
The business of sustainability





Hydrogen: A Business Opportunity for Scotland

Chairman: Kirsty Lynch, Pale Blue Dot



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