



Scotland – Bavaria Joint Opportunities

13th June 2022, Glasgow



Introductions and presentations by members of the
Scottish Hydrogen & Fuel Cell Association



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Bayerisches Staatsministerium für
Wirtschaft, Landesentwicklung und Energie



Introductions and presentations by members of the Scottish Hydrogen & Fuel Cell Association

1. Alan Mortimer, Wood
2. Fergus Tickell, SGN
3. Stuart Mitchell, Hydrasun
4. Kenny Scott, WSG
5. Stephen Crimin, Siemens
6. Ed Macfarlane, ARC
7. Chris Bronsdon, Eneus Energy
8. David Amos, PlusZero
9. Stephen Cunniffe, Doosan Babcock
10. Sam Mackilligin, AECOM
11. Barry Carruthers, Scottish Power
12. Hannah Corbett, University of Strathclyde
13. Salah Mahdy, Howden



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Alan Mortimer
Wood

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Who we are

wood.

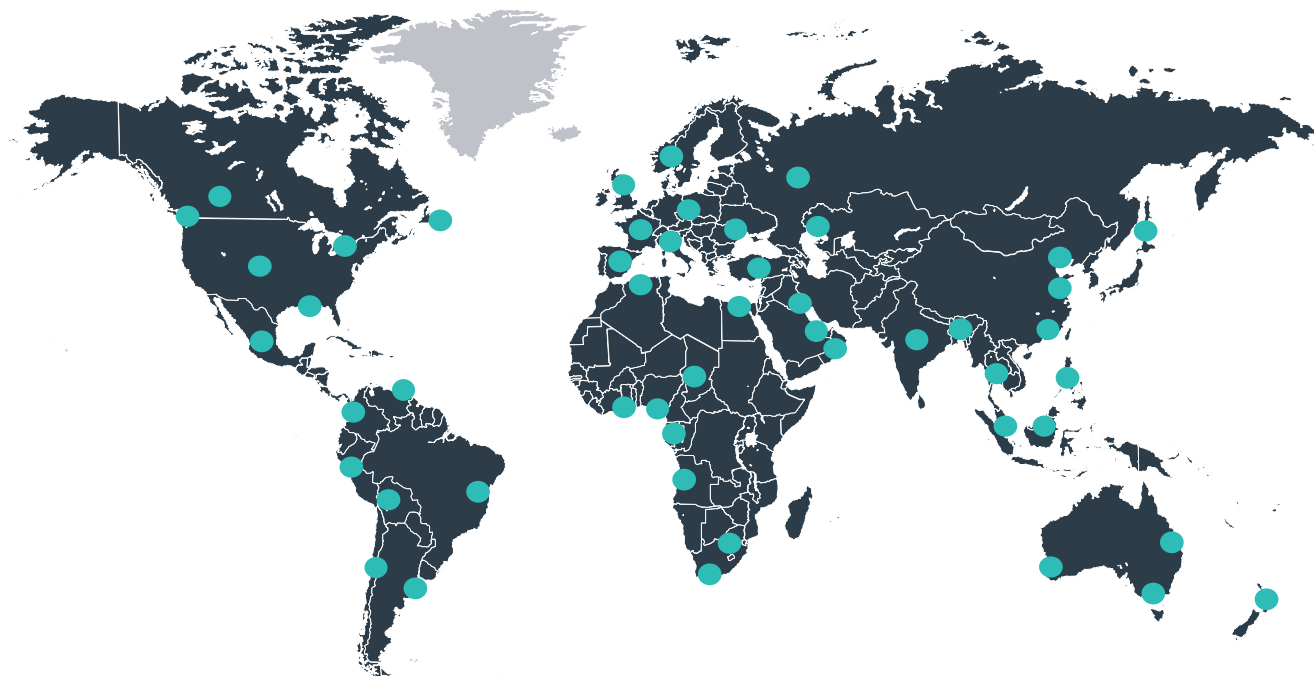
160+
Year history

40,000
People

60+
Countries

400+
Offices

\$10bn
Revenue

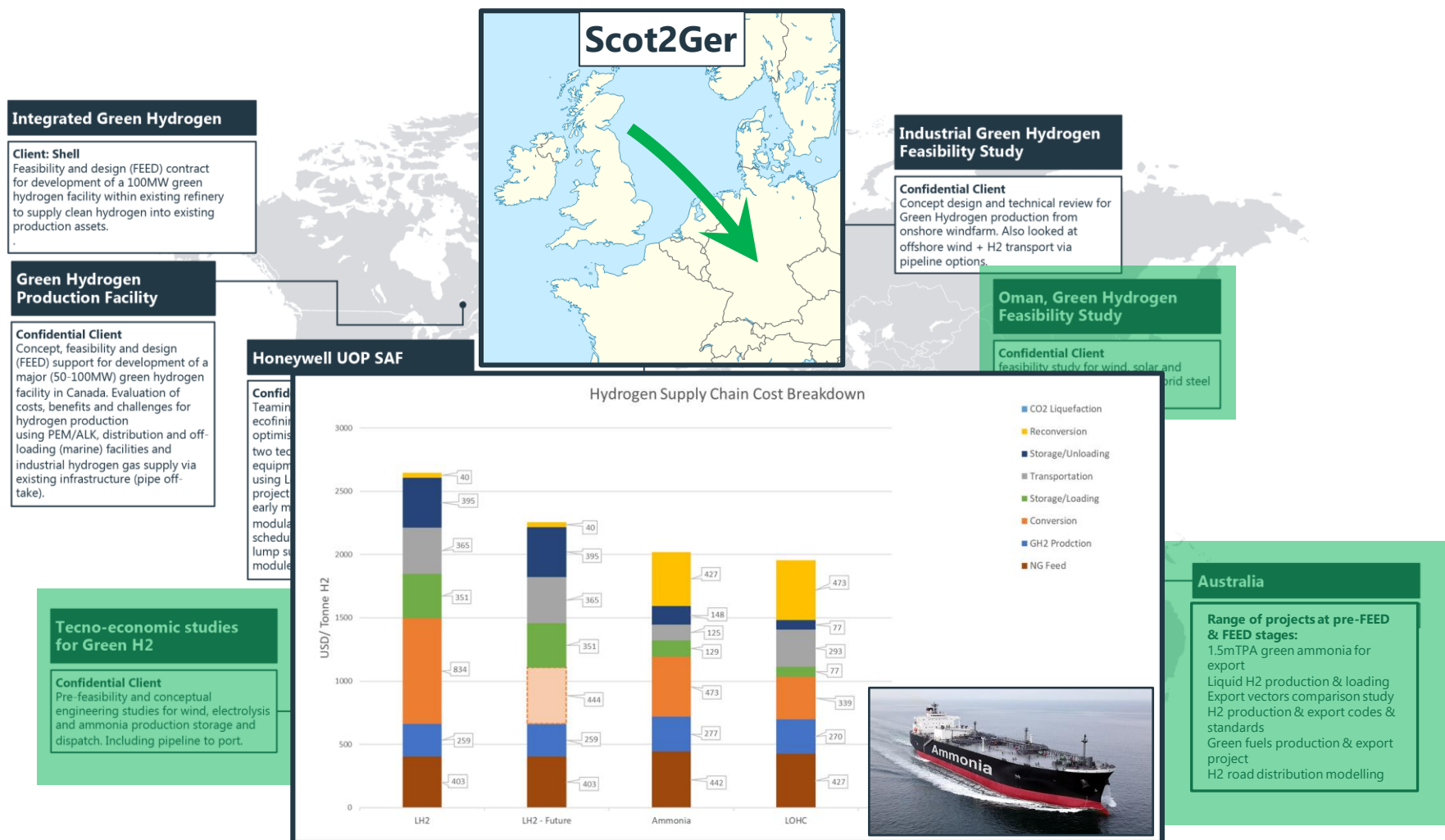


**A global network of skilled professionals, delivering
on our reputation for integrity and assurance**



Global Trade in Green Hydrogen/Ammonia

The global market is emerging. Wood has a broad overview of competing sources from projects we are involved in – selected examples are shown below.





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Fergus Tickell
SGN

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SGN – Bavarian Delegation

Fergus Tickell

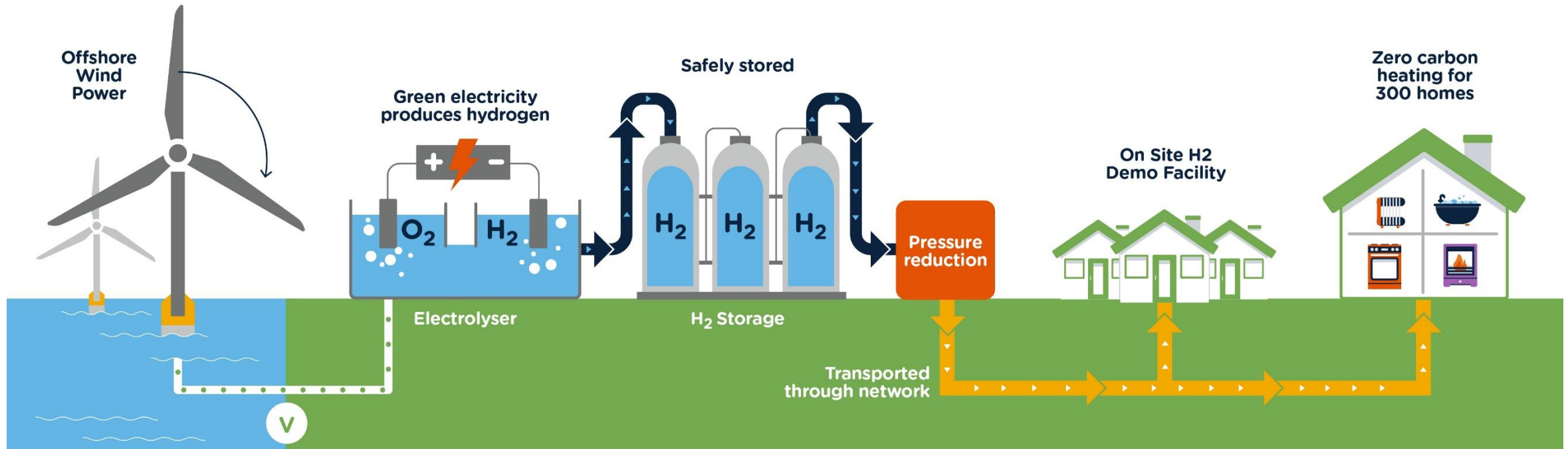
System Transformation and Business Development Lead

June 2022



SGN
Your gas. Our network.

H100 Fife – demonstrating green hydrogen to customers



H100 Fife will provide technical and consumer evidence to support government policy decisions on heat decarbonisation

2020

Funding from shareholders,
Ofgem and Scottish
Government secured

2021

Planning and consent

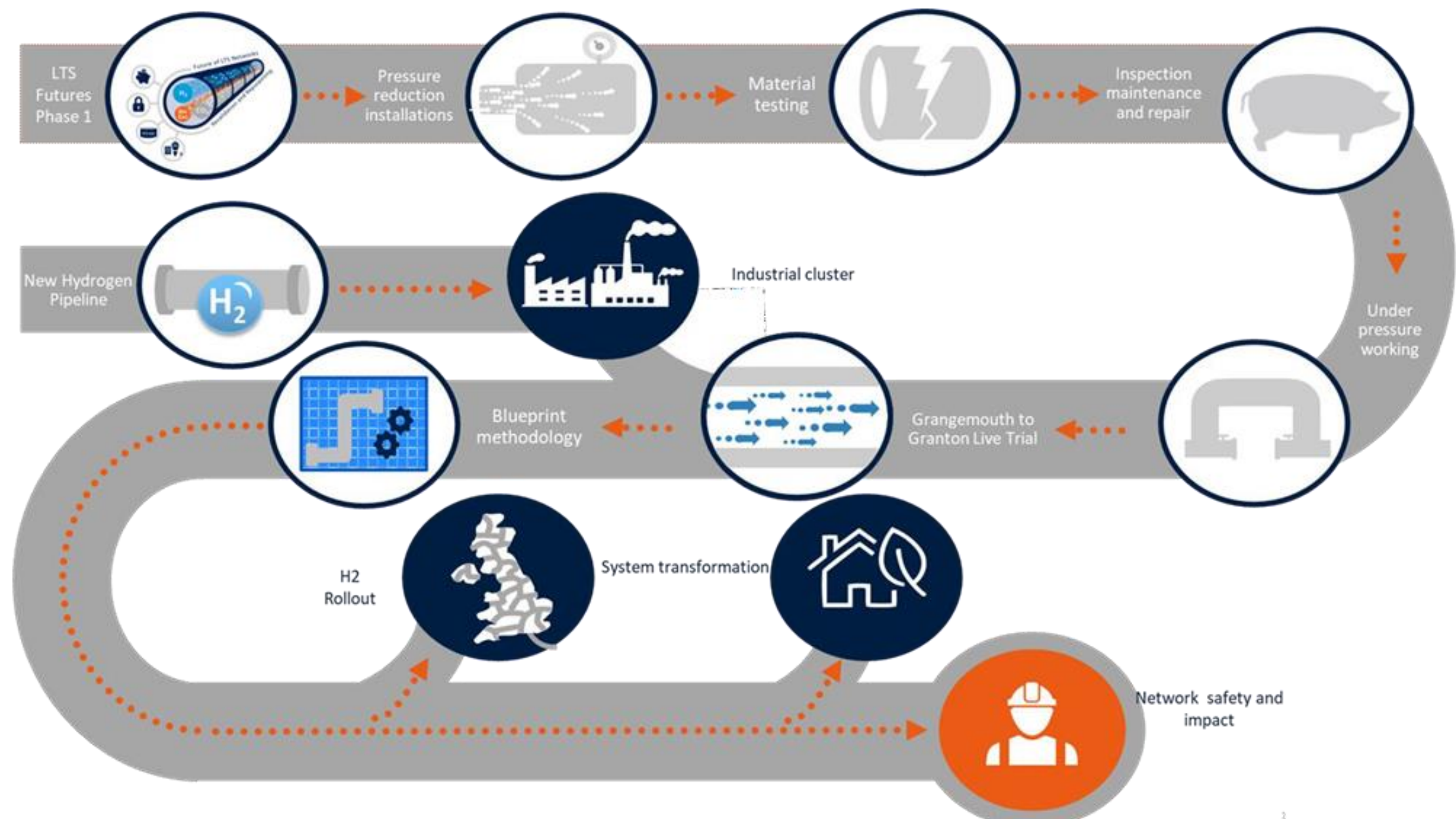
2022

Procurement and
construction

2023

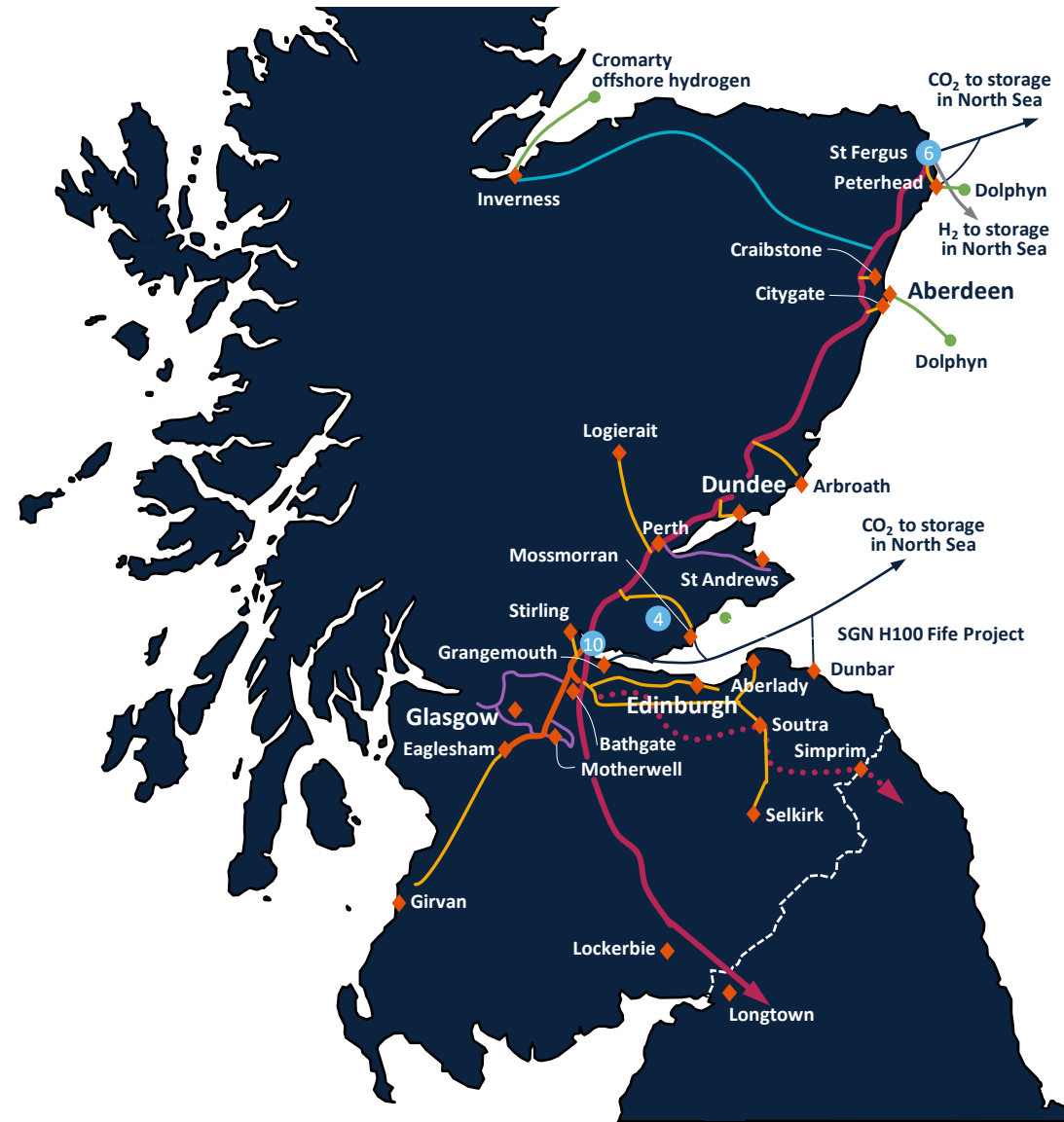
Delivering zero carbon
heat/green hydrogen to
customers

LTS Futures



Delivering a hydrogen network in Scotland

Supporting the delivery of Scottish Government 2030 targets



- Co developed by Wood plc with stakeholder input
- Distributed hydrogen production throughout Scotland
- Onshore hydrogen transmission system
- Offshore CO2 transmission to geological storage
- Acorn project is a central part of the pathway, producing hydrogen and capturing carbon

A three-phase approach is anticipated to deployment:

- **Phase 1**
Aberdeen and St Fergus
- **Phase 2**
Central Belt
- **Phase 3**
East Coast

- New main hydrogen trunkline
- Alternative main hydrogen trunkline
- Main hydrogen spur line
- Repurposed existing spur line
- New hydrogen spur line
- New or repurposed spur line
- CO₂ network
- H₂ network (offshore storage)

- Proposed green hydrogen production
- Proposed blue hydrogen production (No. = SMRs/ATRs to be constructed)
- ◆ City/Town

Scottish Pathway

Projects - Renewable hydrogen

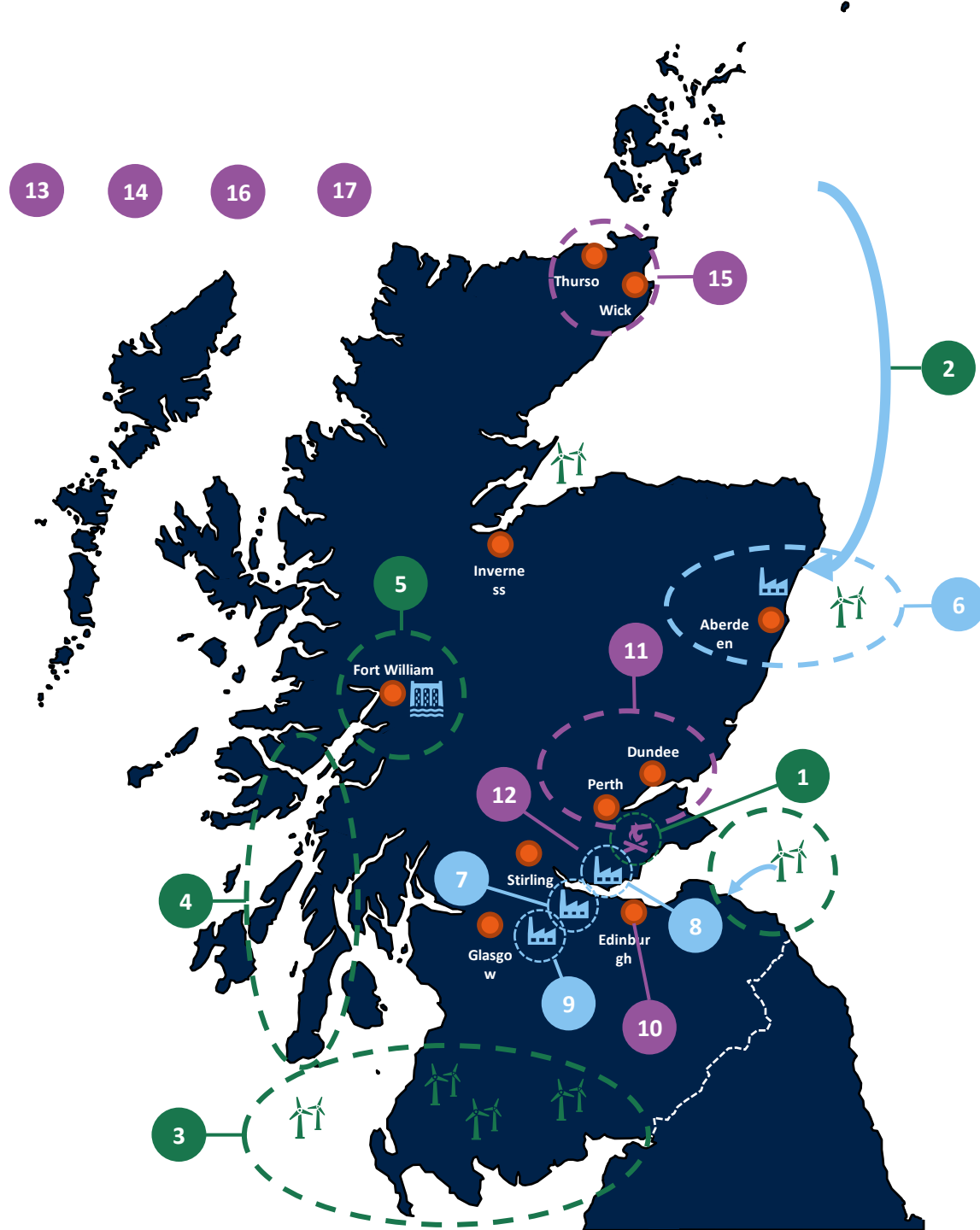
- 1 H100 Fife
- 2 Large Scale Green Hydrogen from Northern Horizons and Scotwind
- 3 South West Hydrogen – Green Hydrogen from existing and future onshore and offshore wind generation for injection to south west coast and flowing to Glasgow and the Central Belt
- 4 Green Hydrogen production for SIUs
- 5 Fort William Hydrogen from Hydropower and onshore wind

Projects - Low carbon hydrogen

- 6 Aberdeen Vision (Accelerated Pathway Phase 1) – Pipeline Pre-FEED, Aberdeen Conversion Planning, Hydrogen from St Fergus, Salamander Project and Dolphyn
- 7 Blue Hydrogen Production at Grangemouth
- 8 Blue Hydrogen Production at Mossmorran
- 9 Glenmavis Masterplan – Blue and/or Green Hydrogen Production

Studies

- 10 H2 Edinburgh & south east Scotland Hydrogen Study
- 11 H2 Tayside Study
- 12 Balgonie Hydrogen Storage
- 13 HyScale LOHC Feed
- 14 Water Study
- 15 SIU CNG Biomethane
- 16 BEIS Hydrogen Business Models (GGG)
- 17 Just Transition Study



Thank you



SGN

Your gas. Our network.



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Stuart Mitchell
Hydrasun

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Hydrasun + Hydrogen

Monday 13 June 2022

Dr Stuart Mitchell
Director, Strategic Business Development

Who We Are

- Headquartered in Aberdeen in the North East of Scotland, Hydrasun is a recognised market leader and specialist provider of integrated fluid transfer, power and control solutions.
- Markets
 - Upstream and downstream O&G, petrochemical, power, marine
 - Renewable and low carbon technology sectors
 - Hydrogen applications
- Hydrasun employs ca. 450 employees worldwide with a turnover of ca. £100M
- Over the past 6 years, Hydrasun has diversified its business to include hydrogen-specific integrated products and services, delivering over 30 projects across the mobility, power and industrial sectors.

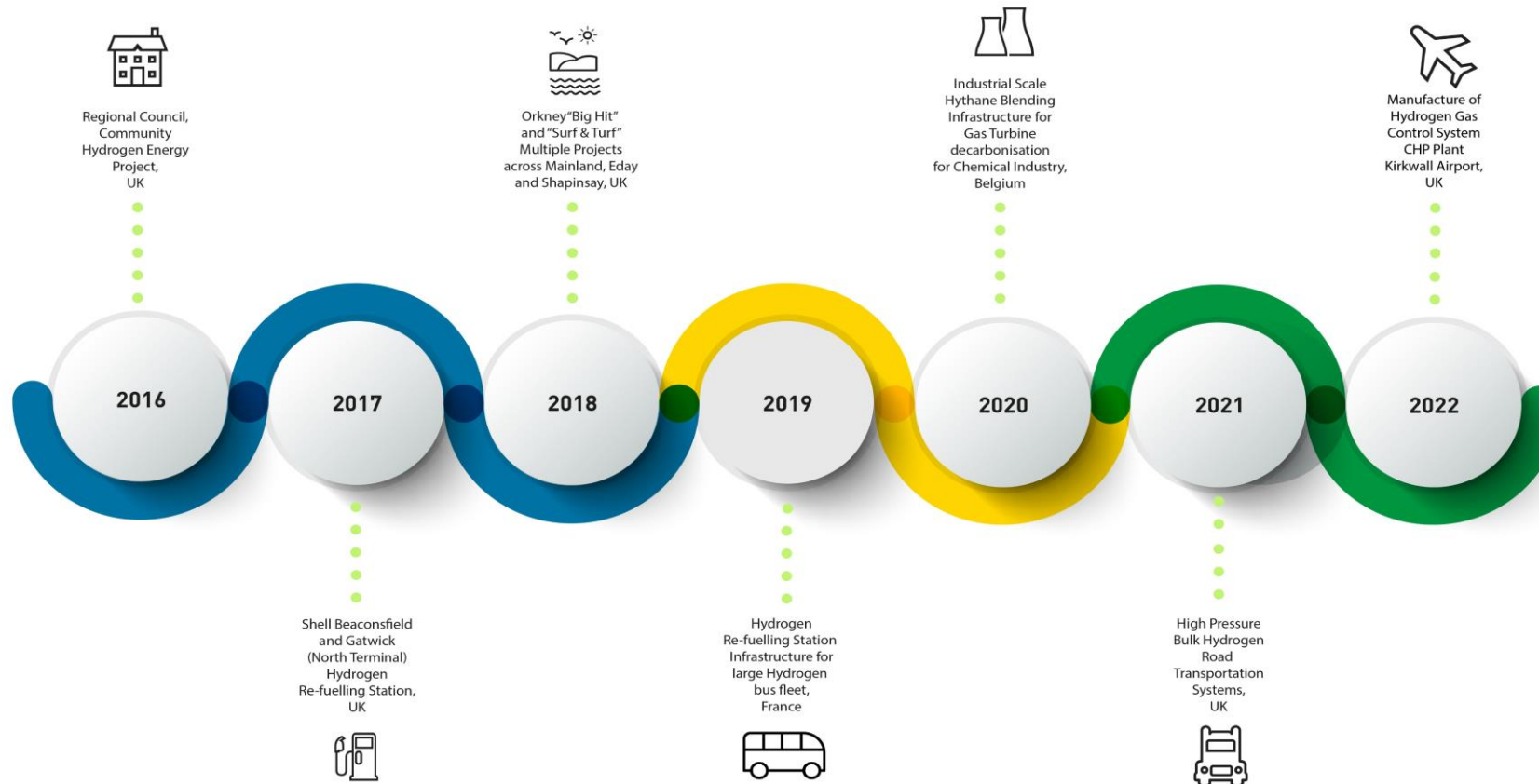


Operational bases and manufacturing facilities

Hydrogen Journey

- Hydrasun vision is to be a market leader in the integration, site installation and maintenance of Hydrogen systems to End Users, Original Equipment Manufacturers and EPC contractors in the UK and Europe

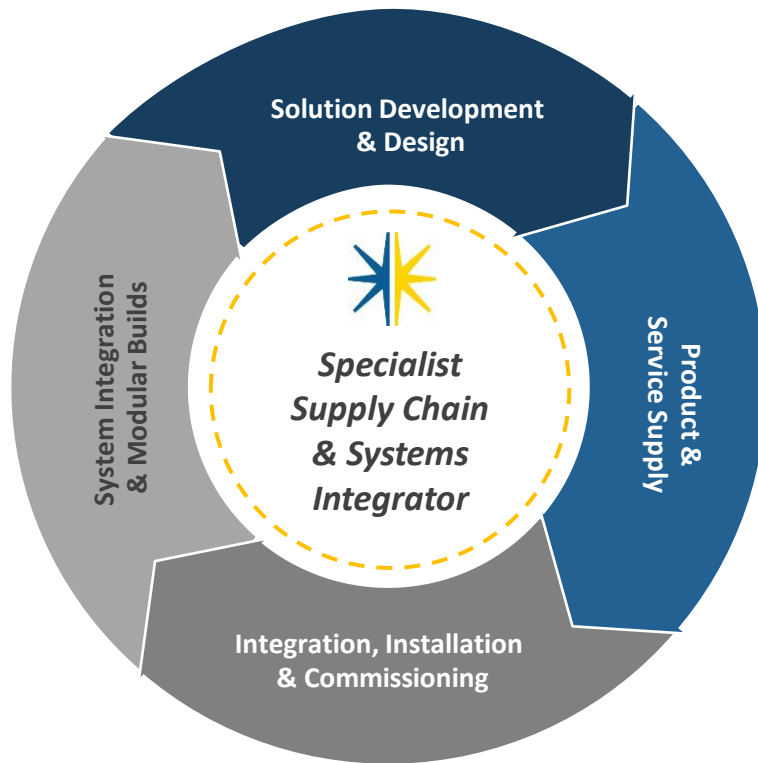
“Specialist in Hydrogen Supply Chain and Systems Integration”



Hydrogen Capabilities

- Hydrasun's mission is to continue to develop high value product and service offerings across the hydrogen value chain for applications in the mobility, power and industrial sectors

"Specialist in Hydrogen Supply Chain and Systems Integration"



PRODUCTS AND SERVICE CAPABILITIES

Solution Development and Design

- Multi-discipline engineering from concept to detailed design across hydrogen applications

Product and Service Supply

- Hydrogen specific components for integration into hydrogen systems including high pressure gas distribution systems, refueling stations, control and instrumentation panels

Integration, Installation & Commissioning

- Hook-ups
- Hydraulic and pneumatic pressure testing
- Certification of lines installed for H₂ distribution
- Turnkey supply and installation

System Integration / Modular Builds

- Expertise in static and mobile H₂ bulk handling, storage and dispensing facilities for buses, light and heavy-duty vehicles

Leak Path Mitigation

- In working with multiple OEM's across the H₂ Industry there is often a general lack of awareness in regards to the application of low, medium and high pressure tubing installations at the design phase.
 - Hydrasun's expertise in the installation of welded and non-welded solutions for commercial tubing Instrumentation, high pressure process delivery and industrial piping services provides a unique perspective on both product supply and product applications.
-
- Knowledge of minimum bend radii and the effects on pressure retaining pipework.
 - Knowledge of alternative products to displace or engineer out leak paths.
 - Bespoke manufacturing of single fitting solutions.
 - Standardising BOM to eradicate multiple manufacturers/threaded formats.
 - Surveying / assessing customer requirements on site to establish optimum design for routing and maintenance of systems.



Leak Path Mitigation

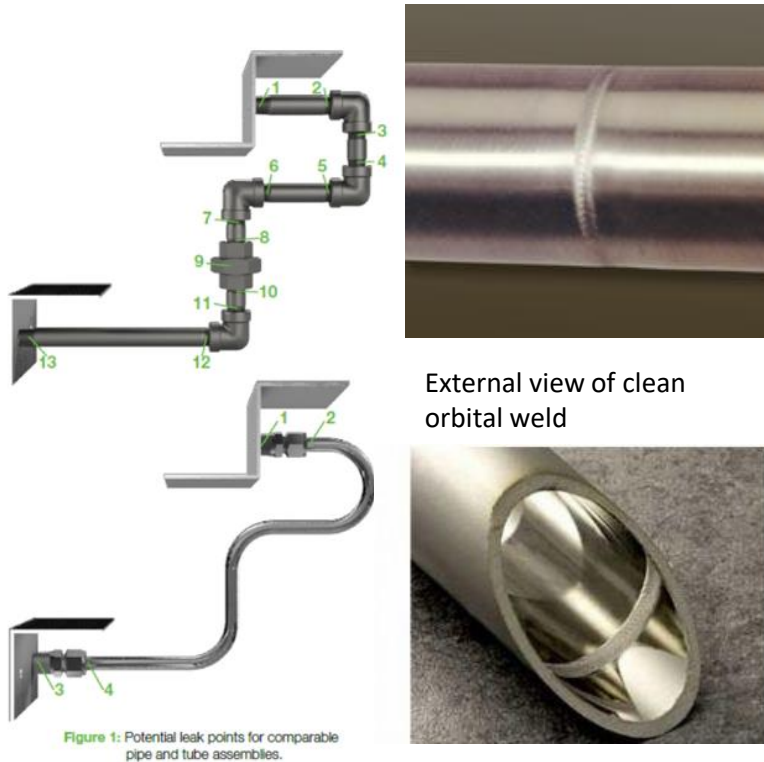
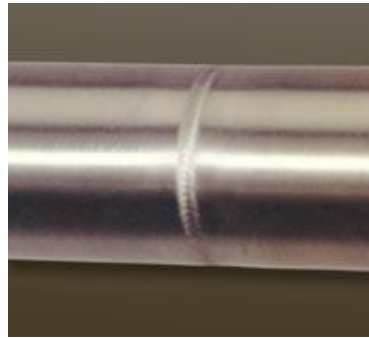


Figure 1: Potential leak points for comparable pipe and tube assemblies.



External view of clean orbital weld



Cut away shows internal quality of orbital welding

With orbital welding, the electrode is rotated in an orbit around a joint on a rotor. The rotor and electrode are housed in the weld head, which rotates around the tube.

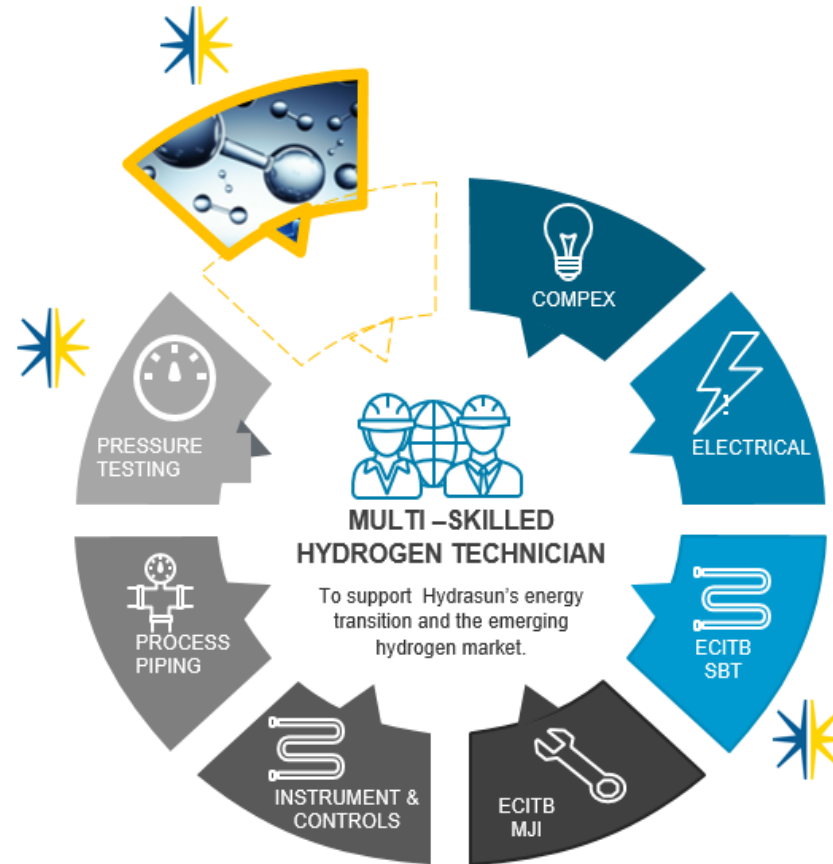
- Hydrogen system overall integrity due to small bore tubing (SBT) failure is a recognised challenge. SBT assemblies are vulnerable to failure
 - Inappropriate material selection for the environment
 - Poor installation
 - Service life
 - Vibration fatigue
 - Lack of inspection and maintenance
- Hydrasun's SBT Leak Mitigation introduced orbital welding to Hydrogen build and retrofit projects to significantly reduce leak paths by removing threaded connections at design stage.
- Orbital welding offers versatility to fuse together components in a range of sizes and materials with a consistency that cannot be matched using manual welding.
- Orbital welding process controls travel speed, arc gap, current and gas flow to minimise variables in the welding process eliminating errors while increasing weld rate reliability and consistency.

Hydrogen Skills Development

“68% of the UK’s oil and gas workers have skills that could transition to the low carbon sector”

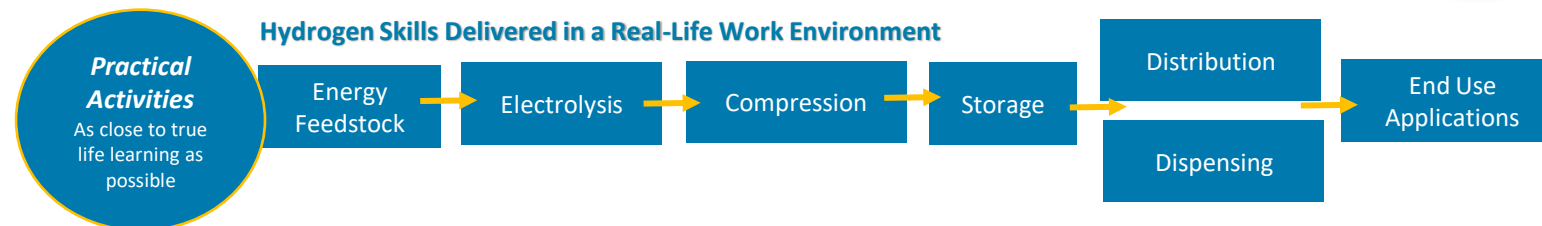
- North Sea Transition Deal.

- Competency frameworks exist on the market currently, but how do we extend these competencies to include hydrogen?
- Hydrasun has a dedicated training facility and resources to deliver industry specific technical training programmes. All training courses are OPITO, ECITB, BFPA and ISO Certified.
- With the support of Scottish Enterprise Green Jobs funding, Hydrasun are opening a Hydrogen Skills Academy’s to extend existing competency frameworks to provide **resources skilled in the deployment of hydrogen solutions** to industry.



Hydrogen Skills Academy

- Hydrasun are developing a suite of training covering;
 - Hydrogen-specific equipment packages
 - Interfaces between these packages
 - Safety requirements for hydrogen systems.
- Hydrogen Skills Academy will aim to deliver training in a real-world environment.
- Ambition is to build an end-to-end hydrogen system on site to create a simulated working environment in order to deliver as close to “true life” learning as possible.
- Training programmes will be designed to ensure that all delegates are prepared for the transition to working in the Hydrogen and renewables sector.
- This will include working under permit to work and safe systems of work controls including (dynamic) risk assessments prior to carrying out any tasks.





Thank you

Stuart Mitchell
Director of Strategic Business Development – Hydrogen & CCUS

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Kenny Scott
WSG

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WSG UK Overview

01. WSG UK Premises - Local reputation, Global Footprint

UK Group



uksales@wellservices-group.com +44(0)1924 898250



02. UK Group Clients





Nitrogen
Purging



Reactor
Cooling &
LNG
Pre-Cooling



N2He Leak
Testing



Pneumatic
Testing



Hydrostatic
Testing



Engineering,
Design &
Consultancy



On Site
Machining



Gas Logistics



Specialist Testing
inc High/Low temp
& PR2 etc



Spares
Supply



Flange
Management



H2 Molecule
supply



Firewater
Encapsulation



NDT / Drone
Inspection



LNG
Installation



Scheduled
Maintenance



Nitrogen
Drying



Valve Overhaul,
Refurb & Testing



Funding
Support



Refinery
Services



Cryogenic tank
Inspection



SMR



station
Installation



Tank Supply



LNG supply



Pipe
Welding



In house CNC
Machine Shop

Workshop Facilities





UK Headquarters

WSG Process & Pipeline Services
WSG Provalve

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WSG Process & Pipeline Services

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Nelson park Ind. Estate
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WSG Industrial Services

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Immingham
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Stephen Crimin
Siemens

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174 years
of innovation and
ingenuity





We leverage our Company Core Technologies across all businesses for the long-term success of Siemens and its customers



Future of automation



Software systems and processes



Simulation and digital twins



Cybersecurity



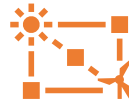
Connectivity and edge



Power electronics



Data analytics, artificial intelligence



Distributed energy systems



Storage applications



Additive manufacturing



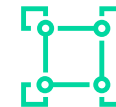
Materials & Manufacturing



Autonomous robotics



Connected (e)mobility



Blockchain applications

Siemens System Solutions



- One supplier for automation, comms, auxiliary & support systems**
- Full or partial digitisation**
- Easy systems integration, saving engineering hours**
- Project risk reduction**
- Worldwide servicing and support contracts**
- Full life-cycle support**



Stephen Crimin

Siemens Digital Industries

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Ed Macfarlane
Abbott Risk Consulting

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Abbott Risk Consulting Ltd



www.consultarc.com



- Independent Limited Company, established in 2002
- Safety, Engineering and Risk Management Services
- Oil and Gas / petrochemical, Civil nuclear, Defense and Rail business units – “high hazard” industries
- circa 140 staff
- Offices in UK and Australia
- Work and support clients and projects globally





Risk / Safety Engineering



- HAZID, HAZOP, SIL and Bowtie Facilitation
- Quantified Risk Assessment
- Fire Risk Assessment
- Radiation & Dispersion Modelling
- Fire & Gas Detector Mapping
- Smoke and Gas Ingress Analysis
- Emergency Systems Survivability Analysis
- Escape and Evacuation Risk Analysis
- Dropped Object Analysis
- Non-process Hazards Analysis
- RAM Management and Assurance
- Noise & Vibration Studies
- Structural Risk Analysis
- ALARP Demonstration & CBA
- Safety / COMAH / HSEIA cases
- Independent Safety Assessment / Expert Witness





Computational Analysis



Computational Fluid Dynamics (CFD)

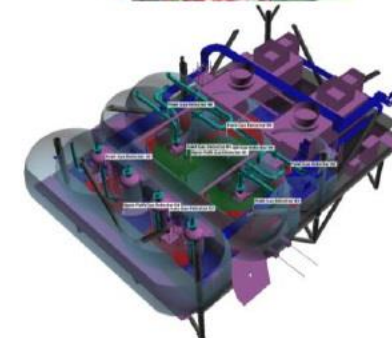
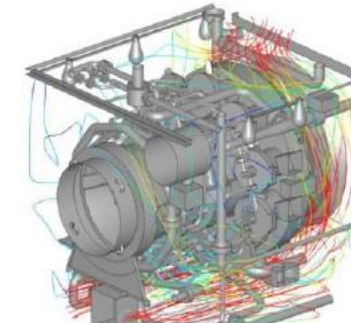
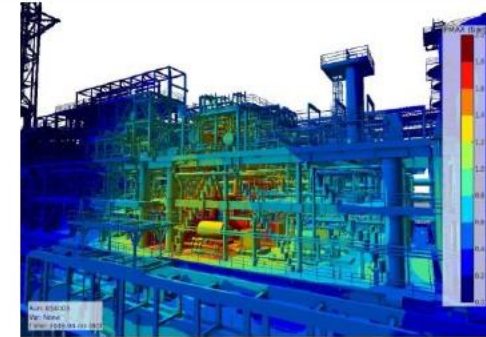
- Gas & Liquid Dispersion Modelling (Flammable, Toxic and Hot Fluids)
- Explosion and Blast Modelling
- Helideck wind Environments
- Natural and Forced Ventilation Efficiency
- Fire / Flaring / Radiation Modelling
- Wind force on Installations and Substructures
- Heat Transfer - Conduction, Convection & Radiation

Structural Analysis

- Stress & Structural Assessment
- Fatigue & Fracture
- PFP Optimisation

Other

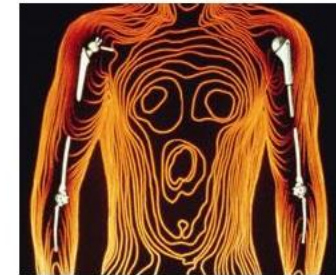
- Fire and Gas Detector Mapping
- Noise Modelling





Human Factors Engineering (HFE)

- HFE Specifications & Company Strategies
- Project HFE Screening & Planning
- HFE requirements, issues & risk management
- HFE in design (FEED & EPC) including:
 - Function & Task Analysis
 - Valve & instrument criticality reviews
 - Layout / operability (3D model reviews)
 - Critical task analysis & human error analysis
 - Control Room / occupied space ergonomics design
 - HMI design / alarm management & usability
 - Working environment (noise & lighting assessments)
 - Health Risk Assessment
 - Human Factors Training
- Competency and Training Needs Analysis
- Staffing, Workload & Fatigue risk assessment
- Critical Procedure reviews & development
- COMAH & HSE Offshore Safety Case Support



Green Hydrogen experience



- Aberdeen City Council - Aberdeen Hydrogen Energy and Supply Facility
- Arcola Energy – Hydrogen Train Demonstrator
- Bright Green Hydrogen - HAZID of Community Power Demonstrator at Methil
- Bright Green Hydrogen - HAZID of Bankhead Hydrogen Storage and Refueller (with Fife Council)
- Bright Green Hydrogen - Fire escalation assessment between hydrogen cylinder storage and electrical substation
- Bright Green Hydrogen - Hydrogen Demonstrator System Safety Support
- Bright Green Hydrogen - Bankhead Hydrogen Re-fuelling Station
- Bright Green Hydrogen - Levenmouth Community Hydrogen power demonstrator Safety Review and HAZOP
- EPS Singapore - Safety studies for an Energy Storage System (hydrogen and battery storage)
- EU Joint Research Centre - HAZOP review - Hydrogen test facility
- European Marine Energy Centre - COMAH Roadmap development - Hydrogen generation
- European Marine Energy Centre – ZeroAvia HyFlyer - Hydrogen Powered Aviation - Safety Assurance Program
- Fife Council - Safety reviews of Hydrogen Refuelling Station at Bankhead
- Frontline Safety - Hydrogen Dispersion Modelling in a Fuel Cell Laboratory
- Hydrogen Trucks Ltd - Support to Innovate UK Application for Low Carbon Trains
- Infinite Blue Energy - Arrowsmith Hydrogen Plant WA
- JRC Petten - Hydrogen fuel tank test facility
- Linde Gas - Hydrogen gas vehicle fuel concept
- Linde Gas - Ilsky Hydrogen Plant HAZOP Study
- Linde Gas - Hydrogen Production Unit Nizhnekamsk - Feed Gas Compressor PU HAZOP
- Linde Gas - Hydrogen Production Package HAZOP
- Linde Gas / FMG - Hydrogen and ammonia production Tasmania
- Linde Gas – Saltend H2H Human Factors & Safety Engineering
- Logan Energy - HAZOP of Hydrogen Refueller
- Logan Energy - HAZOP of Methil Energy Storage System (ESS)
- Logan Energy - Hydrogen Gas Dispersion Analysis for Methil
- Logan Energy - Explosion analysis for Hydrogen Refueller
- Logan Energy - Hydrogen Re-fuelling Station HAZOP, Hazardous Areas and Explosion Analysis
- Logan Energy - Hydrogen Refuelling Station Iso-Container ERA
- Orkney Island Council - Commissioning review of Shapinsay Hydrogen Boilers
- Orkney Island Council - Independent Safety Assessment - Shapinsay Hydrogen Boiler
- Saltend Cogeneration Co Ltd - Hydrogen Drier Purge Pipework Modification HAZOP
- Technip - Hydrogen Plant HAZOP Rumania
- Woodside Energy - Hydrogen Plant Tasmania



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Chris Bronsdon
Eneus Energy

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Green Ammonia to Bavaria

Chris Bronsdon, CEO

June 2022



Overview



- Eneus is a **green ammonia** project development company
- Eneus is amongst a cohort of **first movers for industrial scale plants** in a potential \$12 trillion global market for green hydrogen
- Eneus projects will use **renewable energy** to generate hydrogen, transported as green ammonia to large scale ammonia and hydrogen users, under **long-term contracts**
- Eneus is developing a **10+GW portfolio** of projects across the UK and US
- Eneus has **established relationships** across the supply chain with renewable power providers, electricity suppliers, OEMs, EPC groups, and ammonia logistics providers
- First Plants projected to be operational ~**2025**

Development risk

Project finance

Construction risk

Asset ownership

Global Green Hydrogen Market

- Projected to exceed US\$12 trillion within 30 years
- Governments representing more than 70% of global GDP have adopted hydrogen strategies to achieve 'net zero' targets by 2050
- Green hydrogen (produced using renewable energy) is essential to deliver the energy transition to 'net zero' carbon for sectors that cannot be easily electrified

Fuel for

Transport



Heavy duty and light duty vehicles

Power



Electricity Peaking Plants

Heat for

Industry



Steel, Cement, Paper, Food, Aluminium

Buildings



Residential & Commercial

Feedstock for

Chemicals



Fertilizers, Fuel refining, Plastics

Products



Metallurgy, Food, Steel, Glass



However, hydrogen is difficult to transport and store:

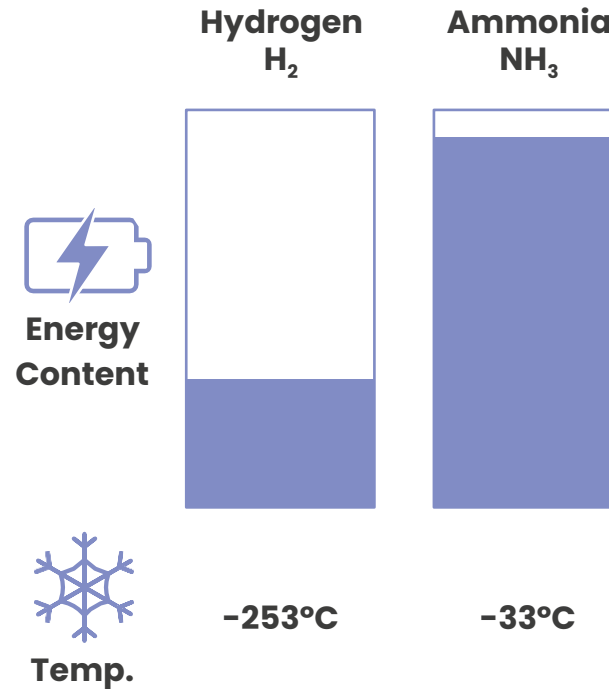
- Low energy density
- Expensive to liquify
- Limited established infrastructure



Green ammonia is the solution

Hydrogen is **easily transported and stored as ammonia**:

- Ammonia is a fuel, and an energy vector for hydrogen
- Much higher energy density
- Easily transported as a liquid
- Established global distribution network
- Ammonia is one of the largest volume industrial commodities in the world



Green ammonia is a global market



Zero-carbon fuel for the maritime sector



Carbon-free fertilizer and food



Best suited long-distance hydrogen carrier

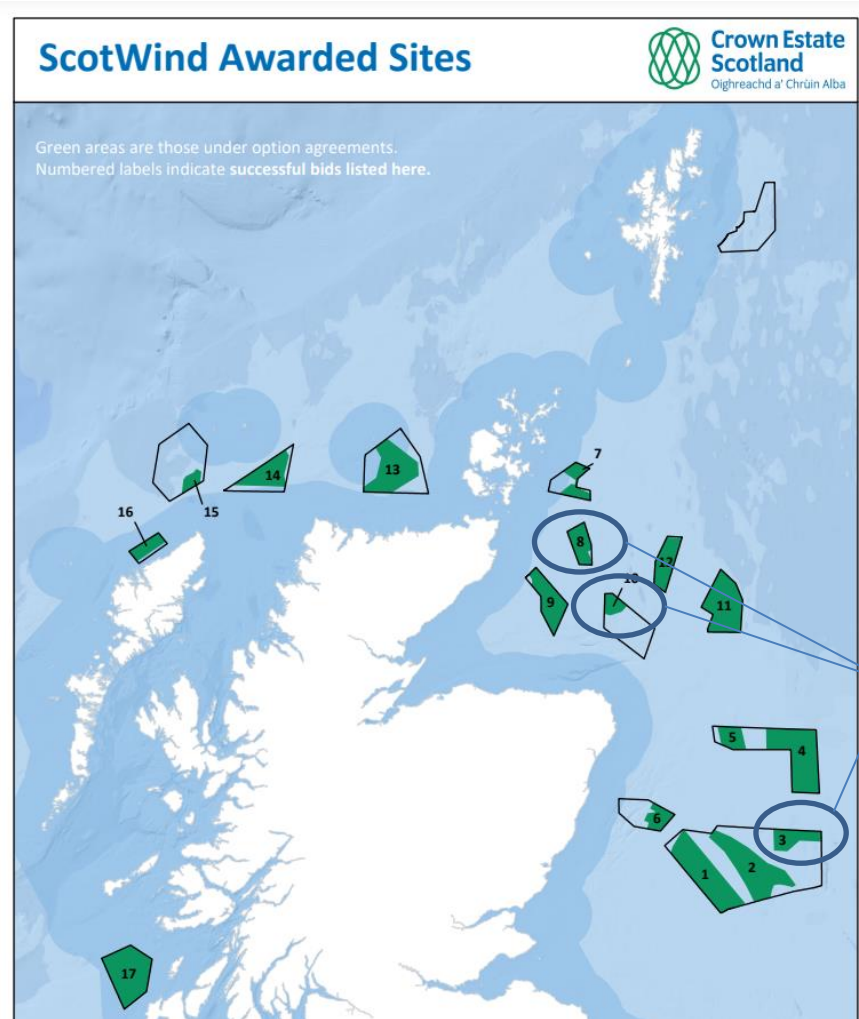


Preferred substitute for coal in renewable energy constrained countries



Industrial applications in automotive, construction and food additives

Scotwind – Green Ammonia



- 10GW Leasing round
- 25GW Leases awarded
 - 17 sites
 - 6 fixed (10GW)
 - 10 Float (15GW)
 - 1 mixed (0.5GW)

Eneus Energy is a partner in 3 projects (2.7GW), and in discussions with other groups



Ammonia has an established global transportation and distribution network

- Established health and safety regime
- Large scale, experienced infrastructure engineering groups



Thank you



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David Amos
PlusZero

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PlusZero⁺

Making Hydrogen Happen

PlusZero Energy

Western Isles Green Hydrogen Production Facility

Opportunity Outline

June 2022

⚡ PlusZero Energy

⚡ Green Hydrogen Production from electrolysis in the Western Isles



⚡ **PlusZero Power**

⚡ Green Hydrogen fuelled portable clean power generator solutions

PlusZero

PlusZero+O

Decarbonising the events sector

**POWERED BY
GREEN HYDROGEN**

PlusZero+O
Decarbonising the events sector

PlusZero+O
Decarbonising the events sector

PlusZero+O
Decarbonising the events sector

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PlusZero+O
Decarbonising the events sector

⚡ The Western Isles Opportunity

Large-scale consented onshore wind farms with new offshore sites successfully auctioned

Supportive local communities who benefit directly from onshore wind



Production facility Ideally located for export to EU



Existing industrial zone and new deep water port development

⚡ For further information

⚡ Contact:

David Amos – PlusZero Managing Director

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Stephen Cunniffe
Doosan Babcock

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Introduction & Overview

Stephen Cunniffe
Hydrogen Development Lead

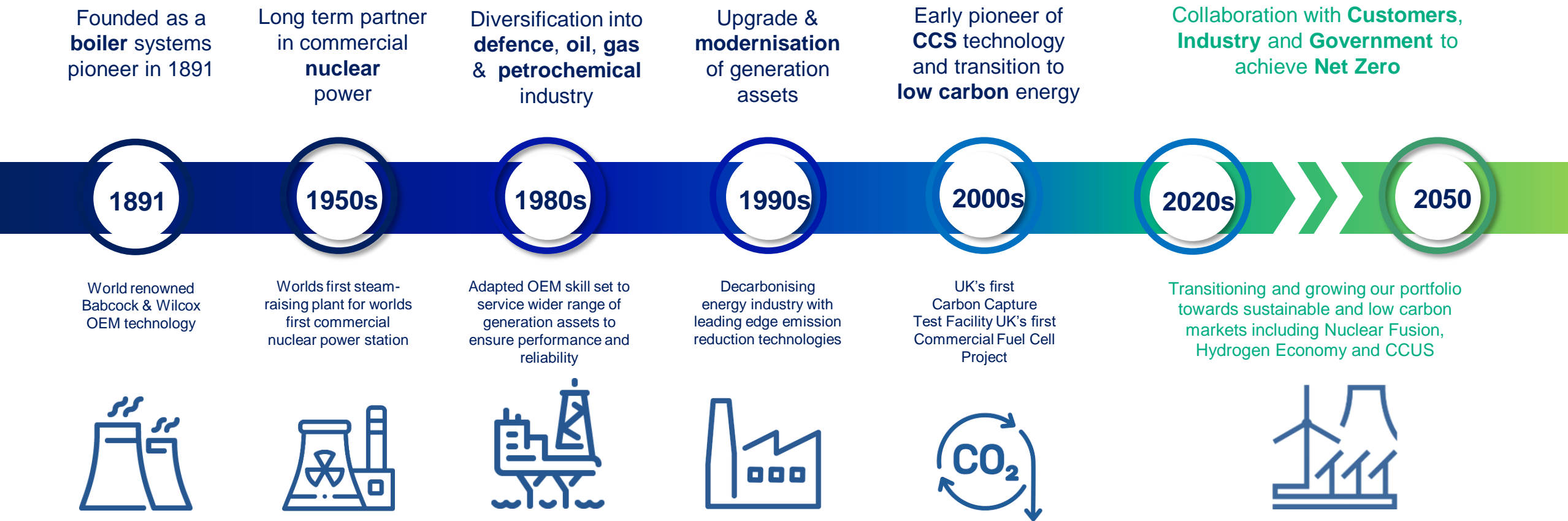
Process & Energy
Doosan Babcock



your engineering partner for a **low carbon future**

Doosan Babcock | Innovating Since 1891

- Specialist, full life-cycle engineering services provider with in-house Construction, Services and Asset Management business units
- Operating in the infrastructure, low carbon, energy, petrochemical and process industries, - globally



Doosan Babcock | Capability & Focus Areas

Capability & Focus

Core Skills:

- Doosan Babcock builds, maintains and extends the life of customer assets
- Full engineering lifecycle experience (Consultancy, Pre-FEED, FEED & EPC)
- Extensive refinery and petrochemical experience including technology licensor interaction

Integrated Project Delivery

- Multiple in-house fabrication facilities in UK
- In-house construction business
- Best in class construction safety performance

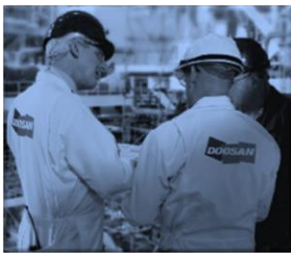
Resource Overview

- UK HQ
- 3500+ Craft Resources typically deployed annually; - + 800 Supervision
- 120+ Process Sector Engineers
- 180+ Specialist consultancy and asset integrity engineers
- 50+ General Engineering team

Our vision

“ With 130 years heritage in thermal, process & energy project delivery, Doosan Babcock has the knowledge, resource and experience to help industry deliver on their energy transition journey as a leading EPC service provider for Net Zero ”

DOOSAN Babcock



DOOSAN Babcock

Key Messages

Place

- **Scotland is well placed to accelerate large scale development of renewables & hydrogen projects**
 - *outstanding natural resources*
 - *skilled workforce*
 - *existing supply chain*

Experience

- **Doosan Babcock are working on a number of new energy projects including hydrogen production and infrastructure developments**
 - *experience in critical infrastructure delivery*
 - *working from concept through to EPC*
 - *developing long-term relationships with client stakeholder teams*
 - *working with strategic technology partners*

Partnerships

- **Doosan Babcock are working with trusted technology & engineering partners to deliver on major Net Zero projects**
 - *We are interested to work with German technology OEMs, project developers*
 - *We are ready to play our part in developing and expanding Scotland's energy infrastructure*



Vielen dank für ihre aufmerksamkeit!

stephen.cunniffe@doosan.com

<http://www.doosanbabcock.com/en/>



Scotland – Bavaria Joint Opportunities

13th June 2022, Glasgow



Sam Mackilligin
AECOM

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Global Multi-disciplinary Infrastructure Consultancy with 50,000 employees

- 700 Staff in Scotland and 150 Staff in Germany
- Delivering Hydrogen projects in both countries and around the world
- Global **green** hydrogen projects co-led from Scotland

Delivering Global Hydrogen projects and services

- **Hydrogen Production**
- **Direct Hydrogen Use**
- **Hydrogen Derivatives**

Consenting Services -

Engineering Services -

Process Safety -

Owner's Engineer -

EPCM Delivery -



‘ATOME Energy plc appoints AECOM as its Owner’s Engineer for the world scale 60MW Villeta Project in Paraguay’

- 60MW PPA from hydro-power signed in May 2022
- Point of connection ready to deliver power
- FID target early 2023
- To produce 8,000 MT/yr Green Ammonia for fertilizer production, target SOP 2024

FEED and EPC contracts now in procurement

ATOME



andy.cross@aecom.com



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Barry Carruthers
Scottish Power

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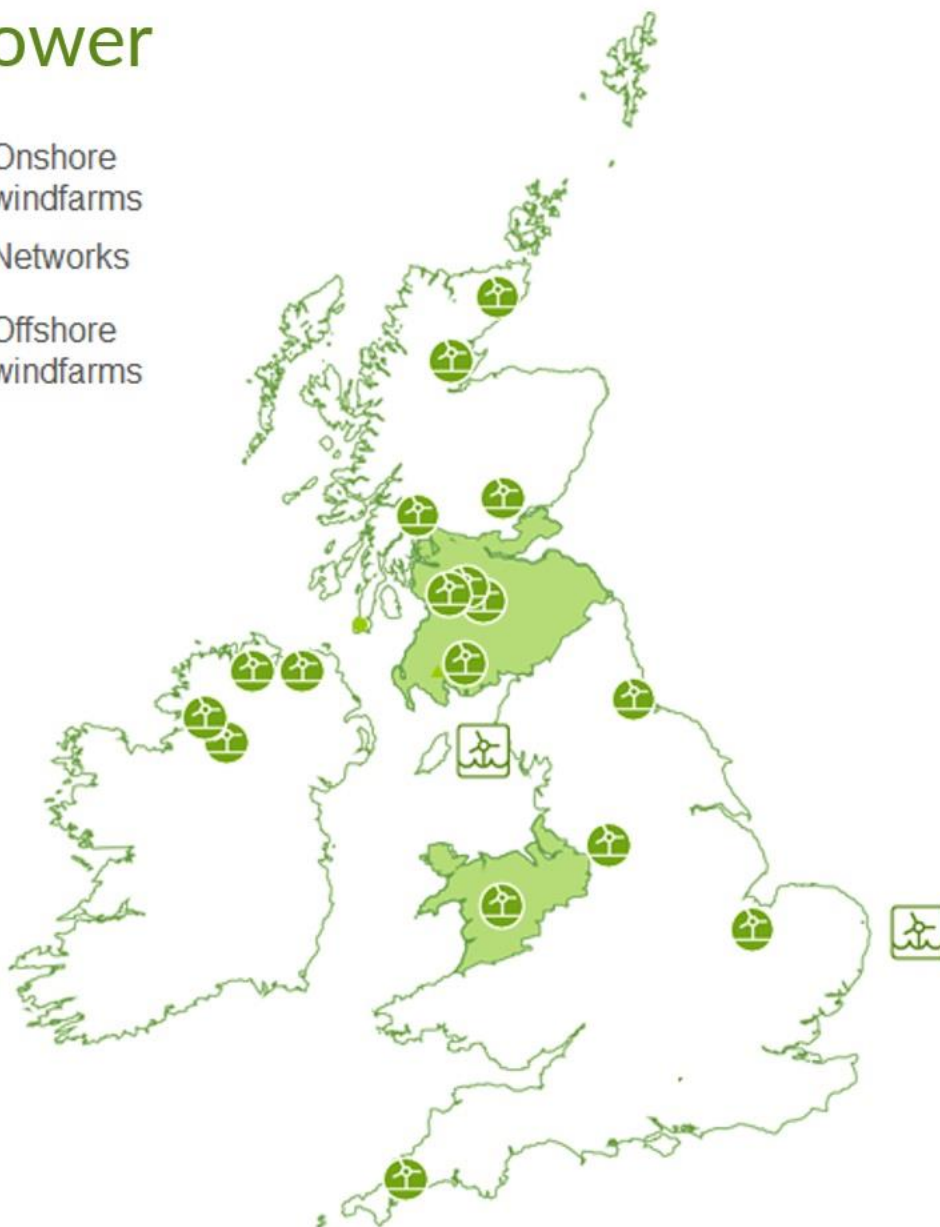


Green Hydrogen Vision

June 2022

ScottishPower

-  Onshore windfarms
-  Networks
-  Offshore windfarms



First integrated energy company generating 100% green energy

- Investing over **£10 billion** in the UK between 2020 and 2025
- 40 operational windfarms in the UK with over 2,900MW of capacity
- >15GW pipeline across wind, solar & storage
- 4.8 million electricity and gas retail customers across the UK
- Networks: 3.5 million points of supply and 110,000 km of power lines
- Over 5,700 employees

Alignment with Energy & Transport Infrastructure

Key locations for coverage across United Kingdom & strategic ports etc.

More than 20 sites across UK & Ire. in development

More than €3Bn
global investments in
Green Hydrogen in
next 10 years



e.g. Central Belt Production

- >8 tonnes / day
available before 2024



e.g. Highlands Production

- >20 tonnes / day
available before 2025



e.g. East Coast Ports

- >1000 tonnes / day, 2x
major sites, available
from 2025



Green Hydrogen Vision

June 2022



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Hannah Corbett
Centre for Energy Policy,
University of Strathclyde

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Working to ensure transitions to mid-century net zero targets deliver sustainable and equitable prosperity.



UNIVERSITY of STRATHCLYDE
**CENTRE FOR
ENERGY POLICY**

About the Centre for Energy Policy (CEP)

- The University of Strathclyde's Centre for Energy Policy (CEP) works with research, government and industry partners to understand and address the pressing public policy challenge of ensuring transitions to mid-century net zero targets deliver sustainable and more equitable prosperity.
- Established in 2014 by [Professor Karen Turner](#)
- Strengthening understanding of the economy-wide impacts of different decarbonisation actions e.g. carbon capture and storage, hydrogen deployment, energy efficiency, low carbon transport in order to identify economically, politically and socially feasible pathways to net zero.
- Funded by UK and Scottish Governments, philanthropic foundations and private sector organisations such as Scottish Power Energy Networks (SPEN) and Volkswagen Group.

Find out more at: <https://www.strath.ac.uk/humanities/centreforenergypolicy/>



UNIVERSITY of STRATHCLYDE
**CENTRE FOR
ENERGY POLICY**

About the Centre for Energy Policy (CEP)

Some of our current projects:

- [**Ocean Renewable Energy Fuel \(Ocean-REFuel\)**](#) - investigating the potential of harnessing offshore wind and marine renewable energy to produce zero carbon hydrogen and ammonia fuels
- [**Scotland's Net Zero Infrastructure programme**](#) - understanding the longer-term economic impacts and job preservation and creation opportunities as Scotland transitions away from oil and gas to low carbon fuels like hydrogen and CO2 removal technologies such as CCS.
- [**Delivering a sustainable and equitable heat transition**](#) – identifying pathways to successfully balance the conflicting technical, economic and socio-political dimensions of the residential heat transition in the UK
- [**Evaluating the impact of Volkswagen Group sustainable transport initiative**](#) on Greek island of Astypalea





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Salah Mahdy
Howden

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Company Overview

Salah Mahdy

Global Director – Hydrogen

Salah.Mahdy@Howden.com

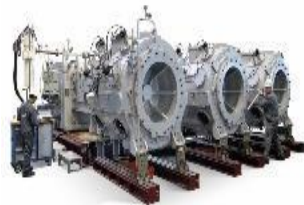
Revolving Around You™

© Howden Group 2022



Howden manufactures, installs and services highly engineered fans, compressors, heat exchangers, steam turbines, and other air and gas handling equipment around the world

Compressors



- Reciprocating
- Centrifugal
- Rotary
- Diaphragm

Fans



- Centrifugal
- Axial
- Variable Pitch Axial
- Cooling
- Jet

Turbine



- Steam Turbine

Heat Exchangers



- Rotary heaters
- Pre-heaters
- Gas-Gas heaters

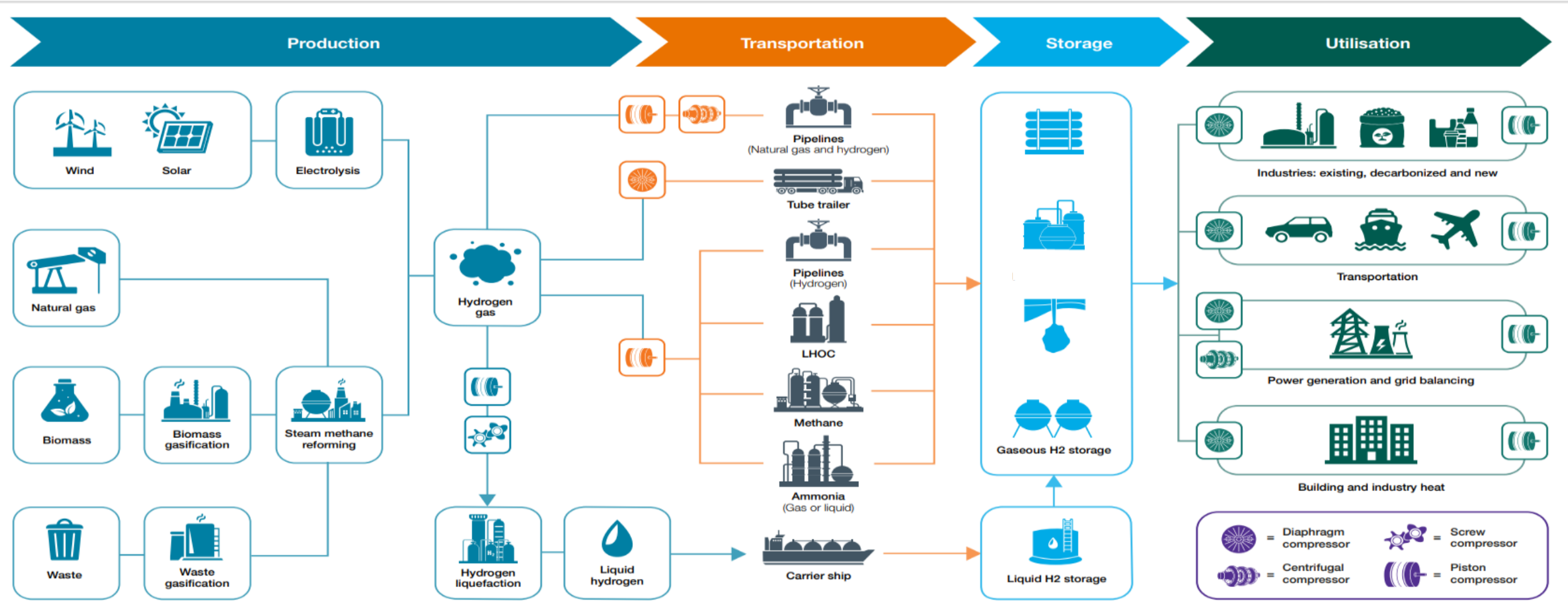
Digital Solutions



- Software
- Digital analytics
- Modelling & control software

Compression is a Key Element Across the Hydrogen Value Chain

Compression is a key component in all hydrogen applications





Burton Corblin®



HOWDEN
Thomassen
Compressors b.v.



Kuhnle,
Kopp & Kausch

Reciprocating Compressors



- Up to 8700 psi (600 bar), 20 000 cfm (34000 m³/h), 44 000 hp (33 MW)
- Non lube up to 3000 psi (210 bars)
- Free Floating Piston™ technology to extend MTBM on dry applications

*** More than 1000 Reciprocating compressors delivered to Hydrogen applications, including more than 30 over 10 MW.

© Howden Group 2022

Diaphragm Compressors



- Up to 29 000 psi (2000 bar), 700 cfm (1200 m³/h), 1300 hp (1 MW)
- Preserve gas purity, ensure gas confinement by static tightness

** More than 2000 compressors delivered in Hydrogen applications.

Hybrid Compressors



- Up to 8 000 psi (550 bar), 700 cfm (1200 m³/h), 1300 hp (1 MW)
- Combined piston and diaphragm technologies on a single frame
- Compact design to achieve specific combination of high pressure and capacity

Screw Compressors



- High availability 99% 5 years continuous operation
- Low operating cost
- Oil free designed for challenging conditions

*** More than 40,000 compressors delivered installed worldwide.

Centrifugal Compressors

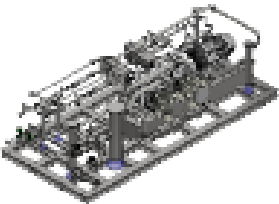


- High Efficiency for low Compression ratio's combined with high volume
- Precise process control and a huge turndown range with a simple constant speed motor.
- Variable speed operation and minimal maintenance requirements make Periflow® compressors simple to use and to service.

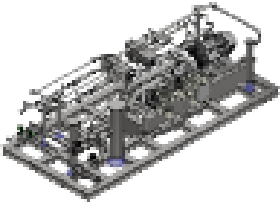
Hydrogen Innovation and Expertise in practice



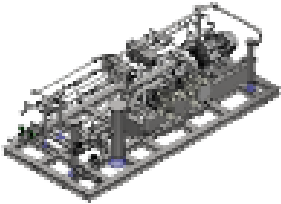
World's Largest Hydrogen Compression Solution



World's First climate-neutral fuels (eFuels)



World's First Green Steel Project



Europe's First Underground Storage



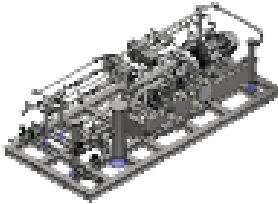
World's Largest Hydrogen Refuelling Station



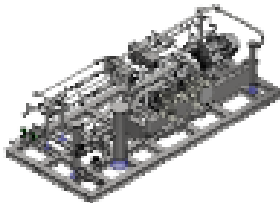
Power to X (Oil Refineries)



Power to X (Process Industries and Grid Balance)



Europe's Largest BioFuels Project



One of Germany's largest Green hydrogen generation plants



- A 8.75 MW Green Hydrogen Plant in Wunsiedel, it will be one of Germany's largest carbon-free hydrogen generation plants
- Siemens Financial Services, Rießner Gase GmbH and SWW Wunsiedel GmbH are investors in Wunsiedel's WUN H2 operating company
- Plant to go into operation in summer 2022 with an annual production of up to 1,350 tons of hydrogen and CO₂ savings of up to 13,500 tons



One of Germany's largest Green hydrogen generation plants



- Kraftanlagen Energies & Services GmbH has been appointed Kraftanlagen Energies & Services GmbH as the general contractor for the construction of a 5 MW hydrogen generation plant encompassing an electrolyser, compression and filling station, electricity supply system and the requisite auxiliary facilities.
- Followed by the installation of the electrolyser and system technology. Commissioning is planned for the second quarter of 2023, with commercial operations scheduled to start in the second half of the year. Using regional green electricity, the electrolyser is anticipated to produce an average of 1,200 kilograms of green hydrogen per day, compress the gas to up to 450 bar and pump it to a filling station and into a hydrogen trailer with a capacity of 1,250 kg. The green hydrogen will be delivered to two bus and truck filling stations in the districts of Munich and Ebersberg, which in turn will supply the regional transport hydrogen fuel cell buses.





Thank you

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Questions & Dialogue

Guided discussion about key topics

Dr Nigel Holmes & Professor Veronika Grimm



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