12 May 2025

Non-Electric Applications of SMRs: Catalyzing Clean Hydrogen Production and Beyond

NNWI
New Nuclear Watch Institute

Panel 3: Industry Applications and Beyond: Hydrogen, Transport, Heavy Industry Solutions

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New Nuclear Watch Institute

Moderator: Vincent Zabielski, Partner, Energy, Pillsbury Winthrop Shaw Pittman LLP

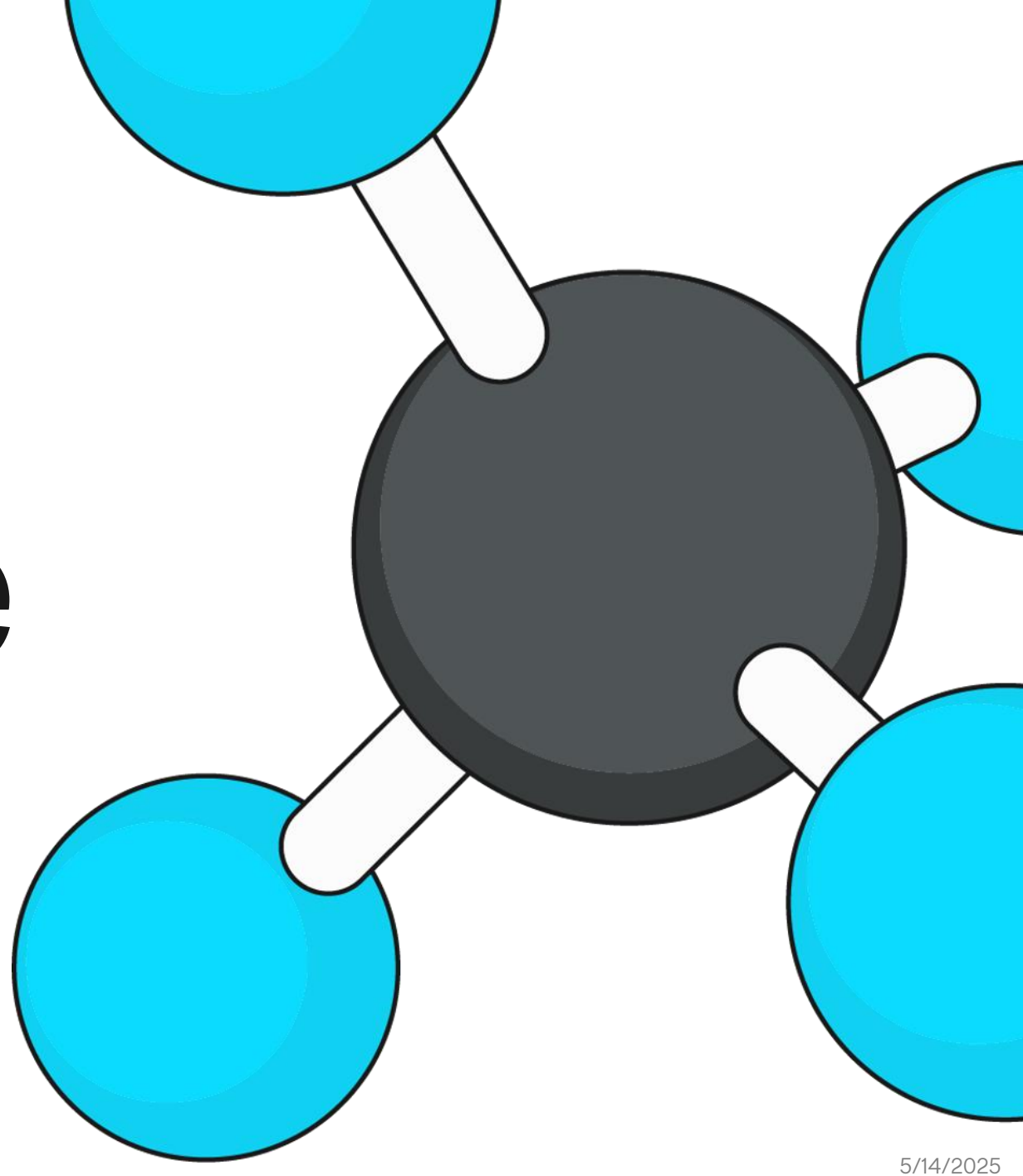
- **Dr. Justin Salminen**, Head of Carbon Processing Plant Concept, Hycamite
- **Brendan M. Bilton**, Co-Founder & Chief Technology Officer, Element 2
- **Mark Allan**, Green Metals & Green Steel Centre Leader, Research & Technology Leadership Team, Materials Processing Institute

hycamite

Hycamite Process for Low-Carbon Hydrogen and Graphite

Justin Salminen

Non-Electric Applications of SMRS, Catalyzing Clean Hydrogen Production and Beyond, London, 12 May 2025

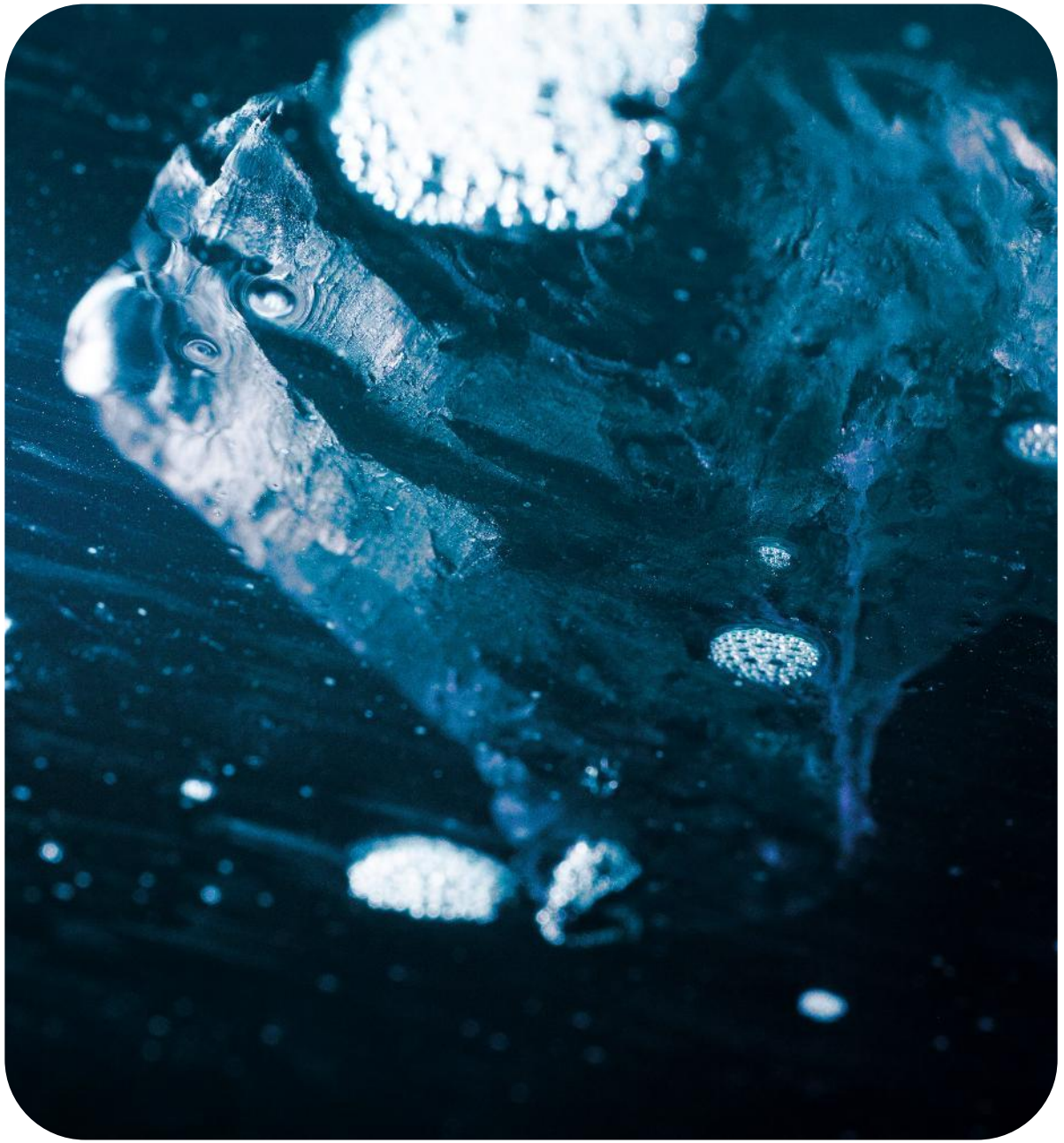


hycamite

Company

A deeptech startup producing low-carbon hydrogen and high-quality carbon

- Industrial-scale low-carbon hydrogen production
- Solid, high-value carbon products including battery-grade graphite
- Technology based on over 20 years of research at the University of Oulu
- Approximately 70 hycamates with different nationalities
- International, strategic investors
- Global coverage of strategic partners
- Industrial-scale demonstration plant capacity 2 kt hydrogen and 6 kt carbon annually



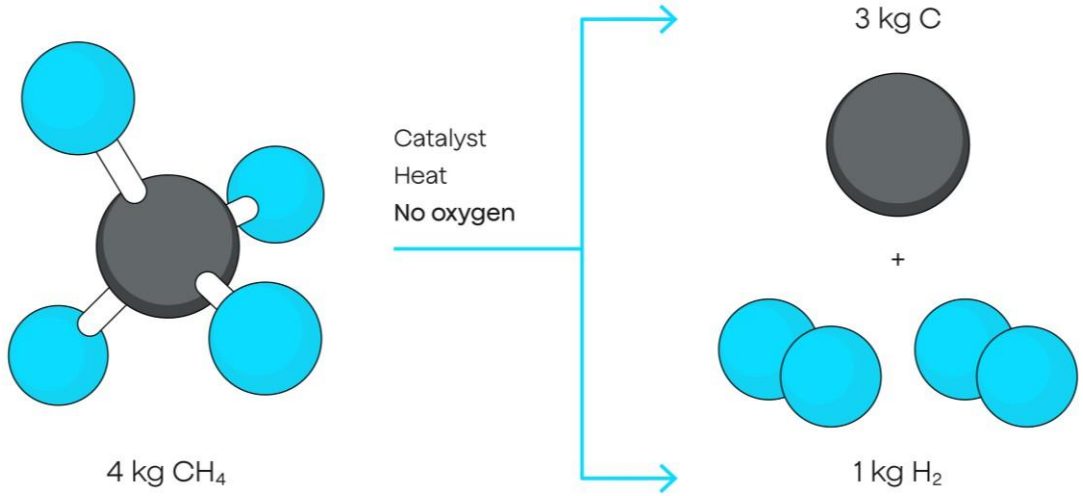
hycamite

What is methane splitting?

Producing hydrogen and solid carbon
- Methane from natural gas or biogas
- No CO_2 emissions from the process

Total life cycle emissions
- Less than 1 kg CO_2e/kg
- Negative if biogas is used as feedstock

Thermocatalytic decomposition of methane (TCD)



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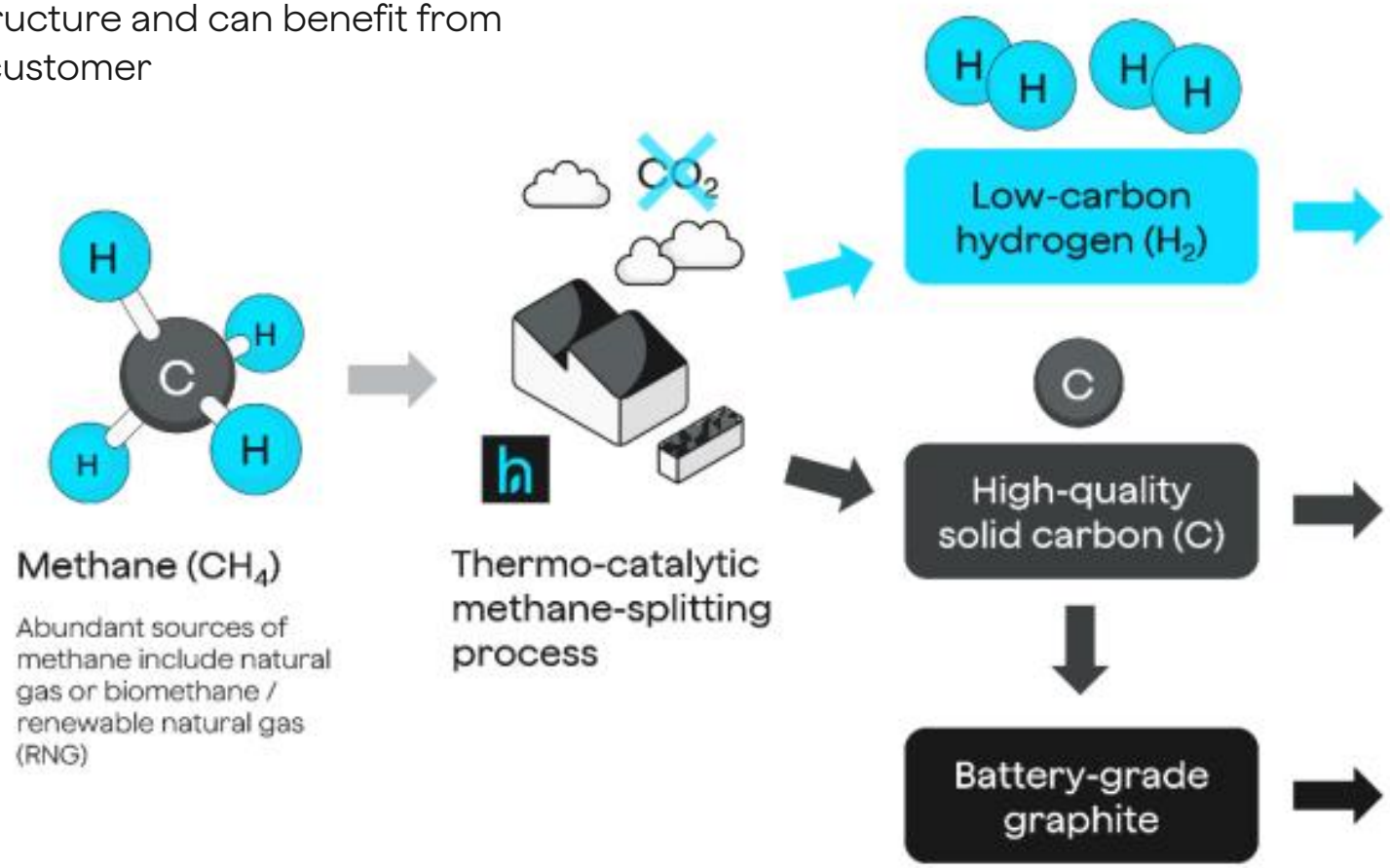
Our solution

Rapid and scalable decarbonization of industry and enable graphite production locally

- Plug-and-play solution to decarbonize industries that use natural gas
- Utilizes existing infrastructure and can benefit from the waste heat of the customer



hycamite

Customer Sample Facility (CSF)

Industrial scale proof of concept

Customer Sample Facility, outside view (September 2024)

hycamite

Customer Sample Facility (CSF)

Industrial scale proof of concept

-Three+ years of pilot plant operations
-CSF is the largest methane-splitting plant in Europe

Customer Sample Facility, inside view (September 2024)

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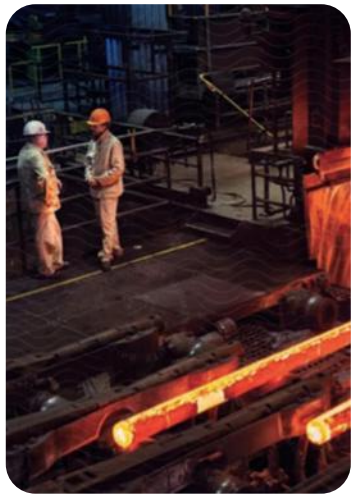
Products

Balanced carbon product portfolio

Batteries

Concrete

Steel



Polymers

Supercapacitors

Tires

- Customized carbon products and production volumes according to the customer's needs
- A wide range of carbon products for various applications, such as the battery industry, concrete and cement industry, steel industry, tire industry or conductive polymers
- Hycamite is the only company able to produce large volumes of battery-grade graphite from methane splitting on an industrial scale

hycamite

Thank you!

All our contact details can be found on our website **hycamite.com**

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Laura Rahikka
CEO, Founder

Matti Malkamäki
Chair, Founder

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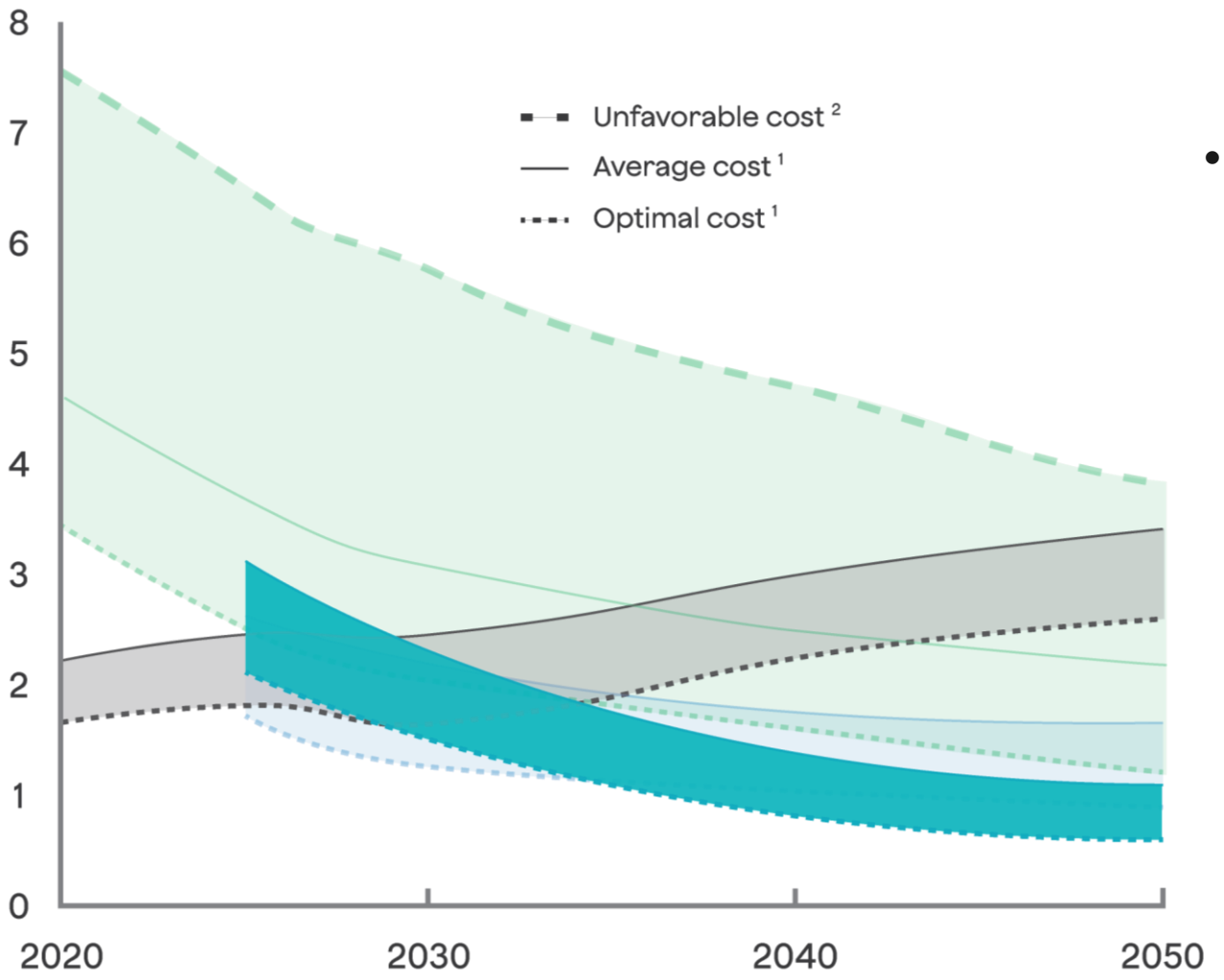
Benefit 1: Price

Competitive pricing due to two revenue streams, hydrogen and solid carbon



- No need for the end customer to pay a premium on low-carbon hydrogen

Gray hydrogen (SMR)

Green hydrogen (Electrolysis)

Blue hydrogen (SMR + CCS)

Hycamite hydrogen (TCD)

Sources:
[1] **McKinsey** Hydrogen & Derivatives Flows Model, October 2022
https://hydrogencouncil.com/wp-content/uploads/2022/10/Global-Hydrogen-Flows.pdf
[2] **World Energy Council**, Hydrogen demand and cost dynamics, December 2021
https://www.pwccn.com/en/industries/energy-utilities-and-mining/publications/hydrogen-demand-cost-dynamics-dec2021.html

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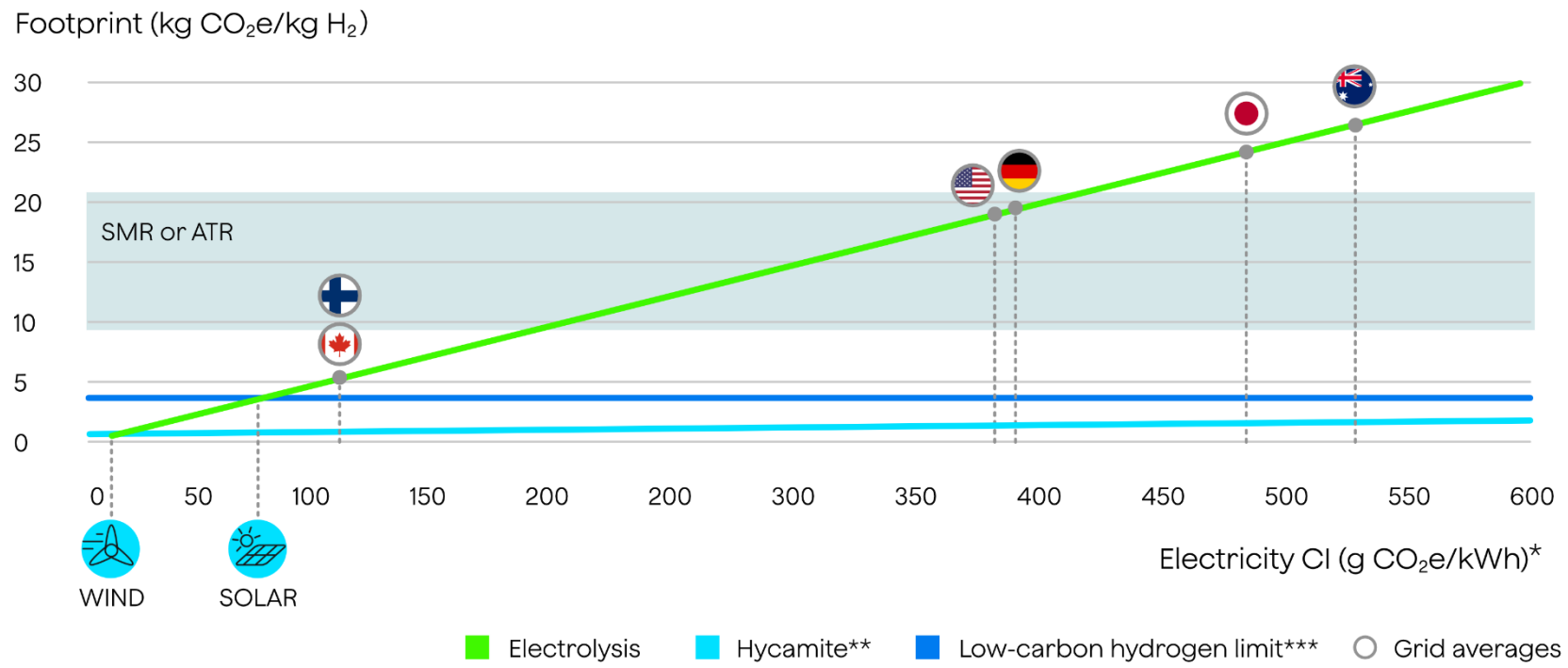
Benefit 2: Life cycle emissions

Ultra low-carbon products due to no CO_2 emissions from the process



- In comparison, our hydrogen typically has the smallest carbon footprint – even with natural gas as feedstock
- Competing technologies require more power – this leads to a growing carbon dioxide footprint

* ourworldindata.org/grapher/carbon-intensity-electricity
** Hycamite's emissions are based on the EU LNG mix (upstream) and the shown electricity CI
*** EU renewable H_2 and Japan: 3.4 kg CO_2e/kg H_2, U.S.A. and Canada: 4 kg CO_2e/kg H_2

ATR: autothermal reforming
SMR: steam methane reforming

hycamite

We produce low-carbon hydrogen and high-quality carbon products by splitting methane

What sets Hycamite apart?

- Compared to steam methane reforming (SMR), we produce no CO_2 emissions.
- A highly energy-efficient process, utilizing only 13% of the energy needed in electrolysis.
- Carbon is captured in solid form and can be used as high-quality carbon products such as battery-grade graphite.

Benefit 1: Price

Competitive pricing due to two revenue streams, hydrogen and solid carbon. The end user doesn't have to pay a premium on low-carbon hydrogen.

Benefit 2: Life cycle emissions

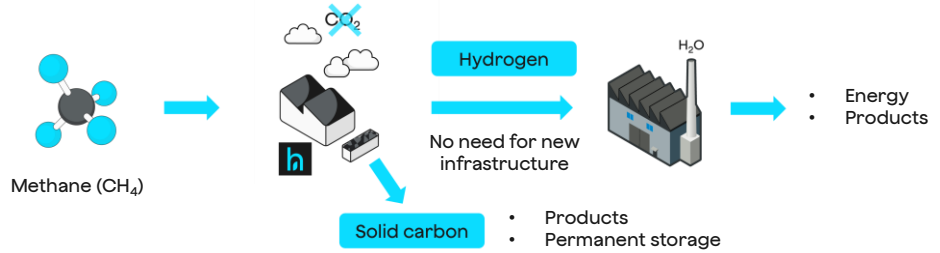
Our ultra-low carbon hydrogen typically has the smallest carbon footprint, even with natural gas as feedstock, compared to other technologies.

Benefit 3: Products

Customized carbon products and production volumes according to the customer's needs. We produce a wide range of carbon products for various applications.

Our solution

A plug-and-play solution to decarbonize industries that use natural gas, utilizing existing infrastructure and can benefit from the waste heat of the customer.



Entering industrial scale

We are now commissioning our Customer Sample Facility (CSF), which is the largest methane-splitting plant in Europe. Once fully operational, the plant will produce 2 000 tons of low-carbon hydrogen and 6 000 tons of high-value carbon annually. The plant's annual decarbonization capacity is up to 18 000 tons of CO_2.

2 kt
CSF's annual hydrogen production capacity

6 kt
CSF's annual carbon production capacity

60+
Employees in the organization

20+
Years of research behind our technology

Contact us:
Hycamite.com
Hycamite

Element-2

Commercialising Hydrogen Transport

May 2025

Brendan Bilton
CTO & Founder

The opportunity of hydrogen transport

Element-2

- **500,000 diesel HGVs** and **4.5 million diesel vans** on UK roads today
- Help increase UK **energy security**
- Help **decarbonise** UK transport
- Help an **affordable** and **just** energy transition

Overview

Element-2

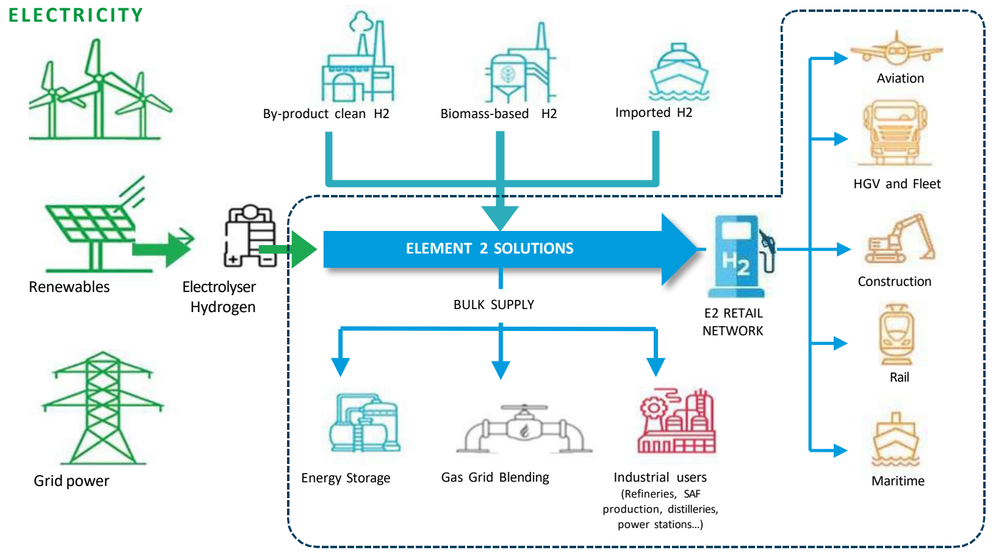
- We are building a **national network** of hydrogen refuelling stations to meet growing **demand** from commercial fleets
- Led by a team of experts with knowledge, and passion in **clean safe** energy
- We target local **green / low carbon** hydrogen
- We install hydrogen refuelling infrastructure at **our cost**, subject to contract
- Electric **and** hydrogen *#ANDnotOR*

TEES VALLEY XPOLogistics EXELBY SERVICES ELECTRA FAUN ZOELLER KIRCHHOFF GRUPPE radius UKfuels VAUXHALL

What we do

Leading UK player in hydrogen trading, retail and transport distribution

- Provide UK-wide infrastructure for industrial and commercial access to hydrogen, working with industrial clusters, fleet operators and local government.
- Buy and retail locally-sourced green and low-carbon hydrogen for the greatest net-zero impact
- Build and operate hydrogen storage, transport and retailing infrastructure, underpinned by long-term offtake contracts
- Own and operate transport containers that distribute our hydrogen through the network, bringing gas transport capabilities in-house and reducing transport costs.



Over 1,700 fuelling events completed to date across these activities

Business Overview

Element-2

Post-revenue UK-centric infrastructure scale-up in the rapidly growing hydrogen retail and distribution market.

- Seeking investment to deliver the capital investment programme for the servicing of active and pipeline contracts and the scaling of the business model to new markets
- Post-revenue and strong margins – 9 sites served to date, from London to Inverness
- Three revenue streams delivering a range of H2 supply and service contracts across hydrogen trading, industrial supply and infrastructure for mobility customers
- Active supply/refuelling contracts with large blue chips customers on multi-year term lengths
- 20+ strategic development sites identified. 4 sites with planning approved, 1 awaiting outcome
- Low technology risk. Commercial development model, using off-the-shelf technologies
- **EBITDA breakeven projected for H2 FY25**

6X Revenue growth
2022-2024
CAGR of 142% 2022 to 2024

£1.5m FY24 Revenue
(£3.0m for 2025)

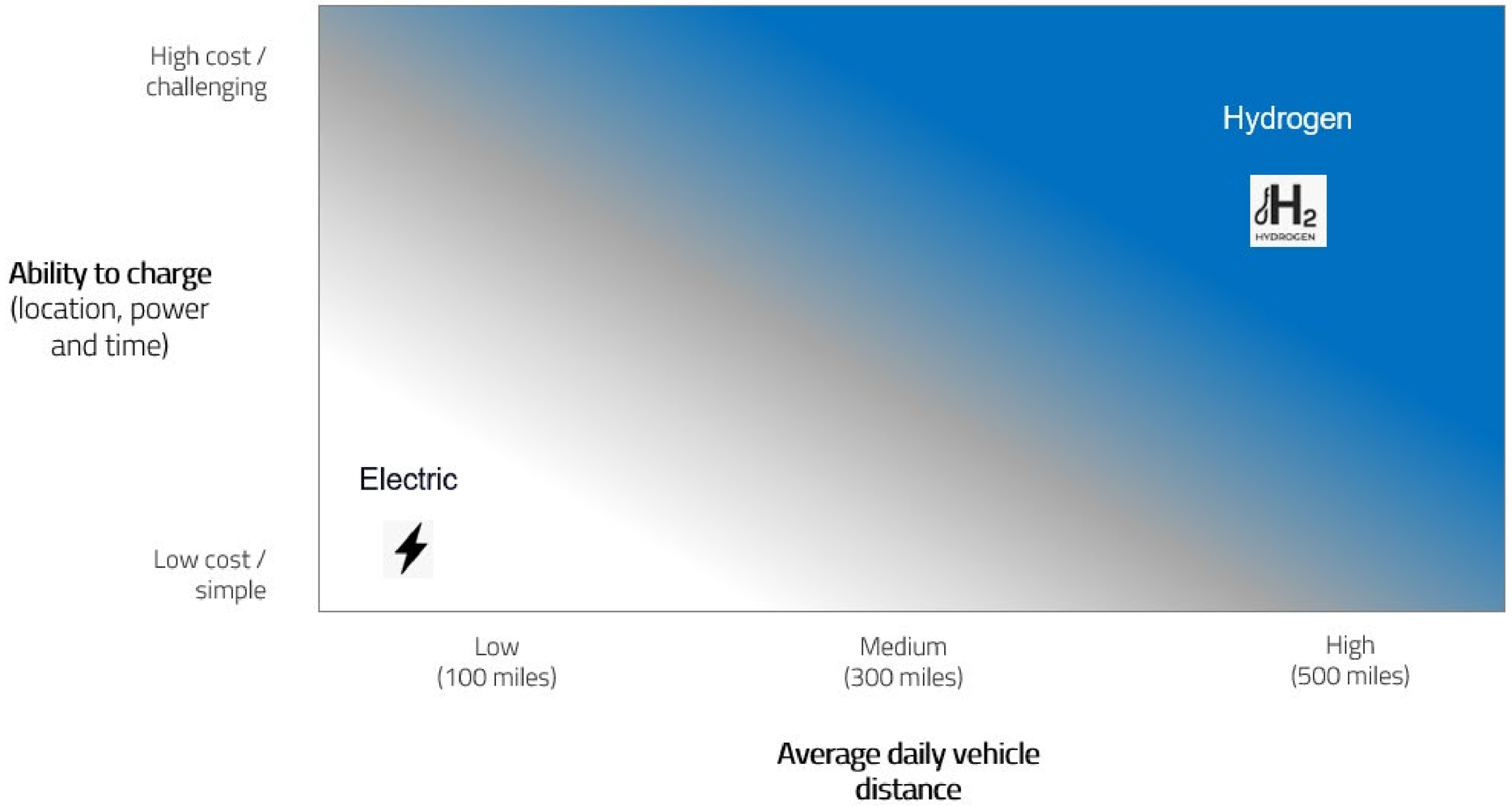
£2.3m FY23/4
Funded Projects

£9m* 18-month pipeline
(Projects in hand)

*Significant potential upside from fuel subsidy supports (currently not assumed in financial model)

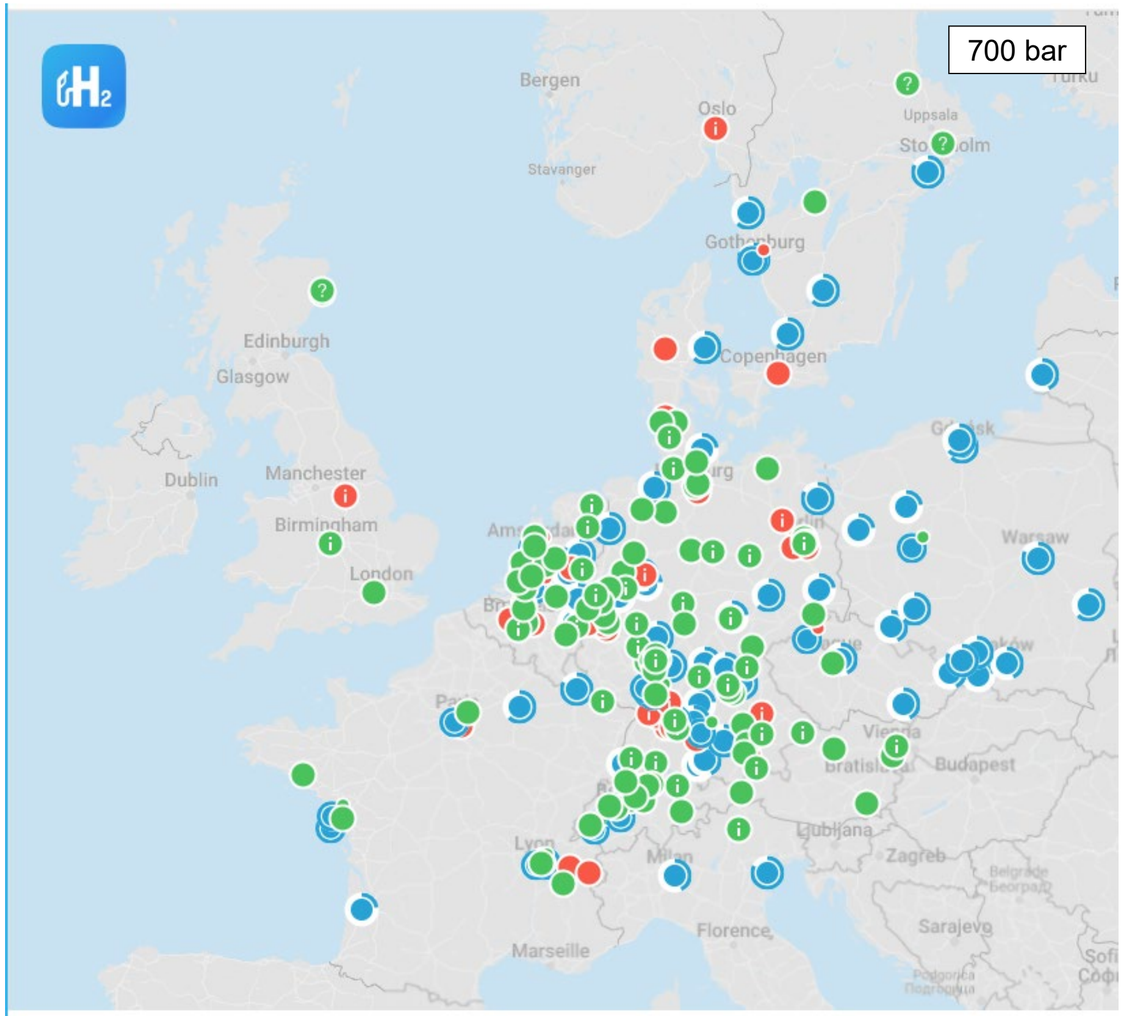
Electric and hydrogen *#ANDnotOR*

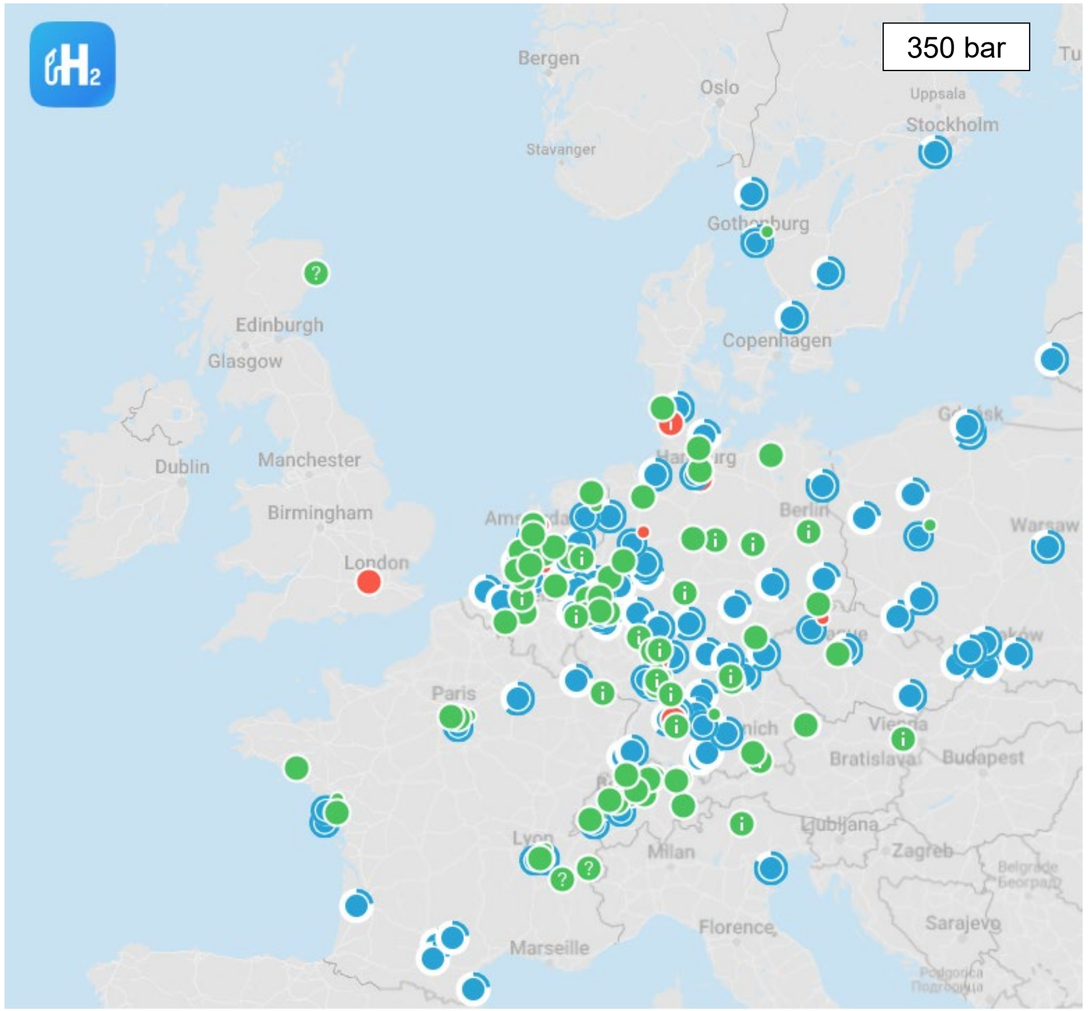
Element-2



H2 live – public hydrogen refuelling sites

Element-2



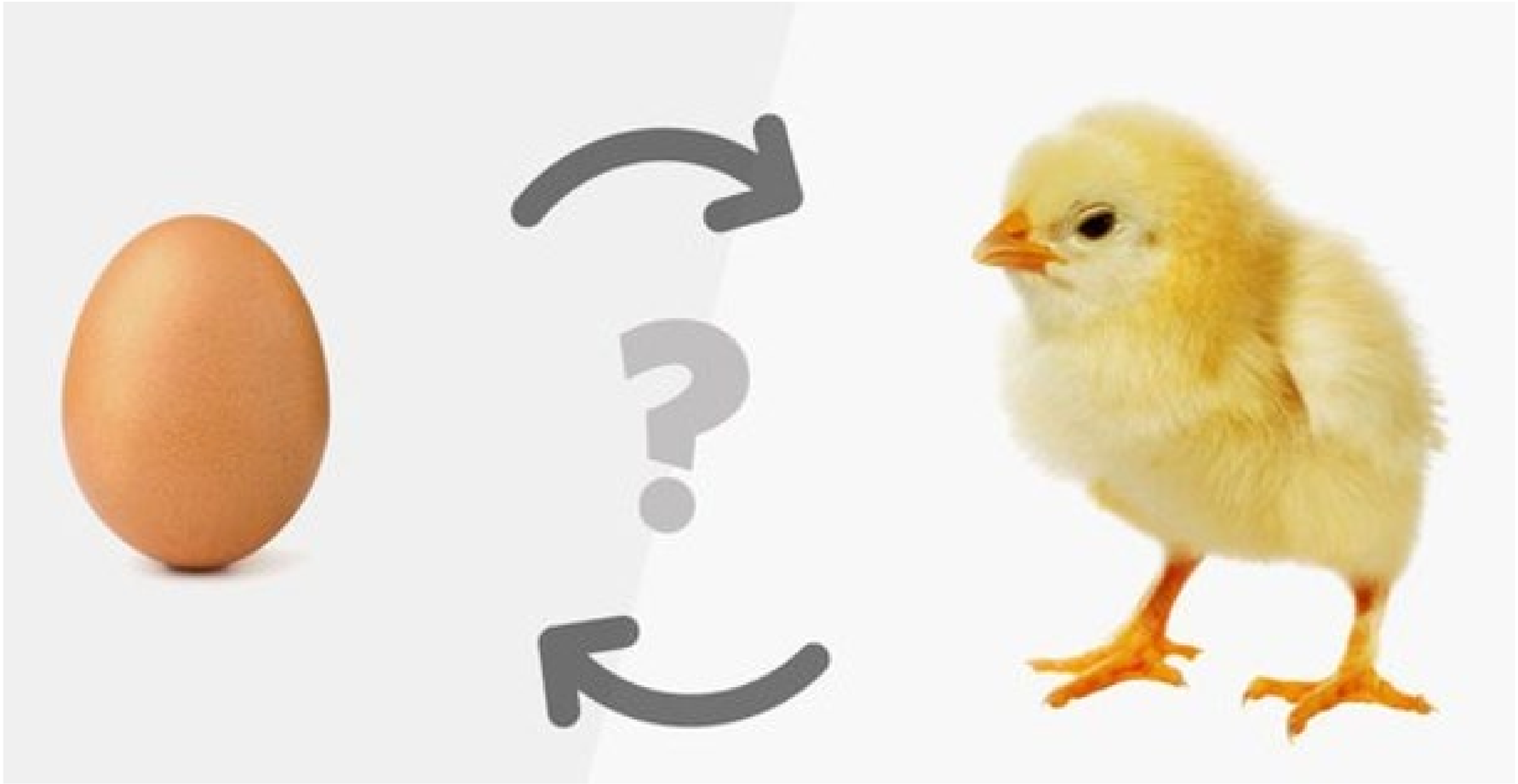


Filling up with H2
Hydrogen mobility starts now

Filling up with H2
Hydrogen mobility starts now

29 Oct. 2024

UK: Chicken versus egg ?

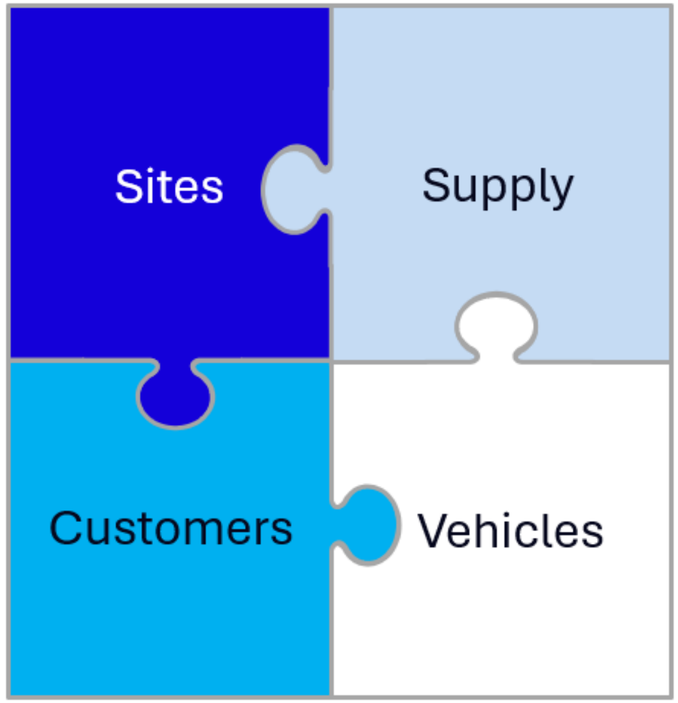


Hydrogen vehicles

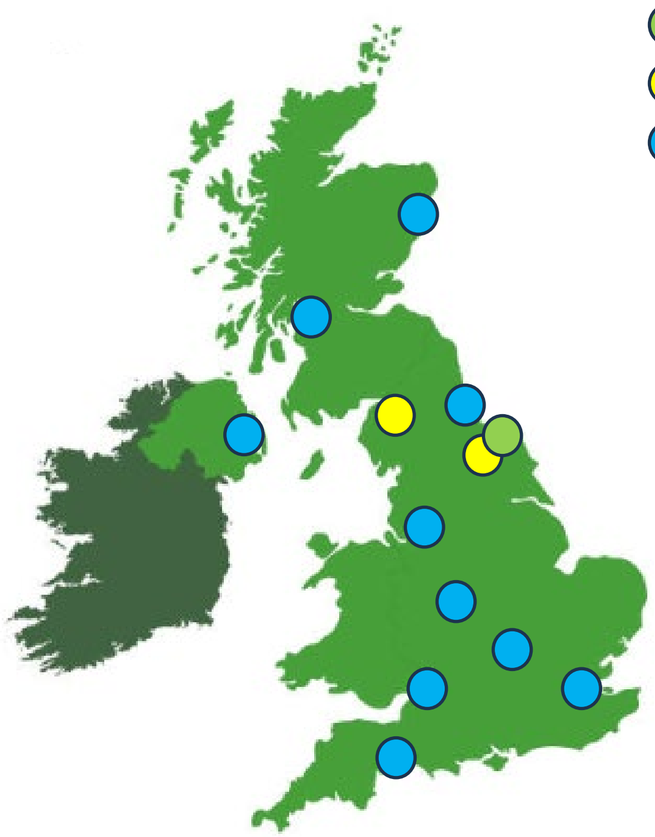
Hydrogen refuelling sites

How we crack it !

Element-2



Collaboration



Teesside International Airport – Innovate UK Tees Valley project (March 2025)

Exelby services (M6, A1(M), planning permission approved)

Hydrogen refuelling hubs / hotspots

HGV tractor unit costs

Approximate prices – based on what we have heard

		g / CO2 / km
Diesel	£ 100,000	*700-1200
Electric	£ 200,000 - £ 400,000	0
H2 fuel cell	£ 600,000 - £ 800,000	0
H2 combustion (like CNG)	£ 130,000	< 1**

**UK Guidance on measuring and reporting Greenhouse Gas (GHG) emissions from freight transport operations (Department For Transport asset) - 2.67 kgCO2eq/litre. B7 bio-blend assumed, thus 93% diesel used in calculation. HGV tractor unit fuel efficiency assumed of 6-10 mpg.*

*** EU REGULATION 2019/1242 - CO2 Emission performance standards for new heavy-duty vehicles*

Zero emission legislation (HGV)

**EU REGULATION 2019/1242 - CO2 Emission performance standards for new heavy-duty vehicles*

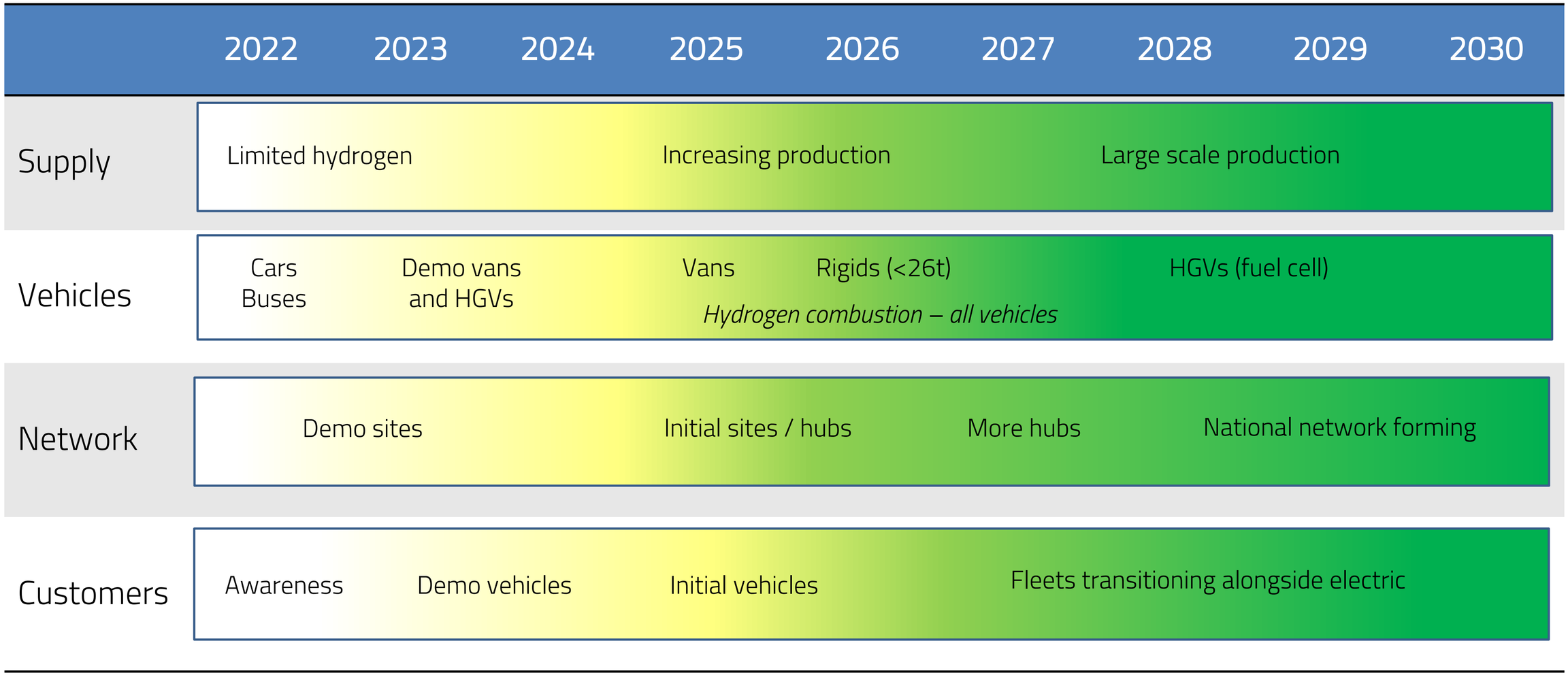
Based on Element 2 understanding	UK	*EU
CO2 reduction targets	-	Vs 2019: -15% (2025-30) -45% (2030-34) -65% (2035-39) -90% (2040+)
Vehicle manufacturer penalties	-	4,250 € / CO2 / tkm
Hydrogen combustion	-	< 1 g CO2/km
Retrofitting (H2) and repowering (BEV) of existing vehicles	-	Yes, classified as a new ZEV sale
Hydrogen stations at least every 200 km and all major cities by 2030 (TEN-T)	-	Yes
Subsidies to support ZEV purchase	-	Yes, all members states requested to have support and/or in place
ICE sales ban	2035 (<26 tonne) 2040 (all HGVs)	-

Result – European HGV manufacturers appear to be focusing on EU and delaying UK plans

Opportunity – Brexit allows the UK to go faster and be bolder

UK Hydrogen transport potential

Element-2



Timeline is based on public announcements, UK Government support, websites, reports and expectations

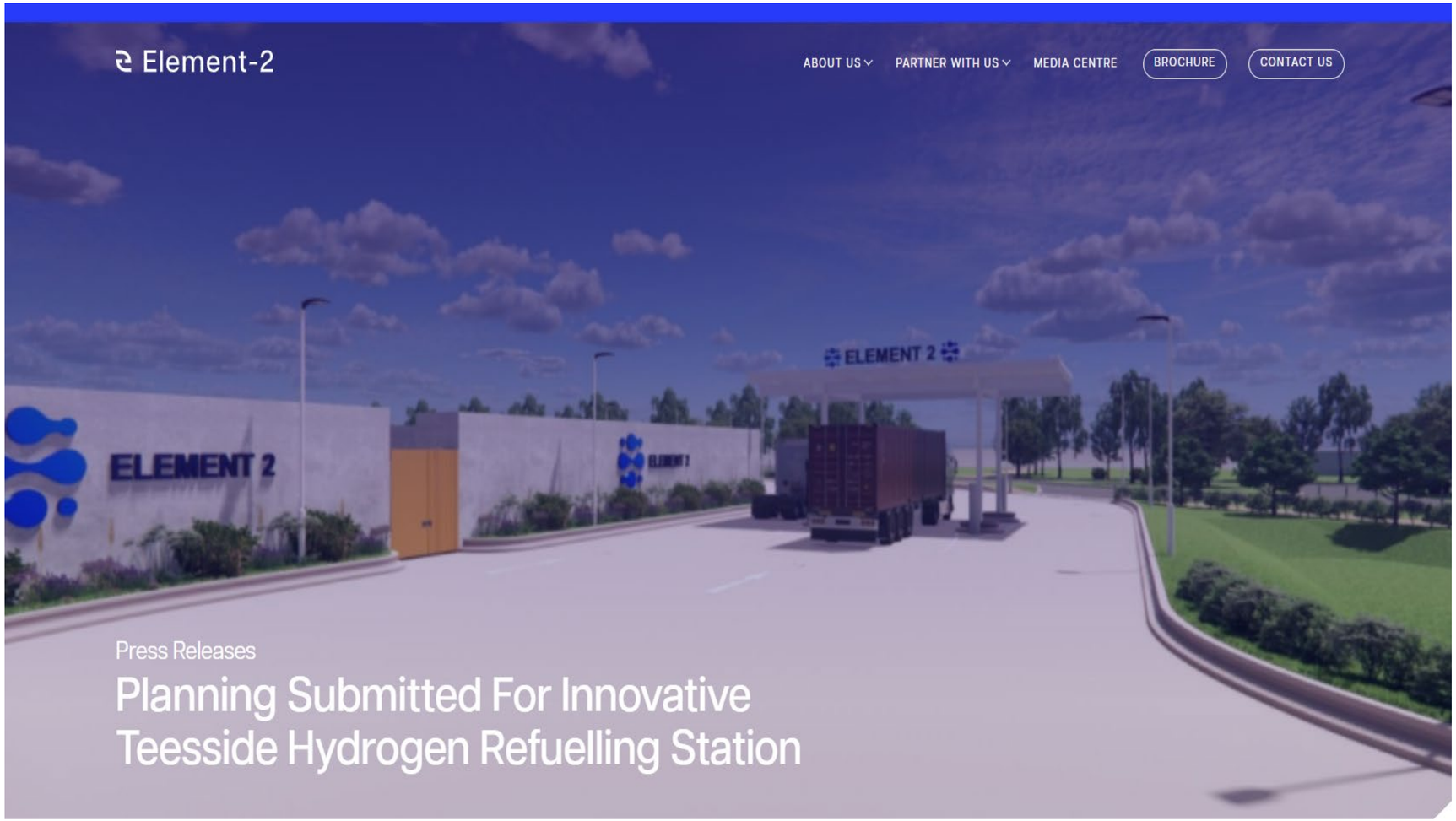
Thank you.

Element-2

For further discussion or investment interest, please contact

nick.shelley@element-2.co.uk

Or connect on LinkedIn



#hydrogennow #ANDnotOR #makedieselhistory

Materials Processing Institute

1944 - 2019 75 YEARS OF INNOVATION

Iron and Steel Evolution x SMRs

Mark Allan, MPI Green Steel Centre

Non-Electrical Applications of SMR's - NNWI, 12th May, London

Materials Processing Institute

SCOTLAND
Aberdeen
Dundee
St Andrews
Stirling
Edinburgh
Glasgow
United Kingdom
Newcastle upon Tyne
Durham
Belfast
Isle of Man
Dundalk

Materials Processing Institute

www.mpiuk.com

Materials and Process Innovation for a Sustainable Future

We are the independent, one-stop shop for scaling up and commercialising innovations in materials, technologies and processes

Established independently out of the UK steel sector in 2014 and now working internationally with and beyond steel, metals, cements and energy

We are proud of our societal mission alongside our technical and economic impact, supporting early careers and workplace wellbeing and diversity

INTERNATIONAL DAY
AGAINST HOMOPHOBIA, TRANSPHOBIA AND BIPHOBIA
MAY 17

Materials Processing Institute

Focus Areas

Advanced Materials

Developing new materials to disrupt industries.

Industrial Decarbonisation

Scaling up technologies for a net-zero future.

Circular Economy

Critical minerals recovery and by-products valorisation.

Digital Technologies

Optimizing processes through integration with artificial intelligence.

Advanced Materials

Characterisation Centre

Advanced lab equipment for detailed material structure and property analysis.

Development Centre

Custom alloy creation and additive manufacturing.

Pilot steelmaking plant (VIM, IM, EAF)

Ensuring that lab-created alloys are feasible for industrial production.

Circular Economy

Divert By-products

Develop solutions to keep materials out of landfills.

Increase Value

Find ways to make by-products more valuable.

Reduce Impact

Minimize the environmental footprint of industrial processes.

Industrial Decarbonisation

Sustainable materials

Facilitating carbon-zero cement solutions.

Energy efficiency

Waste heat recovery, carbon footprint reduction, and LCA.

Fuel switch de-risking

Hydrogen network, furnaces and models to facilitate alternative fuels usage.

Digital Technologies

Process optimisation

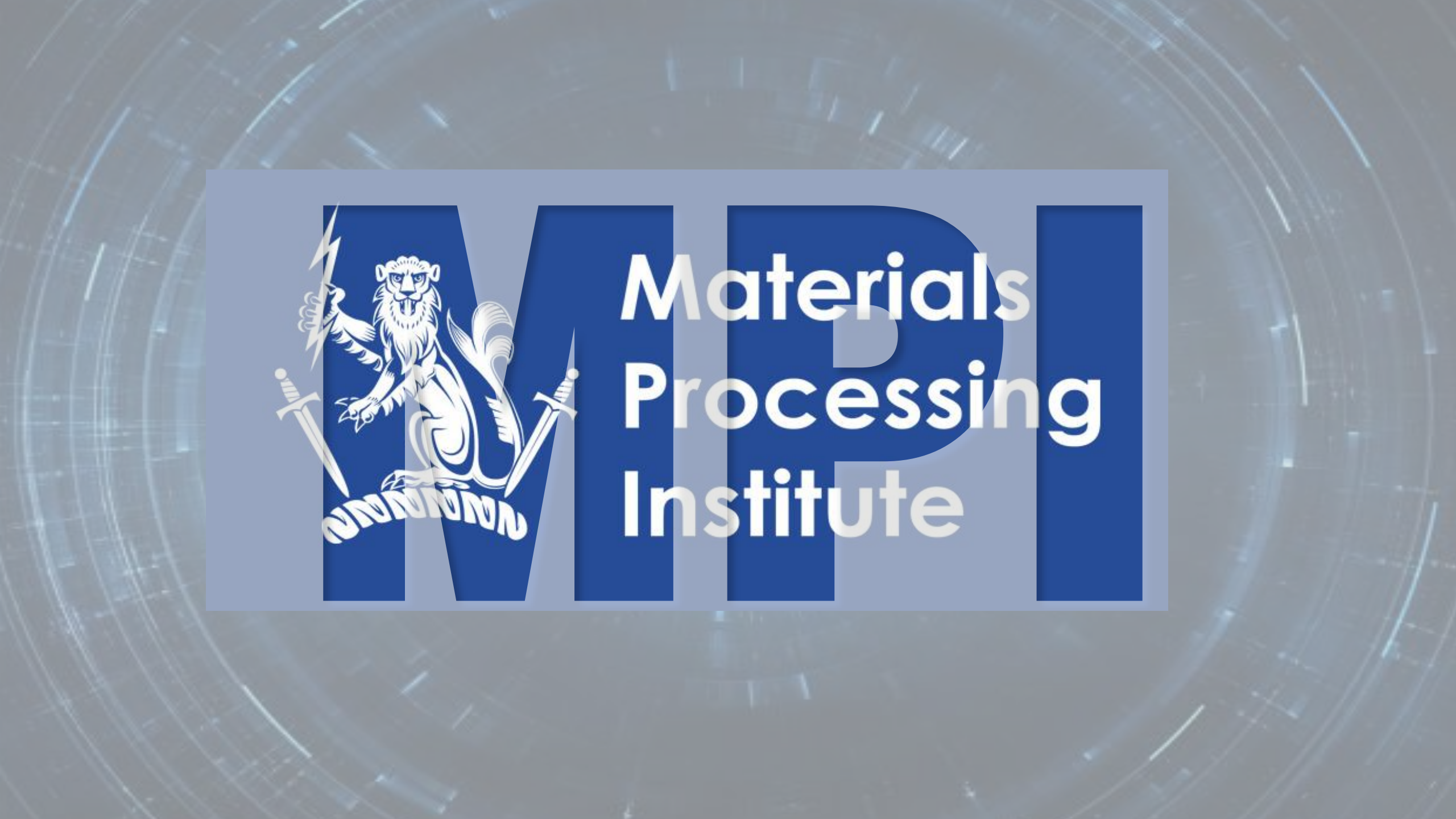
AI / Machine learning models to boost productivity.

Software engineering

Application built for powder metallurgy.

Augmented reality and Virtual reality

Live process data to support operating instructions and maintenance.


MPI
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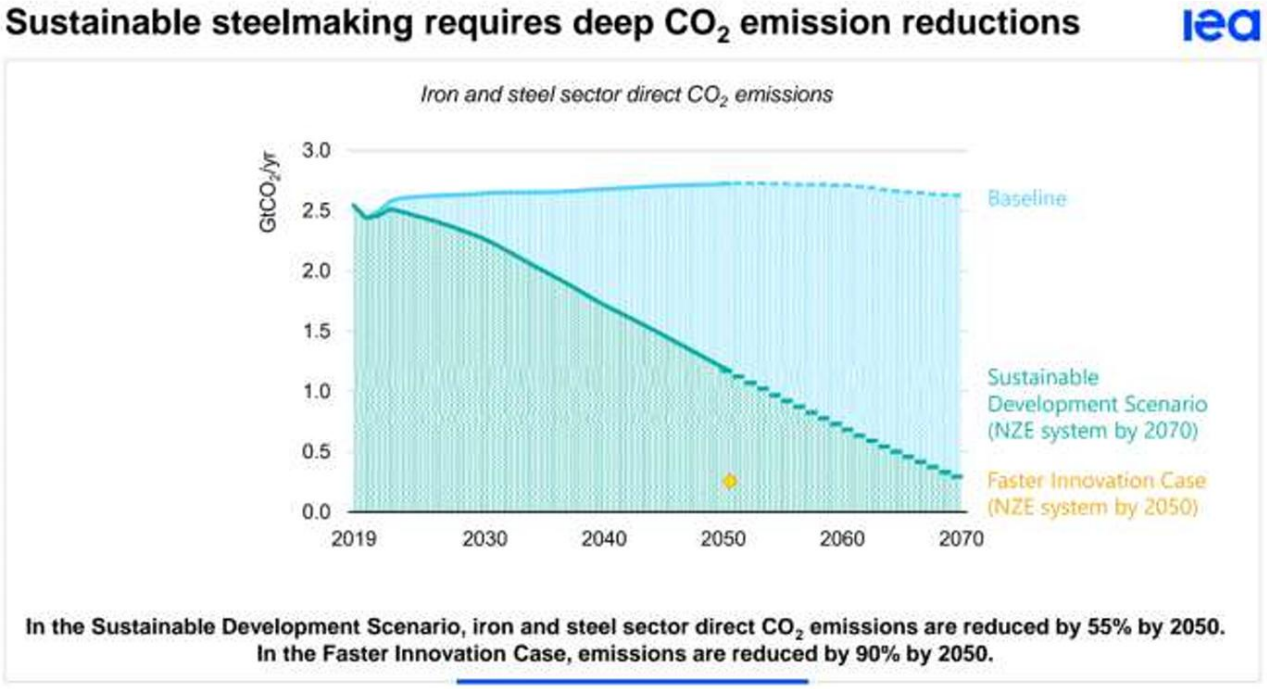
Materials Processing Institute

The Green Steel Centre works with the steel industry and supply chain, to develop and perfect technologies, materials, processes, and knowledge to decarbonise steel production and accelerate the emergence of a sustainable, profitable Green Steel economy

Iron and Steel Evolution x SMRs

- Fossil-free iron and steel is starting to break through as a material of choice for responsible procurement in a sustainable economy.
- Steelmaking globally contributes 8% or more of annual human CO2 emissions. Many steel brands now have a ‘green’ offering and various national or international standards are emerging (Responsible Steel, Global Steel Climate Council, Low Emissions Standard Steel, the Taxonomy of Green Steel for India) in tandem with growing market demand for independently certifiable low embodied emission products.



DEMANDING AND DELIVERING THE UK GREEN STEEL TRANSITION

Green Steel Transition Forum
City of London
26th February 2025

Making the demand-led sustainable steel transition a reality

Materials Processing Institute
PRISM

Iron and Steel Evolution x SMRs

- The issue for iron and steel, from an energy emissions point of view, is that 75% or more of global production is dependent on solid fossil carbon (coal and coke) to produce liquid iron from ore, and refine it into steel, with or without recycled scrap steel additions.
- Almost all the remainder of iron making is ‘direct iron reduction’ (DRI) dependent on fossil fuel gas,
- and almost all the remainder of steelmaking recycles existing scrap metal and is powered by grid electricity for electric arc furnaces (EAF’s), often with supplementary thermal energy from coal or gas.

Iron and Steel Evolution x SMRs

- Deep decarbonisation of iron and steel is possible through a combination of electrification and fuel switching
- The world's first new build 'fossil free' plants are scheduled to come on stream from 2026, reducing iron by DRI but using hydrogen not natural gas, then melting it and blending with recycled scrap in EAFs, casting and rolling it into shape – with the whole operation powered by renewable electricity.
- Other steelmakers and iron ore suppliers are transitioning to these technologies more gradually over the next decade.

- **The transition away from 'integrated' steelmaking (all the ore-to-steel activity on one site powered ultimately by one pile of coal) is disrupting iron ore supply chains, metallic iron supply chains, and steelmaking**

Iron and Steel Evolution x SMRs

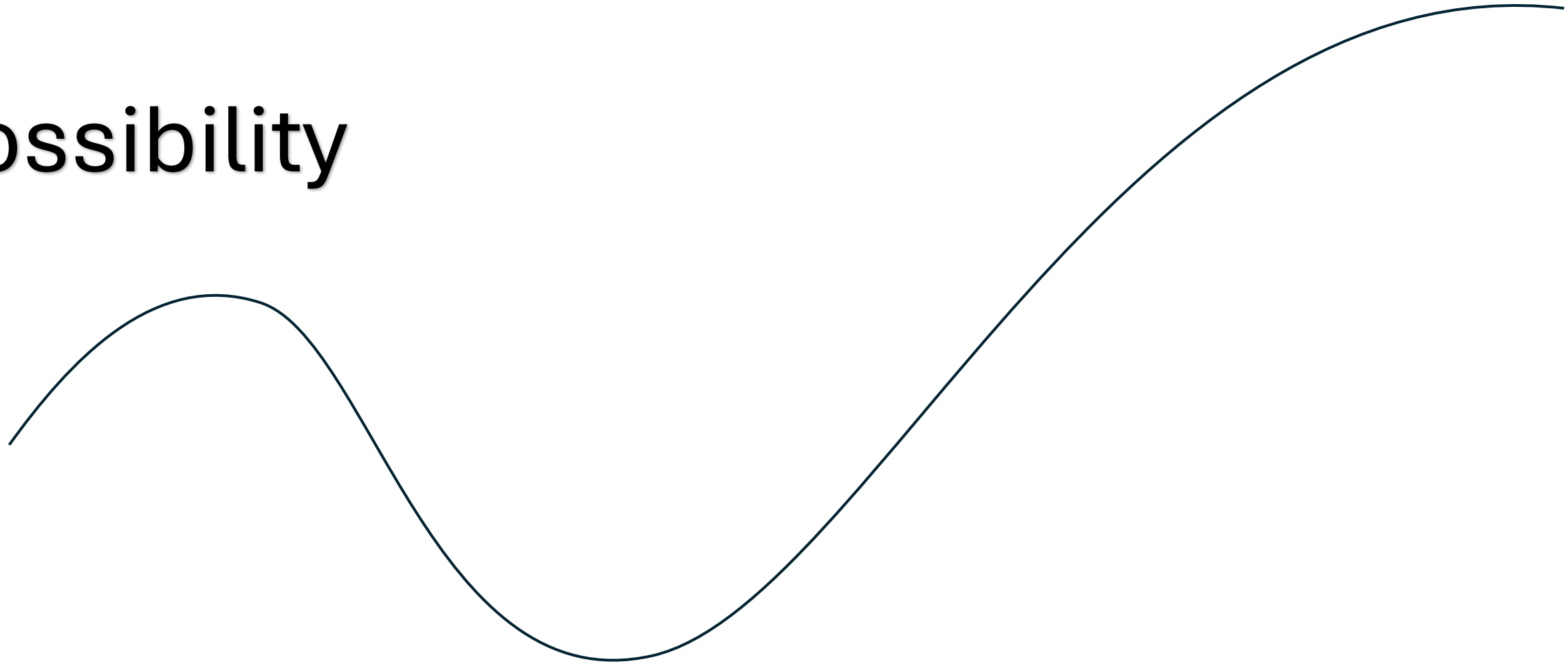
- This level of decarbonisation is significant for any energy grid or supply chain, particularly once DRI plants switch from natural gas to green hydrogen:
- a hydrogen DRI plant producing 2 million tonnes of iron per year would require around 12GWh of electrical power annually for electrolysis and heating of the hydrogen.
- A downstream steelplant would have a similar order of magnitude of electrical load, equivalent to a small city.

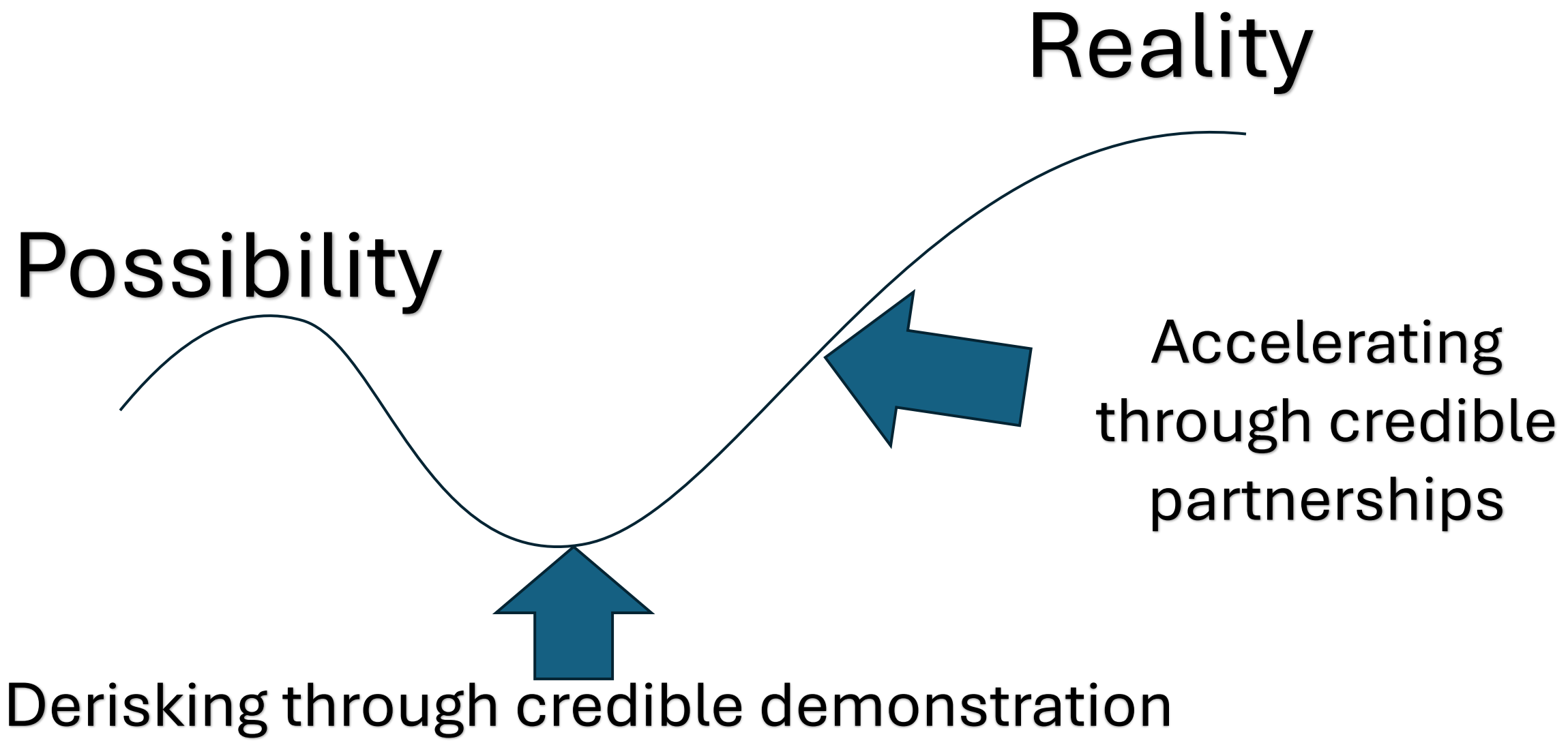
Iron and Steel Evolution x SMRs

- The attractive synergies between large steelplants and nuclear power is that lower point source emissions marry with a high baseload high temperature heat output which can supply electrical power, direct heat and electrical or thermally cracked hydrogen, all three of which can be utilised in making iron and steel, and forming it into products.
- Hydrogen DRI plants typically operate at around 900 °C; electrical steelmaking has a variable and spiky, but predicable load of hundreds of MW, and rolling and forming steel often requires temperatures of 1100 °C or more.
- In terms of hazard management, all major steelmaking sites are already top-tier COMAH.
- Challenges will be around lead times, reliability, whole life costs, and qualification for ‘green steel’ market standards

Reality

Possibility




Reality
Possibility
Accelerating through credible partnerships
Derisking through credible demonstration

Pilot scale innovation – 6D

- Define the outcome (properties, costs, lifecycle)
- Design the recipe
- Derisk the processes
- Deliver the material
- Determine the micro and macro properties
- Deform it (in a good way!)

Repeatability

Reliability

Availability

Affordability

Credibility

Sustainability

Materials Processing Institute

Thank you

Mark Allan, Green Steel Centre Lead

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