GHD Advisory

→ Taylor Hayes

Hydrogen Forward Look: Policy and Market Analysis

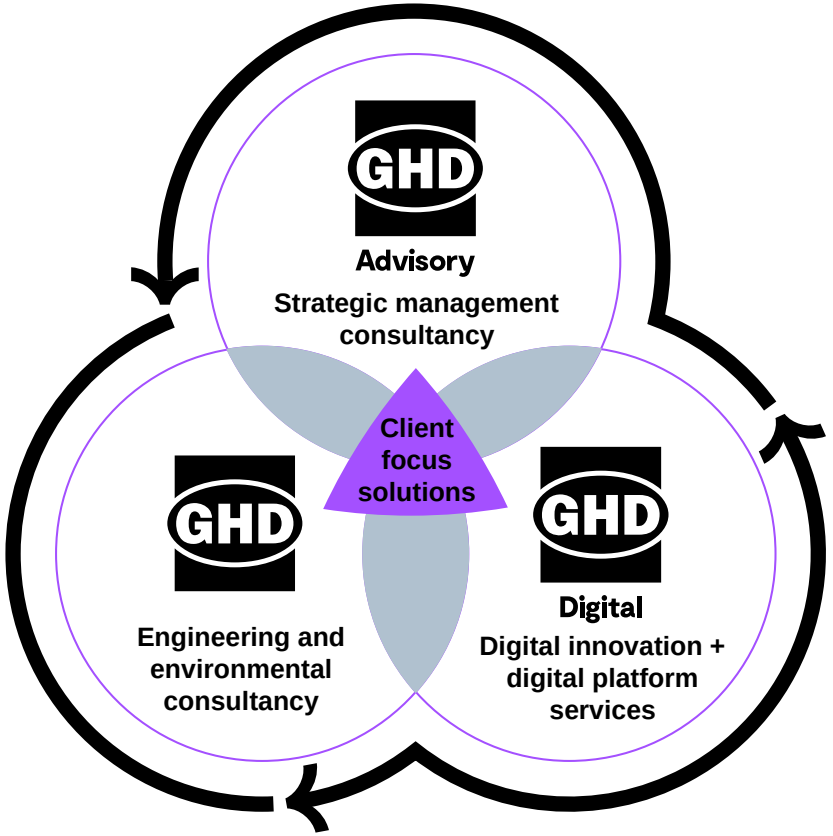
Welcome

GHD overview

90+ years **in operation**
135+ countries **served**
200+ offices **worldwide**
2.2Ⓑ AUD revenue **2021**
5 global markets
10Ⓚ people
50+ service **lines**

↳ Providing engineering, environmental, advisory, architecture, digital and construction services

From ideation to implementation, we are a leading advisory and solutions provider, bringing strategic thinking as well as technical excellence and technological innovation.



Established in

1928 and privately owned by our people, GHD employs

+10k people across five continents and the Pacific region.

Agenda

1 Hydrogen Basics

2 US Policy Landscape

3 Market Understanding

4 Forward Look

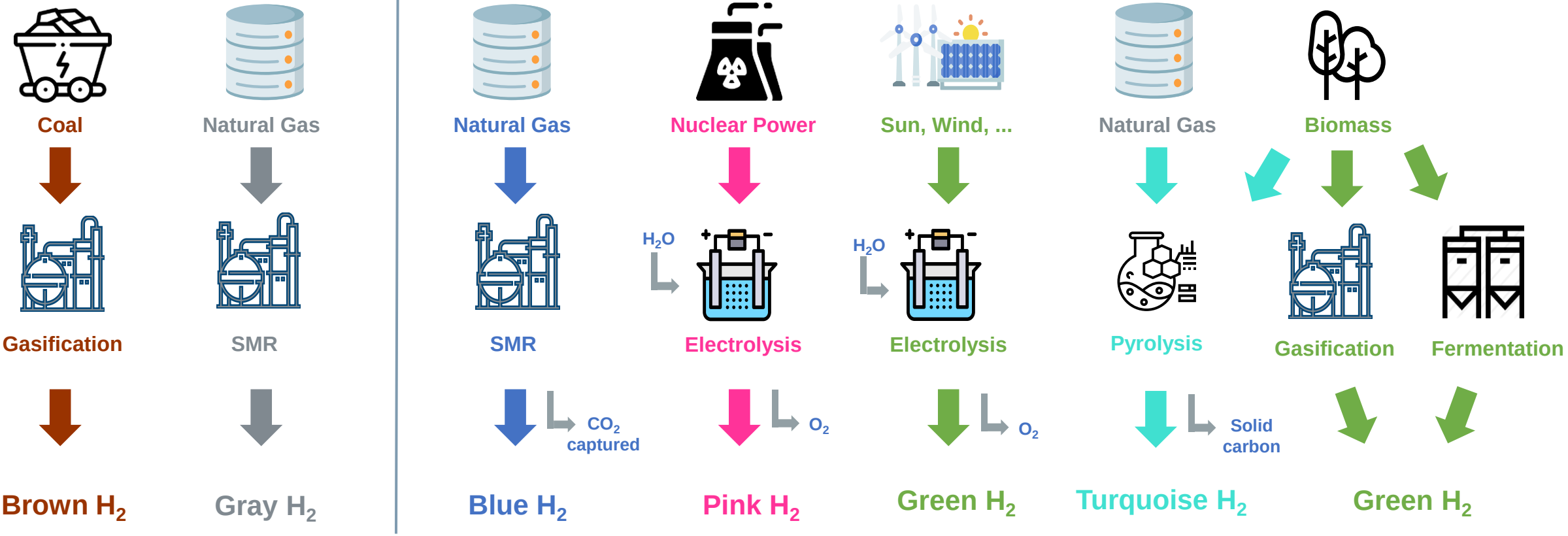
The Present

- World 70 Mt H_2/yr | US 10 Mt H_2/yr
- 99% of H_2 from natural gas & coal
- World H_2 production emits 830 $MtCO_2$/yr
- 90% of H_2 used for refining and fertilizer production

The Future

- Transition to **zero-carbon H_2**
- Adoption of H_2 in **new sectors**: power generation, storage, transportation, heating, blending...
- Exponential improvement in **cost-competitiveness**
- **Export** market for geographies with excess energy

The Colors of Hydrogen



20 kg CO_2/kg H_2	9 kg CO_2/kg H_2	Low or zero-carbon hydrogen (<4kg CO2/KG H2)*

**As defined by the Clean Hydrogen Production Standard - DOE*

Versatile End Uses

FEEDSTOCK

CHEMICALS

- Fuel refining
- Fertilizer
- Methanol
- Plastics

PRODUCTS

- Metallurgy
- Steel
- Food
- Glass

MATURE USES

ENERGY

Fuel for

TRANSPORT

- Forklifts
- Road
- Marine
- Rail
- Aviation

POWER

- Gas turbines
- Fuel cells

Heat for

INDUSTRY

- Steel
- Cement
- Paper
- Aluminum
- Food

BUILDINGS

- Residential
- Commercial

Policy Landscape

→ Changing Tides

National Policy – Summary

United States

- **$369B** is earmarked for Climate and Clean Energy provisions.
- Incentives and regulations **vary by state** in the US – with California as the most advanced (e.g. with *Low Carbon Fuel Standard*).

$13.1 billion

Inflation Reduction Act (IRA)

$9.5 billion

Bipartisan Infrastructure Law (BIL) / Infrastructure Investment and Jobs Act (IIJA)

United Kingdom

- 10-point plan for a Green industrial revolution (Build Back Greener)
- ~£500 million to Hydrogen activities
- (£240 million) of this budget allotted to Hydrogen production facilities.

£140 million

Industrial Decarbonisation and Hydrogen Revenue Support (IDHRS)

£240 million

Net Zero Hydrogen Fund

Inflation Reduction Act (IRA)

Summary

- Introduced by President Biden as of August 2022.
- Federal spending toward reducing carbon emissions, lowering healthcare costs, funding the Internal Revenue Service (IRS), and improving taxpayer compliance.

Production Tax Credits (PTC):

- Received for the first 10 years after a qualified hydrogen facility is placed, cash rebates first 5 years
- x$0.60 per kilogram of “qualified clean hydrogen” by 20% - 100%.
- No domestic content requirements

Investment Tax Credits (ITC)

- Qualifying zero-emissions electricity generation facilities and energy storage technologies (hydrogen).
- Bonus incentives if domestic content, proximity requirements met

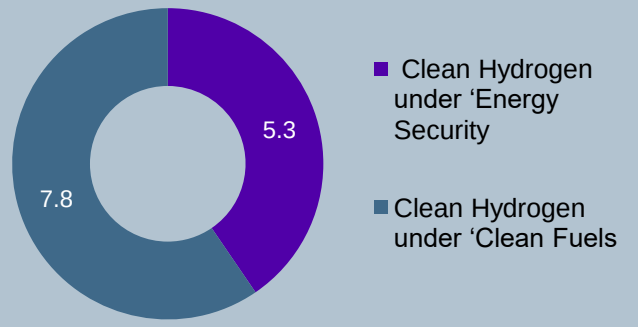
Transport and Fuel Related Credits

- Encourage rapid end-user adoption of hydrogen fuel cell vehicles.
- $7,500 maximum credit for new fuel cell vehicles

Funding:

Amount

- $369 B for Climate and Clean Energy provisions. Of which: ~$13.1 billion is cumulatively committed to Clean Hydrogen within the decade;

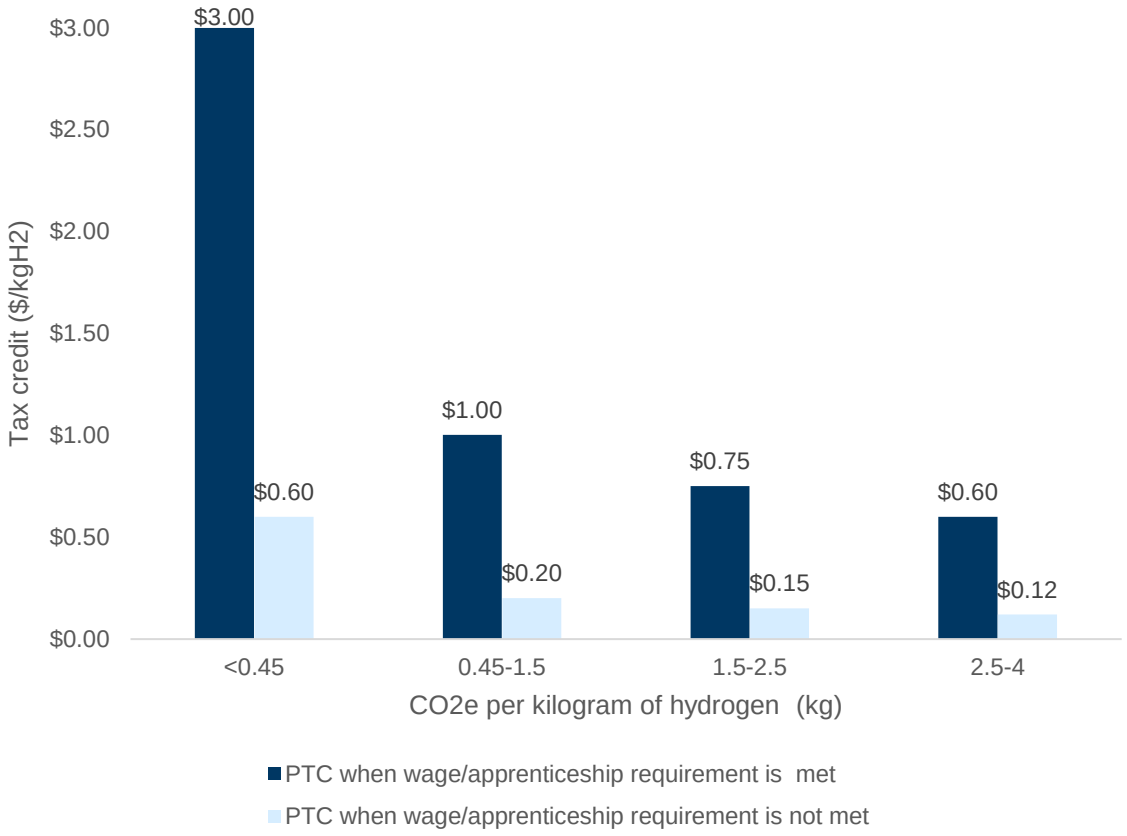


Criteria:

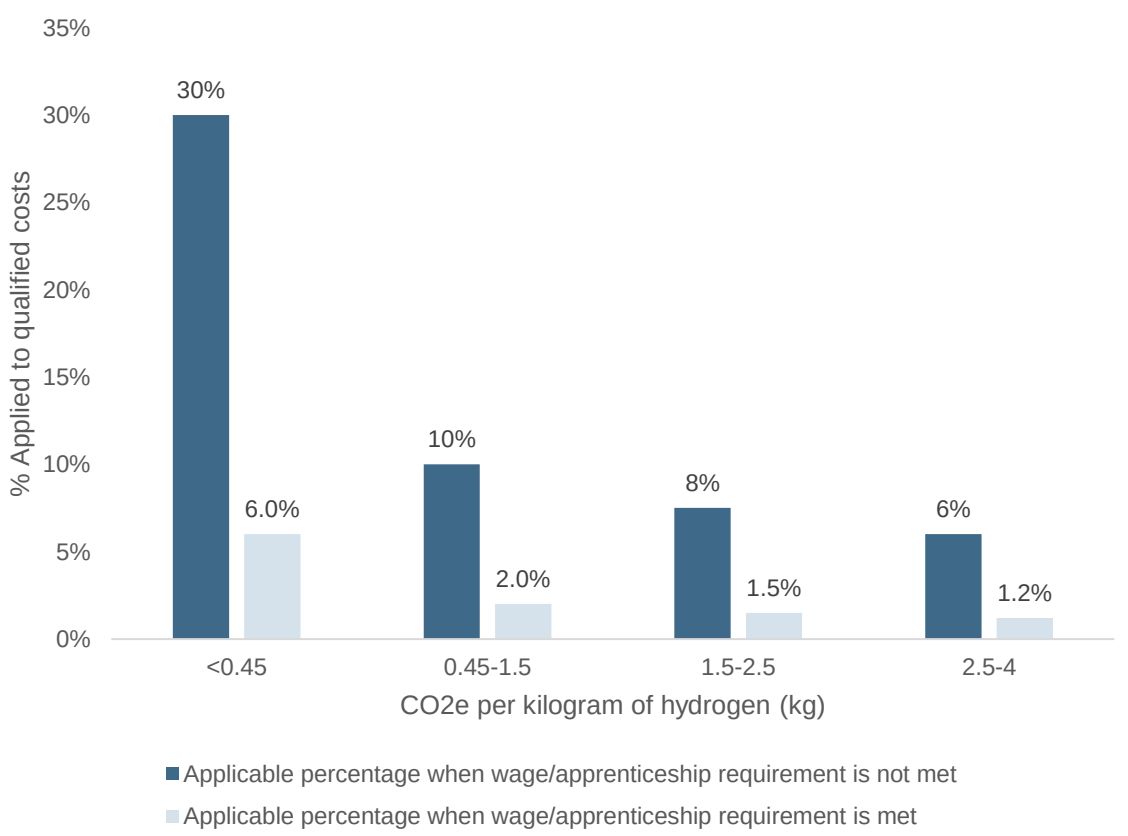
- Qualified clean hydrogen must be produced in the US.
- It must be within the taxpayer’s ordinary course of trade for sale.
- Hydrogen produced must be verified by an unrelated third party.
- The hydrogen producer must also own the facility in which the hydrogen is being produced.
- Funding will be for 10 years

PTC and ITC Credit Value

Inflation Reduction Act: Clean Hydrogen Production Tax Credit (PTC)



Inflation Reduction Act: Clean Hydrogen Investment Tax Credit (ITC)



Note: *PTCs are available for non-taxed cash transfers or can be claimed for non-taxable cash rebate over first 5 years*

Note*: ITCs have additional 10% bonuses for both domestic content & energy community proximity*

Bipartisan Infrastructure Law (BIL) / Infrastructure Investment and Jobs Act (IIJA)

Summary

- Bipartisan Infrastructure Law (BIL) / Infrastructure Investment and Jobs Act (IIJA) intends to expand the low-carbon hydrogen value chain within the US.
- Goal of **$2/kg Clean H_2 by 2025 and $1/kg Clean H_2 by 2030**

Regional Clean Hydrogen Hubs
($8 billion)

- Collective funding to projects that incorporate: production, processing, delivery, storage, and end-use of, clean hydrogen located in close proximity.

Clean Hydrogen and Manufacturing and Recycling Initiatives
($500 million)

- For clean Hydrogen Technology Recycling research, development and demonstration activities funded.

Clean hydrogen Electrolysis Program
($1 billion)

- Accelerate innovation of clean hydrogen production technology which uses electrolysers

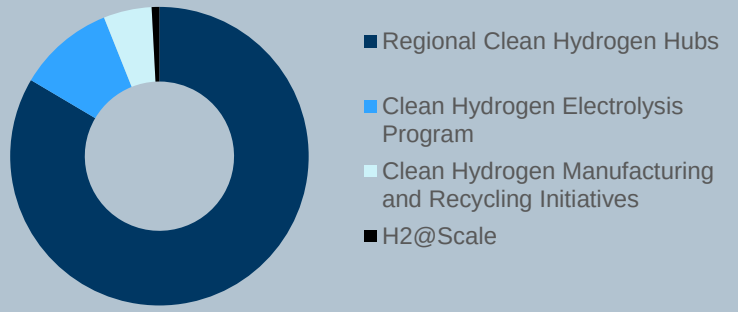
H2@Scale National Laboratories
($8 million)

- Research, development and demonstration for hydrogen technologies

Funding:

Amount

- $9.5 billion total of which:



Criteria:

Regional Clean Hydrogen Hubs:

- Production, processing, delivery, storage, and end-use of, clean hydrogen located in close proximity.

Clean Hydrogen Electrolysis Program

- Technologies that produce clean hydrogen using electrolysers

Clean Hydrogen Manufacturing and Recycling Initiatives

- Efficient, cost effective H2 technology.

H2@Scale:

- Partnership between a DOE National Laboratory and qualified partner

State policy

GHD examined state-level policy that applies to the hydrogen industry for six [6] strategic states: **California. Texas, New York, Michigan, Illinois, Florida**.

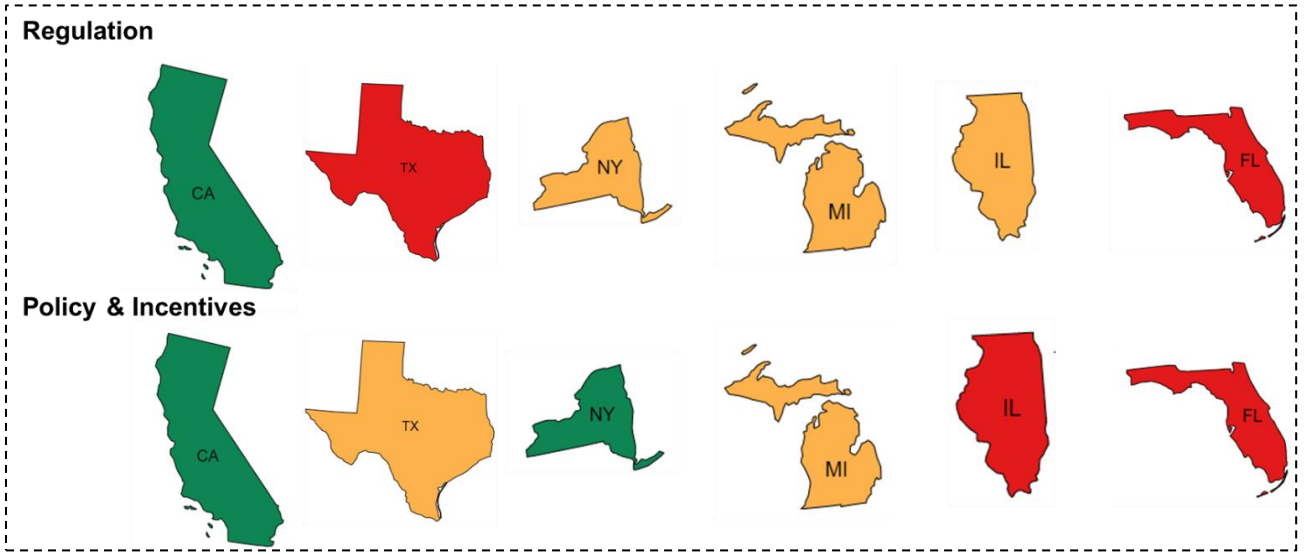
These states were selected as a representation of policy build-out on the basis of:

- • Geography & location – states should be selected to cover all regions of the continental US.
- Potential hydrogen market size – states should have either a high gross domestic product or existing hydrogen industry.
- Hydrogen policy and regulation – states should cover all levels of hydrogen legislature build-out.

States were adjudicated on a **Red-Amber-Green (RAG) rating system** to visually depict the legislature build-out. Both regulatory frameworks and policy and incentives were analysed:

Regulation	No/ poor existence of H2 specified regulation. Regulation only covers one element of the H2 value chain	Some existence of H2 specified regulation. Regulation covers one or two elements of the H2 value chain.	Significant amount of H2 specified regulation. Regulation covers both production and consumption of H2 and a variety of use cases.
Policy & Incentives	Low/ No funding for H2. Tough criteria to access funding Funding covers one or no element of supply chain.	Some funding for H2. Criteria to access funding is reasonable. Funding covers one or two elements of supply chain.	Major funding commitment for H2. Easy access funding. Funding covers both production and consumption of H2.

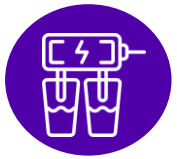
California was the most advanced in relation to regulation and incentive development. Florida has major legislature and policy gap, withs New York representing a middle-ground:



Net Zero Hydrogen Fund (NZHF)

Summary

- The NZHF is intended to support the development and deployment of new low carbon hydrogen production projects, by reducing lifetime costs and de-risking investment.
- NZHF grant allocation is split into 4 strands with strand 1 and strand 2 closing as of June 2022 and July 2022 respectively.



Net Zero Hydrogen Fund

- **Strand 1:** DEVEX support for front end engineering to build the pipeline of hydrogen production projects
- **Strand 2**: provides CAPEX support for hydrogen projects that will contribute to the at-scale production of low carbon hydrogen.

NZHF Funding:

Amount

- £240 million
  - Strand 1: £80,000 - £15 million Grant request
  - Strand 2: £200,000 - £30 million Grant request
  - Strand 3 and 4: In proposal

Criteria:

- Strand 1 provides DEVEX support for front end engineering
- Strand 2 (CAPEX)
  - Projects must not require revenue support via the Hydrogen Business Model.

Industrial Decarbonisation and Hydrogen Revenue Support (IDHRS)

Summary

- BEIS has established the IDHRS to support hydrogen production pathways and facilitate hydrogen within a variety of sectors.

Hydrogen Production Business Models (HPBM)

- In consultation
- Low Carbon Hydrogen Agreement.
- Revenue support to h2 producers.
- Storage and Transport Business Model expected in 2025

HPBM Funding:

Amount

- $140 million
  - £100 million contracts of up to 350MW of electrolytic production capacity in **2023** – further allocations expected in 2024

Criteria:

- Contracts of up to 250MW of electrolytic hydrogen production.
- CfD based model with competitive allocation
- Only hydrogen produced for domestic use is eligible.

Market Analysis

➔ **Strengths, Barriers, and Current Investment**

Market Overview Methodology

GHD engaged hydrogen industry stakeholders to gather market information on three key areas:

1. Existing Market Barriers
2. Existing Market Strengths
3. Current Hydrogen Investments

GHD selected **stakeholders across the hydrogen economy value chain** to ensure a comprehensive market view, including a diverse range of interests. These included but were not limited to:

- Hydrogen policymakers;
- Hydrogen producers & developers;
- Hydrogen transport and storage infrastructure;
- Major utility players;
- Equipment manufacturers;
- Industry special interest groups; and
- Higher education.

Overview of Strengths and Barriers

MARKET STRENGTHS

INDUSTRY MOMENTUM	INITIAL POLICY SUPPORT	STRONG FRONT-END PROJECT DEVELOPMENT	UTILITY INTEGRATION	TECHNOLOGY IMPROVEMENTS & INDUSTRY EXPERTISE	CLEAR AND LEGALLY BINDING GHG TARGETS	ADJACENT INDUSTRY EXPERIENCE
INDUSTRY MOMENTUM	HYDROGEN HUB SUCCESS	STRONG GOVERNMENT FUNDING	BLUE H_2 INFRASTRUCTURE, RESOURCE, AND SCALABILITY	LEVERAGE INDUSTRY KNOWLEDGE AND EXPERTISE	STATE LEVEL LEGISLATION: CALIFORNIA	UTILITY ENTITY SUPPORT

MARKET BARRIERS

POLICY DIRECTION UNCERTAINTY	SUPPLY CHAIN PRESSURES & TECHNOLOGY SCALING	SUPPORTING INFRASTRUCTURE	EDUCATION & WORKFORCE	COMPLEX PLANNING AND CONSENTING	POLICY MISALIGNMENT	SPEED OF POLICY IMPLEMENTATION
POLICY DIRECTION UNCERTAINTY	SUPPLY CHAIN PRESSURES & TECHNOLOGY SCALING	SUPPORTING INFRASTRUCTURE	EDUCATION & WORKFORCE	PROJECT FID – OFFTAKE AGREEMENTS	POWER & GRID POLICY INTEGRATION	

US Market Strengths

The US hydrogen market is **rapidly growing** and has recently seen **substantial investment**. This investment reflects the country's abundance of resource, strong policy backing, land availability, and an established domestic market.

- INDUSTRY MOMENTUM
- HYDROGEN HUB SUCCESS
- BLUE HYDROGEN
- STRONG GOVERNMENT FUNDING
- LEVERAGE INDUSTRY EXPERTISE
- STATE-LEVEL LEGISLATION: CALIFORNIA
- UTILITY ENTITY SUPPORT

UK Market Strengths

The UK's industry best practices, specifically **knowledge around front-end project experience and clear GHG targets,** could be leveraged in the US market to promote collaboration and scaling of the hydrogen demand market.

- INDUSTRY MOMENTUM
- INITIAL POLICY SUPPORT
- STRONG FRONT-END PROJECT DEVELOPMENT
- UTILITY INTEGRATION
- TECHNOLOGY IMPROVEMENTS & INDUSTRY EXPERTISE
- CLEAR AND LEGALLY BINDING GHG TARGETS
- ADJACENT INDUSTRY EXPERIENCE

US Market Barriers

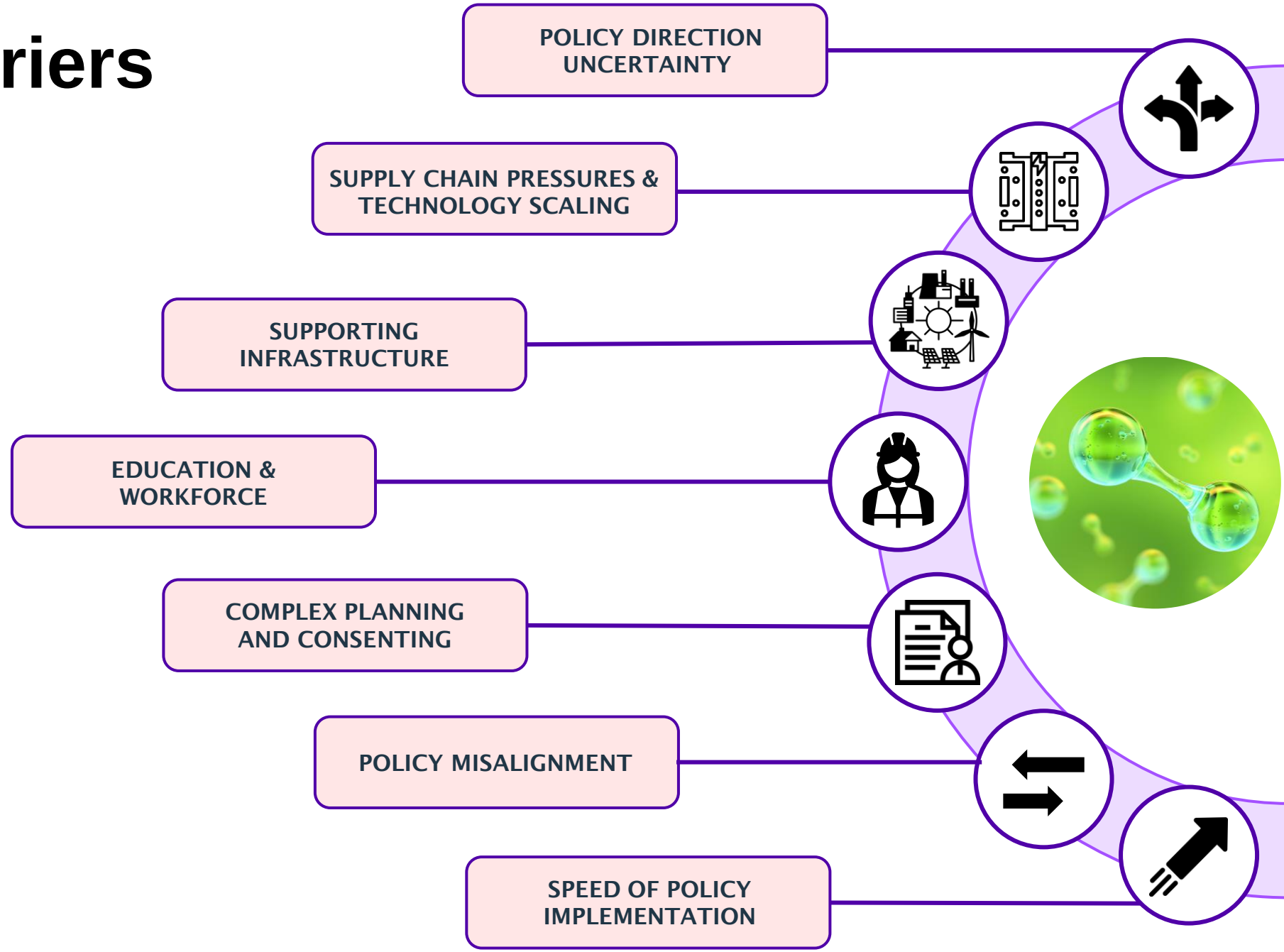
The US hydrogen market is **not without challenges**. Currently, there are constraints around technology supply chains and hydrogen workforce availability. Supporting infrastructure is non-existent in many regions within the US. Further clarity on policy direction and alignment can help to boost investor confidence.

- POWER & GRID POLICY INTEGRATION
- POLICY DIRECTION UNCERTAINTY
- SUPPLY CHAIN PRESSURES & TECHNOLOGY SCALING
- SUPPORTING INFRASTRUCTURE
- EDUCATION & WORKFORCE
- PROJECT FID – OFFTAKE AGREEMENTS

UK Market Barriers

While the UK hydrogen economy is growing rapidly, there are major barriers around supply chains, supporting infrastructure and workforce that will likely hinder growth.

While the UK energy economy is adept at overcoming such barriers, these should still be considered.



Hydrogen Background

Value chain major players:

Supply Chain	Green Hydrogen Production	Storage and transport	End Use
PM Fuel Cells · Power Systems	AIR PRODUCTS *	AIR PRODUCTS *	Shell
PROTON A net Company ON SITE	Linde	Linde	HYZON
Aragon Hydrogen Foundation	Air Liquide	Air Liquide	SunLine Transit Agency
	plug	plug	
PM Fuel Cells · Power Systems	Octopus Energy	Cadent Your Gas Network	Shell
BOC A Linde company	EDF		WRIGHT
JM Johnson Matthey Inspiring science, enhancing life	BP	SGN Natural Gas	
CALVERA Hydrogen	Shell		ALEXANDER DENNIS
ITM POWER Energy Storage | Clean Fuel	inovyn An INEOS company	inovyn An INEOS company	Cummins
		equinor	

H2 Hubs

Western Interstate Hydrogen Hub: *Xcel Energy, Avangrid, Dominion Energy Utah, Los Alamos National Laboratory, DOE's National Renewable Energy Lab (NREL), Sandia National Laboratories*

Heartland Hydrogen Hub:

Bakken Energy, Bakken Energy announced an alliance with Cummins Inc. and Schneider Carriers Inc.

MachH2 coalition: *ArcelorMittal, Governors State University, Nicor Gas, Northwestern University, the University of Chicago, the University of Wisconsin-Madison and the Argonne National Laboratory, NiSource, Applied Research Institute, BorgWarner, Cummins Inc., Energy Systems Network and Rolls-Royce*

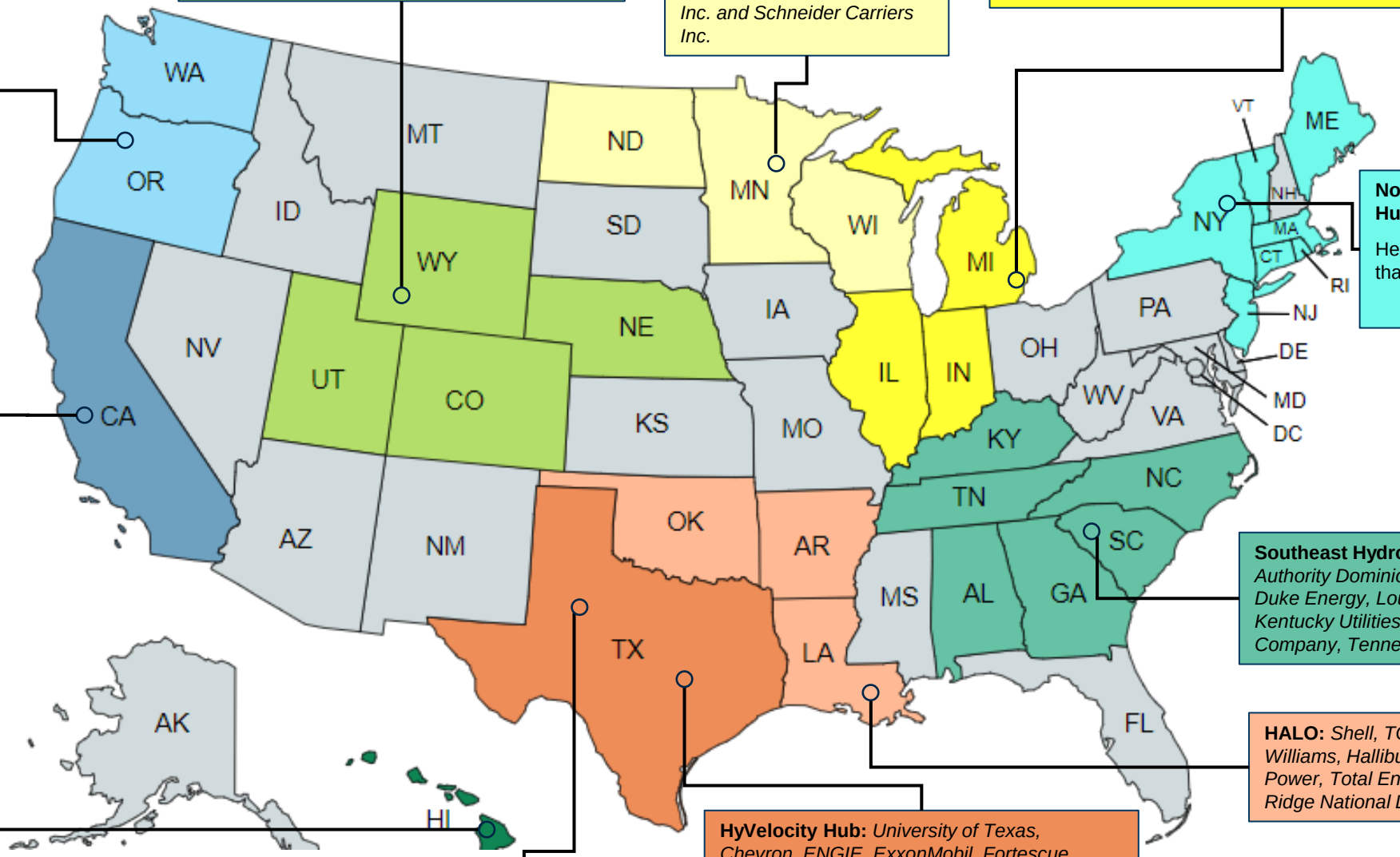
Pacific Northwest Hydrogen Hub:

Undisclosed

Northeast Clean Hydrogen Hub:

Headed by NYSERDA with more than 60 ecosystem partners

California's Alliance for Reliable Clean Hydrogen Energy System: *AECOM and Wood, as well as utility PGE, Toyota Corp., Plug Power, Hyundai, Michelin, BOSCH, Bloom Energy, Avantus*



Hawaii Pacific Hydrogen Hub: *Hawaiian Electric, NREL and the University of Hawaii*

Southeast Hydrogen Hub: *Authority Dominion Energy, Duke Energy, Louisville G&E, Kentucky Utilities, Southern Company, Tennessee Valley*

HALO: *Shell, TC Energy, Williams, Halliburton, GE, Plug Power, Total Energies, Oak Ridge National Lab*

HyVelocity Hub: *University of Texas, Chevron, ENGIE, ExxonMobil, Fortescue Future Industries, Phillips66, Sempra Infrastructure, Shell, Siemens the Port of Houston*

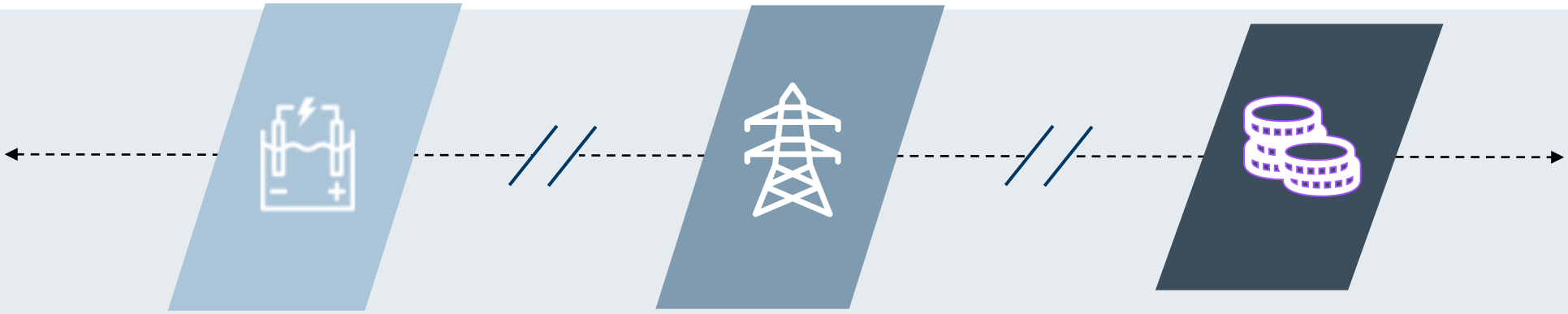
Trans Permian H2Hub: *MMEX Resources, inclues Siemens Energy*

Non-exhaustive

Forward Look

→ **Potential Futures**

Policy Gaps



Non-Producer Support

UK and US policy is geared towards supporting hydrogen producers.

Relatively minimal non-value chain support:

- Scale up of technology
- Scale up of supply chain manufacturing
- Development of supporting hydrogen infrastructure (pipelines, storage, etc.)
- Growth of the hydrogen market

Horizontal Policy and Regulatory Alignment

Both: inconsistent planning and permitting processes.

US:

- No direction on carbon accounting use for hydrogen production

UK:

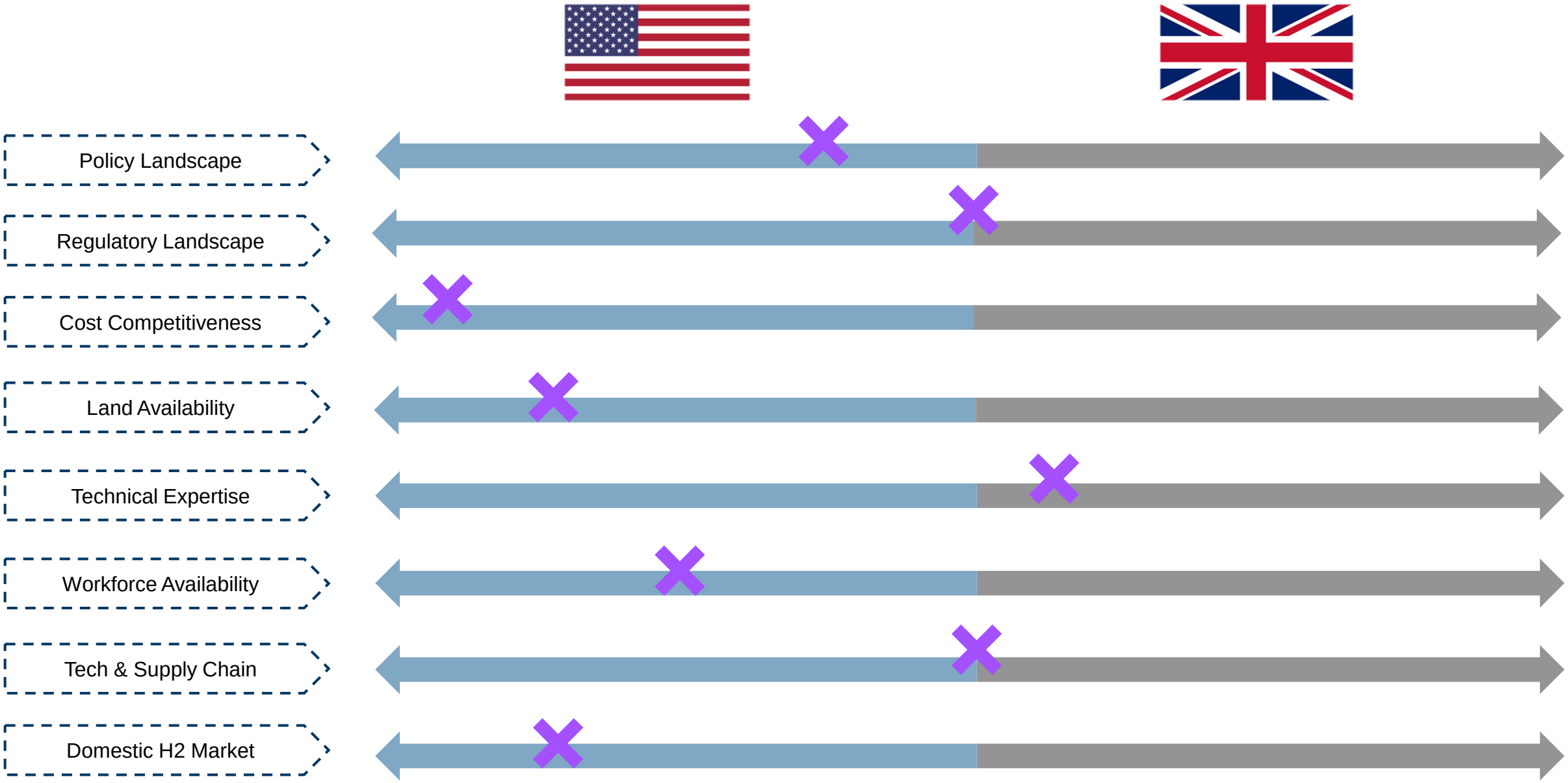
- Low carbon hydrogen standard doesn't allow for grid electricity
- Renewable policy encourages export to grid rather than direct to hydrogen production.
- No direction on carbon accounting use for hydrogen production

UK Hydrogen Ambition & Funding Volume

Funding amounts do not match the ambitious hydrogen targets

- total funding across H2 value chain <£1 B
- Assuming LCOH of hydrogen is ~£ 60/MWh for a PEM electrolysis production, 10 GW of production = £525.6 B production industry.
- Additional costs for supporting infrastructure meant current investment of <£1 B is seen to not support government ambitions.

Investment Driver Comparison



Investment Drivers

Policy Landscape

- Large federal government funding packages is driving investment through co-located Hubs

Cost Competitiveness

- Resource availability
  - Cheaper Renewable Energy
  - Abundant salt caverns
- Existing Infrastructure
- Favourable grid policy

Regulatory Landscape

- State-variable regulation
- Lag in regulation build-out compared to development
- Certification program unclear

Land Availability

- Vast land availability within the continental US for hydrogen value chain development

Investment Drivers

Technical Expertise.

- Low carbon hydrogen is still a nascent industry within the US

Domestic Market

- Large US domestic market, with state-level policy incentives, strong industry momentum and corporate support .
- Hydrogen hubs accelerating low carbon hydrogen growth through supply and demand co-location
- US has knowledge in exporting chemicals and energy; access to Asian markets.

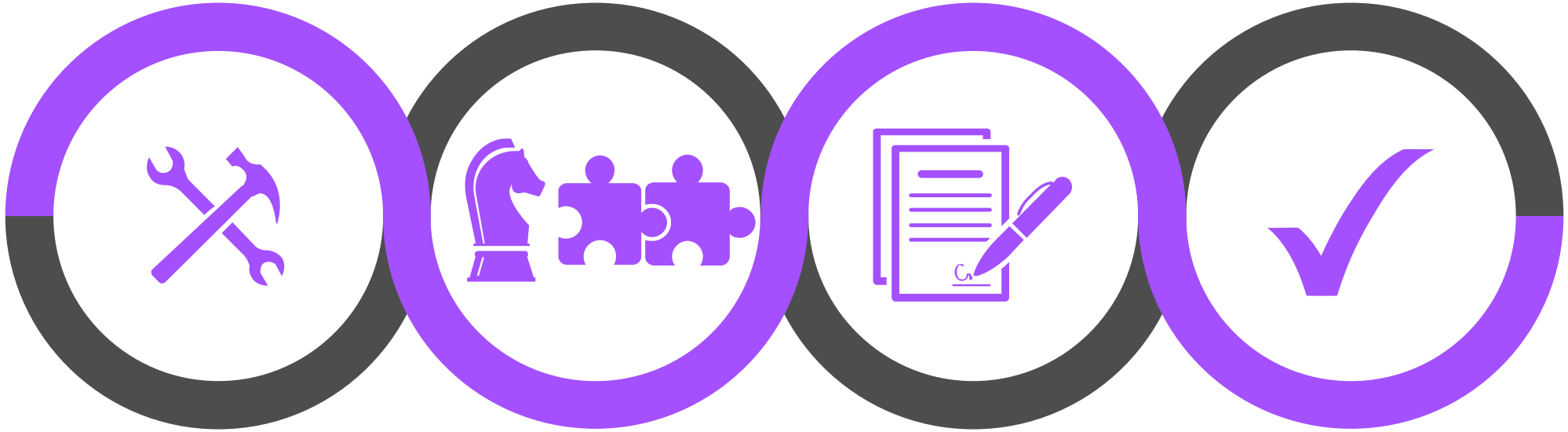
Technology & Supply chain

- Technology scaling challenges in the hydrogen sector
- Supply chain pressures – wider macroeconomics

Workforce Availability

- Adjacent industry with reskilling programs – Oil & Gas, Chemicals
- Current lack of hydrogen specific workforce availability

Market Opportunities



PROJECT DEVELOPMENT

- Government funding
- Growing market
- Resource & land availability
- H_2 Hubs

SOLUTIONS EXPORT

- UK technical expertise
- UK experience with service & technology export

HYDROGEN OFFTAKE

- Future target price – cost competitive
- Policy allowance

GLOBAL CERTIFICATION

- Hydrogen Certification Program
- Global implementation

Key Takeaways

1

Strong and clear policy backed by funding

- IRA Tax Credits – PTC & ITC – $13.1 Billion
- DOE Hydrogen Initiatives - $9.5 Billion
- UK HPBM – strong and integrated policy, less funding than US

2

Many similar strong market drivers, not without challenges

- US – cost competitive, collaborative market with workforce barriers
- UK – increased demand from GHG targets, minimal supporting infrastructure

3

Multiple opportunities for the UK

- Project development
- Solutions export
- Global hydrogen certification
- Hydrogen offtake

GHD Advisory

Thank You

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