# International Hydrogen Progress Index

## Introduction

The International Hydrogen Progress Index was developed jointly by Hydrogen UK and ENA on behalf of Hydrogen UK's members and ENA's gas members. The purpose of the Index was to compare the hydrogen commitments made at national governmental level in the UK and sixteen other countries in 2021 and summer 2023. The seventeen countries were scored across their hydrogen commitments in national strategy and supporting measures for hydrogen supply, infrastructure, demand, and standards. The Index visualises how the UK has fallen behind in the global race for hydrogen investment. For the UK to regain the lead in this space, it is recommended to (i) move faster and be more flexible with production support, (ii) identify and support strategic infrastructure investment now, (iii) give clarity on the minimum roles for hydrogen in end-use sectors, and (iv) maximise the significant economic opportunity on offer.

Although the precise path to reach our Net Zero targets it unknown, it is clear that hydrogen will form an essential part of future low carbon energy systems, both in the UK and across the globe. Globally, the past few years have seen the development of a number of National Hydrogen Strategies, new Net Zero targets, roadmaps for developing hydrogen infrastructure, transport and regulation, and billions worth of investments into the future hydrogen economy.

In this report, we have chosen to compare the UK's hydrogen commitments in August 2021 and summer 2023 with the 16 countries shown in Figure 1 below. These countries span the globe and are geographically diverse; are well-developed and well-equipped to develop their hydrogen capabilities; and have sufficient publicly available information from which to draw sensible comparisons. Some of the countries featured, such as Norway and the United Arab Emirates, were also included because of their more unique energy landscapes and different heating requirements to those of the UK. The two timepoints considered coincide with two key developments in the UK's hydrogen narrative; the first follows the release of the UK's Hydrogen Strategy - when the UK was widely considered to be 'a world leader' in the race to deploy hydrogen at scale - and the second, nearly two years later, follows the suite of policy announcements accompanying Powering Up Britain. During this time, other countries have made major announcements of their own

## List of Countries

| | | | |
|---|---|---|---|
| Australia | Germany | Norway | UK |
| Canada | India | Saudi Arabia | USA |
| Chile | Italy | South Korea | |
| China | Japan | Spain | |
| France | Netherlands | UAE | |

# Methodology

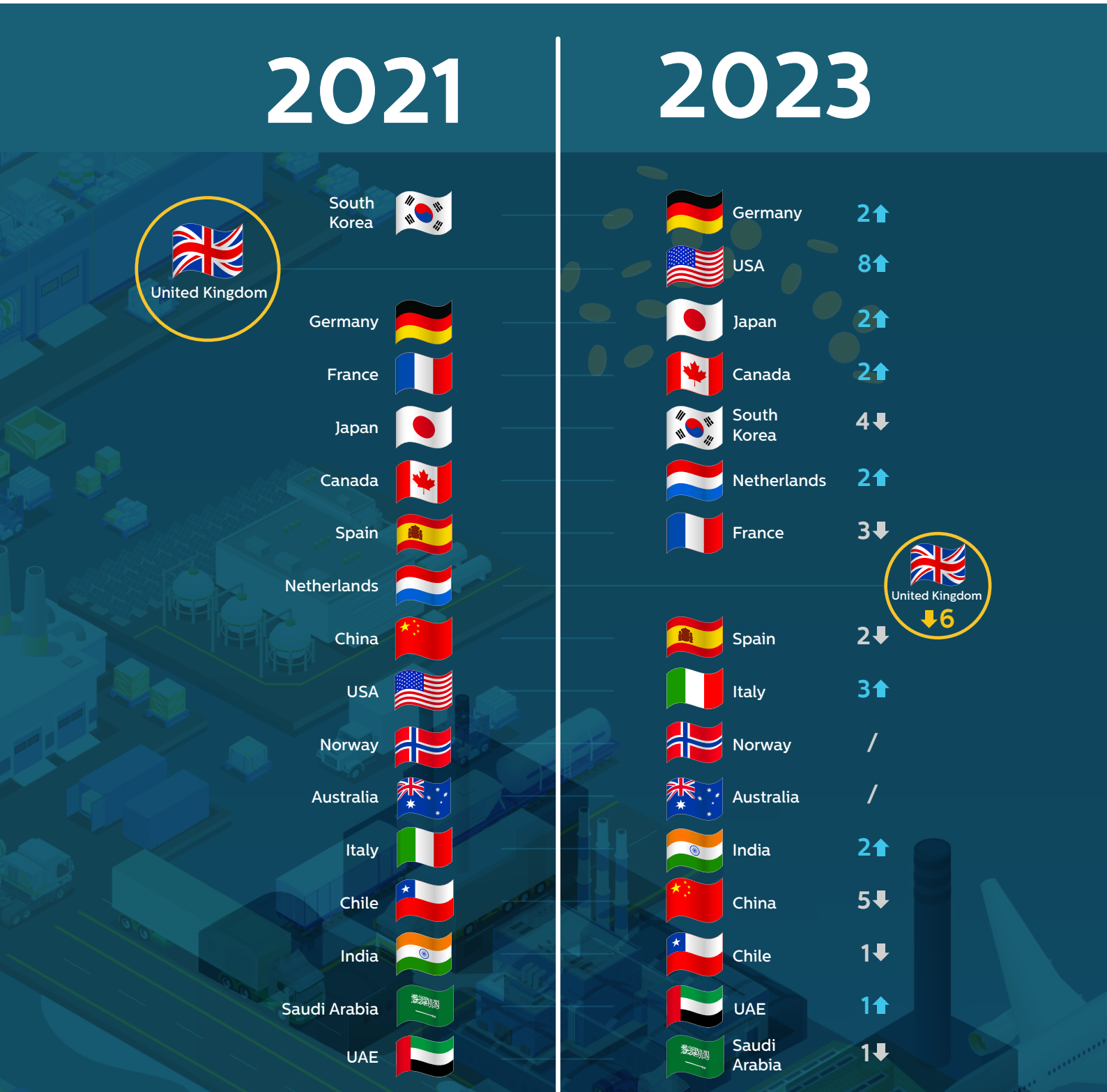
Twelve metrics were chosen across five categories: (i) strategy, (ii) supply, (iii) infrastructure, (iv) demand, and (v) standards (Table 2). Data for each metric was gathered for the seventeen countries (as mapped in the Introduction) as well as the EU at two points in time: (i) August 2021 and (ii) summer 2023. The seventeen countries were firstly divided into three categories for each metric: (i) 'leading', (ii) 'middling', and (iii) 'lagging'. Then, the countries were ranked 1-17 for each metric. Finally, after applying the metric weightings shown in Table 2, an overall ranking of countries was developed.

Disclaimer – the results produced from this project are not a detailed economic analysis for investment decisions, but rather a way to compare the relative market attractiveness as a result of the respective governments' actions in an increasingly competitive landscape.

| Category | Metric | Weighting (%) | Metric Criteria |
|---|---|---|---|
| **Strategy** | Hydrogen Strategy | 10 | Date published, level of ambition: (i) Capacity target (GW) against countries energy demand, (ii) breakdown of production type targets (e.g. electrolytic), (iii) timescale of targets (2025, 2030 etc.) |
| | Imports/Exports | 5 | Targets for import/export quantities of hydrogen and eligibility of import/exports for funding support - including for hydrogen carriers e.g. ammonia. |
| | Net Zero Target | 5 | Year of net zero targets, breakdown of interim reduction targets, mandated law vs governmental target |
| **Supply** | Commercial production funding mechanism | 15 | Deployed vs proposed, type of funding mechanism (capex support, revenue support etc.), ease of access for applicant (simplicity to use) |
| | Spending Envelope | 10 | Size of funding envelope (in relation to GDP of country and production ambition) |
| **Infrastructure** | Transportation | 5 | Strategy for developing hydrogen pipelines within nation, ambition for hydrogen backbone vs more connected pipeline network |
| | Storage | 5 | Hydrogen storage strategy, size of potential/required capacity (TWh) in comparison to targeted production, availability of business models |
| **Demand** | Heat | 10 | Whether a strategy exists for the sector, whether government is supporting trials |
| | Industry | 10 | Whether a strategy exists for the sector, size of funding set aside for sector, are there ongoing hydrogen projects in the sector |
| | Power | 10 | Whether a strategy exists for the sector, size of funding set aside for sector, are there ongoing hydrogen projects in the sector |
| | Transport | 10 | Whether a strategy exists for the sector, size of funding set aside for sector, are there ongoing hydrogen projects in the sector |
| **Standards** | Regulatory Framework | 5 | Carbon intensity threshold for hydrogen to be deemed 'low carbon' |

## Findings

The below graphic is informed by joint analysis undertaken by Hydrogen UK and ENA on behalf of Hydrogen UK's members and ENA's gas members. The analysis is based on hydrogen policy progress in a number of key countries across the globe, comparing the situation in 2021 (at the time of the launch of the UK Hydrogen Strategy) with summer 2023. Each country was assessed and ranked against each other across a number of relevant metrics, with the output of this used to inform an overall ranking of countries in each year.



The metrics we assessed could be broken down into five high level categories as follows:

- Strategy
- Supply
- Infrastructure
- Demand
- Standards

## Strategy

Our analysis broke down Strategy into three categories; the wider 'Net Zero Target' and specific 'Hydrogen Strategy', and 'Imports/Exports'.

Net Zero targets enshrined in law, with interim targets, were seen in leading countries. Detailed hydrogen strategies convey ambition via hydrogen production targets with pathways and measures for how to achieve this. Countries that provide production targets in terms of output (i.e., tonnes per year) are deemed to be better than those that solely point to capacity. Additionally, countries which have updated these targets over the timeline generally show an increase in pace and ambition. A clear strategy for how imports and/or exports will support the country's hydrogen economy was evident in the leading countries.

### *Net Zero Target*

In August 2021, the UK could be seen to be leading in regard to net zero ambition, through mandating a net zero target for 2050 in law, with an interim emission reduction target of 78% by 2035. However, by August 2023, most countries had mandated equally ambitious net zero targets, with Germany mandating a 2045 target. Furthermore, countries had set more granular interim emission reduction targets, compared to the UK's only target for 2035. Canada, for example, have mandated the setting of intermediary targets at five-year intervals (2030, 2035, 2040, 2045), at least a decade in advance of each target, and the requirement to develop emissions reduction plans for these targets.

### *Hydrogen Strategy*

The UK ranked highly in both August 2021 and July 2023, with a drop of just one place over the period. In 2021, The UK launched its Hydrogen Strategy, with a 'twin track' approach supporting both 'green' and 'blue' hydrogen and an ambition for 5 GW of production capacity. The strategy highlighted a number of 'principles' for future policy decisions and included a long list of commitments across the full value chain, though many were 'intentions' or actions to engage/consult/investigate, rather than quantitative targets, which have since slipped in their delivery.

Leading the pack in 2021 were Japan and South Korea. Evidence of the effectiveness of the strategies could be seen in the world leading deployment of fuel cell vehicles and refuelling infrastructure in both countries at the time.

Japan was the first country to publish a national strategy for hydrogen, with a target for production output (rather than capacity) and payback period for fuel cells. It recognised the benefits of international trade and supply chains, including liquified hydrogen, hydrogen derivatives and carriers. It set out the ambition for Japan to become "the first country in the world to realise a hydrogen-based society", highlighting the 2020 Tokyo Olympics as a "good opportunity for Japan to demonstrate to its people and foreign visitors the extent of its forward-thinking initiatives".

South Korea was the next country to publish its hydrogen strategy. It included targets for the deployment of fuel cell vehicles and fuel cells for power generation and domestic use out to 2040, alongside targets hydrogen production output, production technology split and price. South Korea's Hydrogen Act was enacted in February 2020, enabling a host of measures including the creation of a 'Hydrogen Economy Council' and financial support in the form of subsidies, loans and tax exemptions.

France was another of the early movers with its strategy, with an equally extensive, but relatively more ambitious with its target for hydrogen production capacity, all from electrolytic production, taking advantage of the country's extensive nuclear generation fleet.

In response to the events in Ukraine, the British Energy Security Strategy announced an increase in 2030 production capacity targets from 5GW to 10GW, now with an even split between CCUS-enabled and electrolytic production. This increase ensured that the UK remained in the leading pack for this category.

However, other countries have since released more detailed and ambitious strategies, or revised their original strategies, to include not only targeted (rather than projected) consumption figures in end use sectors, but a host of supporting measures to accelerate the uptake of hydrogen. Most notable of these is the USA, where the Draft DoE National Clean Hydrogen Strategy and Roadmap was published September 2022 and finalised in June 2023. The US is to produce 50 Mtpa of clean hydrogen by 2050, with interim targets of 10 Mtpa by 2030 and 20 Mtpa by 2040 — up from "nearly zero" today.

***Imports/Exports***

The leading countries have recognised their relative strengths and weaknesses in terms of their ability to meet domestic hydrogen demand, and have made clear commitments to either import or export hydrogen accordingly. In terms of imports, Japan and Germany recognised very early that domestic hydrogen production alone would not be sufficient to reach their targets, and have developed clear early strategies and alliances with other markets to take imported volumes of hydrogen. Similarly, countries such as Chile and Australia, where the availability of renewable energy outstrips domestic energy consumption, are positioning themselves to be exporters.

The UK has not made any commitments to support imported hydrogen, only highlighting the potential for the UK to become exporter of hydrogen due to it access to abundant renewable energy.

## Supply

Our analysis broke down supply into two categories - 'Commercial Production Funding Mechanism' and 'Spending Envelope' in order to assess the size, certainty, simplicity and pace of the financial support on offer to investors.

***Commercial Production Funding Mechanism***

The UK found itself in a leading position in August 2021 having announced the launch of Net Zero Hydrogen Fund, the Hydrogen Production Business Model, and CCUS cluster sequencing programme. Initially, these funding programmes were considered to be world-leading and well crafted, set to deliver maximum value for money for taxpayers. Whilst the UK's proposed production support mechanisms are familiar to investors in the renewable electricity generation sector, the design is proving to be overly complex and not agile enough for a market starting from scratch. In July/August 2023, progress made within the main production funding schemes has slipped significantly from initially stated timelines, with no major projects able to reach a Final Investment Decision (FID). Furthermore, some major issues with the funding design have been raised by industry including a cap on production volumes and exclusion of risk-taking intermediaries (RTIs), both of which limit the ambition and the pace at which a 'liquid' hydrogen market can develop.

In the ensuing two years, many nations have launched alternative production funding mechanisms that provide developers with a clear pathway to revenue and returns. Again, most notable is the USA which launched the Inflation Reduction Act (IRA) which delivers production tax credits to developers for 10 years, tiered based on carbon intensity up to $3/kg (see below for further discussion on spending envelope). The certainty and simplicity of this funding mechanism is in stark contrast to the UK's heavily negotiated contacts, competitions and allocation rounds. Canada has indicated that it will launch a similar production tax credit funding mechanism.

EU nations such as Germany, France and the Netherlands rank well, benefitting from access to central IPCEI funding as well as national grant and operational funding support mechanisms which have awarded funding to projects an enabled FIDs to be taken.

### *Spending Envelope*

The UK has not stated explicitly the level of financial support it is committing to the development of a domestic hydrogen economy. A number of neighbouring countries, typically EU member states, have, and in doing so, have provided investor certainty into 'how big the pot is'. In the Spring 2023 Budget the UK government committed £20bn to fund the development of the first two clusters to capture and store 20-30 MT CO2 per annum, however did not provide further details of how this will be split between emitters (industry, power generation and hydrogen production) and the associated transport and storage infrastructure. For electrolytic hydrogen production, annual allocation rounds are planned to commence in 2023, with the first to deliver 'up to 250 MW of production capacity', and subsequent allocations delivering on the 2030 target of 'up to 10 GW of hydrogen production, of which at least half is electrolytic'. There is no indication for what load factor, and therefore volume of hydrogen produced, will be funded through the electrolytic allocation rounds. To fund these projects a 'levy' is due to be introduced via primary legislation; however, political debate has delayed this from being passed, adding to the uncertainty already felt by investors. While this makes quantifying the spending envelope difficult, it is quite clear that other countries have made much larger commitments.

The IRA in the USA is once again the game changer. Not only does it promise developers a fixed subsidy per kilogram of low-carbon hydrogen produced, but it is also uncapped.

## Infrastructure

Our analysis broke down infrastructure into 'Storage' and 'Transportation'.

### *Storage*

The UK Hydrogen Strategy made a commitment to design business models to support both storage and transportation infrastructure, recognition for the role that large scale hydrogen storage will have on the deployment of hydrogen in the future energy system. However there has not been enough urgency on the delivery of the business model, and coupled with a lack of a clear strategy for how and when large scale storage assets will be deployed, the UK has again lost ground on other regions. In particular, the USA, China, Germany and Netherlands have moved ahead due to superior strategies or deployment. The German National Hydrogen Council, appointed by the German government to act as an independent, non-partisan advisory board, produced the 'Hydrogen storage roadmap 2030 for Germany' which details demand, timelines, costs along with measures to be implemented before 2024 (incentives for investment decisions). The Netherlands published plans to have four salt caverns operational by 2030 in a clear statement of ambition.

### *Transportation*

The UK has undertaken a lot of work in preparing for a hydrogen network, however there is no official government strategy, with a 'networks pathway' due to be published by end of 2023. As noted above, plans for a transport business model were announced in the hydrogen strategy but will not be available until 2025, slowing down pipeline project development. And a 'strategic' decision on blending is still to be made; in the first instance this will be limited to distribution level, with the timeline for a decision on transmission blending still to be announced by the government.

The Dutch government meanwhile has committed spending hundreds of millions of pounds to develop a national hydrogen network to connect major industrial hubs, build storage facilities and interconnectors with neighbouring hydrogen networks. The country already has more than 1,000 km of dedicated hydrogen pipelines, second only to the USA which is home to more than 1,600 miles of dedicated pipelines. Other EU countries are progressing plans for the European Hydrogen Backbone, with each country developing their own national networks to connect to the backbone. The H2Med pipeline will connect Spain, Portugal, France and Germany, and the SoutH2 scheme, linking Africa to Germany via Italy, is seeking status of a Project of Common Interest (PCI) by the European Commission — which will allow

them to receive EU funding and accelerated permitting.

China has recently had plans for a 400 km hydrogen pipeline included in the country's oil and gas network construction plan, released by the National Energy Administration.

## Demand

Our analysis broke down hydrogen demand across the four main end use sectors; heat, power, transport and industry.

Countries that provide a higher degree of certainty of demand, in terms of mandates and minimum consumption targets, are more attractive to prospective investors, giving sight of how respective hydrogen economies have the potential to be scaled. The RED III directive, passed within the EU, is a prime example of this across the transport and industry sectors via the stipulation of a renewable share in fuel supply, providing a signal for the future market.

### *Industry*

The highest ranked countries in 2023 were Germany, France, USA and Japan. Germany in particular, with its updated strategy in July, has given the strongest signals and support for hydrogen's role in decarbonising industry. A suite of measures including RED III, EU-ETS, CBAM was strengthened with the announcement of a €50bn carbon contracts for difference (CCfD) scheme. In the UK, industry is being prioritised through the cluster sequencing programme, and numerous industrial off-takers are part of the shortlisted projects in the first electrolytic allocation round. However, delays in both processes, a declining UK-ETS price and no commitment to CBAM or CCfD means that the UK drops down the rankings.

### *Heat*

The UK was a world leader when it came to the potential use of hydrogen for heating. The Hy4Heat programme was launched in 2017 to "establish if it is technically possible, safe and convenient to replace natural gas (methane) with hydrogen in residential and commercial buildings and gas appliances". And the UK Hydrogen Strategy made commitments to several important trials to gather the necessary evidence to understand the role hydrogen could play in heating. However, the lack of public government support for low-carbon heating trials has seen the UK fall behind other countries. The Netherlands has jumped to the front, with the world's first live trials of hydrogen for heating in homes launched in December 2022.

### *Power*

The UK has an ambitious target of a decarbonised power system by 2035, subject to security of supply, and the government "sees low carbon hydrogen as a critical component of our broader strategy to deliver energy security". However, the exact role of hydrogen in the future energy system is still to be decided. Most major modelling of future UK energy shows a role for hydrogen in long duration energy storage. The Decarbonisation Readiness requirements create a pathway for hydrogen to be used in thermal power generation assets, however wider market considerations mean this is far from certain, and government intends to consult in 2023 on the need and potential design options for market intervention to support hydrogen to power (H2P).

Other countries have made more explicit statements on the role that hydrogen should play in their domestic power generation mix. Japan is looking to introduce/expand on 30% hydrogen co-firing in gas/hydrogen-fired power generation, but also grow the use of hydrogen fuel cells for off-grid power generation. The USA DoE is acting as the guarantor for a $500mloan for the Advanced Clean Energy Storage project in Utah, with operation of a gas turbine with 30%-hydrogen co-firing slated to begin in 2025.

*Transport*

The UK ranks very lowly for the use of hydrogen in transport at both points in time. In the absence of clear strategy, mandates and targeted subsidies for infrastructure and vehicles, the government's RTFO scheme, which provides a subsidy for renewable transport fuel production including electrolytic hydrogen, has not delivered a robust national refuelling network to be able to support the widespread adoption of FCEVs. The UK is largely focusing on heavy vehicles, with schemes for buses and demonstration projects for freight.

Many Asian and European countries have detailed strategies with stated targets for HRS and vehicle deployment. The recently approved EU AFIR regulation mandates the construction of one HRS every 200 km on the TEN-T core network by the end of 2030, as well as one HRS in every urban node. Importantly, the stations will be accessible to all modes of road transport, not just heavy goods vehicles.

## Standards

The UK published a world leading hydrogen carbon intensity standard, the Low Carbon Hydrogen Standard, with a stringent threshold for maximum carbon intensity set at 20 gCO2e/MJ. The standard has been revised several times, to provide better guidance to developers and allow for more production pathways, and will be ready for the first projects seeking operational funding support. Spain has the most mature standard, already in use for funding eligibility and guarantees of origin certificates.

## Conclusion

Pace and ambition, underpinned by clear policy and a suite of measures – including both 'carrots' and 'sticks' – to achieve the stated targets, are the main drivers for market attractiveness and investor confidence. While the UK made a great first move in 2021 with the publication of its Hydrogen Strategy, the international landscape has changed dramatically in the following two years, and other countries have made more ambitious plans and increased pace in order to capitalise on the significant economic and decarbonisation benefits on offer. Coupled with delays to the UK's main production funding processes, this has seen the UK fall down the international rankings, from a position of strength at the very front, to one at the back of the leading pack.

It is noted by the analysis team that there are many more metrics that could be incorporated, that some countries in the Middle East and Asia are harder to source public data for, and that relative rankings for individual metrics could be debated. However, there is a very clear trend that the UK made a strong first move but has allowed itself to be overtaken by more ambitious countries, with the global landscape in 2023 being far more competitive than it was in 2021.

## Recommendations

1. Move faster and be more flexible with production support
2. Identify and support strategic infrastructure investment now
3. Give clarity on the minimum roles for hydrogen in industry, power, transport and heat, with support measures to make high-carbon expensive and low-carbon affordable
4. Maximise the significant economic opportunity on offer by stimulating domestic supply chains