KPMG

The hydrogen horizon

Clearing the path to H_2 at scale while minimizing investment uncertainty

kpmg.com

Introduction

Pressure to accelerate reduction in greenhouse gas (GHG) emissions continues to drive demand for cleaner sources of energy. Hydrogen will likely be a key element in the transition to net zero, but H_2 solutions need significant investment to reach commercial scale and make a meaningful impact.

Accomplishments to date aren't enough; despite increased attention and efforts, global energy-related emissions rose 0.8 percent in 2022 to a record high.[1]

The US government is shining a particularly strong spotlight on hydrogen as a solution with the recent announcement of the US National Clean Hydrogen Strategy and Roadmap in June 2023, following major funding and incentive structures in the Inflation Reduction Act (IRA) in 2022 and Infrastructure Investment and Jobs Act (IIJA) in 2021.

Increased public and private investment and support can help a growing number of hydrogen applications reach commercial scale, including power generation, transportation, manufacturing, and even storage for intermittent renewable energy sources.

But the new government incentives can't fully counter the uncertainty on the hydrogen horizon. Future H_2 demand is unclear giving organizations pause about putting a clean hydrogen stake in the ground.

In this paper, we take a look at operational hydrogen production and built-in demand potential that can support the case for investment. We also introduce several pragmatic considerations for evaluating hydrogen projects and strategies to introduce greater certainty, improve chances for economic success, and ultimately give global net-zero efforts a much-needed boost.

"The 2023 Statistical Review of World Energy points to the need for urgent actions on the part of all stakeholders to bend the global temperature curve through demand-side initiatives to reduce energy consumption and supply-side interventions to scale up low-carbon resources."

—Anish De, Global Head of Energy, Natural Resources & Chemicals, KPMG International

[1] The Energy Institute in partnership with KPMG and Kearney, "2023 Statistical Review of World Energy," June 2023

Current H_2 use cases

Hydrogen is the most promising decarbonization solution for some of the hardest-to-abate industries.

Certain sectors support logical demand growth and are more likely to adopt clean hydrogen energy first for several reasons. Hydrogen may already be in use, or the cost to switch is low. In other cases, companies may be facing industry-specific policy mandates for decarbonization.

Many of the sectors vital to how we build and travel are the largest emitters of GHG and are where introducing hydrogen will have some of the greatest impact. Examples where hydrogen applications are more mature include the following:

Chemicals. The chemical sector will be both a significant hydrogen producer and consumer in the energy transition, ideally reducing some of the highest emissions across all industries. One way companies are looking to lower emissions from production is by replacing fossil fuels with electrochemically generated hydrogen, which can be used to retrofit existing facilities. Electrolytic hydrogen can also replace fossil fuel-produced hydrogen for chemical feedstock.[2]

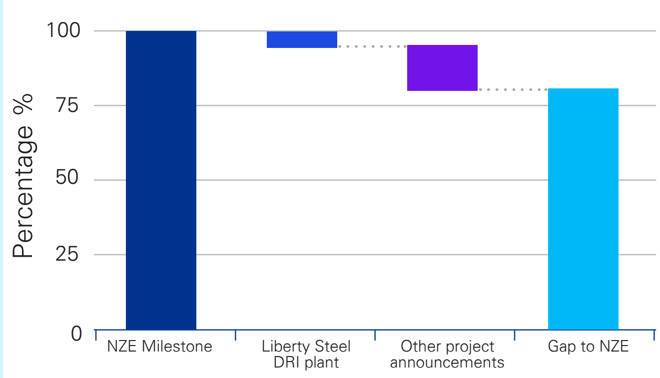
Chemical companies are starting to apply these methods where emissions and consumer demand are both especially high: ammonia, high-value chemicals (the United States is one of the largest producers), and methanol.[3]

> The chemical and refining industries are the largest consumers of hydrogen today. Nearly all of their demand, 90 megatons, is filled by fossil-based hydrogen that could be replaced with electrolytic hydrogen for chemical feedstock.
>
> MIT News, "To decarbonize the chemical industry, electrify it," January 31, 2023

Iron and steel. Most global steel production, 70 percent, requires coal to melt iron ore and is responsible for 7 percent of the world's carbon emissions. Replacing fossil fuels with hydrogen and using carbon capture and storage (CCS) to reduce remaining emissions can significantly progress climate efforts.[4]

Far more hydrogen projects need to come online to meet net-zero goals, according to the International Energy Agency.[5] United States Steel and subsidiaries of Equinor and Shell are studying the potential for hydrogen development with CCS and in the Ohio, Pennsylvania, and West Virginia tristate region.[6]

Gap between steel sector hydrogen announced demonstration projects and net zero (NZE) 2030 milestone of 4 metric tons (Mt) hydrogen



Source: IEA, Iron and Steel

[2] MIT News, "To decarbonize the chemical industry, electrify it," January 31, 2023

[3] IEA, Chemicals, 2022

[4] NPR, "Republican attacks on ESG aren't stopping companies in red states from going green," June 27, 2023

[5] IEA, Iron and Steel, 2022

[6] Upstream, "Equinor, Shell and US Steel to team up on low-carbon and hydrogen industrial hub," August 16, 2022

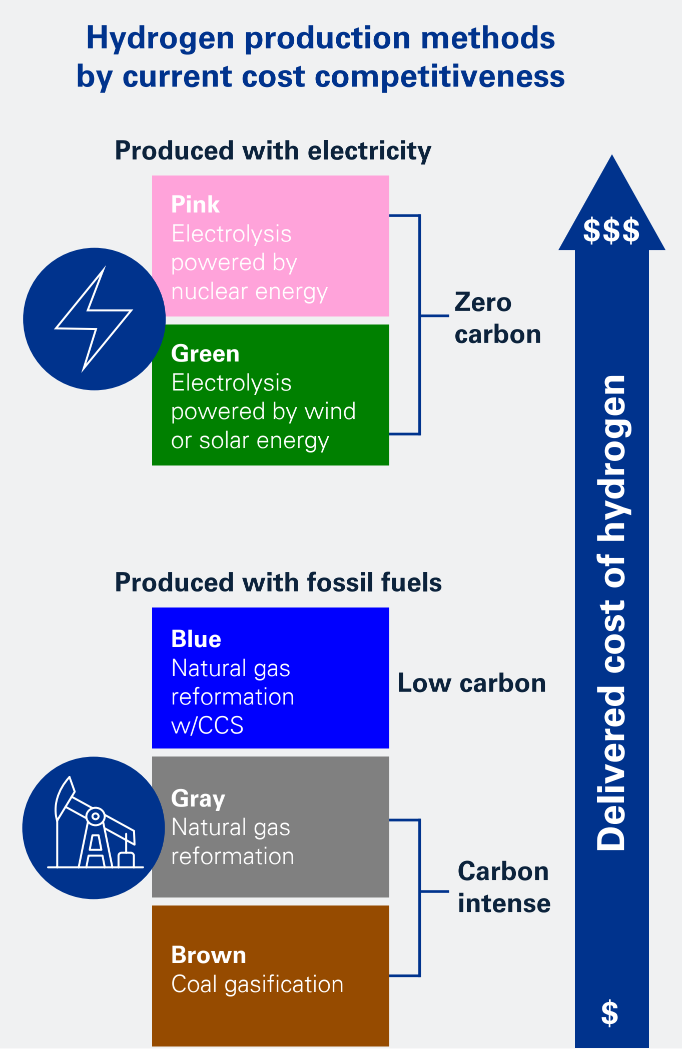
Transportation. Decarbonizing freight transportation of all kinds—trucking, maritime, air, and rail—requires clean, energy-dense fuels produced with low- or zero-carbon feedstocks. Hydrogen and hydrogen-based fuels are leading contenders for applications, such as long-haul trucking, for which battery electric vehicles can't support longer ranges and quick refueling.[7]

The Sustainable Aviation Fuel (SAF) Challenge from US federal energy, transportation, and other agencies is a strategy to scale clean hydrogen as a primary fuel source for aviation. Projects named by the Biden administration include JetBlue's electric and hydrogen aircraft development in partnership with Joby Aviation and Universal Hydrogen; and American Airlines's plans to procure 10 million gallons of fuel produced by Prometheus Fuels through captured CO_2 and renewable electricity.[8]

> Transportation is the highest-emitting sector in the United States, and hydrogen and hydrogen-based fuels are among the leading decarbonization solutions for transporting freight by truck, ship, plane, and train by 2050.
>
> World Resources Institute, "Clean Hydrogen: Outlook for Freight Transport in the United States," January 31, 2023

The hydrogen spectrum

Clean hydrogen as defined by the US Department of Energy (DOE) is produced with a carbon intensity rate of 2 kg or less, but it can be produced from a variety of sources referred to in shorthand by color. While the H_2 source doesn't have direct impact on overall hydrogen demand, different production methods have different emissions profiles and technical requirements impacting cost of delivery, and they are in various stages of maturity. As such, color ultimately factors into individual H_2 investment decisions.



[7] World Resources Institute, "Clean Hydrogen: Outlook for Freight Transport in the United States," January 31, 2023

[8] whitehouse.gov, "FACT SHEET: Biden Administration Advances the Future of Sustainable Fuels in American Aviation," September 9, 2021

Understanding H_2 investment uncertainty

Government measures can help incentivize hydrogen production, but they can't guarantee hydrogen use. In order to calculate risk and reward, organizations want a better sense of the demand side of the equation.

The US government, particularly through direct-pay incentives in the IRA, has helped to encourage clean hydrogen investment with measures to reduce near-term commercial and technical uncertainty. However, longer-term commercial success can only occur if an organic market materializes and producers can take advantage of the IRA's Hydrogen Production Tax Credits (PTC).

The following are several sources of uncertainty that organizations need to navigate when determining risk and opportunity in hydrogen.

Projections can lack the clarity companies and investors typically seek.

Most degree-based global warming scenarios—centered around the action required to hold the average global temperature to 1.5, 2, or 4 degrees Celsius above preindustrial levels—are "goal-seek" models. Supply and demand, project cost, and price forecasts are generated to achieve a target temperature rather than calculated based on traditional, time-tested commercial forecast methodologies.

As a result, goal-seek and other models tend to reflect more aggressive outlooks for the adoption of H_2 without fully considering market, policy, and economic factors.

And unlike Europe, the United States does not have a carbon tax to help evaluate pricing; only a handful of states such as California have or are considering a cap-and-trade program. Organizations are left to make decisions on what could be high-cost, high-risk projects with high uncertainty.

Not that uncertainty is new to many industries used to making big capital decisions about the risk and reward of their projects, especially asset-heavy sectors such as energy, natural resources, and chemicals. They've long used probabilistic modeling and tools to reduce subsurface, commercial, and technical uncertainty using long-term liquefied natural gas contracts, contractor relationships, and other data.

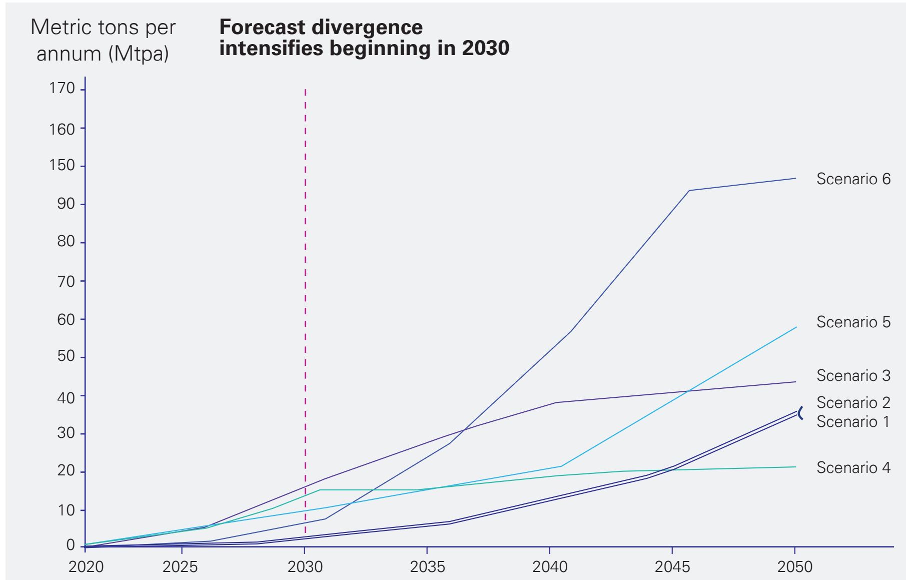
An oil and gas company could spend $100 million drilling an initial exploratory well to determine potential return for a traditional investment. In contrast, H_2 project leaders need to estimate economic, political, and societal developments without the added benefit of looking under the surface of the earth, spending five times as much without knowing for a decade or more if the project will ultimately be profitable.

Future demand for hydrogen becomes less clear the further out we look.

Producers and suppliers of electricity, gas, and chemicals—as well as their banks and private equity investors—know buyers for their products are out there. Not so for hydrogen.

The market is flooded with H_2 supply-demand models from government agencies, climate organizations, analysts, and industry groups. Because these models draw from myriad factors, the range of forecasts for a clean hydrogen market are usually too wide for most organizations to properly consider or justify a large investment.

Scenario demand curves – US low-carbon hydrogen



Source: Analyst projections, KPMG analysis

There's no guarantee that government support will last the life of a hydrogen project.

From 2035 and forward, most assumptions include IRA and other policy incentives and benefits in addition to assumptions for organic commercial growth. But the durability of US government incentives is often a question, and it's not clear when, if, and to what magnitude an organic clean hydrogen market can evolve.

Organizations must decide if they are comfortable making sizable investments in H_2 projects that aren't clearly economic on their own. For some, a clean hydrogen project would be the first capital investment they make where returns are more than a decade away, and government subsidies are a necessity to maximize results.

Shareholders expect profitability and returns, one more factor in the decision.

Finally, the investment case for hydrogen differs from more traditional capital projects. Shareholders reward companies for successfully forecasting and executing traditional business ventures; they will need more convincing that projects as uncertain as clean hydrogen should go forward.

As organizations consider new business models for the energy transition to net zero, project evaluation must evolve to thoroughly evaluate all factors when deciding which H_2 strategies to pursue, when, and to what scale.

Federal funding and incentives

Over the last two years, the US government has thrown its weight behind hydrogen as a critical component for building a clean energy economy.

November 2021
Infrastructure Investment and Jobs Act (IIJA)
The IIJA authorizes and appropriates $9.5 billion for clean hydrogen programs.

- **Regional Clean Hydrogen Hubs.** Up to $8 billion to establish between six and 10 clean hydrogen hubs/networks of producers, consumers, and infrastructure within close proximity to one another. Access to various funding mechanisms, including grants, contracts, and cooperatives and other agreements.
- **Clean Hydrogen Electrolysis Program.** $1 billion for an electrolysis research, development, demonstration, and deployment program to support commercialization.
- **Clean Hydrogen Manufacturing Recycling Research, Development, and Demonstration Program.** $500 million to provide financial assistance to organizations developing technologies and techniques that will help advance clean hydrogen.
- **IIJA-adjacent programs for clean hydrogen deployment.** Funding for programs that indirectly benefit deployment of alternative fuels, mostly through the Department of Transportation.

More information from KPMG: Infrastructure Investment and Jobs Act (kpmg.us)

August 2022
Inflation Reduction Act (IRA)
As part of its inflation reduction mandate, the IRA established energy security and climate change programs, including tax benefits related to clean hydrogen production, carbon sequestration, and facilities.

- **Hydrogen PTC (Section 45V).** Scales based on the lifecycle GHG emissions rate of the production process. Credit amount from $0.60 to $3.00 per kg depending on carbon intensity, credit claimed over 10-year period. Can instead elect to claim up to 30 percent investment tax credit, in lieu of PTC.
- **Carbon Sequestration Tax Credit (Section 45Q).** IRA increased credit rates to up to $85/tonne for permanent storage of captured CO_2, and $60/tonne for utilization of captured CO_2, credit claimed over 12-year period.
- **Investment Tax Credit (ITC) for Energy Property (Section 48).** Available for owners of facilities that produce clean hydrogen for a base credit amount of 6 percent of the investment.
- **Renewable Electricity PTC (Section 45) and Nuclear PTC (Section 45U).** Can be claimed for electricity provided to a facility on which Section 45V PTCs are also claimed.

Organizations can elect to claim section 45V PTC and Section 45Q as a refundable tax credits for first 5-years, credit may be transferred thereafter; note Section 45Q and Section 45V PTC cannot be claimed on same facility. Additionally, the highest credit rates are only available if prevailing wage labor and qualified apprentices are used in construction of projects.

More information from KPMG: Inflation Reduction Act of 2022 (kpmg.us).

June 2023
US National Clean Hydrogen Strategy and Roadmap
A comprehensive framework for accelerating the production, processing, delivery, storage, and use of clean hydrogen with three key strategies:

- **Target strategic, high-impact uses,** especially where limited alternatives exist.
- **Reduce cost by** catalyzing innovation and scale, stimulating private sector investments, and developing the clean hydrogen supply chain.
- **Focus on regional networks** with large-scale production and end use in close proximity.

More information: Biden-Harris Administration Releases First-Ever National Clean Hydrogen Strategy and Roadmap to Build a Clean Energy Future

Many state and local governments also offer incentives and assistance for clean hydrogen development and use, often leveraging clean energy hubs and supporting alternative fuels and transportation. Examples include:

New York

$10 million in funding is available for New York-based clean hydrogen research, development, and demonstration projects that have also applied for federal funding. The program, announced in May 2023, is designed to support four challenge areas: decarbonizing industrial process heat; clean hydrogen production and integration with renewable energy; mitigation of nitrogen oxide emissions from hydrogen combustion; and hydrogen storage technologies.[9] California has a similar program.

California

California residents and private and public organizations have access to numerous different incentives designed to increase hydrogen fuel demand, including the following: The California Air Resources Board offers grants for replacing buses, with a maximum grant amount of $400,000 for a fuel cell transit bus; Santa Barbara County is providing grants to offset the cost of heavy-duty vehicles powered by hydrogen fuel cells among other alternatives; and drivers of hydrogen-fueled vehicles can use the High Occupancy Vehicle (HOV) and High Occupancy Toll (HOT) Lanes regardless of the number of occupants in their vehicles.[10]

Colorado

With the enactment of SB22-193: Air Quality Improvement Investments, Colorado established a clean air grant program to fund projects that reduce industrial and manufacturing emissions, including projects producing or utilizing clean hydrogen. Private entities, local and tribal governments, and public-private partnerships are all eligible, and projects in underserved communities or where air quality falls below standards may receive priority consideration.[11]

[9] New York State Energy Research and Development Authority

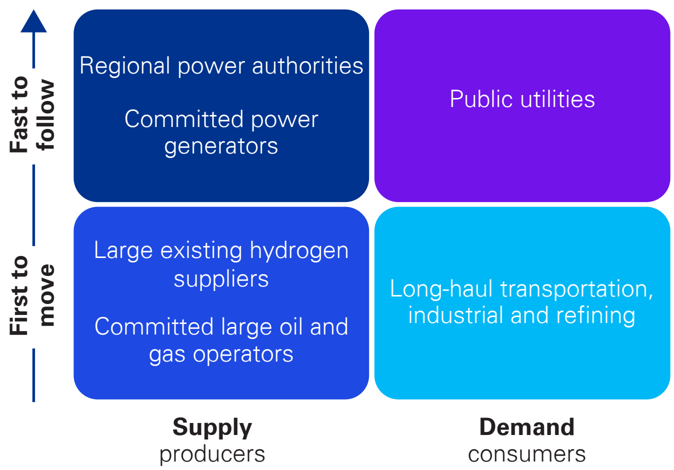
[10] Alternative Fuels Data Center

[11] Colorado General Assembly, June 2, 2022

Paths to participation

Hydrogen has captured the imagination of those searching for new solutions to the climate crisis. H_2 production and use at scale is technical and may require a more complicated value chain; however, much of the apparatus and knowledge around H_2 isn't new. For many, the switch may be easier than it appears.

A review of four high-level approaches to H_2 innovation or production at scale—first movers or fast followers on the supply or demand side—uncovers common strengths and characteristics that can help organizations considering the next step. Importantly, companies can choose any of the four, alone or in combination, and shift the approach as needed based on location, market conditions, and other factors. The end results will look different based on hydrogen "color," but the same thinking applies across the spectrum.



First to move

Characteristics

The initial producers of low-carbon hydrogen at scale will be companies with commercial experience in the space, and with capital and engineering expertise to be successful. Large oil and gas operators that have already committed to hydrogen are paving the way, as well as large existing hydrogen suppliers such as chemical manufacturers.

Long-haul transportation, industrial, and refining companies have started setting up for hydrogen use. These companies may also have larger appetites for risk.

Advantages

- Government support has a time limit; companies acting quickly can use the incentives and access funding.
- Industry standing and track record can open deep pockets to allay some of their own investment risk.
- The ability to establish technical partnerships can accelerate H_2 technology development and implementation.
- The right location supports H_2 projects, including proximity to hydrogen hubs, emitters, underground storage for CCS, transportation, and other physical characteristics.
- First movers work closely with regulators and agencies to help establish industry standards.

Examples

In 2013, Air Products began operating one of the first hydrogen production facilities with CCS in Port Arthur, Texas. The project, sponsored by the DOE, removes more than 90 percent of the CO_2 from two steam methane reformers with negligible impact on efficiency.[12] More recently, Air Products announced plans to build a $4.5 billion blue hydrogen production complex in Louisiana for the mobility and industrial markets, its largest US investment.[13]

ExxonMobil announced plans in January 2023 to build a low-carbon hydrogen plant, including one of the world's largest CCS facilities, at its refining and petrochemical facility at Baytown, Texas. The company estimates it will produce up to 1 billion cubic feet per day of hydrogen from natural gas and capture 98 percent of associated CO_2.[14]

Volvo Trucks was the first to test hydrogen fuel cell vehicles on public roads. The 1,000 km range of the company's fuel cell electric trucks compares to many diesel engine trucks and they can refuel in less than 15 minutes.[15]

---

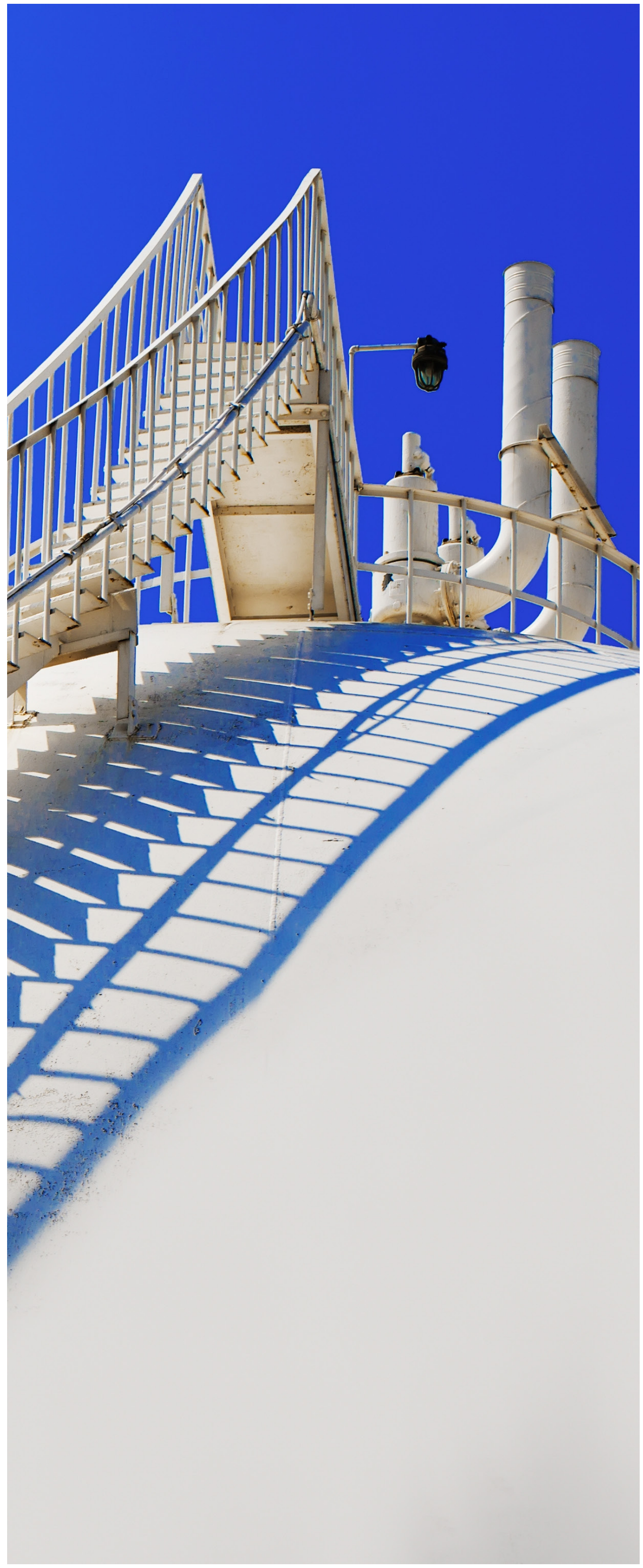
[12] Energy.gov, Air Products & Chemicals, Inc.

[13] Air Products, "Louisiana Clean Energy Complex"

[14] ExxonMobil, "Low-carbon hydrogen: Fueling our Baytown facilities and our net-zero ambition," January 30, 2023

[15] Volvo, "Volvo Trucks showcases new zero-emissions truck," June 20, 2022

Fast to follow



Characteristics

Beyond the first movers, producers fall into two categories. One includes organizations that plan to produce H_2 but at a smaller scale than the first movers. They include local and regional power companies, as well as regional oil and gas operators.

The second category includes companies, most likely large oil and gas operators, that have passed on hydrogen production at scale to date but have the capabilities—capital, engineering expertise, and execution experience—to quickly ramp up their own projects and/or acquire productions assets quickly.

On the demand side, only 12 percent of US energy and utility companies have invested in low-carbon hydrogen, but 63 percent say they will launch an initiative by 2030. Most will need to partner to produce hydrogen at scale.[16]

Advantages

- First movers already helped derisk and ease the foray into hydrogen for those that come next by building infrastructure and securing permits.
- Participation can follow at the same pace as H_2 technology development and implementation, using proven tools and reducing the risk of investing in innovation that soon becomes obsolete.
- Blue hydrogen from fossil fuels is the most advanced, but organizations in regions conducive to solar and wind generation will be ready to integrate renewables with hydrogen as technology, including battery storage and distribution, evolves.
- Rather than build an H_2 project from scratch and carry all the risk, organizations can choose to join a mega project already underway.

Examples

Oil and gas major bp America is working with industrial gases and engineering company Linde to capture CO_2 from Linde's existing hydrogen production and other facilities, and then provide the low-carbon hydrogen to customers along Linde's hydrogen pipeline network.[17]

CF Industries, the largest producer of ammonia, and renewable energy provider NextEra Energy Resources announced a joint venture to develop a green hydrogen project at CF Industries' Verdigris Complex in Oklahoma leveraging DOE funding.[18]

---

[16] Utility Dive, "US firms behind global counterparts on clean hydrogen initiatives but will catch up by 2030: report," April 20, 2023

[17] bp, "bp and Linde plan major CCS project to advance decarbonization efforts across Texas Gulf Coast," May 17, 2022

[18] NextEra Energy, "CF Industries and NextEra Energy Resources announce a memorandum of understanding for a green hydrogen project in Oklahoma to support decarbonization of the agriculture supply chain," April 24, 2023

Additional considerations

Considerations around sector, geography, and investment also can alleviate some of the risk and uncertainty of starting a hydrogen project:

- Understand where existing core competencies and customer base match project requirements and goals.
- Take a portfolio approach; spread investment risk.
- Become educated about how nascent, H_2-adjacent businesses might evolve.
- Decide whether to tailor an investment strategy to one scenario or develop strategies that could cover multiple scenarios.
- Determine the most favorable conditions for more technically and economically feasible projects, including state and local incentives.
- Understand the risks and opportunities around stacking tax incentives given the challenge of establishing project eligibility and modeling credit amounts without clear guidance on determining carbon intensity for different production pathways.
- Define the desired outcome for each stakeholder group.
- Pursue strategies than can improve the environment and shareholder return in tandem.
- Consider how investments align to local political and regulatory strategies and priorities.

About KPMG

When it comes to clean hydrogen investment and strategy, is your organization out in front, weighing its options, or somewhere in between?

Our global team of professionals helps companies across all sectors define their role and explore opportunities in the energy transition to net zero including how to approach the hydrogen horizon with greater certainty and lower risk. Our unique combination of operations, capital investment, and regulatory experience in the energy industry allows us to provide deep insights that companies need to make strategic decisions in a fast-changing environment. We look forward to speaking with you.

About the authors

Brad Stansberry

Partner, Energy and Chemicals Industry
Advisory Leader

Brad is a partner and leads KPMG's Energy and Chemicals Industry Advisory Practice. He leverages more than 20 years of consulting and professional services experience to help the c-suite and finance executives in the energy industry to improve all aspects of the finance function, including defining finance organization strategy and objectives, improving processes, deploying enabling technologies, enhancing talent and skills, and helping ensure finance is a valued service provider to business constituents.

Brooke Harris

Advisory Director,
ESG – Energy Transition

Brooke, a director in the KPMG Advisory Services practice, leads the energy transition team for the KPMG ESG practice. She brings to her clients 18 years of experience at ExxonMobil, including commercial roles in LNG marketing and upstream exploration. Brooke also has a deep background in energy policy and strategy with a focus on natural gas, and experience in carbon offsetting and nature-based solutions strategies.

Zack Schwartz

Manager, Advisory
Energy, Natural Resources, and Chemicals

Zack has more than a decade of experience supporting upstream oil and gas clients across four continents. His exposure to a diverse client mix has allowed him to help operators frame, evaluate, and develop plans for their strategic upstream and low-carbon business ventures. He brings passion and sound analysis to guiding KPMG Advisory clients in the energy transition, helping them evaluate the economic and environmental tradeoffs of CCUS, hydrogen, and upstream decarbonization investments.

Brian P. West

Director, Advisory
Energy, Natural Resources, and Chemicals

Brian, a director in the KPMG Energy Solutions Team, leverages 25 years of ExxonMobil experience in upstream operational and capital project investment to advise clients on the energy transition. His roles included managing large, multidisciplinary, multinational teams at conventional oil and gas companies, as well as overseeing unconventional merger and acquisition teams and defining value-focused research and technology development strategies. With a background in subsurface oil and gas, Brian brings a pragmatic approach to clean energy investment and technical operations, including CCUS and blue hydrogen storage.

About the authors (Continued)

Hannah Hawkins

Principal, Credits & Incentives, Washington National Tax
KPMG LLP

Hannah Hawkins advises on technical issues related to the energy industry. In particular, Hannah has experience with issues and transactions related to wind, solar, and carbon capture and also with the tax issues associated with rate regulated utilities. In addition, Hannah has extensive technical knowledge of various excise taxes, including those related to taxable fuels, heavy trucks and tires, and air transportation. Hannah also advises on various aspects of tax policy and the Treasury and IRS rule-making process.

Before joining KPMG in December 2020, Hannah served as Deputy Tax Legislative Counsel in the Treasury's Office of Tax Policy. During her six-year tenure at Treasury, she was involved in virtually all aspects of the domestic regulatory agenda, including much of the guidance issued under the Tax Cuts and Jobs Act. In addition, Hannah led the development of guidance and internal policy making on tax issues associated with renewable energy, oil and gas, and utilities.

Contact us

Brad Stansberry
Partner, Advisory Industry Leader
Energy, Natural Resources and Chemicals
T: 214-478-6200
E: bstansberry@kpmg.com

Brian P. West
Director, Advisory
Energy, Natural Resources, and Chemicals
T: 281-409-8101
E: brianwest@kpmg.com

Some or all of the services described herein may not be permissable for KPMG audit clients and their affiliates or related entities.