Vinson&Elkins

Power Play
Unlocking the Opportunity of Low-Carbon Hydrogen: Investment, Incentives, and Collaboration

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Introduction

Hydrogen's symbol is H, its atomic number is 1, and at room temperature it is a colorless, odorless gas with the lowest density of all gases. Out of all of the resources that are available to contribute to the transition to carbon neutrality, hydrogen has perhaps the broadest set of applications.

Producing hydrogen in a carbon-neutral manner is challenging (and potentially expensive), but the many colorful means of producing hydrogen provide exciting opportunities. Once available, it can be used in almost every vertical in the energy space — ranging from power generation to energy storage to e-fuels production for aviation and heavy road and rail transport, to cement and steel production, as well as in applications in other carbon-intensive industries.

The regulatory framework for the production and use of hydrogen has taken a number of favorable turns over the past year, which has resulted in projects that were interesting in concept only becoming actionable for the purposes of development. While the regulatory framework has become favorable, it is not in and of itself enough to ensure success. As with any long-term infrastructure project, there are a number of issues that counterparties will have to work through to provide for a viable and bankable[1] hydrogen project.

Production of Hydrogen and Categorization

The United States ("U.S.") currently produces more than 10 million metric tons of hydrogen per year, with the majority of this amount being produced by plants dedicated to the production of hydrogen. Almost all of this production is carbon intensive. However, hydrogen can be produced in "cleaner" or more "low carbon" ways.

The most commonly discussed types of hydrogen produced in the U.S. are:

- **Gray Hydrogen:** The vast majority of hydrogen is produced through steam methane reformation, wherein natural gas feedstock (*i.e.*, methane (CH_4)) and water (H_2O) in the form of steam create carbon monoxide (CO) and hydrogen ($3H_2$). The carbon monoxide molecule is then taken through a water-gas shift reaction whereby more water is added. From this process, carbon dioxide and additional hydrogen is created. The carbon dioxide is released into the atmosphere, and the hydrogen is then available for use. Hydrogen produced from this process, as well as other natural gas-sourced processes (*e.g.*, partial oxidation, auto-thermal reforming), is commonly known as gray hydrogen.[2]

- **Blue Hydrogen:** Blue hydrogen is the same as gray hydrogen, but instead of releasing the carbon dioxide into the atmosphere, it is instead captured and sequestered. Blue hydrogen has been a clear leader in the evolution of the hydrogen industry. Most new-build blue hydrogen facilities today are being constructed with an autothermal reforming process, as this process can achieve better separation and capture of carbon dioxide (CO_2) than a steam methane reforming process.

- **Green Hydrogen:** Hydrogen may also be produced from just water (H_2O) and electricity. Water is run through an electrolyzer, which splits the hydrogen atoms from the oxygen atoms. The oxygen is released into the atmosphere (or in some cases captured), and the hydrogen is available for use. When the electricity used to power the electrolyzer is provided by renewable energy sources, the hydrogen produced is known as green hydrogen.

- **Turquoise Hydrogen:** This color refers to hydrogen that is produced using methane pyrolysis. Like gray hydrogen, a producer starts with natural gas (*i.e.*, methane (CH_4)). However, instead of adding water steam, the producer applies high heat (750–1200 degrees Celsius) to split the methane molecule, with the result being hydrogen ($2H_2$) and carbon in a solid state.[3]

While the hydrogen color scheme is useful for understanding how the hydrogen will be produced, it does not provide real insight into the carbon footprint of the project.[4]

Common Types of Hydrogen Production

Color	Gray	Blue	Turquoise*	Green
Process	SMR or gasification	SMR or gasification with carbon capture (85-95%)	Pyrolysis	Electrolysis
Source	Methane or coal	Methane or coal	Methane	Renewable electricity

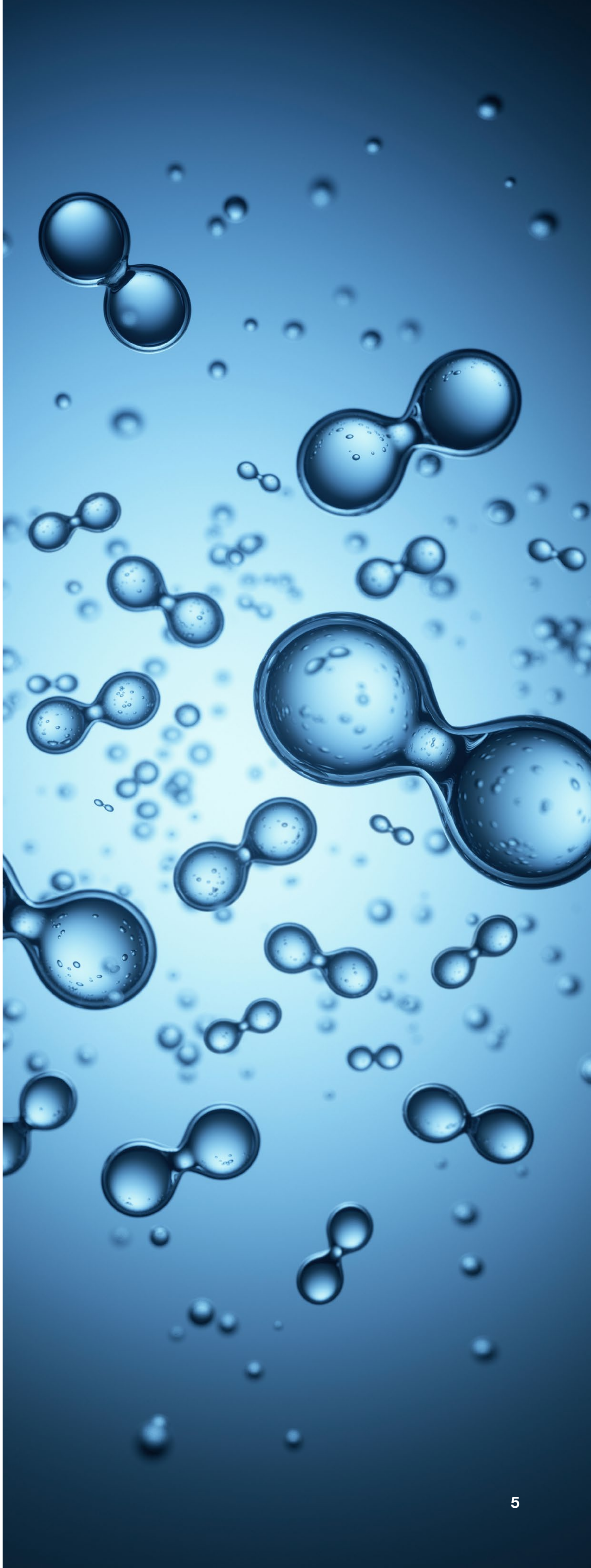
Note: SMR = steam methane reforming. *Turquoise hydrogen is an emerging decarbonization option.

Source: International Renewable Energy Agency

Instead, what many government subsidy programs as well as other regulatory or voluntary carbon reduction programs ("**carbon programs**") rightly focus on is not in the means of production, as indicated by the color, but the end result of the production process — *i.e.*, the "carbon intensity."[5] "Carbon intensity" is used to describe the amount of carbon emissions resulting for every unit of hydrogen produced (normally kg of CO_2 equivalents emitted for each kg of H_2 produced). In most carbon programs, including certain tax credits available following the passage of the Inflation Reduction Act of 2022 (the "**IRA**") and California's Low Carbon Fuel Standards program ("**LCFS**"), the carbon intensity of hydrogen is evaluated through a "life-cycle analysis."

What constitutes and how to calculate the life cycle of a product can vary. For example, for LCFS programs, when accounting for carbon intensity, the California Air Resources Board takes into account all greenhouse gases ("**GHG**") emitted through each stage of production through the end use of the product as a fuel (a "well-to-wheel" analysis). The IRA, on the other hand, often calls for a "well-to-gate" analysis — a calculation from feedstock (including emissions associated with electricity production and use) through the point of production.

One of the challenges historically faced by low-carbon hydrogen production processes has been that they are more expensive when compared to the production of gray hydrogen in a steam methane reformer. While the cost of production of a kilogram of hydrogen will vary based on natural gas and power prices, steam methane reforming without carbon capture is generally the cheapest form of hydrogen production, with a production cost between $0.70 and $1.60 per kilogram in the U.S. Carbon capture and sequestration ("**CCS**") adds to this cost due to the increased capital and operational expenditures associated with it. Electrolysis-based hydrogen production is even more expensive, sometimes resulting in a production cost of $6.00 per kilogram.[6] In light of this, as described further below, there are governmental incentives that may offset the higher costs of low-carbon hydrogen.



Uses for Hydrogen

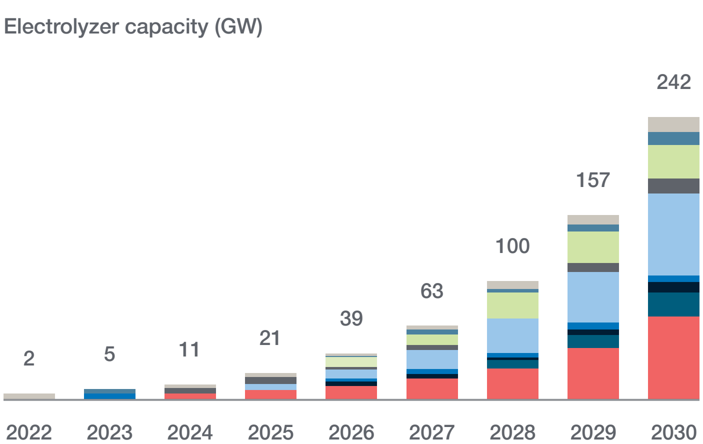
Once hydrogen is in hand, it is extremely versatile (it can be combusted, compressed, liquefied, and so on) and can be used in an incredible number of applications. Currently, hydrogen is used in various petrochemical production processes (*e.g.*, ammonia and methanol production) that require hydrogen as a feedstock. Other uses of hydrogen include:

- **Mobility:** Hydrogen can be used as a fuel in transport applications. One such application is using hydrogen in fuel cells to cause an electrochemical reaction to release and capture ions to produce electricity. When consumed by a hydrogen fuel cell, the only output is energy and water.
- **Energy Storage:** When paired with renewable energy production, hydrogen could be used as a form of long duration energy storage, and as such help maintain the integrity of the grid (*i.e.*, "power-to-gas-to-power").
- **Steel Production:** The production of steel often involves the use of coking coal as a reduction agent in a blast furnace to remove oxygen from iron ore in order to convert it to raw iron, resulting in high levels of CO_2 emissions. Hydrogen can instead be used as a reduction agent, leading to significant reductions in CO_2 emissions.
- **Ammonia and Ammonia-Based Power Generation:** Ammonia is a compound consisting of three parts hydrogen and one part nitrogen, and it can be used as fuel in thermal power generation without emitting carbon dioxide when burned.[7] Further, ammonia is traditionally used as a fertilizer, and as an input for the production of other fertilizers and explosives.
- **Power to Fuels (eFuels):** Many developers are working on projects that use renewable energy to power hydrogen-producing electrolyzers, and combine that hydrogen with CO_2 to create methane, and sometimes from there incorporate gas-to-liquids technology to create naphtha, diesel and/or aviation fuel. These are often denoted as "e-fuels," such as eRD (renewable diesel). The "e" stands for "electric" or "electro." An e-fuel is chemically identical to its conventional counterpart.

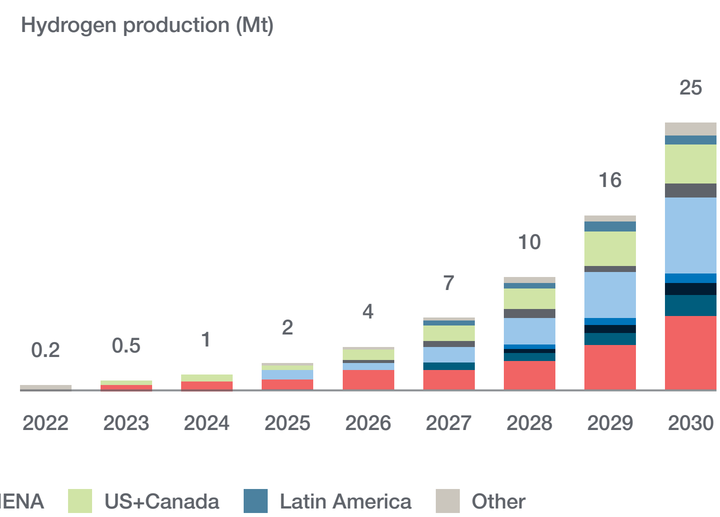
It is important to note that hydrogen must be produced, as opposed to hydrocarbons (which are extracted) or renewable energy (which is generated from wind or sunshine). As such, hydrogen is an energy *carrier*, similar to a battery, but not an energy *source*. There will always be energy from another source needed to produce hydrogen. Once produced, the hydrogen then carries energy to another place. The challenge is to lower the carbon footprint of the energy used to produce the hydrogen, and to minimize the energy lost in producing hydrogen and then turning it back into energy.

Global Growth

Cumulative electrolyzer capacity



Green hydrogen production



Source: BloombergNEF

Handling of Hydrogen

Hydrogen in and of itself is a simple molecule comprised of one proton and one electron. Despite this apparent simplicity, it is nonetheless challenging to store and transport. This explains why hydrogen is typically produced close to the consumption or offtake point. For example, steam methane reformers are frequently co-located with ammonia production facilities, and hydrogen for mobility uses is produced close to dispensing infrastructure.

Physically, hydrogen is not dense, making efficient transportation difficult. To make it more dense through liquefication, its temperature needs to be reduced to negative 253 degrees Celsius — not too far from absolute zero, negative 273.15 degrees Celsius. Refrigeration at this temperature is technically difficult to maintain across the production, transportation, and storage process, and it requires high energy consumption. Further, as the smallest molecule in the universe, hydrogen (H_2) can more easily escape through seals and cracks in pipelines and storage tanks. For the same reasons, storage of hydrogen can also be challenging (although there are some projects that are attempting to use salt caverns to store hydrogen underground). Because of this, the trucking of hydrogen is not feasible at scale. Pipeline transportation is an option, but the pipelines need to be specially built to transport hydrogen, as hydrogen corrodes and embrittles steel. The U.S. has only about 1,600 miles of hydrogen pipelines — far less than the country's three million miles of natural gas pipeline infrastructure.[8]

Ammonia could potentially serve as a transportation vector for hydrogen. Not only is ammonia more dense than hydrogen, but it also liquefies at a more feasible temperature (negative 33.6 degrees Celsius). A worldwide network of ammonia storage and terminal infrastructure along with refrigerated ammonia transportation vessels already exists. As a result, a global ammonia-hydrogen trade network is developing wherein: (1) hydrogen is created; (2) such hydrogen is converted into ammonia; (3) the ammonia is transported across continents and oceans; and (4) upon reaching the end destination, the ammonia is either used directly or broken down to use the hydrogen.

Regulatory Framework

As described above, low-carbon hydrogen has historically been more expensive to produce than gray hydrogen. In light of this, to encourage clean hydrogen development and production, both the U.S. and European Union ("**E.U.**") have implemented programs in an effort to spur significant investment in hydrogen projects.

The U.S. has incentivized the production of hydrogen through the use of tax credits and grants, while the E.U. is implementing rules requiring the use of low-carbon fuels and issuing guidelines as to what qualifies as a low-carbon fuel under these rules. In the U.S., these incentives could significantly impact the cost-competitiveness of low-carbon forms of hydrogen, while the rules in the E.U. could potentially encourage greater hydrogen consumption.

The United States

Tax Credits

In August 2022, the U.S. passed the Inflation Reduction Act of 2022 (the "**IRA**"), representing a historic investment in climate policy in the U.S. and containing a number of tax credits geared towards clean and renewable programs — including programs to facilitate hydrogen development and production.

The Clean Hydrogen Production Tax Credit (§ 45V) is available in certain circumstances for each kilogram of clean hydrogen produced over a 10-year period, beginning on the date the hydrogen production facility is placed in service. The credit amount varies based on the carbon intensity of the hydrogen, but may be as much as $3.00/kilogram for hydrogen produced with GHG emissions below 0.45 kg CO_2e/kg of hydrogen (assuming certain prevailing wage and apprenticeship requirements are met).[9] The credit amount reduces as the carbon intensity increases, and phases out entirely if GHG emissions exceed 4 kg CO_2e/kg of hydrogen. The credit is available only for hydrogen produced after December 31, 2022, at a facility that begins construction before January 1, 2033. The carbon-intensity calculation is conducted through the Greenhouse gases, Regulated Emissions, and Energy use in Transportation model (commonly referred to as the "GREET Model") developed by the Argonne National Laboratory.

In lieu of the Clean Hydrogen Production Tax Credit (§ 45V), taxpayers can elect to claim a Clean Hydrogen Investment Tax Credit under § 48 for the development of a clean hydrogen project. As with the production-based credit, the amount of the Clean Hydrogen Investment Tax Credit is available only if the expected GHG emissions do not exceed 4 kg CO_2e/kg of hydrogen and varies based on the amount of GHG emitted, with the top credit being 30% for projects which are expected to have GHG emissions below 0.45 kg CO_2e/kg of hydrogen (assuming certain prevailing wage and apprenticeship requirements are met).

For green hydrogen projects that source energy from renewable sources, there may be an ability to claim a tax credit in connection with the renewable energy project. Namely, for projects beginning construction before January 1, 2025, either an Electricity Production Tax Credit (§ 45) or Energy Investment Tax Credit (§ 48) may be available. And for projects placed in service after December 31, 2024, either a Clean Electricity Production Tax Credit (§ 45) or Clean Electricity Investment Tax Credit (§ 48E) may be available. Importantly, these credits can be claimed with respect to energy and electricity used in the production of clean hydrogen without upsetting the ability to claim a Clean Hydrogen Production Tax Credit or Clean Hydrogen Investment Tax Credit.

In addition, following the passage of the IRA, an Investment Tax Credit under § 48 or § 48E may be available for facilities that store hydrogen energy.

Separately, for blue hydrogen, a Carbon Capture and Sequestration Tax Credit (§ 45Q) may be available with respect to the amount of carbon captured in the blue hydrogen production process. However, a taxpayer cannot take both the Carbon Capture and Sequestration Tax Credit and the Clean Hydrogen Production or Investment Tax Credit with respect to the same facility, so analysis is required as to which of the credits is expected to provide the greatest economic benefit.

Perhaps most importantly, the IRA provided for additional ways to monetize these tax credits. Taxpayers may elect for "direct payment" of a Clean Hydrogen Production Tax Credit or a Carbon Capture and Sequestration Tax Credit produced in the year the facility is placed in service and the following four tax years — effectively turning the tax credit into a cash payment from the Treasury. For all of the aforementioned credits (including any Clean Hydrogen Production Tax Credits or Carbon Capture and Sequestration Tax Credits produced after the direct pay period), taxpayers may elect to transfer such credits to a third-party buyer in exchange for cash (commonly known as "transferability").

Hydrogen Hubs

The Bipartisan Infrastructure Law, as enacted in the Infrastructure Investment and Jobs Act of 2021, created and allocated $8 billion to the Regional Clean Hydrogen Hubs program (also known as "H2Hubs") to facilitate the development of regional clean hydrogen hubs across the U.S. The goal is to have these hubs serve as bases to create a national hydrogen network. This program provides grants, cooperative agreements, and other financial arrangements for clean hydrogen projects ranging from production to end-use.

Proposed EPA Regulations

The Environmental Protection Agency ("**EPA**") Notice of Proposed Rulemaking for New Source Performance Standards for Greenhouse Gas Emissions from New, Modified, and Reconstructed Fossil Fuel-Fired Electric Generating Units; Emission Guidelines for Greenhouse Gas Emissions from Existing Fossil Fuel-Fired Electric Generating Units was published on May 23, 2023.[10] This standard is based on a proposed "Best System of Emission Reduction" or "BESR."

The EPA is proposing to create three subcategories of new or reconstructed fossil fuel-fired electricity generating units: a low load "peaker" subcategory (with a capacity factor below 20%); an intermediate load subcategory (with a capacity factor between 20% and a source-specific upper threshold, between 33% and 55%); and a base load subcategory (with a capacity factor above such threshold). For peaker units, the BESR focuses on lower emitting fuels (like natural gas and distillate oil).

However, the BESR for the intermediate load subcategory requires units to either install CCS that can reduce emissions by 90% by 2035 or co-fire 30% low-GHG hydrogen (by volume). The BESR for the base load category requires units to either install 90% CCS or co-fire 30% low-GHG hydrogen (by volume) *and* co-fire 96% low-GHG hydrogen by 2038. EPA's proposed definition of low-GHG hydrogen is hydrogen with a carbon intensity below 0.45 kg CO_2e/kg of hydrogen in conformity with IRA requirements. The EPA also proposed an analogous set of subcategories and BESRs for certain large existing fossil fuel-fired electricity-generating units.

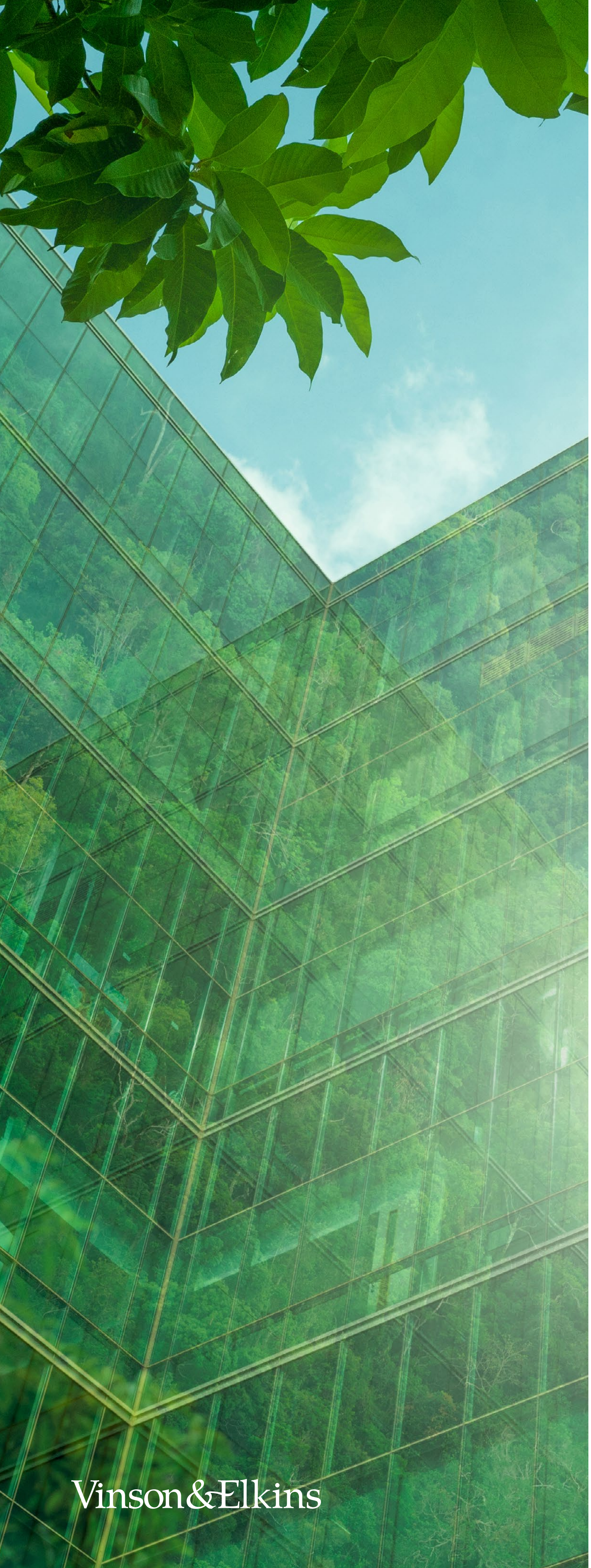
These regulations will obviously face opposition, and the impact of them on the energy sector and the economy as a whole will be debated. However, if implemented, these regulations would obviously be a powerful demand-side stimulus for the low-carbon hydrogen industry in the U.S.

The European Union

The E.U. has recognized the vital role that renewable hydrogen[11] will play in reaching its goals under the European Green Deal and the REPowerEU plan. In particular, the European Commission recently proposed two delegated acts under the Renewable Energy Directive (2018/2001) that define the scope of what constitutes renewable hydrogen in the E.U. The aim of these delegated acts is to provide renewable hydrogen project developers some degree of legal certainty as they seek regulatory compliance and governmental incentives.

Although there are many facets and paths to qualification as renewable hydrogen under these delegated acts, it is important to note two things. First, these proposed delegated acts apply to both domestic and imported renewable hydrogen. Therefore, a renewable hydrogen producer in the U.S. exporting hydrogen to the E.U. must satisfy the requirements set forth in the proposed delegated acts in order for the hydrogen to qualify as renewable. Second, the delegated acts in certain circumstances impose temporal, geographic, and "additionality" requirements.

The temporal and geographic requirements mean that the renewable electricity must be (i) produced and electrolyzed within the same one-hour period and (ii) produced in the same general geographic area as the electrolyzer. The additionality component seeks to ensure that renewable hydrogen is always made with new additional solar and wind energy installations and does not increase fossil fuel reliance. Another criterion for additionality is that the facility supplying the renewable power for hydrogen production cannot have received support in the form of "operating aid" or "investment aid."[12] It remains to be seen exactly what this restriction entails, and whether it would apply to any facility that received renewable hydrogen tax credits under § 45V or used renewable power from facilities that claimed U.S. investment tax credits or production tax credits.



Project Development

Large-scale hydrogen projects may run in the hundreds of millions to billions of dollars, and financing a hydrogen project is no small feat. The governmental incentives described above provide a potential cash flow stream to help hydrogen projects reach bankability, but developers will likely need debt and/or equity financing from third parties at the company and project levels. Hydrogen projects may involve a variety of financing structures, ranging from traditional tax equity investment in a manner similar to the traditional wind and solar space, to project finance loans in a manner similar to downstream assets like petrochemical facilities.

In the U.S., the novelty of financing some forms of hydrogen production facilities may be a space to be filled by the Department of Energy Loans Program Office. Regardless, a well-structured project with bankable agreements is necessary to attract financing.

In this regard, developing a hydrogen project requires specialized expertise on many fronts, some of which are outlined below:

- **Commodities Contracting:** Depending on the form of hydrogen production, hydrogen project developers and operators will need to source various forms of feedstock, including:
  - **Natural Gas Supply:** Similar to electricity, the use of natural gas as a feedstock also presents challenges, namely in the context of price variation and environmental risks. The price variation may be mitigated through fixed-price or hedge agreements. Depending on the release, leaking, or discharge of natural gas, however, there may be various fees and penalties that could be assessed, and this could also have an effect on a life-cycle GHG analysis.

Planned Phases for the Department of Energy's Regional Clean Hydrogen Program

★ Initial Application

◆ Go/No-Go Decisions

	Application	Phase 1: Detailed Plan	Phase 2: Develop, Permit, Finance	Phase 3: Install, Integrate, Construct	Phase 4: Ramp-Up & Operate
	Pre - DOE funding	Up to $10M DOE Funding, Non-Federal Cost Share ≥ 50%, 12-18 Months	TBD DOE Funding, Non-Federal Cost Share ≥ 50%, 2-3 Years	TBD DOE Funding, Non-Federal Cost Share ≥ 50%, 2-4 Years	TBD DOE Funding, Non-Federal Cost Share ≥ 50%, 2-4 Years
Engineering, Procurement, Construction, Operations	• Conceptual Design • Technical Readiness • Project Schedule • Total Project Cost Estimate	• Engineering & Design Documents • Technical Maturation Plans • Integrated Project Schedules	• Mature Engineering & Design • Technical Risk Management • Execution ready schedule & cost estimate, PM Tools • Operations Plan	• Ongoing execution reporting • Interim Go/No-Go reviews	• Ongoing performance Reporting • Technical risk updates, tracking • Final TPC accounting
Business Development & Management	• Business Strategy • Team Description • Workforce Plan • Finance Plan • Market potential analysis	• Project Management Plan • Risk Management Plan • Financial modelling • Site selection	• Finalized project structure, management, financing • Ongoing risk management • Final legal, workforce, procurement agreements • Feedstock & Offtake Plans	• Ongoing execution reporting • Ongoing risk management	• Updated financial analyses • Revised growth plans • Updated Risk Management
Permitting & Safety	• Safety history/culture description • Regulatory approval timeline overview	• Initial Hydrogen Safety Plan (HSP) & Site Safety Plan • Physical, Information, Cyber Security Plans • Environmental & Regulatory preparations	• Execution ready HSP and security plans • Permits & approvals in place for construction	• Ongoing permit, environmental, safety reporting • Permits & approvals in place for operations	• Ongoing permit, safety, and security reporting
Community Engagement & Impacts	• Initial Equity Plan addressing community engagement, Justice40, community consent or benefits agreements, job quality, workers rights, etc.	• Stakeholder engagement and Community Consent or Benefits Agreement drafts	• Finalized Equity Plan, Agreements • Community development targets identified, tracking plans	• Ongoing reporting on Equity Plan activities	• Revised community engagement plans for operations • Ongoing reporting and evaluation
Technical Data & Analysis	• Lifecycle Analysis • Techno-economic Analyses	• Project Production Model • Updated Lifecycle and Technoeconomic Analysis	• Final Lifecycle & Technoeconomic Analyses • V&V and Project Completion Testing Plans	• Periodic analyses updates • V&V data collection • Project completion testing and performance ramp V&V	• Validated performance model • Finalize lifecycle and technoeconomic analyses • Dissemination of analyses, lessons learned

Source: U.S. Department of Energy

— **Electricity:** In the case of electrolyzers, large amounts of electricity are needed to power the molecule separation of water. Operators need to be aware of daily and seasonal price variations, as well as the risk of locational marginal pricing and/or load shedding in the event of regional transmission or grid-level supply shortages. While the pricing may be mitigated through fixed-price or hedge contracts, the operator must be cognizant of potential interruptions to production in the event of electrical transmission or congestion challenges.

— **Water:** Electrolyzers use large amounts of water as a feedstock. Depending on the community where the electrolyzer is located, this can be a key consideration. If water resources are scarce, water prices may be high. Moreover, the applicable governmental authority may limit use of the water.

- **Offtake — Hydrogen and Refined Product Sales:** Hydrogen has been traditionally sold by industrial gas companies pursuant to long-term agreements. These long-term agreements are structured as supply contracts where as much as 75% of the cost of the hydrogen is paid regardless of the amount of hydrogen actually taken (commonly known as "Take or Pay"). This guarantees a source of revenue for the hydrogen supplier. As the hydrogen supplier market diversifies with new entrants into the space, it is an open question as to whether hydrogen suppliers can replicate that model in the future. Despite this, many developers see the merit in using low-carbon hydrogen not as a final product in and of itself, but as feedstock for fuels and ammonia. As such, frequent work with these products, their traditional offtakers, and their traditional markets will be key to securing a bankable offtake agreement for a project.

- **Construction and Operations:** The construction and operation of the production facility requires sophisticated knowledge. This means that developers and sponsors of projects should be selective in their use of EPC (engineering, procurement, and construction) or O&M (operations and maintenance) contractors to construct and operate the facility (respectively), as well as the terms of agreements with those contractors. Further, to qualify for certain state and local development incentives and U.S. tax credits, the hydrogen project may be required to comply with stringent wage and apprenticeship requirements, creating a need for labor expertise.

- **Carbon Capture and Sequestration ("CCS"):** In the case of blue hydrogen, CCS knowledge is required. While this can and often is delegated to third-party operators, hydrogen facility operators and sponsors should be aware of the technical challenges accompanying carbon capture, transport, and sequestration. Further, CCS requires a sophisticated legal approach, including taking into account land and title rights with regard to pore space, rights of way and easements, disruption of reservoir pressure, and the risk of carbon leakage. Carbon leakage can result in the recapture of § 45Q credits and environmental harms. There are not yet "market" approaches for the allocation of these liabilities among the facility developer that produces and captures carbon and the third party that transports and permanently sequesters it.

- **Tax:** Given that hydrogen production for at least the coming decade will be heavily driven by tax credit and liability considerations, hydrogen operators and sponsors must be keenly aware of the implications and compliance requirements of tax credits associated with hydrogen production and use and CCS.

- **Midstream Capabilities:** Hydrogen and the products derived from it, once produced, will need to be processed, transported, and stored. The same applies to carbon to the extent that it is produced for blue hydrogen. The operator of the hydrogen project and its sponsors need to be aware of the technical, financial, and legal implications behind these midstream processes.

- **Permitting and Environmental Issues:** Renewable projects and downstream projects alike face their own set of permitting issues. Hydrogen projects, which operate at the intersection of these two verticals, are likely to face the permitting issues inherent to both of them. In addition, the negotiation of site control documents necessitates an understanding of how liabilities for environmental conditions present at the site are typically allocated. Many site owners are reluctant to let developers engage in invasive testing for fear of the liabilities and obligations that may result if something is discovered. Nonetheless, when a developer begins to excavate, it is always possible that something will be discovered. Experience in navigating permitting processes and knowledge regarding the market for allocation of environmental liabilities is crucial to ensuring completion of a project.

Critical Negotiating Points

The U.S. hydrogen industry is still navigating what is "market" in the IRA era, especially with the entry of so many players in the area. As a result, some commercial and legal points can vary widely between transactions, and sometimes present traditional issues (such as change in law) or new issues entirely (such as ownership of environmental attributes). Some of the issues we are seeing develop in real time include:

- **Tax and Environmental Attributes:** What tax credit(s) and environmental attributes[13] are the parties pursuing? Which party gets which tax credit and/or environmental attribute and in what amounts? To what extent does a party have to cooperate to maximize tax benefits? In the event something goes wrong (*e.g.*, carbon leaking from permanent geological sequestration), who bears ultimate responsibility?

- **Pricing:** Parties should consider how to price a product that chemically speaking is indistinguishable from a commodity (*e.g.*, hydrogen, ammonia, and methanol), but has more value due to its low-carbon attributes. Commodity indices are not yet distinguishing between low-carbon commodities and traditional commodities. As such, the parties should consider other forms of pricing that focus on pass-through of costs or that share the value associated with environmental or tax attributes.

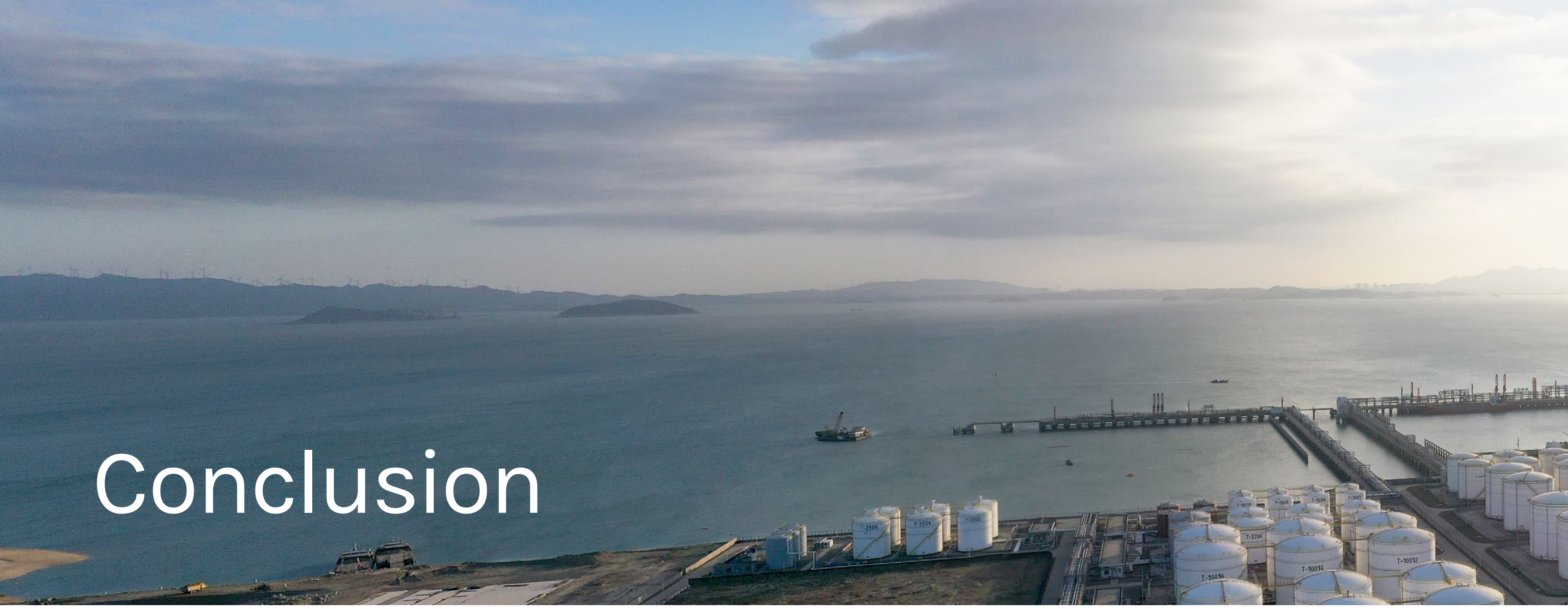
- **GHG Emissions:** What covenants should the parties undertake to mitigate GHG emissions in the production of hydrogen or other products, and what are the penalties for failing to do so? Oftentimes, requirements of the destination market will heavily influence the parties' obligations with respect to GHG mitigation. For example, Europe in many circumstances has more stringent requirements in this regard than most U.S. jurisdictions (other than California).

- **Change in Law:** In the event that there is a change in law that makes hydrogen production either more or less profitable, who benefits or is exposed? Similarly, who should bear the risk of changes in the applicable incentive schemes, especially if offtaker pricing is premised upon the existence of such incentives?

- **Specifications/Carbon Intensity:** Given that hydrogen is often used in complex applications, generally the hydrogen produced must meet precise specifications. Remedies for failing to meet these specifications should be considered. The carbon intensity of the product is often one specification that determines the ultimate value of the product and determines the availability of tax and environmental attributes. But if a product does not meet the required carbon intensity, it is still chemically the same product and can still be used. The purchaser, however, may not believe that a product that fails to meet the required carbon intensity is the product that it bargained for.

- **Certification:** The certification of hydrogen or derivative products as "low carbon," "green," or "blue" is an emerging area without a clear consensus. Some companies opt for their own certification regimes, while others look to third-party environmental consultants who can certify as to compliance with the requirements of certain jurisdictions.

- **Project-on-Project Risk:** Many hydrogen projects will involve project-on-project risk. For example, if a hydrogen production facility utilizing carbon capture comes online prior to the time when the intended permanent sequestration facility is ready to commence operations, then the project potentially will not be able to sell product with the desired environmental attributes to offtakers. In addition, the credit period under § 45Q may commence once the capture equipment is placed in service, but credits will not be generated until the sequestration facility is online. As another example, in a power-to-fuels project, the applicable renewable power generation facilities need to be ready in time for the hydrogen electrolyzers to start commissioning and testing, and then hydrogen electrolyzers must be online prior to the downstream fuel production assets that will consume the hydrogen. In other words, the failures or delays of an upstream project can imperil the success of downstream projects.



Conclusion

Low-carbon hydrogen is critically important for the energy transition, but deploying it at scale is no easy task, and doing so remains far from a reality. The vast majority of hydrogen is still produced through processes that emit large amounts of carbon dioxide. Infrastructure remains too thin — and is developing too slowly — to foster widespread adoption. And international regimes for sales, composition, tax, and permitting are uncertain or nonexistent.

Even so, momentum for low-carbon hydrogen has never been stronger — among both governments and companies. Both see its enormous potential for storing energy, for powering a wide array of applications, and for reducing GHG emissions, especially where doing so has proven difficult.

The task now is to unlock this potential. For project operators and sponsors, this means boosting investment in storage and transport infrastructure, taking advantage of government incentives, and forming project partnerships to mitigate risk, share knowledge, and keep costs manageable. Achieving all three could set in motion a golden era for low-carbon hydrogen and accelerate the energy transition.

Endnotes

1 The term "bankable" is an industry short-hand that means that the applicable item is able to attract financing.

2 In some cases, hydrogen is produced through coal gasification — "black hydrogen" if bituminous coal is used and "brown hydrogen" if it is lignite coal.

3 This is often referred to as "carbon black." Solid-state carbon is not vented into the atmosphere, but instead geologically sequestered or otherwise utilized for commercial purposes, including as a strengthening agent for the rubber, as an insulating agent, or as a pigment.

4 For example, consider whether a nominally "green" hydrogen production facility is still green if it draws solar power during the day and power from fossil fuel power plants at night.

5 References to "carbon intensity" and "carbon emissions" in this paper include not just carbon dioxide, but also other GHG molecules, such as methane, as evaluated on a proportional basis. For example, methane is a far more potent GHG, and as a result, the carbon intensity of methane production is subsequently greater.

6 Cost estimates are mere approximations that vary significantly depending on numerous factors. Suffice it to say, gray hydrogen, without some form of carbon tax, is cheaper to produce than its unsubsidized "clean" and/or green hydrogen counterparts.

7 Note, however, that the combustion of ammonia can lead to the release of nitrous oxides (NOx), which is an air pollutant and a GHG.

8 The vast majority of hydrogen pipelines in the U.S. are located along the Texas, Louisiana, and Mississippi coastlines, where hydrogen has been key to petrochemical refinery operations.

9 For a description of these requirements, see https://www.velaw.com/insights/treasury-issues-initial-inflation-reduction-act-labor-guidance/.

10 For the text of the proposed rule, see https://www.govinfo.gov/content/pkg/FR-2023-05-23/pdf/2023-10141.pdf.

11 The term "renewable hydrogen" is the more common term in E.U. policy instead of "clean hydrogen."

12 First Delegated Act, Article 5, Section 5.

13 The term "environmental attribute" generally refers to other valuable or marketable attributes inherent in a project produced via low-carbon means, such as the right to generate and sell compliance currencies (*e.g.*, RINs, LCFS credits, biotickets); rights to carbon accounting benefits; rights to generate carbon offsets; the right to market a product as "low carbon," "blue," or "green"; and other similar attributes, whether created by private parties or governmental authorities under color of law.

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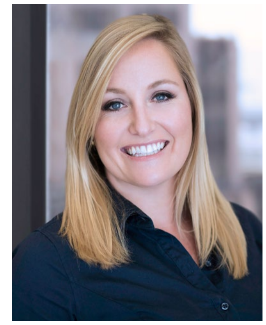

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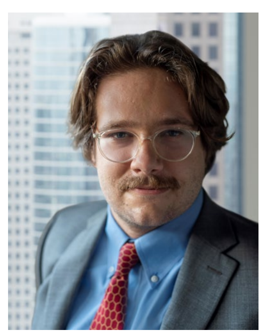

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Why Vinson & Elkins for Hydrogen?

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