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Hydrogen Regulation in the United States

Will Government Financial Incentives Outweigh Regulatory Hurdles?

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3.1 INTRODUCTION

The United States' support for hydrogen shifted in 2021 and 2022. Rather than focusing primarily on research, development, and demonstration projects, as in past decades, laws passed in 2021 and 2022 authorized $8 billion in grants plus lucrative tax credits to stimulate private investment in clean hydrogen. Another $1.5 billion will continue to support research. Under this approach, costs of production and adaptation for new uses will be reduced by government support while market development will be strongly influenced by private investors' decisions and interests.

In 2021, Congress also directed the US Department of Energy (DOE), the lead federal agency for hydrogen market development, to establish a national strategy and roadmap for hydrogen.[1] This was the first hydrogen strategy directive required by Congress since 2005.[2] The US National Clean Hydrogen Strategy and Roadmap (Roadmap), identifying the US government's goals for the production and use of hydrogen and the strategies for achieving those goals, was released in May 2023.[3]

Implementation of the 2021 and 2022 legislation is proceeding, but as of the date of this writing, there are still substantial regulatory gaps, including with respect to four discussed in this chapter: the definition of 'clean hydrogen' as applied to the tax credits; permitting reforms; regulation of the construction and operation of interstate hydrogen pipelines; and safety laws and harmonization of standards. This uncertainty as to if, how, and when various regulatory gaps will be resolved, and the impact that uncertainty will have on costs and sector growth, is unknown.

This chapter focuses primarily on the 2021 and 2022 federal legislation due to its potentially profound impact on the development of the hydrogen market. Section 3.2 will introduce the recent laws and the complex regulatory challenge of defining 'clean hydrogen'. Section 3.3 sets forth in more detail the policies and key laws through which the federal government intends to stimulate the hydrogen market. The private sector response to date to the hydrogen hub program

1 42 USC § 16161b.
2 42 USC §§ 16153, 16154.
3 US Department of Energy, 'US National Clean Hydrogen Strategy and Roadmap' (energy.gov, May 2023) <www.hydrogen.energy.gov/pdfs/us-national-clean-hydrogen-strategy-roadmap.pdf> accessed November 4, 2023 (hereinafter: Roadmap).

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is described in Section 3.4. Section 3.5 will discuss the regulation of hydrogen, with a focus on three areas of regulatory uncertainty that could impede market development.

Additionally, states can act independently from the US federal government to provide incentives or regulate in areas not pre-empted by the federal government. California, for example, has been a leader in promoting hydrogen use.[4] However, state actions are beyond the scope of this chapter.

3.2 WHAT IS 'CLEAN HYDROGEN'?

As referenced above, legislation passed in 2021 and 2022 provided significant financial support for clean hydrogen market development in the United States. The 2021 Infrastructure Investment and Jobs Act (IIJA, also called the Bipartisan Infrastructure Law) directed $9.5 billion to the DOE for hydrogen programs. The 2022 Inflation Reduction Act (IRA) included generous tax credits that could reduce the cost of investing in hydrogen production facilities or producing hydrogen by providing investors with a reduction in the income taxes they owe.[5] The tax credits are administered through the Internal Revenue Service, which is part of the US Treasury Department.

These financial incentives are intended for 'clean hydrogen'. But defining 'clean hydrogen' is not straightforward. The popular color-based hydrogen taxonomy has become increasingly complex as different technologies and fuel sources have sought their own hue, creating a rainbow of green, blue, grey, pink, brown, and turquoise hydrogen. The US government has eschewed the rainbow (or coloring-book) approach in favor of defining 'clean' by the kilograms of carbon dioxide equivalent emitted during production of a kilogram of hydrogen. This approach has the benefit of being both fuel and technology neutral, thus more easily accommodating new production methodologies. However, the statutes have different definitions for clean hydrogen.

The IIJA specifies that the terms 'clean hydrogen' and 'hydrogen' (as used in the IIJA) mean 'hydrogen produced in compliance with the greenhouse gas emissions standard' established by the DOE.[6] Through the IIJA, the US Congress instructed the DOE to set 'an initial standard for the carbon intensity of clean hydrogen production'[7] that would:

- support clean hydrogen production from 'fossil fuels with carbon capture, utilization, and sequestration; hydrogen-carrier fuels (including ethanol and methanol); renewable energy resources, including biomass; nuclear energy; and any other methods the Secretary [of DOE] determines to be appropriate',[8]
- define 'clean hydrogen' as 'hydrogen produced with a carbon intensity equal to or less than 2 kilograms of carbon dioxide equivalent produced *at the site of production* per kilogram of hydrogen produced', and
- 'take into consideration technological and economic feasibility'.[9]

[4] LegiScan, 'California Senate Bill 1075' (legiscan.com) <https://legiscan.com/CA/text/SB1075/2021> accessed December 1, 2022.

[5] Pub L 117–169 (2022), codified in relevant part, generally, at 26 USC §§ 45V, 48.

[6] 42 USC §16152(1).

[7] 42 USC § 16166.

[8] 42 USC §16154(e)(2) (internal subsection numbers omitted).

[9] 42 USC §16166(a)–(b)(1) (emphasis added).

Within five years after the initial standard for the carbon intensity of hydrogen production is set, the DOE must determine whether to lower the standard.[10]

The IRA defines 'qualified clean hydrogen' for use under the tax code as hydrogen produced in such a way as to result in *lifecycle greenhouse gas emissions* of no more than 4 kilograms of CO_2e (equivalent) per kilogram of hydrogen.[11] The IRA requires lifecycle emissions to be determined using the GREET (Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation) model developed by Argonne Laboratories.[12]

After receiving public comments, in June 2023 the DOE set the initial production standard for 'clean hydrogen' (often referred to simply as 'hydrogen') for the purposes of the programs it administers in a manner intended to harmonize with the IRA definition. The DOE's Clean Hydrogen Production Standard (CHPS):

> establishes a target for well-to-gate lifecycle greenhouse gas emissions of ≤4.0 kgCO2e/kgH2. The establishment of a well-to-gate target aligns with statutory requirements to consider not only emissions at the site of production but also technological and economic feasibility and to support clean hydrogen production from diverse energy sources . . . This target is also consistent with the IRA's definition of 'qualified clean hydrogen'. This target is likely achievable by facilities that achieve ≤2 kgCO2e/kgH2 at the site of production, which potentially have additional emissions from upstream and/or downstream processes.[13]

The well-to-gate boundaries, as illustrated in the DOE's guidance document, includes the emissions at each step, from feedstock extraction through production, including fugitive emissions, plus those related to sequestration (if applicable), but excludes component manufacturing and end use.[14] The DOE's endorsement of the GREET model is consistent with the IRA definition and is 'aligned with international best practices' as established through the International Partnership for Hydrogen and Fuel Cells in the Economy's Hydrogen Production Analysis Task Force.[15]

At the time of this writing, the Treasury Department, within which the Internal Revenue Service resides, has not yet issued its final regulations implementing a definition of 'qualified clean hydrogen' for use in the tax provisions it administers, although the IRA required it to do so by August 2023. Like the DOE, the Treasury has engaged in a notice-and-comment rulemaking procedure in which the public participates. A point of contention in the rulemaking is whether 'qualified clean hydrogen' that is produced from renewable resources must rely only on new renewable resources (referred to as 'additionality'), renewable resources that generate power during the same hours ('time matching'), and resources near the point of production. The underlying concern is that absent these constraints, the lucrative tax incentives will divert use of existing clean energy resources to hydrogen production, and thereby increase reliance on fossil

[10] 42 USC §16166(b)(2).

[11] 26 USC §45V(c)(2)(A) (emphasis added). The IRA requires that lifecycle greenhouse gas emissions 'shall only include emissions through the point of production (well-to-gate), as determined under the most recent [GREET] model'. 26 USC §45V(c)(1)(B).

[12] *See* US Department of Energy, GREET: The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model (energy.gov, May 16, 2019) <www.energy.gov/eere/bioenergy/articles/greet-greenhouse-gases-regulated-emissions-and-energy-use-transportation> accessed November 4, 2023.

[13] US Department of Energy, 'Clean Hydrogen Production Standard (CHPS) Guidance' (June 2023) 2–3 <www.hydrogen.energy.gov/pdfs/clean-hydrogen-production-standard-guidance.pdf> accessed November 4, 2023.

[14] Ibid 4.

[15] Ibid 5.

fuels to meet other demands on the grid.[16] Other details also need to be resolved by the regulations, such as the method for determining if a project started construction and became operational within the period to which the tax credits apply. Once all the regulations implementing the tax benefits in the IRA are decided, investors will be better able to assess the financial viability of their planned projects.

3.3 US POLICY AND LAW PROMOTING PRODUCTION AND USE OF HYDROGEN

3.3.1 *The Big Picture*

The Biden administration's hydrogen policy is part of its broader effort to stimulate the US economy through investment and job growth across a wide range of clean energy sectors. Concurrently, the Biden administration is implementing its Justice40 initiative, which promotes energy justice and economic equity.[17] These cross-cutting themes of job growth, justice, and equity are reflected in the DOE's Roadmap and its criteria for awarding grants and other government funding. They are also evident in the structure of the IRA laws, which provide enhanced tax incentives for investing in lower-income communities or communities that have lost jobs due to recent reductions in fossil fuel production and for paying 'fair wages' (typically union wages) and providing job training.

3.3.2 *The DOE Roadmap: Hydrogen Goals and Strategies*

The US National Clean Hydrogen Strategy and Roadmap, published by the DOE in 2023, states how the federal government foresees sector growth over the coming decades, obstacles that need attention, and goals and strategies to guide further government actions. The Roadmap projects that 'clean hydrogen' production and use will contribute 10 percent of the emissions reductions required by the US Long-Term Climate Strategy by 2050.[18] Specific goals include: an increase in annual clean hydrogen production and use to 10 million metric tons (MMT) by 2030, 20 MMT by 2040, and 50 MMT by 2050; and creation of 100,000 new jobs by 2030 and 450,000 new jobs cumulatively by 2050.[19] For context, as of 2022, the United States produced only about 10 MMT of hydrogen per year.[20] Ninety-five percent of that was produced with steam-methane reforming processes using natural gas.[21]

[16] Adithya Bhashyam, 'US Hydrogen Guidance: Be Strict or Be Damned', Bloomberg NEF (September 21, 2023) <https://about.bnef.com/blog/us-hydrogen-guidance-be-strict-or-be-damned/#:~:text=Most%20prominent%20among%20these%20is,in%20the%20US%20by%202030> accessed November 3, 2023. On December 26, 2023, the IRS issued proposed regulations addressing these points, the definition, and other implementation details. US Internal Revenue Service, 'Notice of Proposed Rulemaking: Section 45V Credit for Production of Clean Hydrogen; Section 48(a)(15) Election to Treat Clean Hydrogen Production Facilities as Energy Property (REG-117631-23)', 88 FR 89220 (26 December 2023) <https://federalregister.gov/documents/2023/12/26/2023-28359/section-45v-credit-for-production-of-clean-hydrogen-section-48a15-election-to-treat-clean-hydrogen> accessed January 11, 2024.

[17] The White House, 'Justice40' (whitehouse.gov) <www.whitehouse.gov/?environmentaljustice?/justice40/> accessed November 4, 2023.

[18] Roadmap 1.

[19] Ibid.

[20] US Department of Energy, 'Hydrogen Production' (energy.gov) <www.energy.gov/eere/fuelcells/hydrogen-production> accessed November 4, 2023.

[21] US Department of Energy, 'Hydrogen Production: Natural Gas Reforming' (energy.gov) <www.energy.gov/eere/fuelcells/hydrogen-production-natural-gas-reforming> accessed November 4, 2023.

The Roadmap also sees the United States playing an 'important role' in creation of a global hydrogen market having 'the potential for $2.5 trillion in annual revenue and 30 million jobs … along with 20 percent global emissions reductions by 2050'.[22] Advances in the cost-effective production and deployment of hydrogen in the United States would provide leadership for other countries.

To facilitate the growth needed to meet the goals set forth in the Roadmap, the DOE offers three strategies:

1. 'Target Strategic, High-Impact Uses of Clean Hydrogen.' These uses are primarily industries that require high-temperature processes that cannot be electrified, and thus are otherwise difficult to decarbonize, such as steelmaking and chemical manufacturing.[23]
2. 'Reduce the Cost of Clean Hydrogen.' Cost reductions are sought throughout the supply chain.
3. 'Focus on Regional Networks.' Using IIJA funding (described below), the DOE's strategy is to develop multiple clusters or 'hubs' of hydrogen producers and users in diverse regions of the country that over time would scale up and then spread into a nationwide network.[24] By clustering, participants would be better positioned to share infrastructure, and the region would offer multiple opportunities for job seekers in the hydrogen field at multiple companies.[25] Hubs would also help develop understandings at a regional level of potential synergies (or lack) between hydrogen and electrification, and electric sector evolution that takes into account regional resources and needs.[26]

As envisioned in the Roadmap, industrial uses of hydrogen could expand to include steel and cement manufacturing, industrial heat, and production of bio or synthetic fuels.[27] In addition to hydrogen's current use for forklifts, buses, and light-duty vehicles, the Roadmap points to potential uses for hydrogen in the transportation market for medium- and heavy-duty vehicles, rail, maritime, aviation, and offroad equipment used in mining, construction, and agriculture. Hydrogen could also be used for long-term storage of renewable energy[28] and to integrate renewable intermittent resources into the grid.[29] Blending hydrogen with other fuels in greater amounts than today opens other potential uses in power generation and buildings.[30] The Roadmap asserts that the potential for a significant use of electrolysis in hydrogen production would also simulate growth in clean energy.[31] Cost-competition from dirtier fuels (in the absence of mandates to use clean fuels) remains a concern[32] as does additionality.[33]

The primary obstacles to market growth identified in the Roadmap, based on data collected in September 2021, are the cost to end-users and infrastructure development. The tax incentives in the IRA were not known at the time this data was collected, and therefore are not factored in. Specific issues with expansion identified by the DOE are the compatibility of hydrogen with

[22] Roadmap 5.
[23] Ibid 1, 29–38.
[24] Ibid 48–57.
[25] Ibid 1.
[26] Ibid 26.
[27] Ibid 17.
[28] Ibid 6.
[29] Ibid 17.
[30] Ibid 17.
[31] Ibid 5.
[32] Ibid 31.
[33] See above, text at n 16.

materials and existing fuel transportation methods, such as pipelines and tube trailers, and delays in permitting[34] (which is of general concern in the energy sector). National standards for blending limits, and harmonization of codes and standards, are also important to establishing a national market.[35] Multiple other concerns were identified by the DOE that could affect market growth, including the need for technology advancement; competing technologies; safety concerns; and a lack of suitable end uses.[36] The Roadmap calls for a 'whole of government approach' to address these concerns and asserts the federal agencies will coordinate an efficient response[37] without specifying how that will be accomplished.

Importantly, demand for hydrogen must increase along with production. The Roadmap points to several demand-side measures needed to achieve the DOE's goals for hydrogen, including standard terms for offtake agreements, price transparency,[38] and certainty of supply.[39]

3.3.3 *Research, Development, and Commercialization Programs*

The US government has supported research and development for hydrogen since the 1970s.[40] Building on this history, the 2021 IIJA authorized several new programs encouraging development of hydrogen as an alternative energy source. While authorizations vary by program, generally the DOE is authorized to provide grants, contracts, loans, or cooperative agreements to eligible entities to carry out the work under its major initiatives,[41] subject to the DOE's standard cost-sharing requirements.[42]

The centerpiece of the IIJA's hydrogen support is a four-year, $8 billion grant program for Regional Clean Hydrogen Hubs.[43] These hubs would link hydrogen producers and consumers through connective infrastructure (for example, pipelines, truck routes) to demonstrate the potential for a national clean hydrogen network and accelerate its development. Each funded hub is expected to produce clean hydrogen as defined in the IIJA. The IIJA requires funding of at least four hubs and specifies that production facilities at the four initial hubs must include one fueled by nuclear energy, one from renewable fuels, and one from fossil fuels. End-use demonstrations must also be diversified across industry use, electric power generation, residential and commercial heating, and transportation, and the hubs are to be geographically diverse.[44] In September 2022, the DOE put out its first call for hydrogen hub proposals. The request and response are discussed in Section 3.4.

34 Roadmap 25, 69.
35 Ibid 69.
36 Ibid 24.
37 Ibid 28.
38 Ibid 50.
39 Ibid 24, 50.
40 See US Department of Energy, 'Hydrogen Program: Background' (energy.gov) <www.hydrogen.energy.gov/about/background> accessed 4 November 2023; Kim Talus, Maxwell Martin, 'A Guide to Hydrogen Legislation in the USA: A Renewed Effort', J of World Energy Law & Business (September 24, 2022) <https://academic.oup.com/jwelb/article/15/6/449/6713813> accessed November 4, 2023; Michael Connolly, 'United States: Development in Hydrogen Production, Technology and Use under the Energy Policy Act of 2005', Thelen LLP (January 3, 2006) <https://mondaq.com/unitedstates/chemicals/36954/developments-in-hydrogen-production-technology-and-use-under-the-energy-policy-act-of-2005?signup=true> accessed November 4, 2023.
41 See, *e.g.*, 42 USC § 16161c, 42 USC § 16161d(f).
42 42 USC § 16164; 42 USC § 16352.
43 42 USC § 16161a; US Department of Energy, 'Regional Clean Hydrogen Hubs' (energy.gov) <www.energy.gov/oced/regional-clean-hydrogen-hubs> accessed November 4, 2023.
44 Ibid.

Another important DOE program that was revitalized with IIJA funding is the Clean Hydrogen Research and Development Program (formerly the Hydrogen Program Plan).[45] The IIJA provided $500 million for research, development, and demonstration of 'clean hydrogen production, processing, delivery, storage, and use equipment manufacturing technologies and techniques', including recycling of fuel cells[46] and a four-year $1 billion program for the commercialization and deployment of electrolyser for production of clean hydrogen.[47] The research enabled by the new IIJA funding complements the DOE's work under another program, administered by the DOE in tandem with the Clean Hydrogen Research and Development Program but adopted as part of the 2021 American Rescue Plan, called Clean Hydrogen Energy Shot. Its objective is to reduce the cost of clean hydrogen production by 80 percent, to achieve the goal of $1 per 1 kg of hydrogen in one decade.[48] The IIJA also included funding for training programs for the hydrogen workforce.[49] Another IIJA allocation, directed to the Department of Transportation for alternative fueling infrastructure, could support hydrogen development, but is not earmarked exclusively for hydrogen.[50]

3.3.4 *Tax Incentives to Attract Private Investment*

The Inflation Reduction Act of 2022 supports clean hydrogen by creating a new tax credit for hydrogen production and expanding existing tax credits for investment in clean hydrogen production facilities.[51] Tax incentives to invest in complementary technologies, such as carbon capture and storage, are also included in the IRA. There is no limit to how many qualifying investments can be supported by the tax credits, although there are limits on stacking credits on a single project.

The new production tax credit (PTC) applies to 'qualified clean hydrogen produced by the taxpayer … at a qualified clean hydrogen production facility'.[52] The PTC is available for a period of ten years after the date the facility is placed in service. Construction of the facility must begin before January 1, 2033. The hydrogen must be produced in the United States (or its possessions) in the ordinary course of business, for sale or use, to qualify for tax credits. The maximum available credit is $0.60/kg (subject to adjustment for inflation),[53] but the applicable percentage a taxpayer may claim is scaled, as shown in Table 3.1.

Thus, lower emissions will result in a higher credit. The credit can be increased by a factor of five if construction of the facility complies with certain labor and wage requirements and Justice40-related criteria.[54]

45 US Department of Energy, 'Hydrogen Program Plan' (energy.gov, November 2020) <www.hydrogen.energy.gov/pdfs/hydrogen-program-plan-2020.pdf> accessed November 4, 2023.
46 42 USC § 16161c.
47 42 USC § 16161d.
48 US Department of Energy, 'Hydrogen Shot' (energy.gov) <www.energy.gov/eere/fuelcells/hydrogen-shot> accessed November 4, 2023.
49 US Department of Energy, 'DOE Announces $1.5 Million to Train the Next-Generation Hydrogen Workforce' (energy.gov, November 10, 2022) <www.energy.gov/eere/fuelcells/articles/doe-announces-15-million-train-next-generation-hydrogen-workforce> accessed November 5, 2023.
50 23 USC §151.
51 26 USC §45V, §48.
52 26 USC § 45V.
53 26 USC § 45V(b).
54 26 USC § 45V(e).

TABLE 3.1 *Applicable clean hydrogen production tax credit by emissions level*

Kilograms of CO2e per kilogram of hydrogen		Applicable percentage of credit
Equal to or not greater than 4 kg	Not less than 2.5 kg	20
Less than 2.5 kg	Not less than 1.5 kg	25
Less than 1.5 kg	Not less than 0.45 kg	33.4
Less than 0.45 kg		100

TABLE 3.2 *Applicable clean hydrogen investment tax credit by emissions level*

Kilograms of CO2e per kilogram of hydrogen		Applicable percentage of eligible investment
Equal to or not greater than 4 kg	Not less than 2.5 kg	1.2
Less than 2.5 kg	Not less than 1.5 kg	1.5
Less than 1.5 kg	Not less than 0.45 kg	2.0
Less than 0.45 kg		6.0

This PTC may not be combined with credits under 26 USC §45Q, which incentivizes carbon capture and storage.[55] However, investors may combine the PTC with a tax credit for clean energy or zero-emission nuclear power production.[56] Certain other limitations apply.

As an alternative to the PTC, investors in a hydrogen production facility can elect to take an Investment Tax Credit (ITC) under 26 USC §48(a)(15) of the tax code. This credit allows the taxpayer to reduce its taxes based on its initial investment in the production facility rather than on the annual production of hydrogen. Like the PTC, the ITC incentive uses a tiered approach, tying the tax incentive received to the level of lifecycle greenhouse gas emissions (Table 3.2).

The statutory language further indicates that energy properties are eligible for certain multipliers and additions, which, if made available, would increase the value of the investment tax credit substantially, potentially to a level of 50 percent of the investment.[57] Those multipliers and additions are granted if construction of the facility complies with certain labor and wage requirements;[58] meets certain domestic content requirements;[59] or is located in an 'energy community'.[60] An 'energy community' is, generally speaking, a community adversely affected by the transition away from fossil fuels.[61] These provisions promote the Biden administration's Justice40 and US economic growth policies. The project may not claim the ITC and the PTC for the same facility or combine it with the credit for carbon capture and storage.

Subject to various limitations, the entity entitled to receive the PTC or ITC may transfer the credit for value, tax-free,[62] or treat it as a direct payment of taxes.[63] This flexibility to monetize the tax credits is valued by entities that are tax-exempt, such as governmental bodies or non-profit organizations, or that otherwise are not yet profitable enough to owe taxes, and increases the number of potential investors.

[55] 26 USC §45V(d)(2).
[56] 26 USC § 48V(a)(15)(B).
[57] 26 USC §48(a)(9); 26 USC §48(a)(10), (11), (13), (14).
[58] 26 USC §48(a)(10)–(11).
[59] 26 USC §48(a)(13).
[60] 26 USC §48(a)(14).
[61] 26 USC §45(b)(11)(B).
[62] 26 USC §6418(a); 26 USC §6418(f)(1)(A)(v), (ix).
[63] 26 USC §6417; see also US Internal Revenue Service, 'Request for Comments on Elective Payment of Applicable Credits and Transfer of Certain Credits' (Notice 2022-50, irs.gov, October 5, 2022) <www.irs.gov/pub/irs-drop/n-22-50.pdf> accessed November 3, 2023.

3.4 INDUSTRY, HYDROGEN HUBS, AND GROWTH

As noted above, presently, production and demand for hydrogen in the United States is small compared to DOE goals for the sector's growth. Hydrogen produced in the United States is used mostly in petroleum refining and ammonia production.[64] However, fuel cells, forklifts, and fleet vehicles are growing sectors (which the DOE has supported with funding under prior laws).[65] There is also a small but burgeoning use in the energy sector. As of October 2021, hydrogen fuel cells accounted for about 260 megawatts (MW) of electric generating capacity, and at least two companies were already planning to blend hydrogen with natural gas to fuel natural-gas-fired electric generators.[66] Industry, and state and local governments in California have been promoting the use of hydrogen vehicles since 1999.[67]

The DOE's $8 billion hydrogen hub program and the IRA tax incentives are critical to reaching the commercial scale and momentum needed to transform this small sector into one that fulfills the US goals for clean hydrogen.[68] In September 2022, the DOE issued a funding opportunity announcement offering $7 billion of the $8 billion authorized to fund between six and ten hubs.[69] The solicitation required a 50 percent non-federal cost share, meaning that the participants would have to place a significant amount of their own money at risk. The period for execution, expected to be 8–12 years, would depend on the complexity of the hubs proposed. Funding would be dispersed in four tranches, based on the work accomplished.[70] The DOE applied the following evaluation criteria: technical merit; financial and market viability; the workplan, including how quickly the hub would build out production and expand end-use markets; the management team and partners; and its community benefits plan, including workforce development, jobs, and support for Justice40 initiatives.[71]

In response to the funding opportunity announcement, the DOE received eighty expressions of interest. It encouraged thirty-three of the eighty to submit applications. In October 2023, the DOE selected seven projects for further negotiation. If all are successfully developed, the anticipated total investment would be nearly $50 billion; and they would produce 3 MMT of hydrogen annually and reduce carbon dioxide emissions by 25 MMT by displacing use of other fuels.[72] The hubs alone will not fulfill the goals set forth in the DOE Roadmap, but they are expected to produce about 30 percent of the 2030 production goal and demonstrate the viability of hydrogen.[73]

64 US Department of Energy, 'Hydrogen Production' (energy.gov) <www.energy.gov/eere/fuelcells/hydrogen-production> accessed November 4, 2023.

65 International Partnership for Hydrogen and Fuel Cells in the Economy, 'United States' (IPHE May 2022) <www.iphe.net/united-states> accessed November 3, 2023.

66 US Energy Information Administration, 'Hydrogen Explained' (eia.gov) <https://eia.gov/energyexplained/hydrogen/use-of-hydrogen.php> accessed November 4, 2022.

67 Hydrogen Fuel Cell Partnership, 'About Us' (h2fcp.org) <https://h2fcp.org/> accessed November 3, 2023.

68 IRA incentives can be used independently of the hydrogen hub program as well.

69 US Department of Energy, 'Funding Notice: Regional Clean Hydrogen Hubs' (energy.gov) <www.energy.gov/oced/funding-notice-regional-clean-hydrogen-hubs> (accessed November 4, 2023).

70 Ibid.

71 US Department of Energy, 'Bipartisan Infrastructure Law: Additional Clean Hydrogen Programs (Section 40314): Regional Clean Hydrogen Hubs Funding Opportunity Announcement, DE-FOA-0002779 FOA Type: Mod 000002' (issued September 22, 2022) 91–95 (hereinafter: FOA).

72 US Department of Energy, 'Biden–Harris Administration Announces $7 Billion for America's First Clean Hydrogen Hubs, Driving Clean Manufacturing and Delivering New Economic Opportunities Nationwide' (energy.gov, October 13, 2023) <www.energy.gov/articles/biden-harris-administration-announces-7-billion-americas-first-clean-hydrogen-hubs-driving#:~:text=WASHINGTON%2C%20D.C.%20%E2%80%94%20As%20part%20of,%2Dcost%2C%20clean%20hydrogen%E2%80%94a> accessed November 4, 2023.

73 Ibid.

TABLE 3.3 *Summary of hub proposals selected for further negotiation, 2023*

Hub	Fuel/technology	Consumers	Additional research goals
ARCH2 (Appalachian region)	Natural gas with carbon capture and storage. Emphasis on hydrogen pipelines.	Fueling stations and other end-uses.	Reduce distribution and storage costs.
ARCHES (California)	Renewable energy and biomass.	Decarbonize transportation and ports and prepare ports for potential export of hydrogen. Generation.	Reduce carbon emissions in hard-to-decarbonize sections of the transportation system. Support tribal power needs.
HyVeloicty H2Hub (Texas)	Natural gas with carbon capture and storage and electrolysis from renewables.	Fuel cell electric trucks, industrial processes, ammonia, refineries and petrochemicals, and marine fuel.	Lower cost of distribution and storage to reach more users. Salt cavern storage.
Heartland Hub (Minnesota, North and South Dakotas)	The region's 'abundant energy resources'.	Co-firing for generation, clean fertilizer.	Decrease regional cost of hydrogen; use open-access storage and pipeline infrastructure.
Mid-Atlantic – MACH2 (Pennsylvania, Delaware, New Jersey)	Electrolysis using renewable and nuclear energy.	Heavy transport, manufacturing and industrial, CHP.	Repurpose oil infrastructure. Develop distribution and fueling infrastructure. Innovative electrolyser technologies.
Midwest (Illinois, Indiana, Michigan)	Mixed resources.	Strategic hydrogen uses including steel and glass production, power generation, refining, heavy-duty transportation, and sustainable aviation fuel.	
PNWH2 (Washington, Oregon, Montana)	Electrolysis using renewables.	Heavy duty transportation, industry generation, fertilizer, seaports.	Coordinated with ARCHES to create a west coast hydrogen transportation corridor.

The participants in each hub vary, but typically consist of a consortium of private companies and state and local governments. The primary features of their proposals, as set forth in the DOE-issued descriptions, are summarized in Table 3.3.[74]

While the response of industry to the hydrogen hub solicitation is encouraging, there are still many points of contention. The industry is not yet mature enough to immediately begin producing hydrogen that accords with the DOE's CHPS (the definition discussed in Section 3.2 above) and apply it in hard-to-decarbonize industries. As discussed above, advocates of additionality and hourly matching want users of renewable energy to build new renewable

[74] Ibid; US Department of Energy, 'Regional Clean Hydrogen Hubs Selections for Award Negotiations' (energy.gov) <www.energy.gov/oced/regional-clean-hydrogen-hubs-selections-award-negotiations> accessed November 5, 2023.

resources for hydrogen production, and match hydrogen production to periods of electricity generation from these resources. An industry group argues that such measures will 'stop the clean hydrogen industry' before it gets started. It points to the delays in permitting and interconnecting new renewable generation as an impediment to accessing enough clean energy fast enough to scale hydrogen at the rate needed to meet climate goals.[75] Other industry advocates have suggested that policies and law should encourage growth in sectors where hydrogen already has a foothold, such as forklifts, and phase in the CHPS and decarbonization of hard-to-decarbonize sectors over time.[76]

In sum, the legislation discussed in Section 3.3 has elicited a positive response from industry and provides the United States with the potential for tremendous sector growth.[77] The varied goals of the hub applicants generally align with the Roadmap goals. However, industry members are concerned that some of the legal standards will be set too high to meet at the outset and will derail growth before it begins. As will be described in the following section, there are other regulatory issues as well.

3.5 REGULATORY CONCERNS

3.5.1 *Regulatory Overview*

The DOE, acting through the Sandia National Laboratory, has evaluated the applications of hydrogen that are subject to, or potentially subject to, federal regulation under existing law.[78] The DOE found that hydrogen is covered by many existing regulations, and as many as fifteen different agencies may have jurisdiction at various points in the supply chain.

Emerging uses for hydrogen, including in the consumer sector, will test whether the regulatory framework is adequately comprehensive and flexible, and harmonized sufficiently to facilitate sector growth. A complete analysis is beyond the scope of this chapter. However, the DOE's Roadmap references particular concerns with permitting, safety, and harmonization. Permitting and regulation for new pipelines, in particular, have been subject to vigorous public debate. Because permitting, pipeline regulation, and safety all raise critical and cross-cutting concerns and have been subject to recent study and discussion, they are addressed below.

3.5.2 *Permitting Reform*

Siting of infrastructure is frequently mentioned as critical to the advancement of the hydrogen economy. Infrastructure includes production facilities, pipelines, fueling stations, and transfer terminals. Siting decisions are also critical to the safety, health, and welfare of the public and to the health of the environment. While acceleration of the process for securing permits is important for meeting the aggressive timelines for build-out of the hydrogen sector and other infrastructure needed to reduce greenhouse gas emissions (such as transmission lines to move

[75] Fuel Cell & Hydrogen Energy Association (cleanhydrogentoday.org) <www.cleanhydrogentoday.org/?gclid=CjwKCAjwkY2qBhBDEiwAoQXK5WlKq-4bMJ7icsySp768e1dI38ZKRio8LlILGYIsKItBCOUusxCqfRoCoAIQAvD_BwE> accessed November 3, 2023.
[76] Meghan Briggs, Donna M Attanasio, 'Is the Hydrogen Economy Here? A Summary of Experts' Views from Inside the Beltway' (2023) 2–3 (unpublished conference report).
[77] 42 USC § 16161d.
[78] Austin R Baird, Brian D Ehrhart, Austin M Glover, and Chris B LaFleur, 'Federal Oversight of Hydrogen Systems' (Sandia National Laboratories, 2021) <www.osti.gov/servlets/purl/1773235> accessed November 5, 2023.

renewable energy to load centers), faster timelines can also have unintended and adverse impacts on the environment; cultural or historical sites; people, including environmental justice communities; navigation of aircraft or ships; or recreational areas.

With an important exception for certain pipelines, discussed in Section 3.5.3, decisions about where infrastructure may be placed is largely a matter for state and local jurisdictions. However, even where state or local entities are the primary decision-maker, the federal government has a role, since siting requires compliance with federal environmental statutes, where applicable. For example, where federal funds are used, as in the hydrogen hubs, the National Environmental Policy Act could be implicated.[79]

Accelerating the timeline for permitting new infrastructure through federal action has been pressed in Congress for several years, with members both advocating for, and adverse to, streamlining the process. As of May 2023, there were at least six proposed bills in various stages of development in Congress.[80] One issue is whether only infrastructure for clean energy should be accelerated or all infrastructure. The permitting discussion, except as discussed in Section 3.5.3, is not exclusive to the hydrogen sector and it is unclear whether or if reforms will be forthcoming. However, it is one of the factors often cited as a possible obstacle to achieving the full potential of the hydrogen market.

3.5.3 *Jurisdiction over Interstate Pipelines*

Transportation of hydrogen is a critical link in the supply chain that affects how and where the hydrogen production and use markets will evolve, the cost, and the accessibility of hydrogen for projected uses. Pipelines are the most economic form of land-based transport for large quantities of hydrogen.[81] Therefore the process for the development and regulation of a pipeline network is of great concern, and presently unresolved. The potential applicability of as many as three existing regulatory structures have been suggested as discussed in the following subsection, 'Which Regulatory Structure Applies?'[82] The burdens and benefits of regulation would vary depending on which scheme applies, are explained in 'The Importance of the Debate'. The potential pathways forward are discussed in 'Pathway to Resolution?'

Which Regulatory Structure Applies?

The United States has a comprehensive regulatory scheme for the transportation of commodities in interstate commerce by pipeline. The Interstate Commerce Act, as amended by the Hepburn Act in 1906 (ICA) vested authority to regulate *all* interstate pipelines, except those carrying natural gas or water, in a single federal agency, the Interstate Commerce Commission (ICC).[83] In 1938, the Natural Gas Act (NGA) placed regulation of interstate natural gas pipelines under the jurisdiction of the Federal Power Commission. That authority transferred in 1977 when the Federal Power Commission was replaced by the Federal Energy Regulatory Commission (FERC).[84]

79 FOA 143–145.

80 Sustainable Energy & Environment Coalition 'What Is Permitting Reform? Here's a Cheat Sheet' (seec.house.gov, May 24, 2023) <https://seec.house.gov/media/in-the-news/what-permitting-reform-heres-cheat-sheet> accessed November 4, 2023.

81 Congressional Research Service, Pipeline Transportation of Hydrogen: Regulation, Research, and Policy (R46700, 2021) 5 (hereinafter: CRS Report).

82 William G Bolgiano, 'FERC's Authority to Regulate Hydrogen Pipelines under the Interstate Commerce Act,' 43 Energy L J 1, 19 (2022) (hereinafter: Bolgiano).

83 Ibid.

84 See generally 15 USC §§ 717–717z.

In 1977, authority over oil transportation under the ICA was also transferred to FERC, taking advantage of FERC's deep expertise in energy markets.[85] The remainder of the pipeline regulatory authority that had been contained in the ICA was recodified, and in 1995 placed under the Surface Transportation Board (STB); and the ICC was abolished.[86] Because the federal regulatory regime is comprehensive, hydrogen must be covered, even though not explicitly singled out.[87] Where and how is less clear.

The question of which regulatory structure applies to hydrogen stems from its versatility. Natural gas has a specific yet ambiguous meaning under the NGA: '"Natural gas" means either natural gas unmixed, or any mixture of natural and artificial gas.'[88] Because hydrogen in a pure form does not often occur naturally, pure hydrogen is (arguably) not 'natural gas'.[89] Further Congress understood 'artificial' gas as used in the NGA to have a very specific meaning that did not include pure hydrogen.[90] If hydrogen is not a natural gas, and if hydrogen is not blended with natural gas, then transportation of it by pipeline is (arguably) outside of FERC's NGA jurisdiction. It would instead remain subject to regulation by the STB. This approach is consistent with the fact that hydrogen has uses other than as an energy carrier, for example as a feedstock.

But the issue is not that clear-cut. Reading 'natural gas' as excluding gases not primarily composed of methane may be unnecessarily narrow. For example, a 1960 act explicitly excluding helium from FERC's NGA jurisdiction would have been unnecessary if the definition of natural gas had been read so narrowly.[91] Further, one readily available use for hydrogen is blending it with natural gas. In some cases, natural gas pipelines and other equipment are believed to be physically able to tolerate blends of up to 20 percent hydrogen.[92] A blend of hydrogen and natural gas would fit the NGA's definition of natural gas and be regulated by FERC.

A third possibility is that FERC should regulate hydrogen under the same ICA authority under which FERC regulates oil. The ICA authority granted to FERC in 1977 extended to 'pipeline transportation of crude and refined petroleum and petroleum byproducts, derivatives or petrochemicals'.[93] Proponents of this view argue that FERC's authority over oil has previously been read broadly to encompass other energy products;[94] and hydrogen is often derived from petroleum products and fits well with FERC's expertise because hydrogen is presently valued for its energy content.[95] From a policy perspective the ICA requires oil pipelines to be common carriers, ready to serve all comers, which would facilitate the emergence of this new market.[96] However, treating hydrogen as 'oil' under the ICA would lead to the problem of 'bifurcated

[85] Bolgiano 18; 49 USC § 60502.
[86] Bolgiano 29–30.
[87] Ibid 24.
[88] 15 USC §717a(5); Bolgiano 22–28, 30.
[89] Michael I Diamond, 'Jurisdiction over Hydrogen Pipelines and Pathways to an Effective Regulatory Regime', EBA Brief Vol 3, Issue 2, 6 (Energy Bar Association, Fall 2022) (hereinafter: Diamond).
[90] Bolgiano 77; *but see* Diamond 6.
[91] Diamond 3–4.
[92] CRS Report 4.
[93] Bolgiano 28 (quoting S. REP. NO. 95-367, at 69 (1st Sess. 1977) (Conf. Rep.); H.R. REP. No. 95-539, at 69 (1st Sess. 1977) (Conf. Rep.)).
[94] Bolgiano 68.
[95] Ibid 16, 68.
[96] Richard E Powers, Jr., Testimony before S. Comm. On Energy & Nat. Res. 5–12 (July 19, 2022) <https://energy.senate.gov/services/files/542E24C8-F2A2–4483-869F-1201C6E7D9FD> accessed December 1 2022 (hereinafter: Powers).

regulation' because pure hydrogen would be regulated under the ICA, while hydrogen mixed with even a small amount of natural gas would be regulated under the NGA.[97]

Another option is to wholly exempt interstate hydrogen pipelines from the regulatory schemes described above, just as water is exempt. That, however, would require congressional action because the regulatory sweep encompassing *all* interstate pipelines other than those carrying water suggests it must be regulated.

The Importance of the Debate

The importance of this question comes from the distinctions between the NGA and ICA regarding their scope, degree of flexibility, and control over entry and exit, and the expertise of the regulator. Both statutes grant the regulator authority over rates, terms, and conditions of service, but the NGA also provides FERC with authority over determinations of need, siting, and abandonment of interstate pipelines, storage facilities, and import/export facilities for natural gas, including liquified natural gas.[98] Under the ICA, siting and permitting of pipelines is left to the states.

Unlike oil pipelines, an interstate natural gas pipeline must have a certificate of convenience and necessity from FERC to proceed to construction.[99] Although this may seem burdensome, the certification of need takes into consideration the economic demand for pipeline capacity and therefore limits competition to support the economics of those pipelines that are built. That protection could be valuable to a nascent hydrogen pipeline industry. Further, consolidating jurisdiction under FERC would enable it to coordinate the approval for abandonment of a natural gas pipeline with conversion of the pipeline to use for hydrogen transportation (if technically feasible).[100]

Further, once the certificate of need is issued, the pipeline developer is able to exercise a federal right of eminent domain enabling it to take private property (for fair compensation) that is needed for the pipeline right of way.[101] State authorities are unable to deny access to a certificated pipeline that will cross the state, even if the state sees little benefit to its residents or has other parochial concerns. A rapid build-out of an interstate hydrogen pipeline system, if needed, might be facilitated by a similar federal siting authority.

However, the NGA permitting process can also be lengthy and at least one commentator takes the position that he has seen few issues with oil pipeline siting, despite the lack of federal authority.[102] Further, the importance of federal siting authority depends very much on whether new hydrogen pipeline construction will be primarily interstate or for export (that is, potentially within the federal domain under the ICA or NGA) or intrastate (within state control).

97 Ibid 13.

98 *Compare* 49 USC § 60502 and Federal Energy Regulatory Commission, Oil (ferc.gov) <www.ferc.gov/oil> accessed November 4, 2023, to 15 USC §171 et seq. and Federal Energy Regulatory Commission, Natural Gas (ferc.gov) <www.ferc.gov/natural-gas> accessed November 4, 2023.

99 15 USC § 717f.

100 Powers 9.

101 15 USC § 717f(h).

102 Powers 11. Since each pipeline has unique characteristics, the actual time can vary significantly. Two sources suggest the federal approval process takes on average about 1.5 years. US Government Accountability Office, 'Pipeline Permitting' <www.gao.gov/products/gao-13-221> accessed October 21, 2023. INGAA, 'Pipeline Permitting' 2 <https://ingaa.org/wp-content/uploads/2019/01/34233.pdf> accessed October 21, 2023. However, litigation and other factors can extend the time significantly. How the FERC process compares to a state-by-state process is difficult to assess because state processes differ widely and thus timing would be highly dependent on which states would be involved. Ibid.

Uncertainty itself is of concern. Whichever regime applies, the process for permitting and building a pipeline is lengthy and thus a false start under the wrong regime would be costly in terms of time as well as money.

Pathway to Resolution?

Given the ambiguity, the matter will likely require congressional action. In addition to the three options for federal regulation set out above, a fourth option could be a federal exemption from regulation (like water). A variation might explicitly bring hydrogen within the NGA's federal siting regime, coupled with light-handed rate regulation.[103] If hydrogen is exempted from federal regulation (like water), then under the US federalism system, individual states would have discretion over regulation. Should Congress not act, the question could be posed to the agencies and then the courts to decide the ambiguity described.

The timing for resolution of this important issue is unknown.

3.5.4 *Safety*

The DOE Roadmap repeatedly recognizes additional attention to public health and safety is an important 'enabler' for achieving the US goals for hydrogen.[104] It also endorsed a recommendation from the IEA Future of Hydrogen Report, stating that '[a]ddressing safety codes and standards is necessary for a harmonized global supply chain'.[105] But the pathway for gaining this clarity is unclear. The Roadmap does not include a plan for doing so.

The current US laws include safety standards applicable to hydrogen, but they are dispersed across different agencies depending on the point in the supply chain and the activity involved. For example, six different administrations within the US Department of Transportation regulate some aspect of hydrogen transport.[106] Protecting the health and safety of workers in the private sector and some public sector workers is entrusted to the US Occupational Safety and Health Administration (OSHA).[107] The OSHA identifies nine standards that 'may' apply to hydrogen (and cautions that the list is not exhaustive).[108] Proper labeling can also affect safety, including in the workplace. Labeling of alternative fuels, which includes hydrogen, is the responsibility of the Federal Trade Commission.[109] Thus, regulation is already pervasive, but in some instances unclear. Further, it is important that the requirements are appropriate to new uses of hydrogen and facilitate its transport and use across multiple places and jurisdictions. Inconsistencies can create issues of noncompliance or limit market penetration.

Standard setting, often by industry, can play an important role in resolving some of these issues. For example, 'The National Fire Protection Association (NFPA) is a global self-funded nonprofit organization, . . . devoted to eliminating death, injury, property and economic loss due to fire, electrical and related hazards'.[110] The NFPA is not a government agency but its primary

[103] Diamond.
[104] Roadmap 12, 25, 27, 28, 31, 33.
[105] Roadmap 25, 78.
[106] Roadmap 64–67.
[107] US Occupational and Health Administration, 'About OSHA' (osha.gov) <https://osha.gov/aboutosha> accessed December 1, 2022.
[108] US Occupational and Health Administration, 'Green Job Hazards' (osha.gov) <https://osha.gov/green-jobs/hydrogen/standards> accessed December 1, 2022.
[109] 42 USC § 13232(a).
[110] National Fire Protection Association, 'NFPA overview' (nfpa.org) <https://nfpa.org/overview> accessed December 1, 2022.

work is developing and disseminating codes and standards. It has developed several standards applicable to hydrogen. While these standards do not inherently have the force of law, they are sometimes incorporated into local building codes which are binding. Creating standards through industry groups can facilitate uniformity across jurisdictions, where no single law would be applicable.

The Energy Policy Act of 2005 required the DOE to support the development of 'safety codes and standards relating to fuel cell vehicles, hydrogen energy systems, and stationary, portable, and micro fuel cells'.[111] That effort was funded from 2005 to 2020 and during that period the DOE developed the 'H2 Tools' website to help others.[112] However, the resources on the H2 Tool website are now dated and the project is unfunded.

Consistent with the Roadmap, attention to safety and the harmonization of standards is important to market development. Industry can help, but the government needs to act too.

3.6 CONCLUSION

The market for hydrogen in the United States is poised for growth. The infusion of federal funding and favorable tax provisions are intended to bring government and industry together as partners in its development. The strong interest in hydrogen hubs indicates the potential for success. However, industry is concerned that emerging regulations will set standards it cannot yet meet, thus stymying growth before it begins; and there are areas of regulatory uncertainty that must be resolved to facilitate rapid growth. The question of permitting reform and pipeline regulatory-authority are particularly vexing and may require congressional action to resolve. Both government and industry have important roles in updating and harmonizing safety codes and other standards. As long as these regulatory hurdles remain unaddressed, the potential for rapid growth is uncertain.

FURTHER READING

Baird AR, Ehrhart BD, Glover AM, and LaFleur CB, 'Federal Oversight of Hydrogen Systems' (Sandia National Laboratories, 2021) <www.osti.gov/servlets/purl/1773235> accessed 5 November 2023

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'US National Clean Hydrogen Strategy and Roadmap' (energy.gov, May 2023) <www.hydrogen.energy.gov/pdfs/us-national-clean-hydrogen-strategy-roadmap.pdf> accessed 4 November 2023

[111] 42 USC § 16158.

[112] US Department of Energy, 'Hydrogen Program: Safety' (energy.gov) <www.hydrogen.energy.gov/program-areas/safety> accessed November 3, 2023.