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Hydrogen Law and Policy Initiatives in the United States

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Aus dem Inhalt

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E. Herausforderungen

Die Weiterentwicklung des Rechtsrahmens für den Markthochlauf von Wasserstoff[78] hat mit der wechselseitig sich überholenden Gesetzgebung zu kämpfen, die wenig zur Planungs- und Investitionssicherheit für die Akteure beiträgt. Der deutsche Gesetzgeber schafft Regelungen, die explizit unter dem Änderungsvorbehalt des Unionsgesetzgebers stehen und die Unionsorgane erlassen Regelungen, die zugunsten der Mitgliedstaaten lange Übergangsfristen enthalten und Spielräume belassen, die auszufüllen nicht einfach fällt. Vieles spricht dafür, dass eine konsistente Regulierung die Schaffung eines eigenständigen Wasserstoffgesetzes[79] voraussetzen würde, das ähnlich wie das Klimaschutzgesetz des Bundes an den unionsrechtlichen Vorgaben und deren Weiterentwicklung ausgerichtet wäre, aber eigene Wege gehen könnte, die durch das Unionsrecht nicht versperrt werden.[80] Vier Herausforderungen seien abschließend skizziert:

I. Zeitfaktor

Eine erste zentrale Herausforderung ist der Zeitfaktor. Die Entwicklung der erneuerbaren Energien auf dem Markt zeigt, dass die Marktfähigkeit eines Energieträgers eine gewisse Zeit braucht, die zur Erreichung der Klimaschutzziele nicht vorhanden ist. Ein Abwarten, bis unionsrechtliche Regelungen vorliegen, macht insoweit wenig Sinn, aber ein Antizipieren dieser Regelungen fällt schwer, wenn Zweifel an ihrer Tauglichkeit bestehen.[81]

II. Zielvorgaben oder Anreize?

Offen ist auch die Frage, mit welchen Instrumenten der Markthochlauf von Wasserstoff beschleunigt werden kann. Statt die Instrumente ideologisch als Alternativen gegenüberzustellen, muss das Zusammenspiel ausbalanciert werden.[82] Schon Zielvorgaben steuern den Markthochlauf der Wasserstoffwirtschaft.[83] Ob die Besteuerung fossiler Energieträger ausreicht, maßgebliche Impulse für Investitionen in grünen Wasserstoff zu setzen, kann bezweifelt werden. Unverzichtbar sind direkte Anreize für die Umstellung auf Wasserstoff, was für die Stahlindustrie mit einer Quote oder THG-Minderungsverpflichtung geschehen könnte.[84] Bloße Ziele reichen jedenfalls nicht aus. So ist das Ziel im aktuellen Entwurf eines Klimaschutzprogramms nach § 9 KSG, den Aufbau von Elektrolyseleistung in Deutschland anzureizen und damit Unternehmen einen signifikanten Anschub zu geben, um so das im Koalitionsvertrag festgelegte Ziel von 10 GW Elektrolyseleistung in 2030 zu erreichen[85], nicht mit einem Plan unterlegt, wie das Ziel erreicht werden soll.[86]

III. Notwendigkeit eines Nachweisrechts

Technologieoffenheit mag für den Klimaschutz einen Nutzen haben. Führt dieser gebetsmühlenartig vorgetragene Grundsatz, der schon ordnungspolitisch mit einem Fragezeichen zu versehen ist und als Maxime für das Recht auf wackeligen Füßen steht[87], aber dazu, jeden Wasserstoff unabhängig von seiner „Farbe" zu fördern, schadet es dem Klimaschutz.[88] Es mag sein, dass der Markthochlauf auch den Einsatz CO_2-armen Wasserstoffs erfordert und aus Erdgas erzeugter Wasserstoff vorübergehend hinzunehmen ist.[89] Aber für solche Brückentechnologien fehlt die Zeit. Um Wasserstoff großvolumig erzeugen zu können, wird Strom aus dem Netz benötigt und der auf diese Weise erzeugte Wasserstoff in das Gasnetz eingespeist werden müssen. Dafür bedarf es eines Nachweisrechts, mit dem sichergestellt wird, dass die Förderung und Beschleunigung des Markthochlaufs klimapolitisch gerechtfertigt werden kann, mag die Beschränkung auf grünen Wasserstoff auch überholt sein.[90] Noch bedeutsamer sind belastbare Nachweise beim Import von Wasserstoff, der klimapolitisch nur Sinn macht, wenn er nachweislich zu CO_2-Einsparungen führt.[91]

IV. Spielräume der Mitgliedstaaten

Kaum sind die ersten Schritte zur Schaffung eines Rechtsrahmens für erneuerbaren Wasserstoff vollzogen, so kündigen sich bereits neue Fragen an, die mit dem ebenfalls neu zu schaffenden Rechtsrahmen für technologiebasierte CO_2-Entnahmemechanismen[92] eine vergleichbare Dimension aufweisen.[93] Hier wie dort macht es wenig Sinn, auf Vorgaben des Unionsrechts zu warten. Es spricht nichts dagegen, in Vorleistung zu gehen, also nicht bloß zu vollziehen, was der Unionsgesetzgeber zur Umsetzung aufgibt. Auf diese Weise lassen sich Spielräume nutzen, um mit überzeugenden Regulierungsansätzen oder innovativen Förderkonzepten wie dem beschriebenen H2Global-Programm auf die unionale Ausgestaltung des Rechtsrahmens für die Wasserstoffwirtschaft einzuwirken. Das ist möglich und wünschenswert, jedenfalls vorzugswürdiger[94] als Ausbremsungsversuche[95] mit wenig Aussicht auf Erfolg, sich gegen eine nicht in Stein gemeißelte, aber eben doch in die Pfadabhängigkeiten des europäischen Energieregulierungskonzepts gestellte „Entflechtungsphilosophie" zur Wehr zu setzen. Es sollte nicht übersehen werden, dass die Union ihre Strategie der Wettbewerbssicherung nicht gegen die erwünschten Gemeinwohlbelange stellt, sondern in deren Dienst stellt. Das muss für die Zeitenwende im Klimaschutz kein Nachteil sein. Vielmehr ist der regulative Wettbewerb[96] auch für neue Infrastrukturen zu nutzen. So bleibt noch einiges zu tun, um für den Markthochlauf des Wasserstoffs einen „lernenden" Rechtsrahmen zu schaffen.

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78 Dazu *Buchmüller*, Die Rolle synthetischer Kraft- und Brennstoffe in Energie- und Verkehrswende, in: Rodi (Hrsg.), Handbuch Klimaschutzrecht, 2022, § 22 Rn. 37 ff.
79 Für ein Wasserstoffinfrastrukturgesetz *Langstädtler*, ZUR 2021, 203 (211).
80 Allg. *Franzius*, Rechtliche Möglichkeiten einzelner Staaten zum unilateralen Schutz globaler Umweltgüter, in: Markus/Reese/Köck (Hrsg.), Zukunftsfähiges Umweltrecht III, 2023, S. 89 ff.
81 Zur zeitlichen Staffelung der Regelungen, die auf unterschiedliche Bedarfe in der Zeit abstellen und Lernen ermöglichen *Benrath*, EnWZ 2021, 195 (196 ff.). Zum „lernfähigen Recht" für Innovationen *von Landenberg-Roberg*, ZUR 2023, 148.
82 *Franzius*, VVDStRL 81 (2022), 383 (411 f.). Für die Verkehrswende *Fehling*, ZUR 2020, 387 (389 ff.).
83 *Hoffmann*, EnWZ 2022, 255 (260).
84 Zu den Anreizinstrumenten für grünen Stahl *Altrock u.a.*, Rechtsrahmen (Fn. 7), S. 97 ff.
85 *BMWK*, Entwurf eines Klimaschutzprogramms 2023 der Bundesregierung v. 13.6.2023, https://www.bmwk.de/Redaktion/DE/Downloads/klimaschutz/entwurf-eines-klimaschutzprogramms-2023-der-bundesregierung.pdf?__blob=publicationFile&v=6, S. 11.
86 Krit. *Verheyen/Franke*, Gutachten zur Novelle des Bundes-Klimaschutzgesetzes im Auftrag von Agora Verkehrswende und Agora Energiewende v. 5.7.2023, https://www.agora-verkehrswende.de/fileadmin/Projekte/2023/KSG-Reform-Teil-2/Gutachten_KSG-und-KSP_20230705.pdf, S. 17 f. Zum Politikplanungsrecht *Franzius*, ZUR 2023, 199.
87 Zum Technikermöglichungsrecht *Franzius*, Die Verwaltung 34 (2001), 487.
88 A.A. *Geinitz*, Kein Wasserstoffhammer, FAZ v. 27.7.2023, 15.
89 Noch keine Marktreife hat der „blaue" Wasserstoff, der aus der Dampfreduzierung von Erdgas entsteht, wobei das entstandene CO_2 mittels der umstrittenen Carbon Capture and Storage-Technik (CCS) gespeichert und unterirdisch eingelagert wird; dazu *Weber*, Die Verwaltung 55 (2022), 219 (226 ff.).
90 Siehe für Endkunden das Herkunftsnachweisregistergesetz (HkNRG) v. 4.1.2023, BGBl I 2023, Nr. 9. Die RED III-Richtlinie erfordert eine verordnungsrechtliche Konkretisierung.
91 Vgl. *Hoffmann*, Die Überprüfung rechtlicher Vorgaben bei importiertem grünen Wasserstoff, Diss. Bremen, ersch. demnächst.
92 Vorgesehen ist im novellierten Klimaschutzgesetz eine Verordnungsermächtigung, dazu *Franzius*, in: Kreuter-Kirchhof/Schlacke (Hrsg.), Klimaschutzrecht, § 3b KSG, im Erscheinen.
93 Vgl. *Altrock/Kliem*, ZNER 2023, 8 (13 ff.); *Markus/Heß/Otto/Dittmeyer*, ZUR 2023, 131; *Saurer*, NuR 2023, 370; *Franzius*, CDR-Technologien auf dem Weg in die Klimaneutralität, EurUP 2024, im Erscheinen.
94 Siehe aber die plakative Frage danach, ob der im EnWG geschaffene Rechtsrahmen ein Provisorium oder eine Perspektive darstellt, bei *Schneller*, ER 2021, 135.
95 Siehe auch die opening line bei *Fouquet*, Europarechtliche Grundlagen des Klimaschutzrechts, in: Rodi (Hrsg.), Handbuch Klimaschutzrecht, 2022, § 4 Rn. 1. Zu den Schwierigkeiten einer dezentralen Koordination *Herbst*, Dezentrale Ordnung, Diss. Bremen, ersch. demnächst.
96 Gute Gegenüberstellung zu anderen Wettbewerbsmodellen: *Kersten*, VVDStRL 69 (2010), 288.

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Hydrogen Law and Policy Initiatives in the United States

The article discusses key US federal developments in hydrogen policy, including tax credits and significant funding for hydrogen hubs. Despite hydrogen's potential for decarbonization, establishing a hydrogen economy in the US requires overcoming production challenges and addressing legal, technological, and economic hurdles. Concerns persist regarding public acceptance and effectiveness in reducing greenhouse gas emissions in line with energy justice goals.

This article focuses on the law and policy initiatives to encourage development and deployment of hydrogen in the United States. At the same time that there is substantial activity underway to promote the development and deployment of hydrogen in Europe,[1] the US has also been active in law and policy development, as part of its national strategies to reduce greenhouse gas emissions. With billions of dollars in clean energy tax incentives and other funding, hydrogen has rapidly emerged as one element of the transition in the US toward clean energy and reducing fossil fuel dependence. The two most important recent law and policy developments in the US include the tax credits for hydrogen in the Inflation Reduction Act of 2022, and the hydrogen hub funding by the US Department of Energy (DOE) in 2023 under the bipartisan infrastructure law (the Infrastructure Investment and Jobs Act, or IIJA). Recently, under the latter law, seven regional consortia known as hubs have been selected to receive funding for the development of hydrogen networks. There are other initiatives in place at the state and federal level, but these are widely viewed as the most significant and have the most funding, and will be discussed in depth in this article.

Schlagworte: Decarbonization, Clean energy transition, Hydrogen, Green hydrogen, Inflation Reduction Act, Tax credit, Infrastructure Investment and Jobs Act, Hydrogen hubs, Electric grid, Energy justice

A. Background and Previous Initiatives

Many in the US believe that development and deployment of hydrogen can help decarbonize a variety of energy-intensive sectors, including transportation, industrial applications and applications in the electric grid.[2] One common way of visualizing the potential applications is the „ladder" developed by *Michael Liebreich*, in which hydrogen made in a more environmentally friendly manner can be used most readily in certain applications where there is no functional substitute for hydrogen that is already being used, such as fertilizer manufacturing.[3]

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1 *European Commission*, Clean energy – an EU hydrogen strategy, https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12407-A-eu-hydrogen-strategy.
2 *Shukla /Samuel*, Hydrogen: A Targeted Decarbonization Tool but Not a Panacea, https://www.nrdc.org/bio/shruti-shukla/hydrogen-targeted-decarbonization-tool-not-panacea.
3 *Barnard*, What's New On The Rungs Of Liebreich's Hydrogen Ladder?, https://cleantechnica.com/2023/10/22/whats-new-on-the-rungs-of-liebreichs-hydrogen-ladder/.

Advocates believe that clean hydrogen can help decarbonize key sectors such as long-haul transportation, iron and steel production, oil refining, chemical production, and electricity generation. This view is not without controversy. It comes against a landscape of increased attention to electrification throughout the US economy, and some believe that the increased amounts of electricity generated from renewable resources should not be used to make another fuel instead of using the electricity directly in an end use.[4]

Hydrogen must be produced because unlike other energy carriers like petroleum, it largely does not exist on its own in nature. Researchers have recently identified deposits of so-called „white hydrogen" in many locations, including France and Switzerland, that might be capable of being extracted and developed into fuel.[5] It is not clear that this white hydrogen can be extracted and used commercially for years to come. So for now, hydrogen must instead be produced from other energy sources. At present, 95% of the hydrogen made in the US is produced through the steam water reformation process, which involves using a fossil fuel (natural gas) to electrolyze (split) water molecules into hydrogen and oxygen, which in turn generates considerable amounts of the potent greenhouse gas methane.[6]

There are many pathways to producing hydrogen. To distinguish one means of producing hydrogen from another, these pathways have been designated by colors, including green hydrogen, gray hydrogen, blue hydrogen, and pink hydrogen. In this color scheme, the steam water reformation process is known as blue hydrogen if it involves capturing the fugitive emissions and retaining them through some form of carbon capture and storage, and grey hydrogen if it does not.[7] By contrast, „green hydrogen" involves making hydrogen from electricity that is generated from renewable resources such as wind, solar, or geothermal. Clean hydrogen production exists at a small scale, but is more costly today than the steam water process. At present it accounts for less than 5% of US hydrogen production due to its high cost. Production from nuclear energy is treated separately as „pink hydrogen." There are other color-related terms for hydrogen production,[8] but these are the ones in most common use.

Regardless of how it is produced, hydrogen carries energy and can be stored and delivered for specific end uses. Until very recently, the use of hydrogen in transportation in the US was by far the dominant contemplated end use, compared to European initiatives that sought to find a role for hydrogen throughout the economy in industry, in transportation, and in fuel cells deployed to support distribution of electricity in the electric grid.[9] In the early 2000s, hydrogen was promoted in the US as an alternative fuel in transportation to gasoline and other fossil fuels. Important policy initiatives took place in the state of California. California's Global Warming Solutions Act is popularly known as AB32 after the Assembly Bill that created it. AB32 is a comprehensive state law intending to reduce greenhouse gas emissions throughout the state's economy by the year 2050. The law targeted emissions from motor vehicles, electricity production, and industry.[10] For example, one of California's best known programs is a cap and trade program designed to use market strategies to reduce emissions.[11]

The state's AB32 strategy to promote hydrogen involved the creation of a „Hydrogen Highway."[12] Led by California's governor *Arnold Schwarzenegger*, this initiative intended to have a hydrogen highway network in place in the state by the year 2010. Among its other provisions, the state proposed to have 200 fueling stations located along its major Interstate highways by 2010.[13] Today, there are only about 50 fueling stations in operation and hydrogen fueled vehicles are only viable in a limited area of the state of California,[14] and virtually nowhere else in the US.

Then, as now, those who envisioned that hydrogen could be an alternative fuel to gasoline in motor vehicles in the US faced a number of problems. There are technical challenges involved in making fuel tanks suitable for safe use of hydrogen in motor vehicles. Beyond these are problems of scale. Given the large distances that people drive in the US, a network of hydrogen fueling stations would need to have many stations located in close proximity to one another. And building out this network, with associated pipelines that would be required, would be extraordinarily expensive.[15] In addition, there were no hydrogen fueled cars available broadly on the US market at the time. Even today, there are only about 15,000 vehicles in the US that run on hydrogen,[16] which is a very small fraction of the over 275 million personal and commercial vehicles registered.[17]

4 *Haley*, Hydrogen Competition in the 2022 ADP, https://www.evolved.energy/post/adp2022-hydrogen, Fig. 6.
5 *Symons*, What is 'white hydrogen'? The pros and cons of Europe's latest clean energy source, euronews green, May 11 2023, https://www.euronews.com/green/2023/11/05/what-is-white-hydrogen-the-pros-and-cons-of-europes-latest-clean-energy-source.
6 *U.S. Department of Energy*, Hydrogen Fuel Basics, https://www.energy.gov/eere/fuelcells/hydrogen-fuel-basics.
7 *Osman* et al., Hydrogen production, storage, utilisation and environmental impacts: a review, Environmental Chemistry Letters, Oct. 2021,Seitenangabe .
8 *Id.* (describing "brown" and "turquoise" hydrogen).
9 Dr. Ruven Fleming of the University of Groningen and Professor Joshua Fershee astutely observed this several years ago, in a book chapter summarizing and comparing EU and US hydrogen policies. *Fleming/Fershee*, The 'Hydrogen Economy' in the United States and the European Union: Regulating Innovation to Combat Climate Change, in: Zillmann et al, Innovation in Energy Law and Technology: Dynamic Solutions for Energy Transitions 137, Seite.
10 *Cal. Air. Resources Board*, AB 32 Global Warming Solutions Act of 2006, https://ww2.arb.ca.gov/resources/fact-sheets/ab-32-global-warming-solutions-act-2006.
11 *Cal. Air Resources Board*, Cap-and-Trade Program, https://ww2.arb.ca.gov/our-work/programs/cap-and-trade-program.
12 The California Hydrogen Highway Network was established in Cal. Executive Order S-7-04, https://www.library.ca.gov/wp-content/uploads/GovernmentPublications/executive-order-proclamation/4489-4492.pdf.
13 *Schwarzenegger Unveils 'Hydrogen Highways' Plan*, Renewable Energy World, Apr. 22 2004, https://www.renewableenergyworld.com/storage/schwarzenegger-unveils-hydrogen-highways-plan-11008/#gref.
14 *Halper*, Is California's 'Hydrogen Highway' a road to nowhere?, Los Angeles Times, Aug. 10, 2021, https://www.latimes.com/politics/story/2021-08-10/hydrogen-highway-or-highway-to-nowhere.
15 *Stein/Fershée*, 48 Environmental Law Reporter 10596, 10605 (July 2018).
16 *Voelcker*, Hydrogen Fuel-Cell Vehicles: Everything You Need to Know, Car and Driver, Sept. 26 2022, https://www.caranddriver.com/features/a41103863/hydrogen-cars-fcev/.
17 *Tilford*, Car Ownership Statistics 2023, Forbes, Oct. 5 2023, https://www.forbes.com/advisor/car-insurance/car-ownership-statistics/.

In the early 2000s, the idea of hydrogen fueled vehicles in the US was also criticized as not leading to sufficient greenhouse gas emissions reductions without considerable ramping up of green hydrogen production. Unlike the present day, where the share of electricity in the US generated from wind and solar is increasing rapidly, renewable electricity made up a small percentage of US electricity production in the early 2000s.[18] One law review article called hydrogen motor vehicles „an exceedingly costly greenhouse gas strategy."[19] In addition, opponents of an expanded role for hydrogen in transportation in the US made an argument that recurs today, as noted above: if hydrogen is made greener by using electricity generated from renewable resources in its production, this is „an inefficient way to utilize renewable or zero-carbon primary energy resources"[20] compared to devoting renewable resources such as wind and solar to the generation of electricity that will then be used in the electric grid rather than as an input to produce hydrogen.

Now, however, the picture looks quite different for hydrogen in the US. The past decade has seen a remarkable upsurge in renewable energy development in the US.[21] As in Europe, some in the US believe that this presents an opportunity to use green electricity to produce hydrogen for use in a wide variety of end uses. Green hydrogen is viewed by some environmentalists as a potential means of reducing carbon emissions in industries like oil, steel, and cement production that have two common characteristics in common. First, as shown on the graphic above, they already use hydrogen that today is produced from natural gas, and second, it is not easy to simply substitute electricity made from renewable resources as the inputs to these production processes.

The DOE has demonstrated[22] that while there are many opportunities for hydrogen to play a part in the US clean energy transition, there are also considerable challenges. The challenges can be roughly divided into three categories. First, while most of the hydrogen in the US is currently produced from natural gas, for this production to be greener, the production of green hydrogen will need to be scaled up with a resulting demand for much more electricity generated from renewable resources. Another category of challenges includes transmission and distribution hurdles. This includes moving the hydrogen from where it is produced to where it is intended to be used, with a substantial number of challenges involved in creating the network for production and distribution of hydrogen. Finally, there are challenges involved in determining the appropriate end uses for hydrogen, which can involve substitution of green hydrogen for current uses of hydrogen, or new uses to which the hydrogen is put.

There is a variety of different possible approaches for delivery of hydrogen to end-users. One involves use of dedicated pipelines, whether or not the hydrogen is stored underground along the way in geological storage features. At present, there is a very limited network (1,600 miles) of pipelines that are wholly dedicated to transportation and distribution of hydrogen in the US.[23] If this form of transportation of hydrogen is contemplated on a broader scale, these pipelines would have to be built at considerable expense. In Europe, some nations envision transporting hydrogen through the existing natural gas pipelines, but this would be a complex endeavor in the US. The current network of natural gas pipelines in the US is not currently suitable for movement of large scale volumes of hydrogen, due to the technical needs such as ensuring against material fatigue and sealing against leaks.[24] Moreover, the natural gas pipeline system is already used for the movement of increased quantities of natural gas for the production of electricity, where its use has skyrocketed in recent years. Sorting out how the movement of both hydrogen and natural gas would be accomplished through these pipelines would be technically challenging and would also implicate complex issues of federal jurisdiction over the pipelines.

B. The Current Framework for US Law and Policy Initiatives – The „Hydrogen Shot"

The past two years have seen the US federal government throw its weight behind hydrogen as one component of the clean energy transition, through major legislative enactments and support from federal agencies. The DOE has authority by statute over energy-related research, and domestic energy production and energy conservation. It has been active in facilitating the clean energy transition through commitments to accelerate the development of critical technologies in eight discrete innovation areas. These long-range goals intended to meet major challenges in research, development and deployment of clean energy are known as „Energy Earthshots."[25] The intent is that all eight initiatives taken together will help the US reach its goal of being carbon neutral by the year 2050. As described below, hydrogen is at the core of one of these efforts.

The DOE's use of „Earthshot" is intentional. In the US, the term „moonshot" or, simply, „shot" is used to invoke a specific means of addressing a major problem involving technology. This term has its origins in the announcement by then President *John Kennedy* in 1962 that the US would go to the moon within the next decade, which came to be known as the „moonshot."[26] Since then, the idea of the „shot" has become common in the technology world. The central idea is that announcing a shot serves as a high-profile means of focusing major commitments

18 In the year 2000, for example, renewables other than hydropower accounted for only 4.8% of US electricity production. *U.S. Department of Energy*, Energy Efficiency & Renewable Energy, 2009 Renewable Energy Data Book, August 2010, at 8.
19 *Romm*, 36 Golden Gate U. Law Review 393, 393 (2006).
20 *Id.*
21 See generally *Eisen*, Advanced Introduction to Law and Renewable Energy (2021).
22 *U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy*, H2@Scale, https://www.energy.gov/eere/fuelcells/h2scale.
23 *U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy*, Hydrogen Pipelines, https://www.energy.gov/eere/fuelcells/hydrogen-pipelines.
24 *Nguyen*, Hydrogen Blending as a Pathway Toward U.S. Decarbonization, National Renewable Energy Laboratory, Jan. 24, 2023, https://www.nrel.gov/news/program/2023/hydrogen-blending-as-a-pathway-toward-u.s.-decarbonization.html.
25 *U.S. Department of Energy*, Energy Earthshots Initiative, https://www.energy.gov/energy-earthshots-initiative. As noted below, the eight "Earthshots" include the Hydrogen Shot and others, such as one oriented at reducing the cost of offshore wind energy.
26 *Alayon*, Understanding Moonshot Thinking, Future Today, Dec. 31 2018, https://medium.com/future-today/understanding-moonshot-thinking-783e3399c611.

of resources on a risky, time-consuming, expensive goal. In turn, this goal is expressed in a manner that summarizes an attempt to make a radical breakthrough designed to solve the problem through achieving specific technical and cost targets. By definition, this type of endeavor is meant to be ambitious, transformative, and impactful, requiring a visionary approach to innovation that focuses on high-risk, high-reward projects. And while the US did meet its goal of landing on the moon within a decade, the common understanding is that technology shot projects may not succeed, but nevertheless may achieve intermediate milestones that in themselves may represent significant technological advancements.

The DOE's Hydrogen Shot sets forth a long-range target for hydrogen programs in the US that is expressed in three terms: \$1 (One Dollar); 1 kg (One Kilogram); and 1 Decade.[27] This sets a goal of bringing down the cost of the production of a kilogram of hydrogen from its current roughly \$5/kg to \$1 within a decade, for a decrease of 80%. The DOE states that meeting this target would lead to „at least a 5-fold increase in clean hydrogen use," and potentially as much as „16% carbon dioxide emission reduction by 2050."[28]

To appreciate the efforts to reach this goal, it Is important to understand that broadly speaking, achieving the goal of a technology shot requires three different elements: breakthroughs in technology innovation, adoption of these breakthrough technologies throughout the economy, and government support at all phases of research, development, and commercialization to support technology innovation and adoption.[29] The focus on a specific target is meant to leverage efforts by multiple actors working together to achieve these disparate goals, including university research centers, private sector businesses, and governmental agencies (in the US, a particularly important player is the national laboratories, such as the National Renewable Energy Laboratory, or NREL). Governmental funding can serve as a catalyst for private sector efforts but is not meant to be the sole means of providing resources. Moreover, the range of projects designed to meet the overall goal is meant to be extremely broad, from basic to applied research to demonstration projects and development and deployment of large-scale networks.

C. US Federal Law and Policy Initiatives For Hydrogen Production and Distribution

In the US, two federal statutory provisions have provided the foundation for the efforts to achieve the overall goal of lowering the cost of hydrogen production and accelerate hydrogen distribution throughout the nation. Both are provisions within much larger legislative enactments, the Inflation Reduction Act of 2022 (IRA),[30] and the Infrastructure Investment and Jobs Act of 2021 (IIJA).[31]

I. The Inflation Reduction Act's Hydrogen Production Tax Credits

The IRA is a massive law with numerous provisions designed to reduce the federal government's budget deficit and thereby reduce inflation. It includes major health and tax policy provisions, such as the imposition of a 15% minimum tax on corporations, and a provision that allows Medicare (the federal government health insurance program for Americans age 65 and older and others who qualify[32]) to negotiate drug prices with pharmaceutical manufacturers with the goal of bringing prices down. Still, in the view of many observers, the IRA's climate provisions are its most significant.[33] The level of federal government funding under the IRA (and the IIJA, as discussed below) to address climate change is larger by an order of magnitude than the total of all previous expenditures.[34] The IRA is a „landmark climate law"[35] that makes a „historic down payment on deficit reduction to fight inflation, invest in domestic energy production and manufacturing, and reduce carbon emissions by roughly 40 percent by 2030."[36]

Structure of the IRA Tax Credits

The core policy of the IRA is the use of governmental subsidies on a massive scale to address climate change.[37] The dominant strategy is a reliance on numerous forms of tax credits.[38] Tax credits and other financial incentives are intended to support dramatic growth in clean energy technologies throughout the US economy, and, as noted above, help put the U.S. on track to reach net-zero carbon emissions by 2050.

A tax credit stimulates investment in clean energy technologies by making it less expensive to invest. It reduces the tax liability of those persons or entities undertaking qualifying expenditures on a dollar for dollar basis, with that amount effectively

27 *U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy*, Hydrogen Shot, https://www.energy.gov/eere/fuelcells/hydrogen-shot.
28 *Id.*
29 Of course, there is an enormous body of literature on how technologies are developed and adopted, to which the author has made one contribution with an article discussing "disruption" in technology in the case of rooftop solar development. *Eisen*, 24 Notre Dame Journal of Law, Ethics & Public Policy 53 (2010). As this article is meant to describe the ongoing programs designed to support the development and deployment of hydrogen in the US, it is beyond its scope to assess the likelihood that these programs might succeed in the light of this literature on technology development.
30 Inflation Reduction Act of 2022, Public Law No. 117-169 (2022).
31 Infrastructure Investment and Jobs Act, Public Law No. 117-58 (2021).
32 What's Medicare, Medicare.gov, https://www.medicare.gov/what-medicare-covers/your-medicare-coverage-choices/whats-medicare.
33 *Bivens*, The Inflation Reduction Act finally gave the U.S. a real climate change policy, Economic Policy Institute, Aug. 14 2023, https://www.epi.org/blog/the-inflation-reduction-act-finally-gave-the-u-s-a-real-climate-change-policy/.
34 *Credit Suisse*, US Inflation Reduction Act –A catalyst for climate action, November 30 2022, https://www.credit-suisse.com/about-us-news/en/articles/news-and-expertise/us-inflation-reduction-act-a-catalyst-for-climate-action-202211.html.
35 *Bordoff*, America's Landmark Climate Law, International Monetary Fund, December 2022, https://www.imf.org/en/Publications/fandd/issues/2022/12/america-landmark-climate-law-bordoff.
36 Summary: The Inflation Reduction Act of 2022, https://www.democrats.senate.gov/imo/media/doc/inflation_reduction_act_one_page_summary.pdf.
37 *Bipartisan Policy Center*, Inflation Reduction Act (IRA) Summary: Energy and Climate Provisions, Aug. 4 2022, https://bipartisanpolicy.org/download/?file=/wp-content/uploads/2022/08/Energy-IRA-Brief_R04-9.26.22.pdf.
38 *The White House*, Clean Energy Tax Provisions in the Inflation Reduction Act, https://www.whitehouse.gov/cleanenergy/clean-energy-tax-provisions/.

representing a percentage reduction from the cost of the technology. For example, the IRA provides tax credits for homeowners and owners of commercial buildings to purchase heat pumps and other efficient equipment, at a rate of 30% up to a maximum credit of \$2,000 each year through 2033.[39] Therefore, if a homeowner spends \$10,000 on a qualifying heat pump system, they will receive a tax credit of \$2,000. The IRA also contains an expanded Renewable Energy and Clean Electricity Investment Tax Credit. And it expands the existing tax credit for the purchase of electric vehicles, although it imposes income limits for those eligible to receive the credits and caps on qualifying vehicle prices, together with requirements that include a critical minerals requirement, a requirement that a threshold percentage of battery components be manufactured or assembled in North America and a requirement of final assembly in North America.[40]

Tax credits under the IRA are typically made available for ten or more years. As noted above, the residential energy efficiency credit for heat pumps and other qualifying equipment is available until 2033 – and the hydrogen tax credit lasts until 2033 as well. This has the salutary effect of ending the perennial debates that have taken place over yearly renewal of credits. For example, many observers of the clean energy transition are familiar with the start and stop nature of the tax credit that was available for the production of electricity from wind in the US throughout the 2010s, which in turn had a negative impact on the number of projects that were underway in the years when the tax credit was not available. Because the tax credit provisions of the IRA last for ten years or more, this is no longer an issue.

The Clean Hydrogen Production Tax Credit[41] provides a tax credit for the production of clean hydrogen in the US at any qualified clean hydrogen production facility which commences construction before January 1, 2033. Producers of hydrogen that qualifies as clean receive a tax credit of up to \$0.60 per kg of hydrogen produced, depending on lifecycle greenhouse gas emissions intensity. The highest credit is available for production with an emissions intensity of less than 0.45 kg per kilogram of hydrogen produced.[42] The hydrogen producing facility may earn up to five times the base credit, or a maximum of \$3/kg, if it meets prevailing wage and apprenticeship requirements.[43] As described in the next section, producers making green and blue hydrogen are both eligible for the credit, although blue hydrogen producers will need to demonstrate that their emissions intensity qualifies them for the credit. These producers are also eligible for a separate carbon capture and sequestration credit, although blue hydrogen producers must choose between the production tax credit and the credit for capturing emissions.

Another feature of this tax credit, as well as others in the IRA, is of particular importance. It is called the „direct" or „elective pay" provision.[44] Until now, an entity seeking to take advantage of a tax credit needed to have tax liability to use the credit to offset. This meant that tax credit provisions were not especially useful to governments and nonprofit organizations that typically do not pay sufficient federal taxes to use the credits. With the direct pay provision, that situation has changed. Nonprofits and state and local governments, tribal and native American entities, and rural electric cooperatives can take advantage of the hydrogen production tax credit by receiving a direct payment (hence the name of the provision) that is equal to the full value of the clean hydrogen tax credit, thus providing an incentive for them to undertake projects.[45]

II. The Controversy Over „Green" Production and the Tax Credits

The US Congress tasked the Treasury Department (Treasury) with making a set of rules for the tax credit. These rules will determine how to account for the emissions from the electricity used in the electrolysis process to make hydrogen. If a hydrogen producer does not fit the definition of clean production, it will not be eligible for the tax credit. As a result, there has been great interest in the precise definition in the Treasury rules about ensuring that the source of electricity to produce hydrogen does not result in major emissions increases. This requires some complex analysis. Electrolysis is an electricity-intensive process, and some hydrogen producers are counting on drawing electricity from the US electric grid to produce hydrogen. If hydrogen producers are using electricity from the grid, it is difficult to tell whether their production is a net benefit in terms of reducing US greenhouse gas emissions, due to the structure of the US electric grid.

A vast network of power plants, transmission lines, and distribution centers together make up the US electric grid. The grid is divided into three large parts: the Eastern Interconnection, the Western Interconnection, and the grid in the state of Texas.[46] Within these larger connections, the process of transmitting and distributing electricity is overseen by entities known as regional transmission organizations, and in other locations by large vertically integrated investor-owned utilities and other entities such as rural electric cooperatives. Regardless of the location on the grid at or near which a hydrogen producer might be located, the electricity it would use to produce hydrogen is undifferentiated, that is, it comes from many sources. Some sources of the electricity on the grid are clean, like those that use renewable resources such as wind and solar, but some are not, like power plants that use coal, natural gas and other fossil fuels.

At any given moment, the specific source of a kilowatt hour of electricity cannot be precisely identified, so it is difficult to tell whether production is green or not. Facilities that are grid-connected therefore cannot prove that they are obtaining power

39 26 United States Code section 25C.
40 26 United States Code section 30D.
41 The text of the tax credit is found at 26 United States Code sec. 45V: Credit for production of clean hydrogen.
42 26 United States Code sec. 45V(b)(2).
43 26 United States Code section 45V(e).
44 26 United States Code section 6417.
45 26 United States Code section 6417; The White House, Direct Pay Through the Inflation Reduction Act, https://www.whitehouse.gov/cleanenergy/directpay/.
46 *U.S. Energy Information Administration*, Electricity Explained: How electricity is delivered to consumers, https://www.eia.gov/energyexplained/electricity/delivery-to-consumers.php.

from renewable resources instead of fossil fuels. Indeed, a recent study showed that if hydrogen producers were simply allowed to use electricity from the grid at all times of the day and night without any restrictions, as they prefer to do, this might be worse in terms of emissions than not attempting to produce green hydrogen at all.[47] And this also amplifies the concern that many in the environmental community have with blue hydrogen. Some environmentalists believe that all new hydrogen should be green hydrogen, because relying on electricity generated from fossil fuels to make hydrogen would possibly increase greenhouse gas emissions, not reduce them.[48]

Some projects will connect electrolyzers directly to new sources of renewable electricity built on site, such as self-contained wind, solar, and geothermal facilities. For these projects, it is not difficult at all to decide that the electricity is green, and therefore that the projects should qualify for the tax credit.[49] But the situation is different if the production facility is connected to the grid. Because it is impossible to tag electrons precisely, it is necessary to come up with some means of measuring whether the electricity withdrawn from the grid is green or not. The discussion over these issues has centered on three main topics that are comparable to those contained in EU hydrogen regulations.[50] The first is additionality, which entails some form of ensuring that the electricity that is used is both green (originating from renewable resources) and new, or „additional" to that which is already being produced.[51] That is, there would be a requirement for electrolyzers to be powered by new renewable assets to prevent existing green electrons from being drawn away from the grid. The second factor asks whether the electricity used is both local (near the hydrogen production facility) and deliverable (capable of being transmitted to the facility).[52] This is principally a matter of geography and the structure of the electricity distribution grid. The questions that are asked in models of new hydrogen production are whether the electricity is capable of getting to where it is needed without traveling over long distances, without difficulties imposed by congestion on the grid. As one study puts it, „allowing resource procurement over large geographic areas can lead to significant consequential emissions from hydrogen production."[53]

The third major topic involves time matching. The principle behind this is straightforward. At present, we cannot tell which electrons added to the grid are used to power a hydrogen electrolyzer. If it were possible to match the electrons being added to the grid at any given moment to those that are withdrawn, then it might be more feasible to determine that renewable electricity was used to make hydrogen. At a minimum, many believe that the amount of green electricity added to the grid should be matched to the aggregate amount of electricity withdrawn annually for the production of hydrogen.[54] In practice, the time matching of electricity withdrawn from the grid to hydrogen production is difficult to assess. There are a number of variables involved. For example, how closely should the matching be done? Some argue for hourly matching, that is, hydrogen facilities would be restricted to using the same amount of electricity generated in a given hour as produced from new wind and solar facilities on the same grid. A study done in 2022 by Princeton's *Jesse Jenkins* concluded that hourly matching would reduce emissions without dramatically increasing the production cost of hydrogen.[55] However, some disagree. The Edison Electric Institute, the trade association representing the largest utilities in the US, believes that a tax credit based on hourly matching would dramatically increase the cost of hydrogen production.[56] It argues instead for annual matching of green electricity production to the amount of electricity used in hydrogen production.

In December 2023, the Internal Revenue Service (part of the Treasury Department) issued the proposed rule for the tax credit.[57] The proposed rule incorporates criteria that address all three issues described above. Regarding additionality, the proposed rule stipulates that the only clean power generation which qualifies is that which began commercial operations within 36 months of the hydrogen facility being placed into service. Regarding deliverability, the proposed rule provides that the clean power production must come from the same region as the hydrogen facility, as matched to the list of regions presented in the National Transmission Needs Study that the DOE released on October 30, 2023.[58] Regarding time matching, the proposed rule provides for hourly matching, but, recognizing that only two of nine tracking systems in the US can provide data on an hourly basis, it allows for annual matching for electricity generated before January 1, 2028.

Over the past decade, there has been considerable debate in the US about how quickly the economy should shift to clean energy production. On the one hand, some advocates argue that the current energy portfolio, with its reliance on fossil fuels such as coal, and increasingly, natural gas, cannot be easily transformed into one that is solely reliant on renewable electricity. This leads them to advocate for incremental approaches, or, in the case of hydrogen, a sort of pragmatism that getting production of hydrogen scaled up quickly is more valuable than ensuring that all of it is green production. On the other hand, advocates argue that given the climate crisis urgency, the need to reduce emissions should be paramount even at risk of hydrogen production not scaling up as quickly as it could. Those espousing this view were supportive of the criteria in the proposed rule that require the electricity used to produce hydrogen be additional, clean, deliverable, and time matched on an hourly basis by 2028 once tracking systems can handle it.[59] The proposed rule encompasses an aggressive approach to ramping up hydrogen production through a tax credit structure that ensures that the hydrogen produced will truly rely on clean sources of electricity.

47 *Ricks/Xu/Jenkins,* Minimizing emissions from grid-based hydrogen production in the United States, Environmental Research Letters (forthcoming), linked in .
48 *Id.*
49 *Piper/Krause/Janzow*, Rocky Mountain Institute, The Hydrogen Credit Catalyst, Feb. 27 2023, https://rmi.org/hydrogen-credit-catalyst/.
50 *Esposito/Gimon/O'Boyle*, Energy Innovation, Smart Design of Hydrogen 45V Production Tax Credit Will Reduce Emissions And Grow the Industry, April 2023, https://energyinnovation.org/wp-content/uploads/2023/04/Smart-Design-Of-45V-Hydrogen-Production-Tax-Credit-Will-Reduce-Emissions-And-Grow-The-Industry.pdf at page 4.
51 *Ricks/Xu/Jenkins*, *supra* note 47, at 3; *Esposito/Gimon/O'Boyle*, supra note 50, at page 4.
52 *Esposito/Gimon/O'Boyle*, supra note 50, at page 4.
53 *Id.* at 13.
54 *Giovanniello et al.*, Clean electricity procurement for electrolytic hydrogen: A framework for determining time-matching requirements, MIT Energy Initiative, Sept. 2023, https://energy.mit.edu/wp-content/uploads/2023/04/NE_Revised_Paper_September2023-1.pdf.
55 *Ricks/Xu/Jenkins*, *supra* note 47. A different study suggests hourly matching can be phased in by 2026. *Esposito/Gimon/O'Boyle*, supra note 50, at page 4.
56 *Chu*, Energy groups mount campaign against tough US clean hydrogen rules, Financial Times, July 30 2023, https://www.ft.com/content/b8815253-64c6-4509-ac33-06d4745a6caa.
57 Internal Revenue Service, Section 45V Credit for Production of Clean Hydrogen; Section 48(a)(15) Election to Treat Clean Hydrogen Production Facilities as Energy Property, 88 Federal Register 89220 (Dec. 26, 2023). In the US, a proposed rule is not final until an agency has issued a final rule after it has received and responded to comments.
58 U.S. Department of Energy, Grid Deployment Office, National Transmission Needs Study, October 2023, https://www.energy.gov/gdo/national-transmission-needs-study.

III. Hydrogen Hubs in the Infrastructure Investment and Jobs Act

In November 2021, President Joe Biden signed into law the Infrastructure Investment and Jobs Act (IIJA), often also referred to as the Bipartisan Infrastructure Law.[60] This law included funding for hydrogen through the DOE, which was tasked with establishing „hydrogen hubs."[61] The IIJA is a huge law that authorizes $1.2 trillion for transportation and infrastructure spending in the US, with $550 billion of that figure going toward new investments and programs. In the US, Congress often passes infrastructure laws that make investments in highways, other roads, and other transportation projects such as public transit programs. Going beyond this type of traditional use of infrastructure funding in the US for transportation and road proposals, the IIJA also provided funding for broadband access, clean water and electric grid programs.

1. The Hydrogen Hubs

Roughly half of the funding in the IIJA is intended for surface transportation, which as noted above is the traditional objective of an infrastructure law. The remainder of the new funding supports a range of other programs, including $65 billion for modernization of the US electric grid. Within that total, $8 billion was allocated for hydrogen hubs over the five-year period between 2022 through 2026, to spur the production and distribution of increased volumes of hydrogen in the US. The IIJA and the DOE define a hydrogen hub (H2Hub) as a „network of clean hydrogen producers, potential clean hydrogen consumers, and connective infrastructure located in close proximity."[62] The development of H2Hubs across the nation is the first step toward the creation of a national network that matches producers and consumers.[63] The law directed DOE to fund a minimum of four hubs,[64] and from the outset the DOE estimated that it would use $7 billion of the funding to support up to six to ten H2Hubs. The DOE has also noted that if funds become available, a second round of funding might support additional hubs beyond those initially selected.

The IIJA provided statutory requirements for the DOE to implement in its choice of the hubs. The DOE was required to choose hubs that employed different feedstocks for producing hydrogen. At a minimum, the DOE was required to select one hub that would produce hydrogen from fossil fuels, one from renewable energy and one from nuclear energy.[65] Two hubs at a minimum were required to be located in US regions with abundant natural gas resources. The DOE was also required to create diversity in the end uses to which hubs planted to use the hydrogen, with the provisions of the law directing the DOE to select at least one hub demonstrating the end use of clean hydrogen in each of the following sectors: (1) electric power generation; (2) industrial, residential and commercial heating; and (3) transportation.[66] In addition, the DOE was required to put a priority on geographic diversity, such that each hub would be located in a different region of the country and use energy resources that are abundant in that region. The DOE was also tasked with considering the extent to which each hub will provide skilled training and long-term employment to residents in the region.

The DOE also envisioned that the advent of the hubs would result in significant engagement of local and regional stakeholders. To that objective, the DOE required that „Community Benefits Plans" (CBP) accompany all proposals submitted for funding through the hydrogen hubs program. The DOE issued a guidance document[67] describing the content that it expected to see in applicants' CBPs. The guidance document spelled out four principles: engaging communities and labor; investing in America's workforce; advancing diversity, equity, inclusion, and accessibility; and implementing the Justice40 initiative.[68] The Justice40 initiative aims to create equity in a wide range of federal government infrastructure investments. Its overall goal is to ensure that for projects such as clean energy initiatives undertaken by the federal government, 40 percent of the overall benefits flow to disadvantaged communities that are marginalized, underserved, and overburdened by pollution (as identified by a geographic screening tool).[69] As an example of the DOE's guidance, an applicant was required to describe its „plans and actions to engage and partner with stakeholder groups in the com-

59 *See, e.g.*, Ben Schaefer, Natural Resources Defense Council, Proposed Hydrogen Tax Credit Rules a Win for Climate, Industry, Electricity Consumers, December 22, 2023, https://www.nrdc.org/press-releases/proposed-hydrogen-tax-credit-rules-win-climate-industry-electricity-consumers.
60 Infrastructure Investment and Jobs Act, Public Law No. 117-58 (2021).
61 42 United States Code § 16161a.
62 42 United States Code § 16161a(a).
63 *Majkut/Nakano/Zacarias*, Center For Strategic and International Studies, Making Hydrogen Hubs a Success, July 29 2022, https://www.csis.org/analysis/making-hydrogen-hubs-success.
64 42 United States Code § 16161a(b).
65 42 United States Code § 16161a(c)(3)(a).
66 42 United States Code § 16161a(c)(3)(b).
67 *U.S. Department of Energy, Office of Clean Energy Demonstrations*, Guidance for Creating a Community Benefits Plan for the Regional Clean Hydrogen Hubs, October 2022, https://oced-exchange.energy.gov/FileContent.aspx?FileID=9c024599-7d5c-4e84-9029-d307d7621ab7. A guidance document is a document issued by a federal agency that is intended to guide regulated parties in complying with the law, and does not by itself establish separate legal obligations. Congressional Research Service, Agency Use of Guidance Documents, April 19 2021, https://www.everycrsreport.com/files/2021-04-19_LSB10591_9477746a9161f3ee6f2d127a70eb84cdcec6e4df.pdf.
68 Guidance for Creating a Community Benefits Plan for the Regional Clean Hydrogen Hubs, supra note 67, at 1.
69 *The White House*, Justice40, /The screening tool is called the Climate and Economic Justice Screening Tool, and is found at https://screeningtool.geoplatform.gov/en/#3/33.47/-97.5.

munity or communities most impacted by project development, such as underserved, overburdened, or disadvantaged communities and members of those communities; host communities; and labor unions representing workers or trades that will be needed for both construction and ongoing operations/production activities associated with the project.“[70]

In September 2022, the DOE released a „funding opportunity announcement“ (FOA) for the H2Hubs.[71] A FOA is a publicly available document that a federal agency (the DOE, in this case) uses to announce that it is beginning a competition for funding that it has available from the US Congress under a federal law (in this case, the IIJA) to give at its discretion. A FOA usually includes information to allow prospective applicants to determine whether to pursue the application process, which then often has numerous steps after the FOA. In this case, the FOA specified an extensive list of criteria regarding the focus of the H2Hub program. The H2Hub FOA is a lengthy document, so it is only possible here to summarize some of its major provisions.

First, the FOA required that each H2Hub project must demonstrate that it will lead to advancements in the production, processing, delivery, storage, and end uses of clean hydrogen.[72] The hub sponsors were required to describe how the networks would be created and show how they would maintain the network throughout the lifetime of the four phases of funding of the program, and to detail their plans for commercial-scale demonstrations of their production and distribution network. By selecting multiple hubs, the statute and the DOE intend that the program will showcase hydrogen's versatility. Hubs are intended to create networks of production, transport, storage, and end-users selected that differ from each other in feedstocks used to make hydrogen, production techniques, and end uses, allowing the DOE to meet the requirements imposed on it by the IIJA.

The FOA defined eligibility for H2Hub funding broadly. Those eligible to apply included individuals, institutions of higher education, for-profit and non-profit organizations, state and local governments, and tribal nations. Indeed, it was expected – and eventually happened – that proposals would originate from consortia that would be local, statewide, or even multi-state initiatives, with private sector companies, investors, community groups, and state and local governments coming together to make the proposals. Proposals varied widely in their scope, and there were considerable differences among them in feedstocks, production techniques, and end users. Some proposals from groups located in areas of the US with abundant fossil fuels such as natural gas intended to use these fuels to produce hydrogen. Others proposed to use all or mostly renewable electricity to make the hydrogen. This led to criticism that some proposals that contemplated the production of blue hydrogen should not be considered at all by the DOE.

The H2Hub program has a cost share requirement that applicants must meet for their total project costs and individually for costs for each of the four funding phases. In the US, a „cost share“ arrangement with a federal agency means that the recipient of federal funds contributes a portion of the costs of the federally assisted project or program, with that portion as a result not being supplied by the federal government.[73] The purpose of cost sharing is two-fold: first, it leverages the federal funding to increase the project's total economic impact; and second, it ensures that recipients of federal funding have a financial stake in the project. Cost sharing must come entirely from non-federal sources and may take two forms: cash contributions to offset personnel costs, supply costs, and indirect and fringe costs; and in-kind contributions encompassing „all contributions to the project made by the recipient or subrecipient(s) that do not involve a payment or reimbursement and represent donated items or services.“[74] The applicable DOE regulations governing cost sharing provide for a 50 percent cost share for projects such as the H2Hub program,[75] and applicants for hub funding were required to document how they would meet this requirement.

The DOE provided that implementation of the H2Hubs would proceed in four phases, with the $7 billion in DOE funding supporting the first phase. In Phase 1, the H2Hub team would conduct initial planning and analysis activities to ensure that its overall concept for a regional hydrogen production and distribution network is technologically and financially viable. Remaining phases would include engineering, business development, contracts, community engagement and construction and, finally, full operations.[76] Following the issuance of the FOA, each applicant was required to submit a „concept paper“ for their proposed H2Hub by November 2022. This 20-page (maximum) document required, among other things, a summary description of the proposed integrated H2Hub, a preliminary development plan and timeline, identification of necessary equipment and facilities, and a description of the proposed H2Hub's team and qualifications. The DOE received 79 concept papers. Of these, DOE encouraged 33 teams to formally continue in the process by submitting a full application by April 2023.[77] The rest of the teams were discouraged from continuing in the application process.

The criteria that the DOE used to evaluate concept papers and winnow the group down from the 33 teams that submitted concept papers to a final seven that were selected as Regional Clean Hydrogen Hubs included the following, according to the DOE:

70 Guidance for Creating a Community Benefits Plan for the Regional Clean Hydrogen Hubs, supra note 67, at 2.
71 *U.S. Department of Energy, Office of Clean Energy Demonstrations*, Funding Notice: Regional Clean Hydrogen Hubs, September 22 2022, https://www.energy.gov/oced/funding-notice-regional-clean-hydrogen-hubs.
72 *U.S. Department of Energy, Office of Clean Energy Demonstrations*, Regional Clean Hydrogen Hubs, https://www.energy.gov/oced/regional-clean-hydrogen-hubs-0.
73 *U.S. Department of Energy, Office of Clean Energy Demonstrations*, Cost Sharing Guidance, May 2023, https://www.energy.gov/sites/default/files/2023-05/OCED%20Cost%20Sharing%20Guidance.pdf.
74 *Id.* at 1.
75 2 Code of Federal Regulations § 910.130.
76 *U.S. Department of Energy, Office of Clean Energy Demonstrations*, Funding Notice: Regional Clean Hydrogen Hubs, September 22 2022, https://www.energy.gov/oced/funding-notice-regional-clean-hydrogen-hubs.
77 *Bioret/Zhu/Krupnick*, Hydrogen Hubs: Get to Know the Encouraged Applicants, Resources, February 7, 2023, /An interactive map of the encouraged proposals is available at Resources For the Future, Hydrogen Hub Explorer, https://www.rff.org/publications/data-tools/hydrogen-hub-explorer/.

- Technical Merit and Impact, including but not limited to the ability of the proposed hub to deploy infrastructure and produce at least 50-100 metric tons of clean hydrogen per day and reduce greenhouse gas emissions.
- Financial and Market Viability, including growth potential and market competitiveness of the proposed hub.
- Workplan, including the speed at which the hub could begin operations and overall project management details.
- Management Team and Project Partners, including the team's ability to execute the plan with a high level of success.
- Community Benefits Plan, including an assessment of community and labor engagement, quality job creation and workforce development, diversity equity inclusion and accessibility, and the Justice40 Initiative.[78]

On October 13, 2023, the DOE announced the selection of the first seven Regional Clean Hydrogen Hubs.[79] The hubs are distributed geographically throughout the US, from the east coast to the west, and from north to south.[80] The selected hubs include the following:

(1) Mid-Atlantic Hydrogen Hub (Mid-Atlantic Clean Hydrogen Hub (MACH2); Pennsylvania, Delaware, New Jersey);
(2) Appalachian Hydrogen Hub (Appalachian Regional Clean Hydrogen Hub (ARCH2); West Virginia, Ohio, Pennsylvania);
(3) California Hydrogen Hub (Alliance for Renewable Clean Hydrogen Energy Systems (ARCHES); California;
(4) Gulf Coast Hydrogen Hub (HyVelocity Hydrogen Hub; Texas);
(5) Heartland Hydrogen Hub (Minnesota, North Dakota, South Dakota);
(6) Midwest Hydrogen Hub (Midwest Alliance for Clean Hydrogen (MachH2); Illinois, Indiana, Michigan); and
(7) Pacific Northwest Hydrogen Hub (PNW H2; Washington, Oregon, Montana)[81]

An example of the types of consortia developed by winning applicants and the activities proposed for the hubs is the ARCH2 Hub (Appalachian Regional Clean Hydrogen Hub). The partners in this hub include the state of West Virginia, the EQT Corporation (the largest natural gas producer in the US), the Battelle research and development firm, and GTI Energy (an energy R&D firm). Its mission statement indicates that, „ARCH2 will use the nation's lowest-cost NG [natural gas] as primary feedstock to enable and sustain a regional H2 economy across multiple end-use sectors in the Appalachian region while ensuring economic benefits are shared fairly and equitably among local communities.“[82] The aim of ARCH2 is „bringing together private industry, state and local government, academic and technology institutions, NGOs, and community organizations across the Northern Appalachian region including West Virginia, Ohio, Pennsylvania, and Kentucky.“[83]

2. The Energy Justice Critique

The H2Hubs program has proceeded forward under significant controversy, having generated opposition from environmentalists, scholars & pipeline safety advocates. Some of this opposition is derived from a basic objection to using fossil fuels or electricity generated from renewable resources to make another fuel instead of using that fuel directly in an end use. But opposition is also aimed at the makeup of the H2Hubs program and the process which led to the winning bids, which has been argued to run counter to the goals of the growing energy justice movement.[84]

To begin with, because some hub sponsors proposed to produce blue hydrogen (again, using fossil fuels as feedstocks and meeting the statute's requirements to do so), critics believe that this would not reduce emissions of greenhouse gases as much as is necessary to meet the world's agreed upon target for reducing global temperature. For example, a recent study claims that producing blue hydrogen may be worse than burning coal for an end use such as building heat, due to the release of fugitive methane during the production process.[85] As a result, the ARCH2 hub proposal, among others, generated substantial opposition. Because the ARCH2 hub intends to produce hydrogen from natural gas, it fits within the statutory requirement that at least one hub use fossil fuels to produce hydrogen.

On the other hand, this lends credence to the critique that because some hubs will produce blue hydrogen, the program is not designed for maximum emissions reductions. Indeed, before the DOE announcement of the winning hub proposals, 32 organizations from the eastern mountain region of Appalachia signed a letter to DOE Secretary *Jennifer Granholm* opposing the designation of a hydrogen hub in that region.[86] Among other objections, the letter stated that, „Funding hydrogen hubs will lock in dirty fossil fuel production at a time when the U.S. urgently needs to phase out oil and gas," and that, „The process of producing gray and blue hydrogen is a major source of fugitive methane emissions from flaring, transportation, and other upstream processes – releasing even more potent greenhouse gasses and exacerbating atmospheric warming over the next two decades.[87] Another article concurred, noting that the hubs would

78 *U.S. Department of Energy, Office of Clean Energy Demonstrations*, Regional Clean Hydrogen Hubs Selections for Award Negotiations, https://www.energy.gov/oced/regional-clean-hydrogen-hubs-selections-award-negotiations.
79 *The White House*, Biden-Harris Administration Announces Regional Clean Hydrogen Hubs to Drive Clean Manufacturing and Jobs, October 13, 2023, https://www.whitehouse.gov/briefing-room/statements-releases/2023/10/13/biden-harris-administration-announces-regional-clean-hydrogen-hubs-to-drive-clean-manufacturing-and-jobs/.
80 *Bioret/Zhu/Krupnick*, supra note 77.
81 *Bioret/Zhu/Krupnick*, supra note 77.
82 Appalachian Regional Clean Hydrogen Hub, https://www.arch2hub.com/.
83 Appalachian Regional Clean Hydrogen Hub, Concept, https://www.arch2hub.com/about/arch2-concept/.
84 For a discussion of energy justice, see generally *Welton/Eisen*, 43 Harvard Environmental Law Review 307 (2019).
85 *Howarth/Jacobson,* How green is blue hydrogen?, Energy Science & Engineering, Aug. 12, 2021, https://onlinelibrary.wiley.com/doi/full/10.1002/ese3.956.
86 Letter, Re: Don't believe the "Hydrogen Hype" – Reject all applications for Department of Energy Regional Clean Hydrogen Hubs (H2Hubs) funding, August 22 2023, https://www.biologicaldiversity.org/programs/climate_law_institute/pdfs/National-Hydrogen-Letter-8_22_23.pdf.
87 *Id.* at 2.

„entrench our fossil fuel dependence and distract from real climate solutions.“[88]

Another set of objections to the program centers around a perceived lack of transparency in the development of the proposals. Over the past decade, the energy justice movement has highlighted the historical development and siting of major industrial energy facilities without the involvement or consent of the affected communities.[89] As a result, there has been considerable discussion in the US about how to foster more robust community engagement in the siting of energy facilities. From the outset, however, environmental groups were concerned that the H2Hub proposals were not sufficiently responsive to community concerns and were being designed without sufficient community input.[90] The Environmental Defense Fund crafted a „BetterHubs“ initiative, „built around 10 core objectives that summarize the main environmental and social considerations that should be present for a Hub to ensure positive outcomes on the ground.“[91] For example, these included a commitment to „meaningful and actionable dialogue and proactive partnership and consultation with all potentially impacted communities, public health officials, and environmental justice leaders.“[92] As noted above, the principal vehicle for addressing these concerns in proposals was that applicants for funding for hubs were required to include Community Benefits Plans describing their engagements with community and labor groups, and their work to bring benefits to disadvantaged groups. This requirement of the proposals was termed a „key“ feature of delivering on the Biden Administration Justice40 commitments.[93]

But some were critical that this was actually being accomplished in practice. Critics note that to a large extent, the development of the proposals was a „black box," with transparency „sorely lacking.“[94] The DOE did not make key portions of H2Hubs proposals publicly available throughout the application process. And while applicants were required to develop a Community Benefits Plan, the extent to which they intended to involve localities and determine that the Justice 40 requirements would be met was left up to them. Once again, this is inconsistent with the involvement sought by energy justice advocates, who argue that communities should be active partners in developing proposals for siting of energy facilities from the beginning. Given the sort of massive infrastructure that would be built under the proposals for the hubs, the Community Benefit Plans struck many as an insufficient way of involving local communities that have already felt the burdens of large energy infrastructure. Undoubtedly, there will be considerable pressure in the coming years from energy justice advocates to improve hub sponsors' engagement with affected communities.

D. Conclusion

Hydrogen may well be a „fuel of the future," and the US has made it a cornerstone of its efforts to bring about a clean energy transition. As noted above, the US federal government has taken tangible and important steps toward promoting hydrogen's production, transportation and distribution throughout the nation. However, there are significant technological challenges involved in ramping up a hydrogen economy in the US, and there is a steep hill remaining for advocates to climb to secure more public acceptance of widespread production of hydrogen. Over the coming years, the funding from the two flagship federal programs will be important in determining hydrogen's future in the US.

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90 *Kamrath/Budden*, Natural Resources Defense Council, Success of Hydrogen Hubs Requires a Step Increase in Transparency, October 19 2023, https://www.nrdc.org/bio/erik-kamrath/success-hydrogen-hubs-requires-step-increase-transparency.
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Hochlauf der Offshore-Elektrolyse – ein Praxisbericht

Der AquaVentus Förderverein wurde im Oktober 2020 auf Helgoland gegründet. Das satzungsgebundene Ziel ist die Realisierung und Förderung von regenerativ erzeugten grünen Offshore-Wasserstoff; diese Ziele umfassen Herstellung, Speicherung, Transport und Weiterverarbeitung. Mit seinen rund 100 Mitgliedern auf Wissenschaft und Wirtschaft sieht sich der AquaVentus Förderverein als Schlüsselakteur zum Hochlauf der Offshore-Wasserstoffgewinnung und notwendiges Bindeglied zwischen Wirtschaft, Politik und Forschungsgemeinschaft. Diese Schnittstellenfunktion ist erforderlich, um die Transformation nationaler Energiegesamtsysteme hin zu Klimaneutralität und Resilienz mithilfe des großskaligen Einsatzes von regenerativ erzeugtem grünen Wasserstoff realisieren zu können.

Nach der im Juli 2023 aktualisierten Nationalen Wasserstoffstrategie soll bis 2030 1 Gigawatt (GW) Offshore-Elektrolyseleistung als Blaupause für einen massiven Hochlauf realisiert werden.

Schlagworte: Offshore-Elektrolyse, Wind-Wasserstoff, Versorgungssicherheit, nachhaltige Wertschöpfungsketten, geoenergetische Resilienz, Entenschnabel, grünes Kraftwerk

A. AquaVentus-Genese

Bereits im Jahr 2035 will der AquaVentus Förderverein eine Million Tonnen grünen Wasserstoff pro Jahr bereitstellen.[1] Um diese Menge erzeugen zu können, sollen neben der Ostsee vor allem in der Nordsee aus 10 GW Windenergie mittels Offshore-Elektrolyse Wasserstoff erzeugt und über eine Pipeline an Land transportiert werden.

Was sind die Beweggründe, dieses ambitionierte Ziel auszurufen?

I. Klimaziele nur mit grünem Wasserstoff zu erreichen

Grüner Wasserstoff wird ein Eckpfeiler defossilisierter Volkswirtschaften werden. Er wird diese herausfordernden Transformationspfade erst ebnen und ermöglichen. Ohne den großvolumigen Einsatz grünen Wasserstoffs werden keine ambitionierten Klimaziele zu erreichen sein.

Dabei wird Wasserstoff nicht nur als Grundstoff für beispielsweise die Düngemittelproduktion oder die Stahlherstellung Verwendung finden, sondern auch als Speichermedium für grüne Elektronen, um später wieder verstromt zu werden oder um in die Industriezentren transportiert werden zu können.

II. Neue Märkte

Die Wasserelektrolyse ist in ihrer Funktionsweise seit über 200 Jahren bekannt. Allerdings fristete sie bisher ein Schattendasein gegenüber alternativen und billigeren Wasserstofferzeugungsmethoden;[2] diese Vorzeichen haben sich aufgrund von CO_2-Vermeidungsvorgaben in Wirtschaftszweigen, Sektoren und Wirtschaftssystemen grundlegend gewandelt.

Gleichzeitig stellt der „fuel-switch“, die Umstellung per se funktionierender volkswirtschaftlicher Kreisläufe – angetrieben von Öl und Gas – auf defossilisierte integrierte Energiekonzepte eine noch nie dagewesene Aufgabe für Produzenten, Konsumenten und Distributoren dar.[3]

Mit Blick auf die Offshore-Elektrolyse als neue Transformationstechnologie wird daher eine steile Lernkurve während des Hochlaufs zu erwarten sein. Gleichzeitig wird wie bei allen grundlegenden sozio-ökonomischen Transformationsprozessen zu Beginn staatliche Förderung notwendig sein.

Es herrscht Konsens, dass mit verlässlichen regulatorischen Rahmenbedingungen auch in Deutschland und Europa die Offshore-Elektrolyse grünen Wasserstoff zu konkurrenzfähigen Preisen herstellen und damit einen „business case“ darstellen kann.[4]

III. Aus der Vision zur Mission

Das Zusammenwirken der Bedeutung von Wasserstoff für die Energiewende und die unternehmerischen Chancen, die sich für innovative Akteure am Markt auftun, waren die Bausteine, aus der sich die AquaVentus-Vision im Jahr 2020 zusammensetzte.

Der Zeitpunkt der Veröffentlichung der Nationalen Wasserstoffstrategie (NWS) im Juni 2020 – also wenige Monate vor Gründung des AquaVentus Fördervereins – war richtungsweisend. Erstmals in der Geschichte der Bundesrepublik wurde eine langfristige Regierungsstrategie für einen einzelnen Energieträger formuliert.

Dem Wunsch nach Präzisierung und Fortschreibung des Strategiepapiers kam die Bundesregierung im Juli 2023 nach. Für die Offshore-Elektrolyse und AquaVentus war die Fortschreibung der NWS grundsätzlich positiv zu bewerten, da für sie explizit 1 GW als Bestandteil des 10 GW Elektrolyseziels für das Jahr 2030 ausgewiesen wurde.

1 Grüner Wasserstoff wird in diesem Artikel als Wasserstoff umschrieben, der im Einklang mit den in Art. 2 Nr. 1 der Richtlinie (EU) 2018/2001 (RED II) dargelegten Methoden aus erneuerbaren Energien gewonnen wurde.
2 Hier zu nennen vor allem die partielle Oxidation von Schweröl, die Kohlevergasung und die Erdgasdampfreformierung, die bisher das Gros der direkten Wasserstofferzeugung liefern. Vgl. hierzu *Wasserstoff-Kompass*, https://www.wasserstoff-kompass.de/handlungsfelder#/h2-erzeugung (abgerufen am 29.11.2023).
3 Dass sich bei einem solch erzwungenen Systemwechsel (fuel-switch), das bisher viele monetär- und geopolitisch lukrative Regime hervorbrachte und stützte, massiver Widerstand formiert, liegt in der Natur des Homo Oeconomicus. Diese Widerstände können jedoch überwunden werden, wenn es dem Erneuerbaren Energiesektor im Allgemeinen und der grünen Wasserstoffwirtschaft im Speziellen gelingt, tragfähige Geschäftsmodelle anzubieten.
4 Vgl. hierzu beispielsweise: *Fraunhofer ISE* et al., Projekt OffsH2ore: Offshore-Wasserstofferzeugung mittels Offshore-Windenergie als Insellösung – Endbericht, 2023.