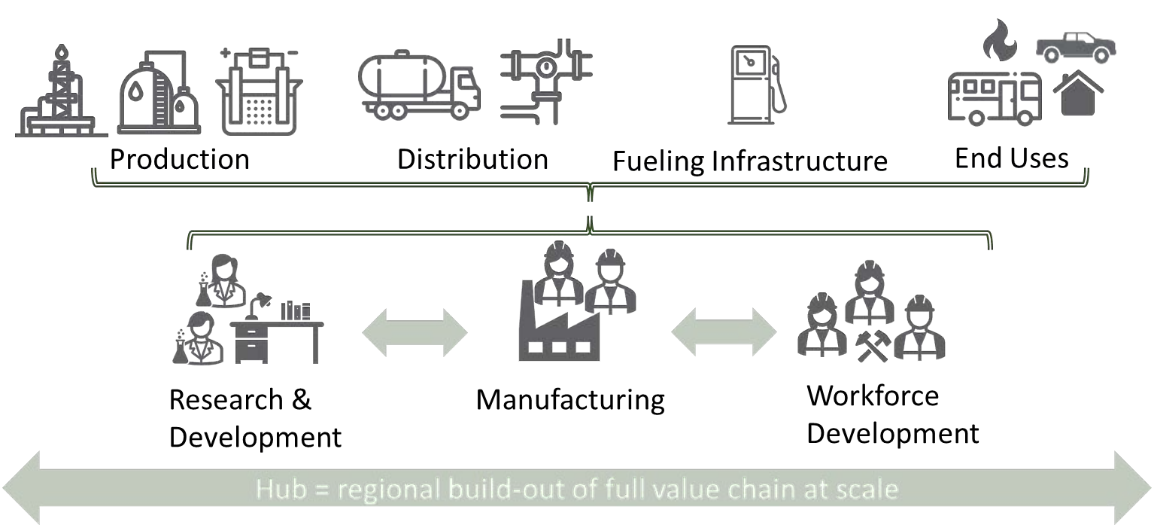
Defining and Envisioning a Clean Hydrogen Hub for New Mexico

January 2022

THE HYDROGEN HUB VISION

"We have exactly what it takes to become an international hydrogen hub, bringing more jobs, more infrastructure, and more economic development to New Mexico communities as we continue our clean energy transition."

- Governor Michelle Lujan Grisham



The Hydrogen Hub Concept

EXECUTIVE SUMMARY

States across the west are grappling with a clean energy future and the transition to accomplish it. By way of our existing and planned production capabilities and infrastructure, New Mexico can meet even the most demanding of requirements in delivering clean energy for the western US. Many promising state-wide opportunities for the production and use of hydrogen have been identified through this study. These opportunities provide a path toward ensuring New Mexico remains an energy powerhouse. Better yet, a clean energy powerhouse.

- Production –NM is an outstanding resource for wind and solar and has major natural gas production and reserves. This existing infrastructure provides the feedstock for clean hydrogen production. These resources make New Mexico ideal to be a major producer of clean hydrogen.
- Distribution –New Mexico, along with other states in the four corners are perfectly situated for multi-directional hydrogen distribution (and hydrogen-fueled power generation) in that the existing infrastructure includes significant electrical transmission, major interstate pipelines, interstate highways and rail lines.
- End-use – The three top end-use opportunities for hydrogen in New Mexico are power-to-gas, freight, and industry. Power-to-gas is one of the best long-duration storage options for deep decarbonization of the electricity system. Freight will be another important end use as significant goods movement occurs through the state. Finally, much of industry is typically considered a difficult sector to reduce carbon emissions, with hydrogen being a competitive option.
- Export – New Mexico is currently a key power, oil, and gas exporter to the rest of the United States. Hydrogen presents an opportunity for New Mexico to continue being an energy exporter for the rest of the US as well as internationally, given the state's proximity to major electrical transmission, key interstate highways, rail lines and pipelines that serve critical markets.
- Opportunities – Keen interest has been expressed in building out New Mexico's hydrogen infrastructure including modernizing the electrical grid, retrofitting, or replacing coal-fire power generation facilities, carbon capture and sequestration demonstration projects, capturing fugitive methane emissions to fuel vehicles and rail fleets, and utilizing existing oil and gas infrastructure for transport to major markets.
- Recommendations – Several recommendations are provided to develop and guide policy discussions such that New Mexico can lead the transition toward a clean energy economy and continue to utilize her existing, developing, and potential resources to remain an energy powerhouse for the Western United States thereby enjoying a strong diversified economy while attracting future industries.

Developing a clean hydrogen economy is a strong economic development and energy diversification tool that the state has within its grasp due to having so many intrinsic attributes. The clean hydrogen opportunities and their newfound economic investments are seeking a place to land and while the state is perfectly situated for this investment it must seize the opportunity through thought and political leadership.

Purpose

The purpose of this report is to provide the State of New Mexico a thorough compendium of the advantages the state enjoys and the challenges which it confronts regarding the development of a clean-hydrogen economy. It is further the purpose of this report to offer policy recommendations to the executive and the legislature (as well as communities across the state) in the pursuit of New Mexico being designated a clean-hydrogen hub as defined in the 2021 Infrastructure Investment and Jobs Act. This report has been developed in conjunction with and funded by the New Mexico Economic Development Department and with partnership from the New Mexico Environment Department, Energy, Minerals and Natural Resources Department and Indian Affairs Department.

This report seeks to broadly answer the questions: ***how can clean-hydrogen be leveraged to develop diversified economic development and employment opportunities for the State of New Mexico? How can the state best work collaboratively with Tribal Nations and other states in our region in the pursuit of these opportunities? How does the state of New Mexico and the United States achieve net zero emissions without tools and incentives to incent decarbonization? What are the environmental considerations in this pursuit as the state moves forward toward a low- and no-carbon energy future? What are the first steps to get started?***

Disclaimer

This policy report, including its recommendations, has been written as part of a grant provided by the New Mexico Economic Development Department (EDD). New Mexico energy Prosperity and other contributors and participants are advisory in nature providing independent advice and recommendations on the issue of hydrogen energy development in New Mexico. In addition, the materials, opinions, findings, recommendations, and conclusions expressed herein, and in any study or other source referenced herein, should not be construed as adopted or endorsed by any organization with which any contributor or participant is affiliated. This report has not been reviewed for approval by the EDD, and hence, its contents and recommendations do not necessarily represent the views and the policies of the EDD, nor of other agencies in the Executive Branch of New Mexico state government.

With the passage of the 2021 Infrastructure Investment and Jobs Act allocating $8 Billion for the development of at least four clean-hydrogen hubs across the United States the topic of a hydrogen based economy has become in vogue. While significant effort is timely it also is important to establish that the shelf life could be limited based a rapidly evolving topic.

TABLE OF CONTENTS

Disadvantaged Communities and their Economies **5**

Introduction To Hydrogen **6**

What is a Hydrogen Hub? **8**

The US Definition of a Hydrogen Hub 9

What Else Does the Infrastructure Investment and Jobs Act Say about H_2 Hubs? 9

Generic Criteria for the establishment of a Clean Hydrogen Hub 9

Feedstock and End-use diversity requirements 10

Job Creation 10

Other Major Considerations for Hub Selection 10

How to Ensure a Just Energy Transition and advancement **13**

Carbon Intensity of Hydrogen Production **15**

What is Blue Hydrogen and Why Consider It in New Mexico? 17

Carbon Capture Opportunities (as part of a hydrogen hub) **20**

Water Intensity of Hydrogen Production **22**

Hydrogen Hub Opportunities in New Mexico **24**

Building a Hydrogen Hub for New Mexico 28

Key Clean Hydrogen Consumers 31

Vision 31

Recommendations Moving Forward **33**

Contributors & Participants **35**

Appendix A - Colorblind Hydrogen **37**

DISADVANTAGED COMMUNITIES AND THEIR ECONOMIES

Northwest New Mexico has experienced decades of prosperity for the area as an energy supplier to the western US. From coal-fired power generation to natural gas production, the area has literally powered the Western United States for decades.

But, with coal-fired power plants being shuttered, and weakness in natural gas prices extending back to the global economic crisis of 2008; the Four Corners region has been hit hard economically.

According to the Initial Report to the President on Empowering Workers Through Revitalizing Energy Communities[1], "It is home to one of the top 20 producing coal mines in the United States; two of the top 20 by power generation capacity coal power plants; three refiners; more than 64,000 active oil and gas wells, representing 8% of active oil and gas wells in the country; and one of the top 20 producing natural gas power plants."

Farmington, NM was cited as "America's Fastest Shrinking City" in 2016 based on US Census data[2]. It experienced a negative population growth of -8.76% from 2010 to 2016. Further, Farmington's non-adjusted gross receipts tax collection, a key indicator of a community's financial well-being, dropped by 13.5% from 2009-2018[3].

The Navajo Nation sprawls across New Mexico and other Four Corners states. The Navajo Nation is the largest Native American Reservation by way of land and is the largest Native American Tribe by population[4]. The Navajo has an astounding 35.8% of households under the federal poverty level (FPL) in 2020, an unemployment rate of 16.8% from 2015-2019, and 35% of households without access to running water[5].

The Jicarilla Apache Nation also lies within the San Juan Basin just to the east and south of Farmington. The Jicarilla have 17.6% of families living below the FPL and an unemployment rate of 23.5% from 2015-2019[6]

The Four Corners is one of five priority areas across the USA identified by the Revitalizing Energy Communities Report[7] for "focusing initial federal investments…and delivery of investment to Energy Communities."

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[1] Initial Report to the President on Empowering Workers Through Revitalizing Energy Communities (2021). Retrieved from: https://netl.doe.gov/sites/default/files/2021-04/Initial%20Report%20on%20Energy%20Communities_Apr2021.pdf
[2] Retrieved from: https://www.forbes.com/sites/niallmccarthy/2016/04/15/the-fastest-shrinking-cities-in-the-u-s-infographic/?sh=3171d4ce18bf
[3] http://fmtn.org/DocumentCenter/View/17376/2018-Strategic-Financial-Planning---FINAL
[4] https://www.census.gov/history/pdf/c2010br-10.pdf
[5] https://www.census.gov/tribal/
[6] Ibid.
[7] Initial Report to the President on Empowering Workers Through Revitalizing Energy Communities (2021). Retrieved from: https://netl.doe.gov/sites/default/files/2021-04/Initial%20Report%20on%20Energy%20Communities_Apr2021.pdf

INTRODUCTION TO HYDROGEN

Hydrogen is the first element on the periodic table as it is the simplest and lightest element on earth – approximately fourteen times lighter than air. Hydrogen is the most abundant element in the universe, accounting for about 75% of all mass. In its natural and gaseous state, molecular hydrogen is invisible, odorless, tasteless, and non-toxic, making it difficult to detect.

Like electricity, hydrogen is an energy carrier and must be produced. The combination of feedstock and conversion technology is a key descriptor when talking about hydrogen.

The colors of hydrogen have been presented as a way for easy communication of different feedstock-technology combinations. Figure 1 shows the colors of hydrogen and their connection to the feedstock-technology combination.

The downside of this communication structure is that there can be significant differences among carbon intensities within a single color, e.g., blue hydrogen could be used to describe two plants, one with at fairly high carbon intensity and one with a low carbon intensity due to carbon capture rates and other life cycle nuances. Additionally, it makes it difficult for describing unique technologies or technologies with mixed feedstock.

	Terminology	Technology	Feedstock/ Electricity source	GHG footprint*
PRODUCTION VIA ELECTRICITY	Green Hydrogen	Electrolysis	Wind | Solar | Hydro Geothermal | Tidal	Minimal
	Purple/Pink Hydrogen		Nuclear	
	Yellow Hydrogen		Mixed-origin grid energy	Medium
PRODUCTION VIA FOSSIL FUELS	Blue Hydrogen	Natural gas reforming + CCUS Gasification + CCUS	Natural gas | coal	Low
	Turquoise Hydrogen	Pyrolysis	Natural gas	Solid carbon (by-product)
	Grey Hydrogen	Natural gas reforming		Medium
	Brown Hydrogen	Gasification	Brown coal (lignite)	High
	Black Hydrogen		Black coal	

*GHG footprint given as a general guide but it is accepted that each category can be higher in some cases.

Figure 1: The colors of hydrogen[1]

The opinion submission attached as Appendix A entitled, "With hydrogen, 'clean' should be colorblind" most effectively summarizes the need to look at hydrogen production through the lens of a life cycle carbon intensity methodology. The op-

[1] Source: https://globalenergyinfrastructure.com/articles/2021/03-march/hydrogen-data-telling-a-story/

ed states, "The cleaner the producer can make the production process (including upstream processes) the more value the product will have."

Hydrogen is currently essential to society for use in ammonia production, oil refining, methanol production, and metal processing. Ammonia production and oil refining dominate the current hydrogen demand. The demand for hydrogen has steadily grown. New demand for hydrogen is emerging as societies look to decarbonize. Using multiple energy carriers in this transition will be important for secure and reliable energy supply as well as transitioning and expanding the workforce needed in this transition. A single energy carrier, i.e., electricity, increases supply chain risks and increases workforce transition issues.

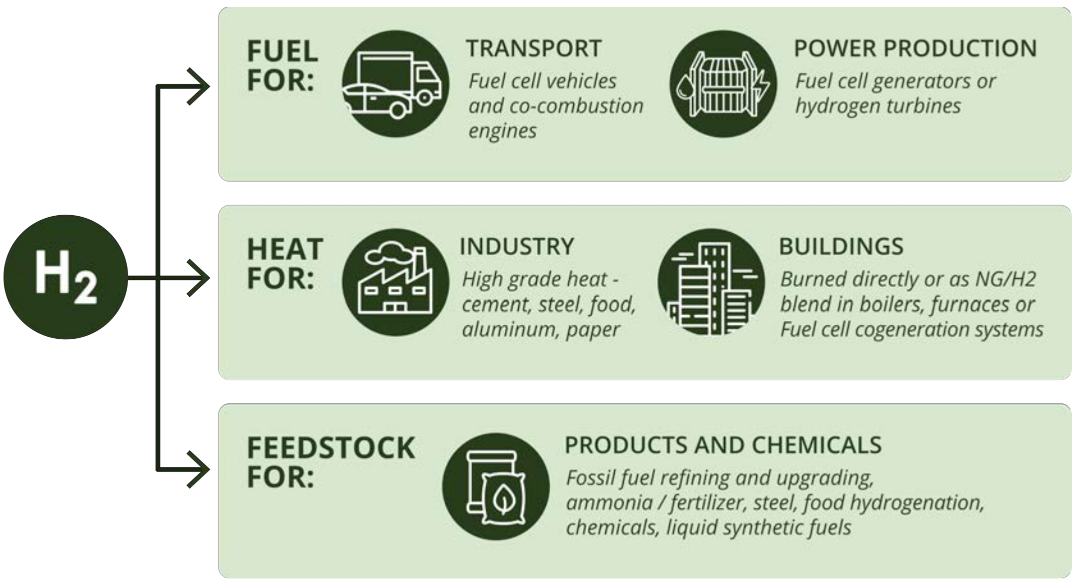


Figure 2: Various end-uses for hydrogen in a decarbonized economy

Hydrogen is a versatile and unique energy carrier that enables economic and environmental benefits and can play a significant role in decarbonization of energy systems. As a compressed gas or liquid, hydrogen is a multifaceted energy carrier. It has the highest energy per mass of any fuel allowing it to transfer large amounts of energy from its point of production to end-use application.

Hydrogen used as a fuel in fuel cell electric vehicles (FCEVs) is quickly becoming an attractive zero-emission alternative for transportation, especially heavy-duty vehicles and transit buses that require long range and short refueling times. A fuel cell chemically converts hydrogen and oxygen yielding electricity and water—there is no carbon dioxide and no pollutants such as nitrous oxide. Hydrogen can also be used as a fuel for power generation which allows for load management, and energy storage. This enables the growth of the variable renewable power sector. Hydrogen can be burned directly or as a blend with natural gas to reduce carbon emissions in providing building heat and high-grade heat for industry.

WHAT IS A HYDROGEN HUB?

The hydrogen hub concept has been used frequently in hydrogen strategies globally as a method to achieve scale across the hydrogen supply chain in a region. These hubs can then be interconnected over time to create national and international hydrogen markets. The European Hydrogen Backbone builds on this concept by using pipeline to interconnect hubs developed across Europe[1].

The schematic in Figure 3 illustrates the various value chain elements. Hydrogen Hub definitions have varied slightly across different strategies and deployments, but the focus of establishing scale by securing not only the production but also the distribution and end-use of the hydrogen is key. This scale-up requires accelerated deployment that must also be accompanied by research and development (R&D) as well as workforce development and training to ensure operability of the value chain but also at the manufacturing facilities. These hubs will likely become centers of R&D and workforce development.

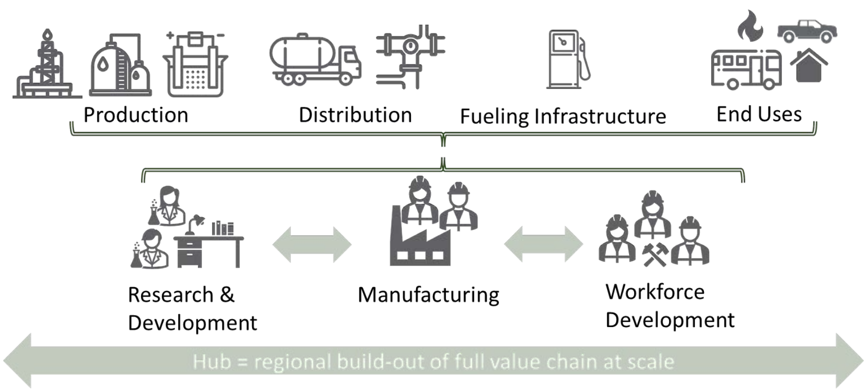


Figure 3: Hydrogen supply chain and hydrogen hub deployment

The Port of Rotterdam Hydrogen Hub is an important and illustrative example of a major hydrogen hub where many different production and distribution pathways are interconnected to various end-uses. The concept of importing and exporting hydrogen is also key to their vision. It should be noted that the 2 Gigawatt (GW) onshore electrolyzer will be built in phases with the first electrolyzer build of 200 Megawatt (MW) has a commercial operation date of 2023.

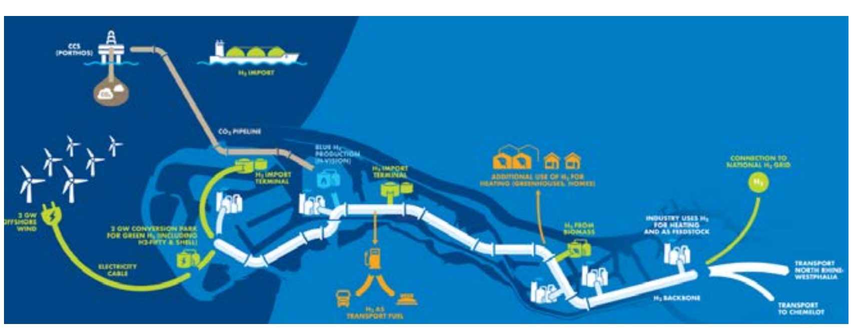


Figure 4: Illustration of the Port of Rotterdam Hydrogen Hub[2]

[1] https://gasforclimate2050.eu/wp-content/uploads/2021/06/European-Hydrogen-Backbone_April-2021_V3.pdf
[2] https://www.portofrotterdam.com/en/port-future/energy-transition/ongoing-projects/hydrogen-rotterdam

The US Definition of a Hydrogen Hub

The recently passed Infrastructure Investment and Jobs Act[1] provides the most relevant definition: "the term 'regional clean hydrogen hub' means a network of clean hydrogen producers, potential clean hydrogen consumers, and connective infrastructure located in close proximity".

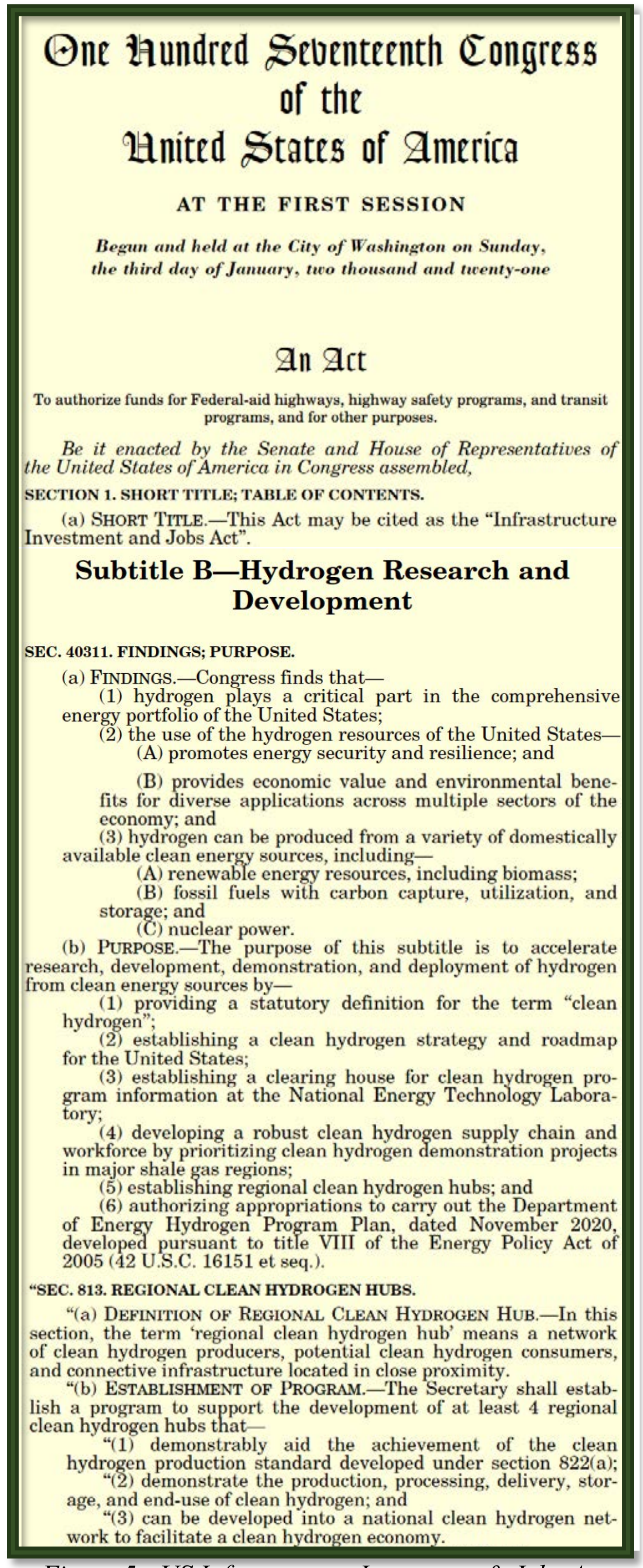
What Else Does the Infrastructure Investment and Jobs Act Say about H_2 Hubs?

The Infrastructure Investment and Jobs Act appropriates $8 Billion for at least four "Clean Hydrogen Hubs" for 2022-2026 Fiscal Years. The United States Department of Energy (DOE) is to release a solicitation within 180 days of passage of the infrastructure package which will be May 14, 2022. Awards are required to be made within one year of proposal submission. Details related to "Clean Hydrogen Hubs" will come as part of the solicitation, but given the complexity and interaction required, the DOE is working to provide earlier communication on what is to be expected.

The requirements for selection of hydrogen hubs across the United States are broadly guided by the Infrastructure Investment and Jobs Act including 1) generic criteria for establishment of a hub, 2) feedstock and end-use diversity minimum requirements, and 3) job creation.

Generic Criteria for the establishment of a Clean Hydrogen Hub

1. demonstrably aid the achievement of the clean hydrogen production standard developed under section 822(a)[2]
2. demonstrate the production, processing, delivery, storage, and end-use of clean hydrogen;
3. and can be developed into a national clean hydrogen network to facilitate a clean hydrogen economy.



One Hundred Seventeenth Congress
of the
United States of America

AT THE FIRST SESSION

Begun and held at the City of Washington on Sunday, the third day of January, two thousand and twenty-one

An Act

To authorize funds for Federal-aid highways, highway safety programs, and transit programs, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE; TABLE OF CONTENTS.

(a) SHORT TITLE.—This Act may be cited as the "Infrastructure Investment and Jobs Act".

Subtitle B—Hydrogen Research and Development

SEC. 40311. FINDINGS; PURPOSE.

(a) FINDINGS.—Congress finds that—
(1) hydrogen plays a critical part in the comprehensive energy portfolio of the United States;
(2) the use of the hydrogen resources of the United States—
(A) promotes energy security and resilience; and
(B) provides economic value and environmental benefits for diverse applications across multiple sectors of the economy; and
(3) hydrogen can be produced from a variety of domestically available clean energy sources, including—
(A) renewable energy resources, including biomass;
(B) fossil fuels with carbon capture, utilization, and storage; and
(C) nuclear power.
(b) PURPOSE.—The purpose of this subtitle is to accelerate research, development, demonstration, and deployment of hydrogen from clean energy sources by—
(1) providing a statutory definition for the term "clean hydrogen";
(2) establishing a clean hydrogen strategy and roadmap for the United States;
(3) establishing a clearing house for clean hydrogen program information at the National Energy Technology Laboratory;
(4) developing a robust clean hydrogen supply chain and workforce by prioritizing clean hydrogen demonstration projects in major shale gas regions;
(5) establishing regional clean hydrogen hubs; and
(6) authorizing appropriations to carry out the Department of Energy Hydrogen Program Plan, dated November 2020, developed pursuant to title VIII of the Energy Policy Act of 2005 (42 U.S.C. 16151 et seq.).

"SEC. 813. REGIONAL CLEAN HYDROGEN HUBS.

"(a) DEFINITION OF REGIONAL CLEAN HYDROGEN HUB.—In this section, the term 'regional clean hydrogen hub' means a network of clean hydrogen producers, potential clean hydrogen consumers, and connective infrastructure located in close proximity.
"(b) ESTABLISHMENT OF PROGRAM.—The Secretary shall establish a program to support the development of at least 4 regional clean hydrogen hubs that—
"(1) demonstrably aid the achievement of the clean hydrogen production standard developed under section 822(a);
"(2) demonstrate the production, processing, delivery, storage, and end-use of clean hydrogen; and
"(3) can be developed into a national clean hydrogen network to facilitate a clean hydrogen economy.

Figure 5: US Infrastructure Investment & Jobs Act

[1] https://www.congress.gov/bill/117th-congress/house-bill/3684/text
[2] Section 822(a) directs the DOE in consultation with the EPA to define an initial standard for the carbon intensity of clean hydrogen production. It requires that the carbon intensity be equal to or less than 2 kilograms of carbon dioxide-equivalent produced at the site of production per kilogram of hydrogen produced. The section also allows this number to be adjusted further downward 5 years after developing the initial standard.

Feedstock and End-use diversity requirements

1. Feedstock diversity: at least one from fossil, at least one from nuclear, at least one from renewable
2. End-use diversity: at least one in electric power generation, at least one in industrial, at least one in residential/commercial heating, at least one in transportation

> "(1) SOLICITATION OF PROPOSALS.—Not later than 180 days after the date of enactment of the Infrastructure Investment and Jobs Act, the Secretary shall solicit proposals for regional clean hydrogen hubs.
> "(2) SELECTION OF HUBS.—Not later than 1 year after the deadline for the submission of proposals under paragraph (1), the Secretary shall select at least 4 regional clean hydrogen hubs to be developed under subsection (b).
> "(3) CRITERIA.—The Secretary shall select regional clean hydrogen hubs under paragraph (2) using the following criteria:
> "(A) FEEDSTOCK DIVERSITY.—To the maximum extent practicable—
> "(i) at least 1 regional clean hydrogen hub shall demonstrate the production of clean hydrogen from fossil fuels;
> "(ii) at least 1 regional clean hydrogen hub shall demonstrate the production of clean hydrogen from renewable energy; and
> "(iii) at least 1 regional clean hydrogen hub shall demonstrate the production of clean hydrogen from nuclear energy.
> "(B) END-USE DIVERSITY.—To the maximum extent practicable—
> "(i) at least 1 regional clean hydrogen hub shall demonstrate the end-use of clean hydrogen in the electric power generation sector;
> "(ii) at least 1 regional clean hydrogen hub shall demonstrate the end-use of clean hydrogen in the industrial sector;
> "(iii) at least 1 regional clean hydrogen hub shall demonstrate the end-use of clean hydrogen in the residential and commercial heating sector; and
> "(iv) at least 1 regional clean hydrogen hub shall demonstrate the end-use of clean hydrogen in the transportation sector.
> "(C) GEOGRAPHIC DIVERSITY.—To the maximum extent practicable, each regional clean hydrogen hub—
> "(i) shall be located in a different region of the United States; and
> "(ii) shall use energy resources that are abundant in that region.
> "(D) HUBS IN NATURAL GAS-PRODUCING REGIONS.—To the maximum extent practicable, at least 2 regional clean hydrogen hubs shall be located in the regions of the United States with the greatest natural gas resources.
> "(E) EMPLOYMENT.—The Secretary shall give priority to regional clean hydrogen hubs that are likely to create opportunities for skilled training and long-term employment to the greatest number of residents of the region.
> "(F) ADDITIONAL CRITERIA.—The Secretary may take into consideration other criteria that, in the judgment of the Secretary, are necessary or appropriate to carry out this title

Figure 6: Hydrogen Hub Selection Criteria

3.Natural Gas Producing Regions: At least two regional clean hydrogen hubs shall be located in the regions of the United States with the greatest natural gas resources

4.Geographic Diversity: located in different regions and use energy resources abundant in that region

Job Creation

The United States Secretary of Energy shall give priority to regional clean hydrogen hubs that are likely to create opportunities for skilled training and long-term employment to the greatest number of residents of the region.

Other Major Considerations for Hub Selection

Climate, Energy, and Environmental Justice

DOE's Office of Economic Impact and Diversity will lead an effort through a new role committed to implementing President Biden's Justice40 Initiative —a plan to deliver 40% of the overall benefits of climate investments to disadvantaged communities and inform equitable research, development, and deployment within the DOE.

President Biden's Executive Order 14008, "Tackling the Climate Crisis at Home and Abroad", created a government wide "Justice40 Initiative" that aims to deliver 40 percent (40%) of the overall benefits of relevant federal investments to disadvantaged communities. Federal agencies will be working toward identifying disadvantaged communities, ensuring 40% of federal funding reaches those communities, and reporting to the administration on progress toward the 40% target.

The Justice40 Initiative includes the Infrastructure Investment and Jobs Act and should be a major consideration in a Hydrogen Hub proposal and award. Details on the identification of disadvantaged communities regarding Hydrogen Hub proposals will likely come in the solicitation to be released by the DOE in late spring 2021.

Figure 7: The interaction of energy, climate, and environmental justice in a Just Energy Transition[1]

The Office of Management and Budget Interim Implementation Guidance for the Justice40 Initiative[2], "supports the Administration's comprehensive approach to advancing equity for all in line with Executive Order 13985." Executive Order 13985, "Advancing Racial Equity and Support for Underserved Communities Through the Federal Government"[3], clearly outlines that it is the "policy of the [Biden] Administration to pursue a comprehensive approach to advancing equity for all.

In Executive Order 13985, "equity" is defined as "the consistent and systematic fair, just, and impartial treatment of all individuals, including individuals who belong to underserved communities that have been denied such treatment". "Underserved communities" refers to populations that have been systematically denied a full opportunity to participate in aspects of economic, social, and civic life including Native Americans, persons living rural areas and those adversely affected by persistent poverty.

As outlined previously, the Four Corners clearly lies within the intent and the direction outlined in the Justice40 Initiative.

Specifically relating to self-determination of Tribal Communities directly related to the investments made by the American Jobs Plan, a coalition of thirty-one tribal entities – including the All Pueblo Council of Governors – wrote, "For decades, the federal government has recognized that Indian Country has substandard infrastructure in every sector … Depravation and disparities and not the resources our ancestors bargained for when they entered a trust and treaty relationship with

[1] https://iejusa.org/section-1-defining-energy-justice/
[2] https://www.whitehouse.gov/wp-content/uploads/2021/07/M-21-28.pdf
[3] https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/20/executive-order-advancing-racial-equity-and-support-for-underserved-communities-through-the-federal-government/

the United States as political sovereigns ... As the U.S. shapes its infrastructure package, it must prioritize the honoring of its trust and treaty obligations to Tribal Nations."[1]

The Tribal entities quantified that "one-quarter of the nation's oil on-shore oil and gas reserves, one-third of the nation's western low-sulfur coal, 3.5% of the nation's wind energy and approximately 5% of the nation's total solar energy potential" are resources of Tribal Nations. Yet, it is noted that "Tribal Nations encounter significant financial and regulatory barriers to developing resources within their homelands"[2].

For decades traditional fossil fuel developing Tribal Nations have enjoyed not only good paying jobs but also revenue to tribal coffers because of that development. It goes without saying that these Tribal Nations want to assure their tribal members that revenue will continue to be realized and good jobs will continue as a clean energy transition is implemented. As a transitional economy is contemplated it is essential for Tribal Nations to have a seat at the table and for their benefit to be clear.

In testimony provided to the House Committee of Natural Resources Subcommittee on Energy and Mineral Resources by the Honorable Rickie Nez, Delegate and Chair of the 24th Navajo Nation Council Resources and Development Committee most effectively stated, "Myself and my colleagues on the 24th Navajo Nation Council will continue to work in actively transitioning to a new energy future "responsibly," but I cannot stress this point enough – Indian Country and the Navajo Nation need to be at the table when discussing the energy future and transition for the United States[3].

1 https://ncai.org/NCAI_Indian_Country_Infrastructure_Letter_-FINAL_Update-.pdf
2 Ibid.
3 Retrieved from: https://naturalresources.house.gov/download/testimony_-chairman-rickie-nez-navajo-nation---emr-ov-hrg-061521pdf

HOW TO ENSURE A JUST ENERGY TRANSITION AND ADVANCEMENT

A just energy transition involves the following core elements[1]:

1. **Process:** Have marginalized communities participated meaningfully in the policymaking process with sufficient support?
2. **Restoration:** Does the policy aim to remedy prior and present harms faced by communities negatively impacted by the energy system?
3. **Decision-making:** Does the policy center the decision-making of marginalized communities in implementation?
4. **Benefits:** Does the policy center economic, social, and health benefits for marginalized communities?
5. **Access:** Does the policy make energy more accessible and affordable to marginalized communities?

A just energy transition matters because of the impacts borne by "frontline communities" (those historically harmed by the energy system) in the development of the current energy system.

Clean hydrogen will contribute to a just energy transition in New Mexico because it can contribute to the Restoration, Benefits and Access of marginalized communities. But more importantly, clean hydrogen may be an option that these marginalized communities see as an optimal way to transition to a net-zero carbon emission future. Hearing the input from these marginalized communities in the policy- and decision-making processes during this energy transition will be paramount in ensuring the transition is just.

Finally, it should be stated that development and implementation of a Clean Hydrogen plan by the state will:

- Ensure New Mexico is part of a national, tribal, state, and local comprehensive, durable, and enforceable climate policy framework,
- Guarantee equity and justice are clearly shaping and underpinning clean energy decisions and investment,
- Encourage hydrogen development as a key part of the overall goal of carbon free electricity production by 2035 and net zero by 2050.
- Drive clean energy jobs into rural areas and develop a local workforce not requiring advanced education.
- Immediately bring opportunities in a cleaner energy supply, skilled jobs, and stable economic growth to the large tribal nations in New Mexico[2]

[1] https://iejusa.org/wp-content/uploads/2021/09/Justice-in-100-Scorecard-Interactive-PDF-Final-Version.pdf

[2] New Mexico and the Four Corners states border the largest tribal nation by land and population in the United States, the Navajo Nation, and this tribe has a history of energy production and considerations of restorative justice. See https://www.census.gov/history/pdf/c2010br-10.pdf

- Bring similar opportunities to those communities in New Mexico that have struggled with the volatility of fossil fuel production (e.g., Farmington area)
- In the long term, as clean hydrogen transitions away from fossil feedstock to more renewable feedstock as mandatory carbon reductions increase, the opportunity of clean hydrogen stays due to the good renewable resources available to New Mexico in Solar, Wind, Geothermal, and Biomass (New Mexico is top 5 in the US)[1]

Hydrogen investment allows a once in a lifetime opportunity coordinate federal government, Tribal Nations, and NM state departments, to ensure workforce training programs are inclusive, locate new training programs in tribal and rural areas, prioritize minority and women owned businesses, promote project labor agreements, and situate pre-apprenticeship programs across the region.

[1] New Mexico ranks among the top five states in the US for renewable hydrogen potential based on: M. Melania, et al. (2013). *Resource Assessment for Hydrogen Production*. Retrieved from: https://www.nrel.gov/docs/fy13osti/55626.pdf

CARBON INTENSITY OF HYDROGEN PRODUCTION

Like electricity, hydrogen is an energy carrier and must be produced. Figure 8 shows various feedstocks and conversion processes for producing hydrogen. Today, most hydrogen generated around the world is made through steam methane reformation (SMR), in which natural gas and high-temperature steam react to produce hydrogen and (carbon dioxide) CO_2. This pathway is not considered low-carbon because of the CO_2 produced; however, if (carbon capture utilization or storage) CCUS is employed, the emissions can be significantly reduced, resulting in lower-carbon hydrogen[1]. Figure 9 shows the carbon intensities of various hydrogen production pathways.

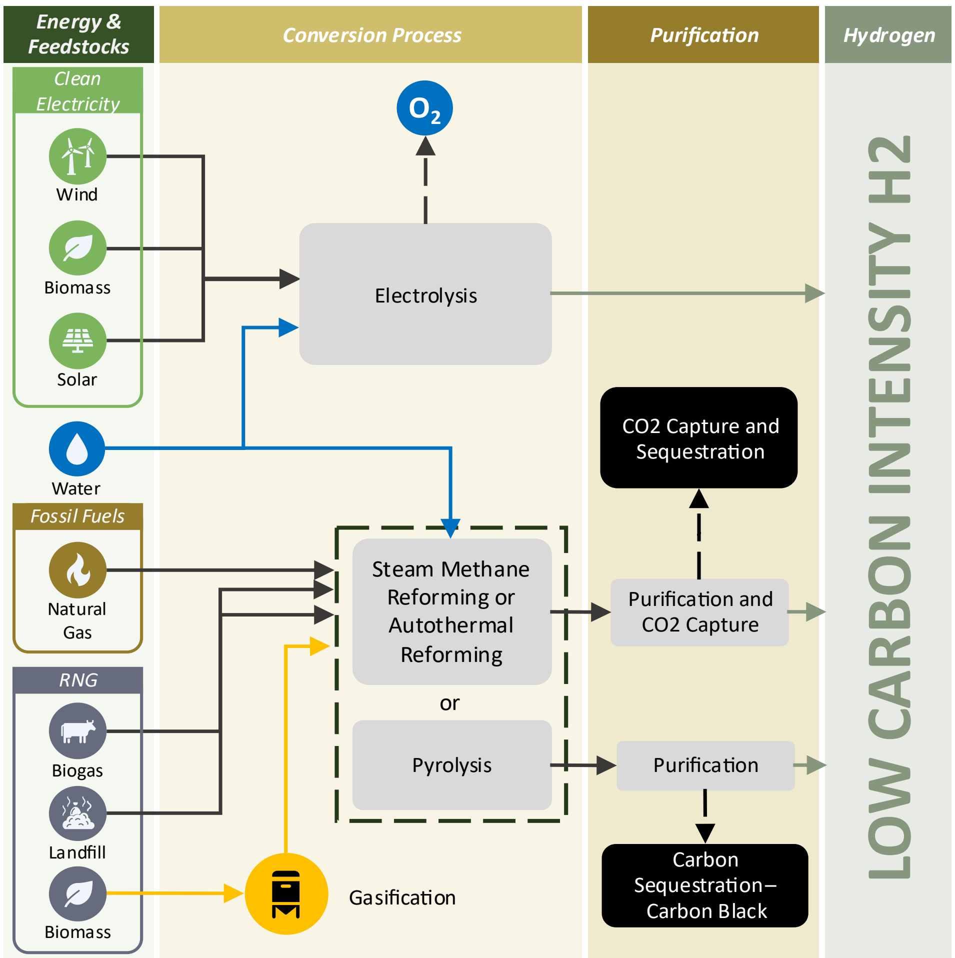


Figure 8: Hydrogen Production Pathways

Pyrolysis also uses natural gas as a feedstock where hydrogen is produced by decomposing natural gas in an environment without oxygen into its two constituents: hydrogen, as a gas, and carbon black, as a solid. Since CO_2 is not produced in the

[1] It should be noted here that SMR with CCUS (90%) that uses only natural gas as feedstock will not meet the definition of "clean hydrogen" in the Infrastructure Investment and Jobs Act. For comparison, a threshold for low-carbon hydrogen being used in Europe is 36.4 g-CO2e/MJ (5 kg-CO2e/kg-H2). See CertifHy Webinar (2018). Retrieved from: https://www.youtube.com/watch?v=k2E4TQwxLxA

reaction, the emissions from this pathway are limited, and the hydrogen produced is low-carbon.

The emissions related to SMR and pyrolysis can be further reduced if renewable natural gas (RNG) is used as a feedstock instead of fossil-based natural gas. The RNG could be produced from biomass feedstocks such as landfills, municipal waste, wastewater treatment, manure, or wood waste.

A final pathway that is rapidly growing around the world is electrolysis, in which electricity is used to split water into hydrogen and oxygen. The hydrogen produced can be low-carbon but are heavily dependent on the carbon intensity of the electricity. If only renewable sources, such as wind and solar, are used as feedstock, the carbon intensity of the hydrogen will be zero. However, if the electricity is generated by high-emitting sources like coal, the CI of the hydrogen can be relatively high. In fact, this is shown in Figure 9. As the Public Service Company of New Mexico grid becomes cleaner because of the Energy Transition Act[1], the carbon intensity of the electrolytic hydrogen using grid electricity will be reduced.

Comparing among the hydrogen production pathways in Figure 9 and their ability to achieve the low-carbon threshold of 2 kg-CO2e/kg-H2, several important conclusions are

- Electrolysis-based pathways can achieve 0 kg-CO2e/kg-H2, but it should be noted that when considering life-cycle intensities the use of critical minerals have a carbon impact to be taken in account.
- It is difficult to establish pathways using only fossil-natural gas as feedstock to achieve 2 kg-CO2e/kg-H2 → some RNG or other renewable feedstock must be used. An innovative example is a SMR system that uses renewable electricity for the required heating needs (e.g., STARS[2] and Nu:Ionic[3]).
- RNG used as input to SMR+CCS (or Pyrolysis) can achieve negative kg-CO2e/kg-H2

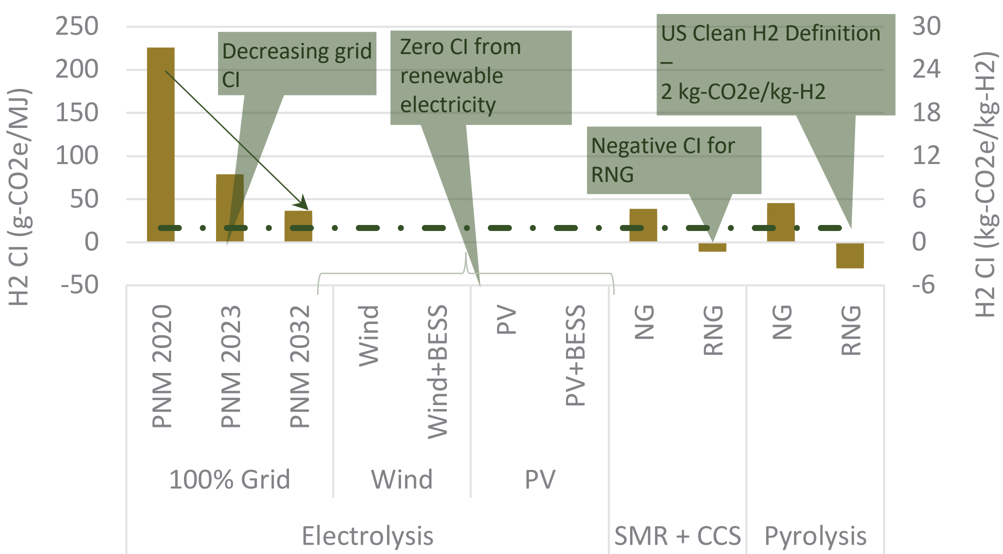


Figure 9: Hydrogen carbon intensity by production pathway

[1] PNM. (2021). PNM 2020-2040 Integrated Resource Plan. Retrieved from https://www.pnmforwardtogether.com/assets/uploads/PNM-2020-IRP-FULL-PLAN-NEW-COVER.pdf
[2] https://www.starsh2.com/
[3] https://www.nuionic.com/

What is Blue Hydrogen and Why Consider It in New Mexico?

Opportunities Specific to Blue Hydrogen

There are those who offer criticism of blue hydrogen, and one peer-reviewed publication[1] has brought those criticisms to the forefront. But, in reality, an overwhelming percentage of all hydrogen currently is produced through SMR, which creates CO2. With the addition of ensuring the feedstock is produced responsibly and CCUS to these processes a near carbon-zero fuel industry can flourish.

The above referenced study asserts that electricity generated from blue hydrogen has a higher carbon intensity greater than that of coal, and much of the hypothesis is supported by assumptions related to fugitive methane emissions. The authors claim that 3.5% of all natural gas production results in a fugitive emission released to the atmosphere as an intense greenhouse gas.

The 3.5% emissions factor is directly challenged by Alvarez, R. et al. in the 2018 paper "Assessment of methane emissions from the U.S. oil and gas supply chain." In this paper Alvarez asserts that methane emissions are estimated at 2.3% of gross U.S. gas production, with 1.9% sourced from production, gathering and processing.

Another key determining factor in the conclusions put forward by the Cornell study is the Methane Global Warming Potential (GWP) set at 20-years. David Joffe, Head of Carbon Budgets at the United Kingdom's Climate Change Committee (CCC) has stated that, "The 20-year GWP metric used in the paper ignores climate beyond 20-years" and Ted Nordhaus, Executive Director at The Breakthrough Institute recognizes that, "There is an ongoing debate whether 20-year or 100-year GWP is an appropriate metric for methane."

The key overall rebuttal is that proper regulation would account for those emissions that criticisms typically identify as problematic. The proper regulation would therefore identify those processes with problematic emissions as not low carbon. A proper regulation would employ life cycle analysis techniques to establish a process' carbon intensity when that process registers with the regulating agency.

For example, in California, the Low Carbon Fuel Standard uses the GREET model (developed by Argonne National Labs and tuned to California's specifics) to calculate each process' carbon emissions across the entire supply chain including methane leakage emissions (it is important to note that the agency responsible tracks the literature with respect to methane leakage and makes regular updates to the values used). The program also has a CCS section that penalizes those sequestration projects that don't sequester the carbon.

Criticisms of blue hydrogen development along with their rebuttals as sub-bullets are below:

[1] Howarth and Jacobson. (2021). How green is Blue Hydrogen? Retrieved from: https://onlinelibrary.wiley.com/doi/full/10.1002/ese3.956

- The rate of carbon capture is much lower in existing plants deploying CCS technology than typically used in carbon intensity calculations, which also contribute to blue hydrogen not being low-carbon.
    - The projects referenced are not state-of-the-art[1].
    - 90% is achievable on new SMR plants. 85% is achievable on older plants with retrofit.
- Methane leakage upstream contributes to blue hydrogen not being low carbon
    - This is a problem, but using the leakage rates from California's GREET model, blue hydrogen can be low-carbon if carbon capture rates are high enough and some amount of renewable feedstock is used to achieve the low-carbon threshold of 2 kg-CO2e/kg-H2.
    - New Mexico also has the strongest methane regulations in the US for natural gas capture from the upstream and midstream sectors, with a goal of at least a 98% capture rate by 2026 and strong measurement and verification requirements.
- The carbon emissions from auxiliary electricity used in the plant can be high especially in areas with a carbon-intense grid, which also contributes to blue hydrogen not being low-carbon
    - This can be a problem but can be addressed in various ways (procure renewable electricity, etc.), all of which would be accounted for in a properly designed regulatory structure that uses reputable life cycle analysis techniques.

While experts continue to research and seek consensus on appropriate baseline assumptions to conclude the environmental impact of methane production, New Mexico has moved forward to address the concerns. With the implementation of methane rules, New Mexico is certainly a leader in the development of responsibly sourced natural gas.

To go beyond regulation, it is our recommendation that the natural gas industry continue to work collaboratively to develop an independent measures, verification, and certification for the production of natural gas. Such a certification program has been suggested to be developed and implemented in the State of New Mexico at the San Juan College School of Energy who could then train New Mexicans to identify methane emissions and offer suggestions to eliminate them. This would provide yet another economic development opportunity for New Mexican's.

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[1] Bauer et al. (2021) On the Climate Impacts of Blue Hydrogen Production. Retrieved from: https://chemrxiv.org/engage/api-gateway/chemrxiv/assets/orp/resource/item/6141926f27d906e30288cff1/original/on-the-climate-impacts-of-blue-hydrogen-production.pdf

Blue Hydrogen Makes Sense in a Transition

Blue hydrogen can be a market catalyst for the other clean hydrogen: renewable hydrogen.

The concept is that hydrogen infrastructure downstream of production in the supply chain will benefit from scale. Scaling up hydrogen infrastructure with the lower-cost low-carbon production technology will not put as much pressure on the costs across the supply chain. The scaling will bring cost reductions across the supply chain due to faster learning rates as each market participant gains familiarity and brings their value-adds to the hydrogen industry. This will ultimately "prime the pump" for renewable hydrogen. For example, the balance-of-plant (compressors, etc.) issues remain a reliability issue at many current small-scale hydrogen deployments because some compressor manufacturers have not yet dedicated resources to "figuring out" hydrogen compression in a highly reliable system as required in fully developed market mostly due to the limited size of the hydrogen market currently. Figure 10 shows energy system modeling that captures this.

Figure 10: New Mexico Energy System modeling of hydrogen's role in decarbonization[1]

[1] Ennis et al. (2021). New Mexico's Hydrogen Hub Needs Climate Guardrails. Retrieved from: https://www.nrdc.org/experts/jacqueline-ennis/new-mexico-hydrogen-hub-cannot-delay-climate-progress

CARBON CAPTURE OPPORTUNITIES (AS PART OF A HYDROGEN HUB)

Throughout the governmental, academic, and private sectors, there is broad agreement that the US climate goals as established by the Biden administration cannot be achieved without the implementation of Carbon Capture, Utilization and Sequestration (CCUS) which is the only application to remove carbon from the atmosphere. While Solar, Wind and other renewable energy technologies replace carbon-emitting power generation, their construction and installation create an emission source as an unintended byproduct. While these renewable energies are greatly beneficial, CCUS is essential to create a truly carbon-neutral system.

Due to several unique attributes of the state, New Mexico could lead the nation in CCUS. Just as California has led the country in solar power usage and Texas leads the nation in wind power usage, New Mexico has an opportunity to make its mark with CCUS. New Mexico is blessed with unique traits that are found in few other states, specifically (i) enormous geologic storage potential, (ii) experience in the required elements of CCUS, (iii) established industrial infrastructure and (iv) and a highly skilled & capable workforce. New Mexico's statewide CO2 emissions account for less than 1% of the United States' output (EIA 2017 data). The preceding factors create a special scenario which allows New Mexico to become the first carbon negative state in America.

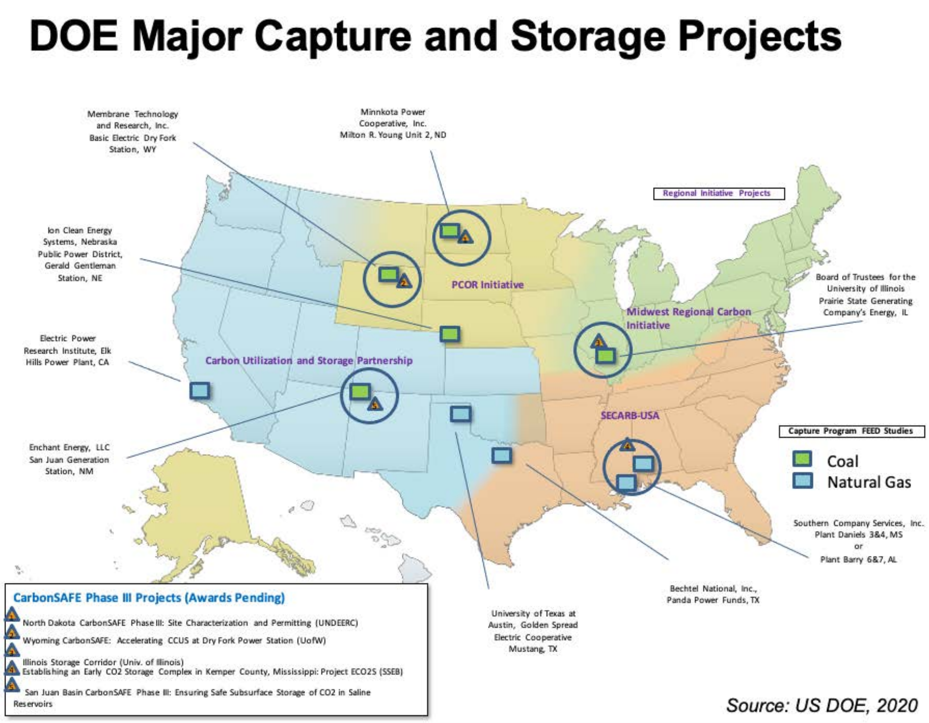

Figure 11: US DOE Major Carbon Capture & Storage Projects[1]

[1] Presentation Slide from 2021 Hydrogen Roundtable Discussion, Dr. William Ampomah, https://youtu.be/Poy0YmcmPfc

CCUS utilizes proven technologies. The components of CCUS have been in practice for decades: amine-based carbon capture, CO2 transportation, and the injection of supercritical CO2 into geologic strata. Primarily, the new developments in CCUS are awareness, improved definition around revenue sources, and public desire. The establishment of CCUS in New Mexico will encourage related industries to flourish in the state.

As CCUS projects are implemented on traditional industrial sources, the prolific geologic storage capabilities of the state will become proven and evident. This practice will act to 'de-risk' CO2 sequestration and attract industrial activity coupled with CCUS. Most new industrial projects including Blue Hydrogen are capitally intensive and require many years of planning and construction. The advancement of CCUS today will act as a catalyst for broad industrial growth throughout our state for decades, proving to be a highly valuable investment.

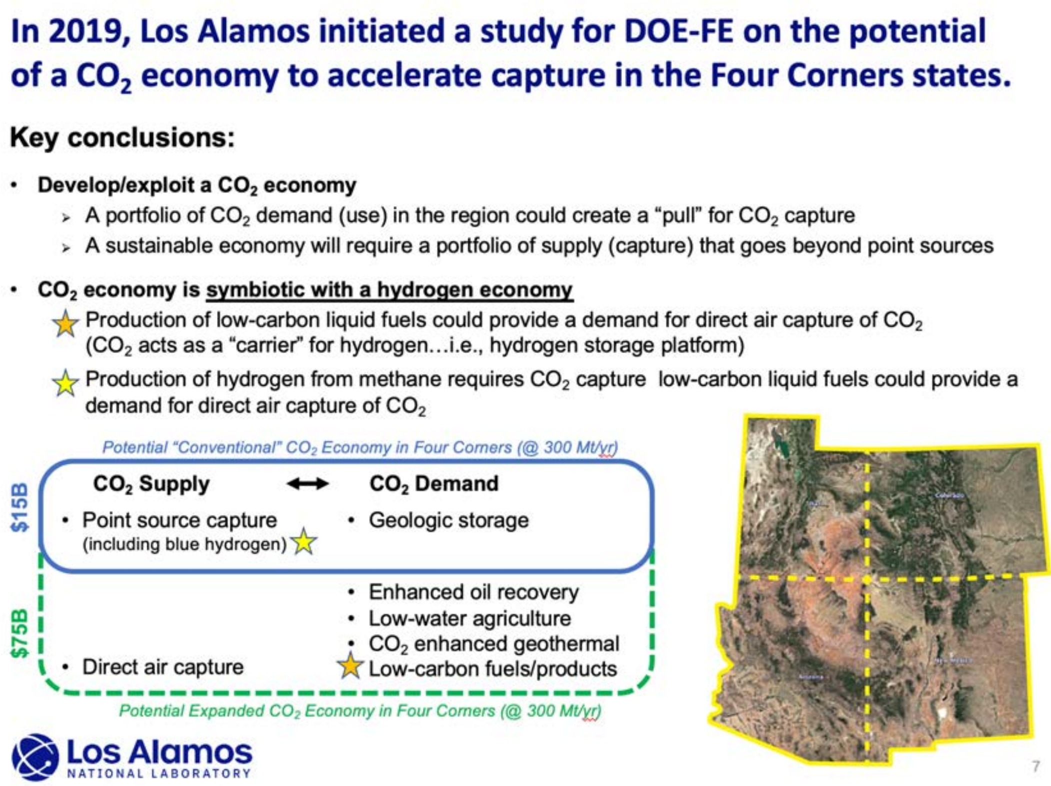

Figure 12: Carbon Capture Potential in the Four Corners[1]

[1] Presentation Slide from 2021 Hydrogen Roundtable Discussion, Dr. George Guthrie, Jr. https://youtu.be/Poy0YmcmPfc

WATER INTENSITY OF HYDROGEN PRODUCTION

In addition to greenhouse gas (GHG) emissions, it is important to consider the water requirements of hydrogen production. Electrolysis and SMR both require significant quantities of water to produce hydrogen. Autothermal reforming provides a less water intense option that is conceptually similar to SMR. Figure 13 shows the estimated water consumption for each pathway compared to the water consumption required to produce other fossil fuels. Pyrolysis requires less water, which is a major advantage in a dry region.

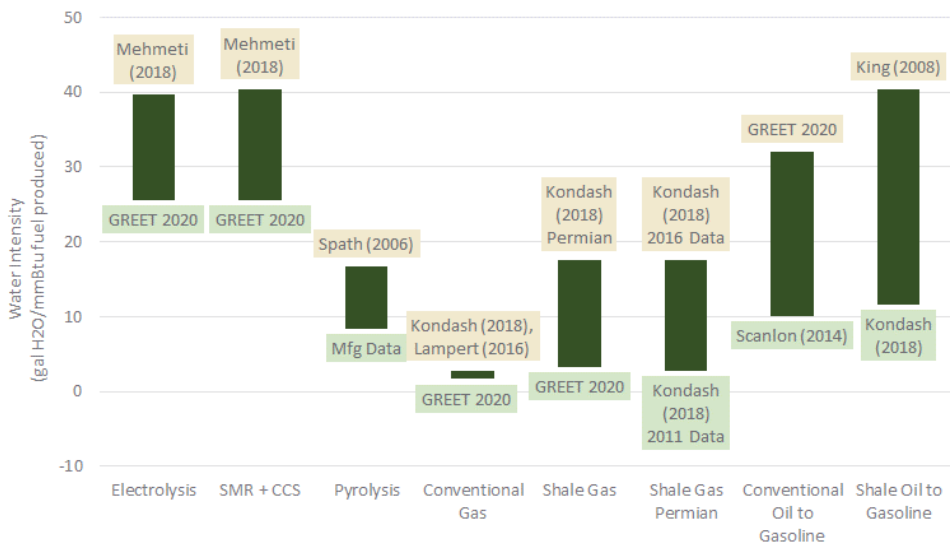

Figure 13: Water consumption hydrogen and fossil fuel production pathways[1,2,3,4,5,6,7]

There is a large range in values for fossil fuel production water intensity. However, some of the more recent research suggests that water intensities are increasing for unconventional resources such as shale gas and oil. Interestingly, the research indicates a potential advantage in lower water intensity to using natural gas from the San Juan basin versus the Permian basin. However, other thermochemical conversions besides SMR should likely be used to minimize stress on local water resources, e.g., pyrolysis or autothermal reformers.

[1] Spath, P. et al. (2006). Biomass to Hydrogen Production Detailed Design and Economics Utilizing the Battelle Columbus Laboratory Indirectly-heated Gasifier. Retrieved from: https://www.nrel.gov/docs/fy05osti/37408.pdf

[2] Kondash, A. et al. (2018). The intensification of the water footprint of hydraulic fracturing. Retrieved from: https://advances.sciencemag.org/content/4/8/eaar5982.

[3] Mehmeti, A. et al. (2018). Life Cycle Assessment and Water Footprint of Hydrogen Production Methods: From Conventional to Emerging Technologies. Retrieved from: https://www.mdpi.com/2076-3298/5/2/24

[4] Argonne National Laboratory (2020). The Greenhouse gases, Regulated Emissions, and Energy use in Technologies Model. Retrieved from: https://greet.es.anl.gov/greet_1_series

[5] King, C. et al. (2008). Water Intensity of Transportation. Retrieved from: https://pubs.acs.org/doi/10.1021/es800367m.

[6] Scanlon, B.R. et al. (2014). Comparison of Water Use for Hydraulic Fracturing for Unconventional Oil and Gas versus Conventional Oil. Retrieved from: https://pubs.acs.org/doi/10.1021/es502506v

[7] Lampert, D. et al. (2016). Wells to wheels: water consumption for transportation fuels in the United States. Retrieved from: https://www.osti.gov/pages/biblio/1392949

Using recycled and purified produced water also represents an option. Produced water from oil and gas extraction may contain many contaminants of concern, such as barium, radioactive material, hardness, organics, and dissolved solids. Treatment steps to remove these contaminants could include chemical precipitation, reverse osmosis, and thermal evaporation. Rather than treating the water for use in agriculture or recycling for drilling new wells, a potential value-add offtake of this produced water is use in an electrolyzer. Rough calculations based on Permian basin water sample data from 1991-2001 (TDS level of 87,523 mg/L) and using a thermal driven evaporator show that the cost increase to an electrolysis system of $1/kg could be expected with ~1% increase to GHG emissions from the system.

HYDROGEN HUB OPPORTUNITIES IN NEW MEXICO

> ***Our area has all the components for a successful project: natural gas, wind, sun, water, transmission lines, pipelines, and a workforce that can transition into this industry.***

The state of New Mexico has shown its commitment to reducing GHG emissions by enacting and proposing major policies focused on decarbonization (e.g., the Energy Transition Act, Executive Order 2019-003, a proposed Clean Fuel Standard, a proposed methane emission reductions in oil and gas sector, and a new Clean Car rulemaking process). Executive Order 2019-003 also created the Interagency Climate Task Force which includes ten interagency Climate Action Teams responsible for proposing, planning, and implementing strategies to reduce greenhouse gas emissions and enhance New Mexico's ability to adapt to climate change. New Mexico has also shown commitment to diversity, safety and worker training through its implementation of the Sustainable Energy Task Force.

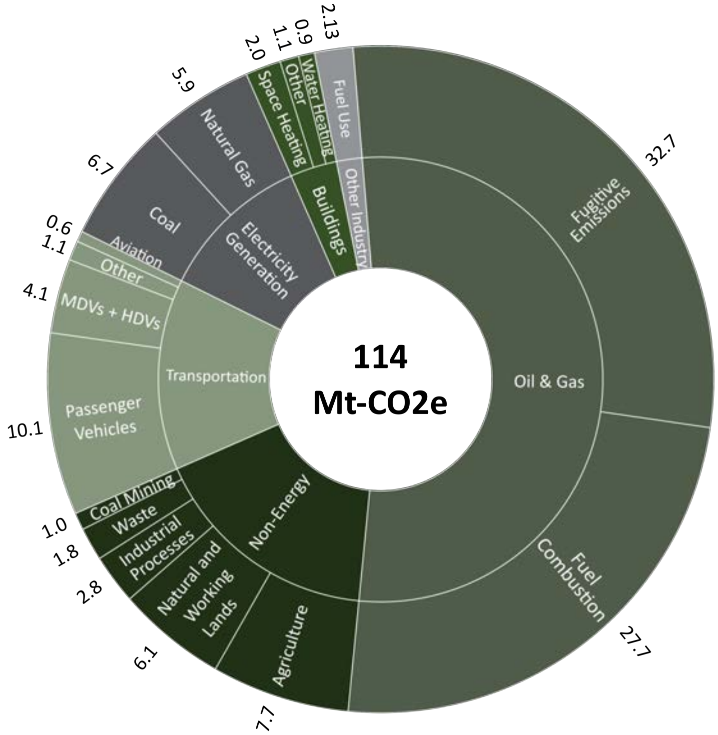

Figure 14: New Mexico GHG Emissions Inventory[1]

[1] E3, Inc. (2020) New Mexico GHG Inventory and Forecast. https://cnee.colostate.edu/wp-content/uploads/2021/01/New-Mexico-GHG-Inventory-and-Forecast-Report_2020-10-27_final.pdf

A challenge for New Mexico in reducing GHG emissions will be the significant emissions associated with oil & gas, which can be seen in Figure 14. This challenge will be an advantage in competing for "Clean Hydrogen Hub" funding because New Mexico can serve as a lighthouse project for how low-carbon hydrogen from fossil resources can be used to maintain and create jobs in the state related to fossil energy, while growing hydrogen production from the state's vast renewable resources[1] and ultimately transitioning to those resources over time. This phased approach will minimize shocks and avoid pushback to a low-carbon economy[2].

New Mexico's Winning Attributes

New Mexico can serve as the key link between major hydrogen demand markets in California and Texas through blending and transporting hydrogen in natural gas pipelines, providing clean hydrogen for heavy-duty transportation, and transmitting electricity produced by clean hydrogen and renewables to the southwest and mountain west regions.

The southwest region of the United States, specifically the four corners, has some of the greatest hydrogen production potential to be economically produced below $2 USD per kg as displayed in Figure 10. New Mexico brings many attributes in the development of clean hydrogen.

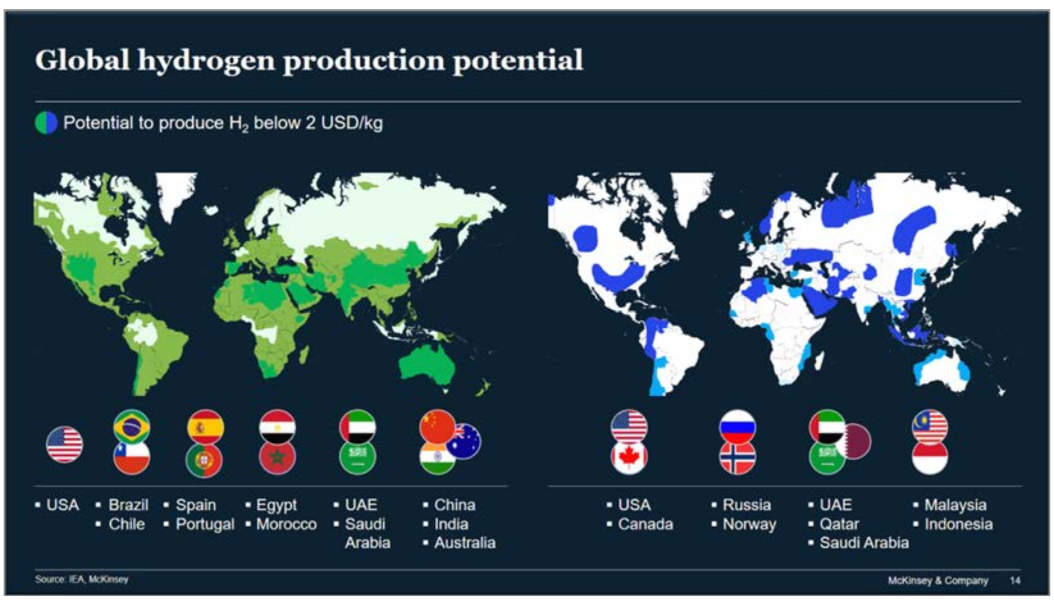

Figure 15: Global hydrogen production potential below $2 USD[3]

- Energy Justice
    - Major fossil energy producer historically

[1] New Mexico ranks among the top five states in the US for renewable energy potential based on NREL data retrieved from: https://www.nrel.gov/gis/assets/docs/us-re-technical-potential.xlsx
[2] Energy Futures Initiative. (2021). Accelerating an Equitable Clean Energy Transition in New Mexico. https://ceepr.mit.edu/wp-content/uploads/2021/11/NM-Case-Study-Draftv20211129.pdf
[3] US DOE Hydrogen Earthshot Seminar (8/31/21), McKinsey & Company

    - State revenue and many jobs depend on the fossil industry
    - Hydrogen is an energy carrier of the future that aligns with the skills of the fossil energy workforce
    - The largest population of Native Americans is in the Navajo Nation and Native Americans also have a history of energy production and other restorative justice considerations[1]
- High renewable resource potential
    - New Mexico has one of the best renewable resource potentials in the US
- Large fossil resources and infrastructure
    - New Mexico continues to be one of the largest fossil energy producers in the US
    - Major oil, gas, refined products, and CO_2 pipelines cross the state some of which are at low utilization, and some abandoned providing opportunities for retrofit
    - Significant existing pipeline rights of way and the strong potential for blending as being researched by Sandia National Labs (Hyblend).
    - Applying existing oil and gas sector technologies for drilling and injection, subsurface characterization, and site monitoring.
- Government and agencies focused and motivated on decarbonization
    - Recent legislation (Energy Transition Act) and regulation (Methane Leakage) prove this with proposed legislation further bolstering this
- Freight corridors
    - Major interstates with significant freight movement at the north and south of the state
- Industry and Mining
    - The top three GHG point sources (excluding electricity generation, oil and gas production) are refineries, cement (Tijeras), and mining[2].
    - Major mining operations with several large potash and copper mines[3]
    - Significant infrastructure at legacy coal facilities that have valuable electric transmission and infrastructure that can be repurposed to serve both green hydrogen production and electrical generation output produced from hydrogen fuels. Utilization of this infrastructure would provide clean energy jobs to tribal communities most impacted by coal power plant closures.
- Innovation Assets in the Hydrogen Industry
    - Sandia and Los Alamos National Labs
    - Focus on energy related research and work force development at universities, colleges and technical schools.
    - San Juan College's School of Energy has been identified as New Mexico's Center of Excellence in Renewable Energy and Sustainability. Hydrogen is a strategic priority for the Center of

[1] https://www.census.gov/history/pdf/c2010br-10.pdf
[2] Bauer, J. Natcarb, 2018-09-27, https://edx.netl.doe.gov/dataset/natcarb, DOI: 10.18141/1474110
[3] USGS (2014). Minerals Yearbook. Retrieved from: https://www.usgs.gov/centers/nmic/mineral-industry-new-mexico

Excellence. The school is prepared to deliver the workforce training required for the hydrogen industry.
    - Strong connection between research, demonstration and scalability as evidenced by Bayotech and PESCO.
- Bonding Authority
    - Existing financing mechanisms in state law where state and federal highway funding can be bonded for energy transportation systems as a financing securitization methodology
- A hydrogen economy in this region can benefit from its intersection with an emerging CO_2 economy in two ways:
    - Captured CO_2 can be used as a hydrogen carrier; ultimately this will require green hydrogen and direct-air captured CO_2 but deployment and development can be started with point-source capture to get things going.
    - CO_2 capture (and use) is integral to blue hydrogen.

Building a Hydrogen Hub for New Mexico

The first step is to assess the production and end-use attributes in the region and how they might interconnect with each other. See Figure 16 for an initial illustration of different attributes and their locations.

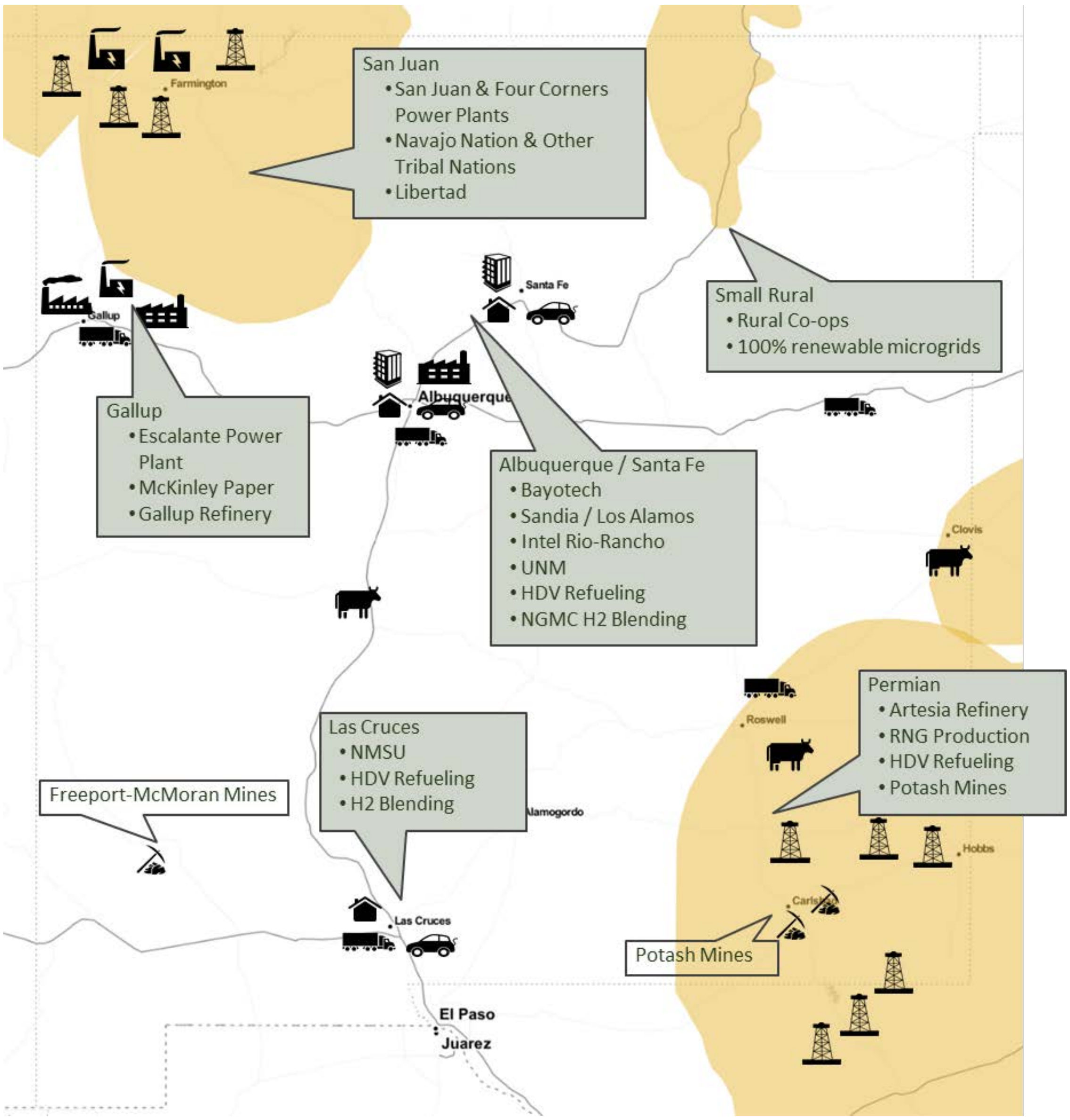

Figure 16: Illustrative sketch of potential Hydrogen Hub participants

An initial sketch of the interconnection among different hub participants is shown in Figure 17. Various fossil infrastructure and their rights-of-way could be leveraged in interconnecting participants. The key is to begin identifying them and, in particular, to identify those participants that can participate at scale.

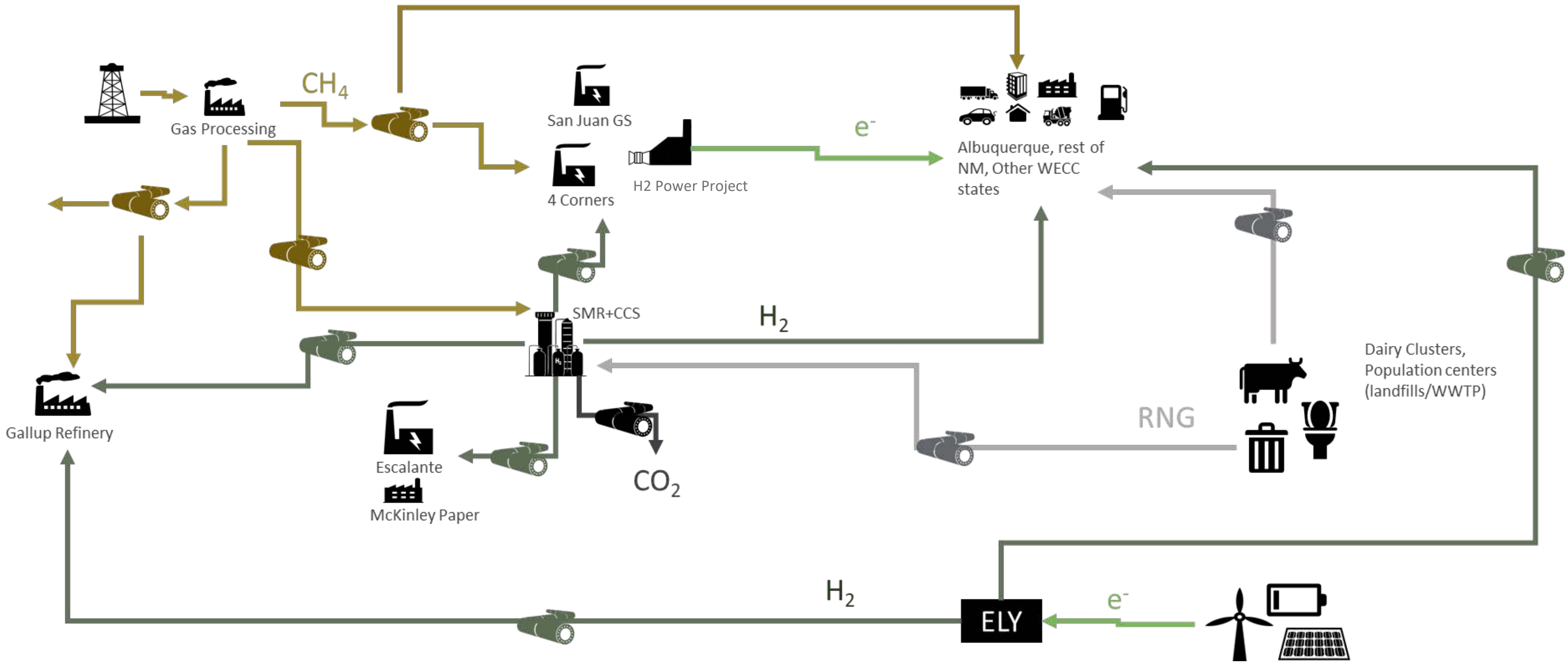

Figure 17: Illustrative sketch of interconnection among Hydrogen Hub participants

Thereafter, it is important to evaluate if New Mexico could accomplish fulfilling every aspect within the hub definition. To reiterate, "regional clean hydrogen hub' means a network of clean hydrogen producers, potential clean hydrogen consumers, and connective infrastructure located in close proximity". To fulfil the expectation, it is most likely that New Mexico will need to work collaboratively with other complementary states especially considering the Navajo Nation extends across the borders of the four corners. Figure 18 also shows an important consideration in linking hubs in New Mexico with assets and hubs across the Intermountain-West. There are complementary assets in these regions with mutual benefit.

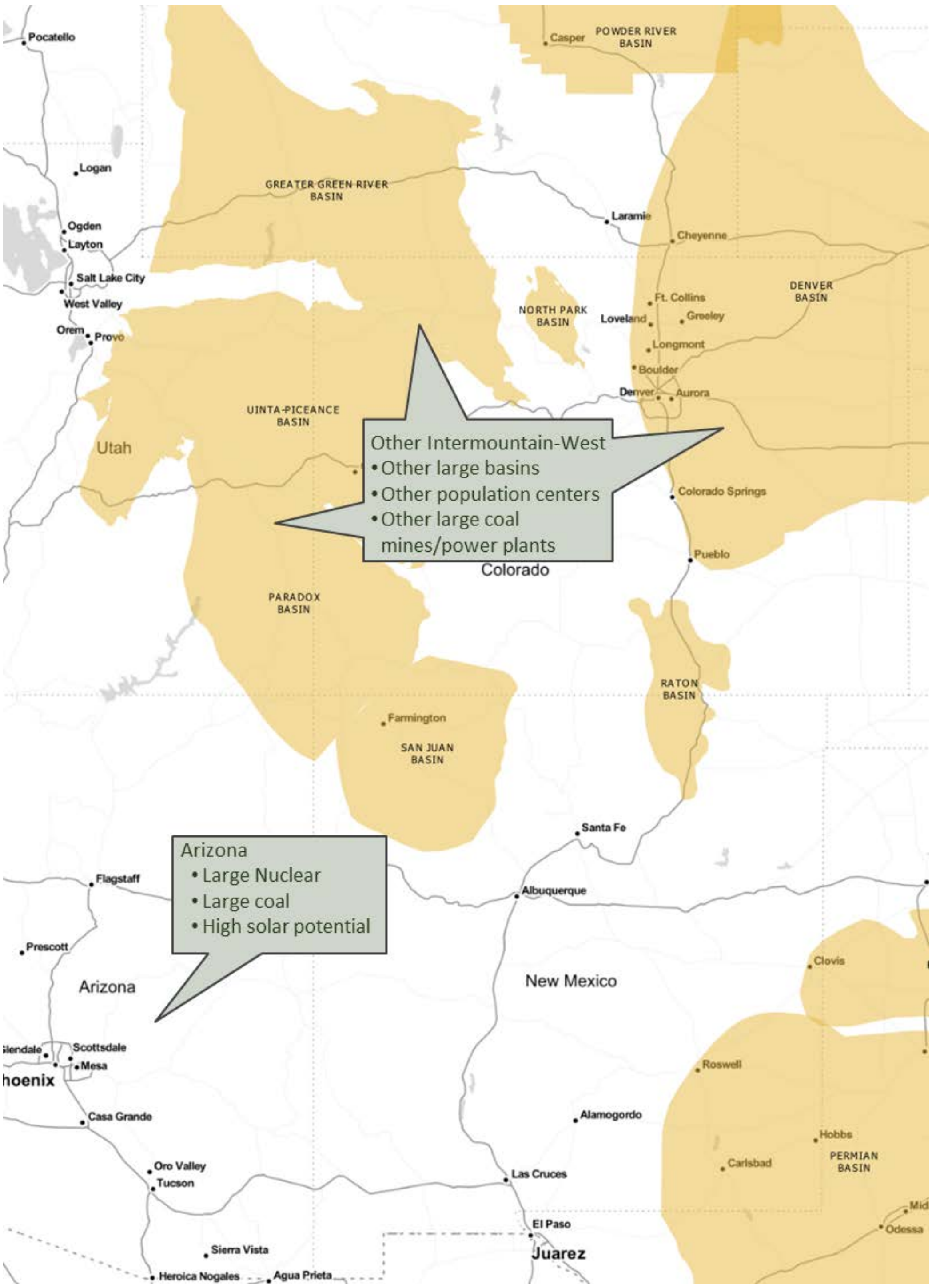

Figure 18: Intermountain-West and opportunities for connecting

Key Clean Hydrogen Consumers

Electric Power. Existing power generation capacity in San Juan County is predominantly coal-fired, with much of that recently retired and more scheduled for retirement. However, the existing transmission structure is vast, and several utilities have expressed interest in clean hydrogen power.

Similarly, in the southeast part of the State, there is substantial legacy natural gas generation capacity, and more nearby in western Texas. These plants, nearby to potential southeastern hydrogen production sites, may be good candidates for future hydrogen firing, either as a blended fuel or as more extensive plant conversion. Alternatively, new hydrogen-fired generation capacity could be built to supply growing electricity demands.

Transportation fuels. The national market for clean hydrogen-based transportation solutions is expanding rapidly to include heavy-duty trucks, rail locomotives, and a growing variety of fleet/network vehicle applications. New Mexico's Interstate highways and rail lines carry a substantial part of national rail and truck traffic, critically linking California and Texas markets. New Mexico's location, roughly midway between these two vast markets, can become one of the Nation's most important fueling stops.

Industrial markets. Several industries are looking at hydrogen applications as a means to decarbonize, particularly where electrification is problematic. San Juan County is a long-standing industrial area, seeking to expand its base beyond predominantly fossil fuel extraction and use. Hydrogen can replace fossil fuels in some carbon intensive industrial processes, such as in the steel or chemical sectors, hydrogen liquefaction plants, ammonia plants, etc. Having these hydrogen consumers at or near the hydrogen production and storage facilities would enable scale economies to be achieved and create savings in storage costs by leveling demand.

Oil and Gas Field operations. The San Juan Basin will continue to be an important production area for many years. Most of the field operations are not electrified, and the gas and diesel power equipment now in use constitute substantial emitting sources. Hydrogen can help make these operations less emitting, either by helping electrify operations or by using clean hydrogen on-site for direct heat applications and/or hydrogen fuel cells.

Vision

New Mexico has the opportunity to serve as not only the inspiration about the possibility but as a supplier to make the possibility a reality. States across the west are grappling with a clean energy future and the transition to accomplish it. New Mexico has the capability and the opportunity to deliver to the most demanding of requirements in the US and internationally in distributing clean energy for the western US. Currently, these market expectations are predominantly driven by off-takes and consumers in California. Being able to effectively sell into the California market represents a key threshold for clean hydrogen investments and delivery at a large scale.

Figure 19 provided by the US DOE, highlighting the Department's guiding framework for realizing the potential of hydrogen, is a visual summary of the opportunities that present themselves for the production, transportation, and commercialization of hydrogen which New Mexico has the intellectual leadership, infrastructure, fuel sources, workforce, and commercial development prospects to be a trailblazer for the region and ultimately the United States. The future of this clean energy economy rests in the hands of the state should it choose.

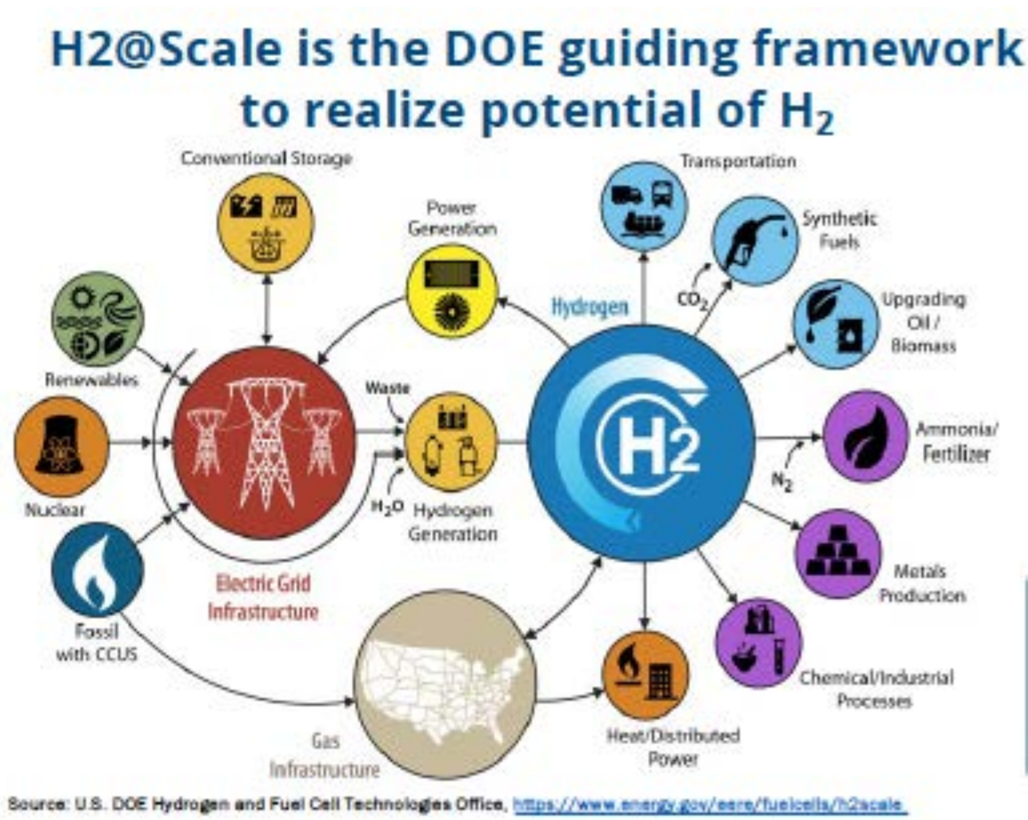

Figure 19: DOE hydrogen potential framework

RECOMMENDATIONS MOVING FORWARD

1. New Mexico should continue supporting these efforts inside and outside of the state for the betterment of our citizens. The Biden administration has strengthened America's decarbonization desires through the rejoining of the Paris Climate Agreement and setting forth ambitious goals, including (i) a 50% reduction in greenhouse gas emissions by 2030, (ii) a carbon-free power sector by 2035, and (iii) a nationwide net-zero carbon achievement by 2050. We applaud these efforts and urge New Mexico to work expeditiously to achieve them.
2. Coordination and cooperation with research partners (national labs and universities) workforce development and deployment will be essential components of a clean hydrogen hub. Hubs are identified as "centers for accelerated deployment of technology" which will require new types of partnerships between business and research providers. A successful NM hub will need to get these new types of partnerships established and functioning, so they are incorporated into the hub including partnerships with regional colleges and Tribal Colleges to use hubs for teaching and training. This also serves as a component of equitable transition.
3. Move quickly to pass legislation demonstrating New Mexico's commitment in being a leader in the development of clean hydrogen on behalf of western states and their foreseeable energy needs. This legislation should set out definitions for clean hydrogen, ensure environmental and energy justice goals are met, ensure hydrogen is developed in a fairly regulated manner, and incentivize hydrogen hub development and a hydrogen economy in the state.
4. The Legislature and the Governor should identify, bring together and provide state funding for a network of partners from New Mexico's Tribal Nations, research and development professionals, institutions of higher learning (including community colleges and Tribal colleges), commercial hydrogen developers, environmental and energy justice advocates, and community leaders to be charged with the development of a detailed hydrogen hub plan extolling New Mexico's advantages and seeking collaboration with those who most effectively round out our opportunities to be a recipient of investments.
5. The Legislature and the Governor should identify, bring together and provide state funding for a network of partners from other Tribal Nations and states considering clean energy and hydrogen hub development seeking collaboration with those who most effectively round out our opportunities to be a recipient of investments. This regional approach must consider an interstate governance structure and appropriate fiscal agent.
6. State investment by way of grants and loans should be by way of targeted tax credits and public-private partnerships to attract clean hydrogen producers, transporters, and consumers.
7. The role of CCUS is most likely a critical path for NM and policy makers have an opportunity to work collaboratively and be thought leaders regarding carbon capture public policy. Looking at the Rotterdam example, of course, shows CO_2 storage as an integral part of a hydrogen hub, and exploiting this synergy (CO_2 and hydrogen) in planning is likely to be an advantage for New Mexico. CO_2 storage needs to be available to achieve the stated climate goals. Several significant CCUS projects are under consideration in New Mexico today. These projects have the opportunity to act as early success cases and the state should encourage their advancement.

a. The state should develop and empower a carbon capture task force with a primary focus pursuing primacy for Class VI CO_2 wells.
b. The state should consider the ownership and liability management of sequestration sites after the CO_2 injection has ceased. This post-injection policy consideration is active in other states as they consider CCUS opportunities.
c. Most likely there is an elevated importance for identifying CO_2 storage sites rather than CO_2 being used for enhanced oil recovery. Identifying capacities within geological reservoirs and transportation (i.e., pipeline) capacity to such a reservoir would also be impactful.
d. CO_2 storage likely involves producing brine to make room for the CO_2 and clearly understanding the ownership of pore-space. Brine could be used for a feedstock for hydrogen, but this will require clarification of water-rights and ownership for non-potable brine. Further, clarifying pore-space ownership will facilitate deploying on-site storage. Clarifying both unknowns would establish New Mexico provide an advantage in the development of a clean hydrogen hub and further establish the state as a leader.

8. As New Mexico is intrinsically a leader in providing feedstock, production, and has significant infrastructure to get clean hydrogen to market; it is imperative to identify major offtake partners (e.g., thirty-plus ton per day) and develop offtake agreements to a broader market across the Western United States. It is most likely that through coordination with private-industry partners as well as other states and Tribal Nations, New Mexico will provide an effective means to establish this broader hydrogen hub and ensure locating a hub in the region is attractive for investment.

9. New Mexico Economic Development Department should dedicate staff through an Office of Clean Energy Development to better understand broad market requirements for clean energy offtake in large scale markets which are already interconnected to the state, assist with transitioning existing businesses to fulfill these needs, attract suppliers who will meet these requirements.

    a. This same office should serve as a conduit between entities in the state of New Mexico and the federal government regarding the many federal grant opportunities regarding clean energy development and assistance for energy communities.

    b. The office of Interstate Natural Gas Markets currently housed at the Energy, Minerals and Natural Resources Department should be combined into the newly created Office of Clean Energy Development.

CONTRIBUTORS & PARTICIPANTS

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“…Strong sovereign-to-sovereign relations, and strong Tribal Nation economies, often benefit local surrounding communities as well, through increased job opportunities and increased commerce.”

- NCAI Indian Country Infrastructure Letter to Congress

April 13, 2021

APPENDIX A - COLORBLIND HYDROGEN

https://www.santafenewmexican.com/opinion/my_view/with-hydrogen-clean-should-be-colorblind/article_fa7241d6-5e15-11ec-8ba4-db0e072707b7.html

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With hydrogen, 'clean' should be colorblind

By Daniel E. Klein and Joseph M. Merlino

As the world looks for ways to decarbonize, hydrogen has emerged as a leading candidate for this transition. In addition to filling an important role for electric power reliability, hydrogen offers carbon-free energy for large-capacity transport and other hard-to-decarbonize industrial applications.

The potential market for hydrogen is huge: hundreds of billions of dollars, and hundreds of thousands of jobs, in the U.S. alone.

Early efforts to brand hydrogen by color — primarily blue, green, pink or gray — have led to confusion over the end goal of a decarbonized economy. Recently, the U.S. Department of Energy has started using the term “clean hydrogen.” That’s a goal-focused characterization agnostic as to method of production, and encourages technology innovation and environmental progress. Clean hydrogen focuses on the environmental qualities of the final product, regardless of the technologies used.

For kick-starting a clean hydrogen economy, the Southwestern U.S., and New Mexico in particular, have many outstanding attributes that make it uniquely well-suited to lead in this new era. New Mexico’s abundant wind and solar resources, low-cost natural gas and subsurface capabilities for hydrogen storage and carbon sequestration can support a wide range of hydrogen production technologies, provided the hydrogen is made cleanly.

Hydrogen’s greenhouse gas attributes (and subsequent environmental value) are best measured by “life-cycle carbon intensity.” A life-cycle analysis is a “cradle to grave” assessment that facilitates more consistent comparisons across energy technologies.

Life-cycle carbon intensity is not a new concept; it’s frequently used in comparing technologies. It’s used in the Environmental Protection Agency’s assessment methodology for its renewable fuel standard as well as California’s low-carbon fuel standard. It makes these markets more credible and environmentally efficient.

For different hydrogen production methods, carbon intensity takes into account all of the carbon dioxide and other greenhouse gasses throughout the life cycle of the fuel, including upstream emissions. As such, hydrogen derived from natural gas with carbon capture would need to account for any fugitive methane emissions that might be associated with the feedstock supply, as well as any uncaptured portion of CO_2 emissions in the production process.

Similarly, hydrogen produced using water electrolysis powered by renewable energy would need to account for the greenhouse gas impacts going into the production of the critical minerals, water procurement and purification, solar panels and wind turbines involved in the energy and water inputs.

One cannot conclude that one hydrogen production method is in all cases better or worse than another. A life-cycle carbon intensity can ensure a full and unbiased accounting.

Importantly, a carbon-intensity measure does more than provide an impartial assessment across hydrogen production methods; it also creates incentives for improving hydrogen production methods over time. Under traditional command-and-control regulatory approaches, producers see advantage in bare-minimum compliance; anything more might add costs but not value.

In contrast, under a life-cycle carbon intensity methodology, the cleaner the producer can make the production process (including upstream processes), the more value the product will have. The regulatory script has now been flipped; the “race to the bottom” mentality has now been replaced by incentives for continuous improvement, with concurrent GHG benefits.

Clean hydrogen holds enormous potential for a decarbonized economy. A life-cycle carbon intensity measure can help get us there most efficiently.

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