New Mexico Hydrogen Hub Development: An Analysis of Hydrogen Energy and Energy Economic Development in New Mexico

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Executive Summary

In 2021 Biden proclaimed himself as the climate president and passed Executive Order 14008 Tackling the Climate Crisis at Home and Abroad. EO14008 calls for the United States of America to take climate action that "must go hand in hand" with international guidance and to begin developing and implementing national climate initiatives under the Paris Climate Agreement. Under the United Nations Framework Convention on Climate Change (UNFCCC), the Convening of the Parties (COP) is an annual meeting of nation states, the international stage that sets the tone to negotiate and deliberate on adaptation and mitigation initiatives to lower global greenhouse gas emissions. A mechanism of the Paris Agreement, is the participation of the public-private sector to aid in the implementation of new energy technologies and investments meant to propel the just transition from fossil fuels to renewable energies. Many U.S. states are also looking for international guidance for tackling the climate crisis. New Mexico is also looking to implement climate initiatives and utilize federal financing packages for the state's energy just transition. Hydrogen energy production, which is being touted as a way to implement a just transition from fossil fuels, is a form of energy that the state has interest in developing to expand the state's energy portfolio but also follow international and federal financial climate initiatives and incentives. Hydrogen energy production is still a nuanced and very emerging energy investment that has only been introduced into New Mexico this past year.

This paper's analysis will present a position that hydrogen is neither a clean energy nor is it a mechanism or tool for a just transition in New Mexico. In fact it continues the extraction of resources without proving to actually lower greenhouse gas emissions. The color spectrum of hydrogen also sheds light that fossil fuels and other dirty energy sources can be used to produce hydrogen and therefore are not forms of clean energy. Even though hydrogen doesn't emit greenhouse gas emissions when burned or "burns clean," its production, depending on the variation of color, is not clean and can be resource intensive. Blue, gray, pink and green hydrogen have been pushed in global climate convenings, like this past COP27, and are energy investments that New Mexico is interested in because it means federal money and support. Further, with the absence of meaningful tribal consultation and engagement with local stakeholders, local democratic processes are undermined and the lack of education on hydrogen is leading stakeholders and tribes astray. Ultimately, hydrogen energy production is a false climate solution and the state needs to shift focus on more economic diversification in wind and solar, remediation and clean up, and avenues for local, regional and tribal safeguards to protect residents and natural resources from new energy development.

Keywords: hydrogen energy, hydrogen hub, false climate solution, public-private sector, greenwashing, blue hydrogen, gray hydrogen, green hydrogen, pink hydrogen, nuclear energy, radioactive waste, carbon capture and storage (CCS), fossil fuels, indigenous, tribal consultation, New Mexico, San Juan Basin, Permian Basin, UNFCCC, COP27

Background

Globally, climate initiatives are centered on policy decisions to implement market mechanisms to lower carbon emissions. Many local and regional energy initiatives are being funded by federal finance packages to incentivize renewable energies like solar and wind but also to funnel billions of dollars into other types of energy investments and production infrastructure. Some of these technologies haven't been proven to work on both the market and scientific level but are being backed by the private-public sector. Energy investments like Carbon Capture and Storage (CCS), advanced nuclear reactors, and hydrogen (H_2) energy to make the transition from fossil fuels to renewable energy. Hydrogen production specifically has been an adopted energy initiative by the Michelle Lujan Grisham administration in the state of New Mexico but has some lingering concerns of whether this form of energy production is sustainable for the future of New Mexico's energy economy. This paper will discuss the various processes of hydrogen production, various geographies in New Mexico that are considering the development of hydrogen energy production, its potential impacts to water and natural resources, the continuation of fossil fuels, and the top-down policy initiatives and financing mechanisms that undermine or surpass local, regional and tribal governance.

This policy review provides further and alternative policy recommendations for environmental and community health safeguards that may be implemented by local, regional, and tribal governments. Additionally, we briefly discuss a couple of options of energy economic diversification in areas of New Mexico and tribal lands under review for hydrogen hubs due to their declining fossil fuel economies.

Research Methodology

For this paper, we began with several key research questions based on our group's understanding of hydrogen proposals and policies in New Mexico. Several group members have worked on advocacy and analysis on hydrogen energy hub proposals which gained traction in 2021 and 2022, and one member monitors uranium activities and nuclear facilities. We aimed to understand the hydrogen energy process and production in New Mexico. Due to recent state action, we understand that the hydrogen economy is coming, so we must be proactive in crafting environmental and community health safeguards for communities on the frontlines of extractive industry, like the forthcoming hydrogen economy in New Mexico. We consider a focus on regulatory standards so that industry is accountable and communities have tools to monitor pollution and impacts on local resources. Our process includes considerations on how local governments and tribal governments implement air and water quality standards near hydrogen production and storage sites, ongoing pollution monitoring, prevention of freshwater use for hydrogen energy production, and community education initiatives. Moreover, given the top down approach to hydrogen energy production and siting in New Mexico, how can community members counter with bottom up initiatives on the local and regional levels. To look at these issues and provide the reader with the hydrogen energy landscape in New Mexico, we have looked at a broad range of materials and sources.

We reviewed research papers on hydrogen fuel and energy policy. We have studied federal energy proposals and memos, press releases, hydrogen and nuclear company websites, energy statistics and studies, and reviewed local newspaper articles from the last three years. We have compared community and industry press releases, local and national articles and company information to decipher plans for New Mexico. And, we have reviewed information from community organizations on community opinions and analysis on hydrogen hub development. Additional information was sourced from climate gatherings like the UNFCCC COP27 which were attended by two group members this year in Sharm el-Sheikh, Egypt.

The Paris Climate Agreement

Much of local and regional climate initiatives we are seeing are coming from the international platform as nation states are convening to negotiate, debate and decide global climate change policies to lower greenhouse gas emissions (GHG). The United Nations Framework Convention on Climate Change (UNFCCC) annual conference on climate change, known as the Convening of the Parties (COP) is an on-going discussion to negotiate, ratify and enforce international treaties on climate change mitigation and adaptation; the convention's summary is "preventing 'dangerous' human interference with the climate system is the ultimate aim of the UNFCCC." At the 1992 United Nations "Earth Summit," in Rio de Janeiro, Brazil, the United Nations (UN) had adopted an international treaty to commence the UNFCCC convention, ratified by 192 countries and enforced by the year of 1994 (Norton Rose Fulbright, 2018). The first convention (COP2) started in March, 1995 in Bonn, Germany to discuss the nation states' human intervention to address climate change, and unveil fossil fuels' root contribution to rapid climate change from excessive GHG emissions. Since then, many of the convenings have been to adopt international treaties or concepts to guide nation states to develop climate initiatives to maintain the planet's habitable temperature. 2015 was the year of COP21 and the year of the Paris Climate Agreement (Paris Agreement). The Paris Agreement is an international-legally binding treaty signed by 196 nation states (parties) to lower their GHG to limit global warming to well below 2 degree Celsius, preferably to 1.5 degrees Celsius, compared to pre-industrial levels (UNFCCC, 2022).

What the Paris Agreement doesn't include, unlike its older sibling agreement the 1997 Kyoto agreement (COP3), is that the dominant nation states like the US, Canada, China and the UK emit the most GHG therefore are the states that need to decrease their emissions the most. Even though it's been identified that poorer and more vulnerable nation states will first feel the impact of climate change with contributing to the crisis the least, the Paris Agreement adopted that climate change is a shared problem and all states must decrease their GHG emissions. What this does is shed less of the burden on dominant nation state powers and only provide guidance to nation states to decrease their GHG emissions on a national level. Some argue that the Paris Agreement is not a legally binding treaty whereas the Kyoto protocol identified that developed nations are the main climate change contributors and are legally bound to decreasing GHGs (Friedman, 2020).

The Paris Agreement demonstrates that the parties recognize the "urgent threat of climate change" and provides guidance for parties to "respect, promote, and consider their respective obligations to human rights, the right to health, the rights of indigenous people, local communities, migrants children, persons with disabilities and people in vulnerable situations and the right to development, as well as gender equality, empowerment of women and intergenerational equity." Article 6 of the Paris Agreement which was mainly discussed during the COP26 in Glasgow, Scotland was to emphasize the importance of financing global climate initiatives, nations' states participation in the voluntary market and, in Section 8, the importance of enhancing the public-private sector's participation. After the passing of Article 6, the current Biden administration and other democratic states looking to comply with the Paris Agreement to implement climate initiatives and while the intention is great, in this paper, we are are providing an analysis that identifies the need for local/regional and tribal compliance and partnership in order to make equitable decisions towards a just transition.

Federal Policy

The United States was one of the original parties to sign onto the Paris Agreement and rejoined on February 19, 2021 after President Trump disbanded the agreement during his administration. The

Biden administration's commitment to hitting climate targets was outlined in Biden's Executive Order 140008 on Tackling the Climate Crisis at Home and Abroad which called that the United States of America's action on climate "must go hand in hand" with international policies and begin the process of developing its nationally determined contribution under the Paris Agreement. In 2022, the Department of Energy (DOE) announced its appropriations for "clean regional hydrogen" energy production in the Bipartisan Infrastructure Act to help boost the country's energy economy and implement mechanisms for a "just transition."

The Biden administration has intensive plans for spurring hydrogen energy production nationwide. The administration views the production of hydrogen energy as both economically and environmentally beneficial and part of a just transition toward decarbonizing energy and manufacturing development. This especially for geographies that have declining, fossil fuel-dependent economies like New Mexico. At least two federal initiatives—the U.S. Department of Energy's Regional Clean Hydrogen Hubs Program (H2Hubs) and Biden's executive order to establish an "Interagency Working Group on Coal and Power Plant Communities and Economic Revitalization," currently secures the trajectory of hydrogen energy development in New Mexico ("Regional Clean Hydrogen Hubs," n.d.; "Initial Report to the President," 2021). The former is part of the Bipartisan Infrastructure Law (also referred to as the Infrastructure Investment and Jobs Act) of 2021, which allocated up to $7 billion in funding for the development of six to ten "clean hydrogen hubs" nationwide. Hydrogen hubs are defined as "a network of hydrogen producers and consumers, and the connective infrastructure located in close proximity" nationwide ("What Are Clean Regional Hydrogen Hubs?," n.d.). The latter is intended to identify and formulate infrastructure funding plans for twenty-five "energy communities" which have been impacted by declines in coal-fired power generation.

There are now many public-private partnerships that can include other entities, such as labor unions, colleges and universities, non-profits, and community-based organizations, that are all currently competing for hydrogen hub grant funding through the H2Hubs Program. The DOE has already begun to solicit proposals for such grant funding. Concept papers for applications were due on November 7, 2022; and full applications are due on April 7, 2023. Applicants include the public-private partnerships such as the Pacific Northwest Hydrogen Association, the Southwest Clean Hydrogen Innovation Network, Team Pennsylvania, and the Western Inter-States Hydrogen Hub (WISHH). WISHH involves a partnership between New Mexico, Colorado, Wyoming, and Utah, and Atkins Nuclear Solutions. What this MOU illustrates is that the need for public-private sector participation is necessary for the implementation of these infrastructure bills. Three concept papers were submitted for New Mexico in 2022.

State of New Mexico Climate Prevention

The state of New Mexico with Governor Michelle Lujan Grisham's administration are in coalition with other states who have adopted the Paris Agreement on a state level; this bipartisan coalition is the US Climate Alliance. The coalition is a bipartisan coalition of governors committed to reducing GHGs consistent with the goals of the Paris Agreement (US Climate Alliance, 2022). Many of the states within this coalition have adopted energy initiatives and climate targets to do their part for the climate crisis and follow in the footsteps of decisions made on the international platform.

In 2019, Gov. Lujan Grisham released an Executive Order on Addressing Climate Change and Energy Waste Prevention. This EO which orders the "adoption of a comprehensive market-based program that sets emission limits to reduce carbon dioxide, and other greenhouse pollution across New Mexico" is in alignment with the Paris Agreement. This raised many red flags locally after cultivating a baseline

understanding of how market-mechanisms can appear in new climate policies and initiatives which ultimately depend on global capitalism to address problems caused by global capitalism and transnational corporations in the first place. Grassroots, Indigenous and youth organizations across the country would deem these market-mechanisms as false climate solutions or "false solutions," because arguably the market is what caused the crisis in the first place (Gilbertson, 2017).

During the 2022 NM State Legislature, the governor had introduced House Bill 4, the Hydrogen Hub Act, to codify into state law the use of federal dollars and state resources to develop regional hydrogen hubs in New Mexico as a way to transition from fossil fuels to renewable energy. But there was firm opposition from environmental groups against hydrogen hub development due to concerns of resource intensive hydrogen production; green hydrogen using a lot of water; gray and blue hydrogen using natural gas; pink hydrogen using nuclear energy and so on. Subsequently, Democratic legislators introduced hydrogen bills two more times before the legislature adjourned, and both times it was voted down. After the legislative session, Gov. Lujan Grisham signed the Western Inter-state Memorandum of Understanding (MOU) with Colorado, Utah, and Wyoming to share hydrogen funding to build out regional hydrogen hubs and form the WISHH. There was an additional MOU signed with Sandia National Labs and Los Alamos National Labs to research technology for hydrogen production and receive federal financing. The MOUs outlines that the four states and the labs would share the 7 billion dollars of bipartisan infrastructure act money to develop regional hydrogen hubs.

Community Pushback: Indigenous, Youth and Environmental Justice Groups Oppose Hydrogen Hub Development in the 2022 New Mexico State Legislature

Briefly mentioned earlier, during the 2022 New Mexico State Legislative Session, there were three different bills introduced related to hydrogen production and subsidies. Prior to the session, the Governor announced plans to include hydrogen hub development as a key piece of our energy transition and climate plan. Soon after, Indigenous, environmental, social justice and public health groups organized to denounce these proposals to make NM a hub for hydrogen production. One month prior to the session, these groups held a December 2021 press conference to start debunking what they consider to be *greenwashed solutions* including hydrogen hubs and other climate trends like "carbon net zero," "carbon offsetting," and "carbon sequestration and storage." On the opening day of the session, Indigenous and environmental justice groups like Youth United for Climate Crisis Action (YUCCA), Pueblo Action Alliance (PAA), and Southwest Organizing Project (SWOP) organized a disruption to raise awareness about some issues with the legislation, including investments in the fossil fuel industry furthering the state's dependency on volatile fossil fuel extraction and revenue. Citing one of the latest Intergovernmental Panel on Climate Change (IPCC) reports groups are heeding the urgent warnings that "we have less than 8 years to cut our carbon emissions in half in order to mitigate the impending climate catastrophe threatening the future of my generation and generations of New Mexicans after us" (IPCC, 2021; YUCCA Letter, 2022).

Image: YUCCA Banners from January 2022 protest regarding hydrogen hub proposals.

Throughout the short 30-day session, these organizations and others continued to organize New Mexican stakeholders and held information sessions and teach-ins to educate the public and advocate to oppose these bills and to contact legislators. Three bills made it to the discussion table and due to such strong opposition and consistent lobbying against these bills, they were voted down. Despite this, the Governor and her administration bypassed democratic processes and sought other action to pursue hydrogen hub development and state investment. It is likely that there will be hydrogen hub related bills or provisions in proposed bills during the longer sixty day session starting in January 2023.

What does this mean for regional, local and Tribal governance?

The nation states at COP believe that the private-public sector is a "bottom up" approach but fails to include tribal nations and local/regional stakeholders meaningfully (Bazilian et al., 2022). During the New Mexico state legislative session, Pueblos and tribes were not vocal on their position when it comes to hydrogen energy production and in many cases are only hearing the perspectives from pro-hydrogen entities. Without meaningful consultation, unbiased education and meaningful relationships and partnerships, the implementation of hydrogen in New Mexico is coming from a top-down approach which undermines tribal sovereignty and local democratic processes.

The Forms of Hydrogen Energy

Hydrogen can be used in industrial production processes or in fuel cells to generate electricity or heat. Hydrogen (H_2), as a fuel and energy carrier, is produced through different processes, from different inputs including biomass, water, natural gas, nuclear energy, and renewable energy sources. Each type is often described by different shades or colors. Steam methane reformation and electrolysis are the primary production methods used to produce hydrogen whereas naturally occurring pure hydrogen is very rare.

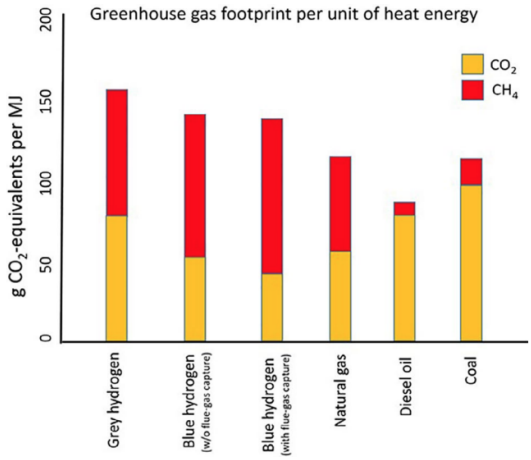
Gray hydrogen is a form of hydrogen-based fuel produced from methane (CH_4), one of the most potent GHG and compared "mass-to-mass it is more than 100 times" more potent than CO_2 (Howarth & Jacobsen, 2021). In 2021, it was estimated that ninety-seven percent (97%) of the world's hydrogen production was gray hydrogen (Chemical Industry Digest, 2021). The process, known as steam methane reforming (SMR), uses steam to split the methane molecules to extract the hydrogen molecules (Hermesmann and Müller, 2022). According to the DOE, this is a "mature production process in which high temperature steam (700-1000 ℃)" reacts with methane and a catalyst under pressure (DOE, 2022). This process emits carbon dioxide (CO_2)–a greenhouse gas–as a byproduct, which is not captured in the process. The input and output includes fossil fuel sources and other GHG, which make this a non-renewable and a non-carbon neutral energy source.

Associated color	"Grey"	"Blue"	"Turquoise"	"Green"
Primary feedstock	Natural gas	Natural gas	Natural gas	Water
Production technology	Steam methane reforming (SMR)	SMR with carbon capture & storage (CCS)	Methane pyrolysis (MP)	Polymer electrolyte membrane water electrolysis (PEMEL)
Technology readiness level (TRL)	Commercial (TRL 9)	Industrial scale (TRL 8-9)	Research & Development (TRL 3-4)	Commercial (TRL 9)
Process-related CO_2 emissions	High-CO_2	Low-CO_2	CO_2-free	Carbon-free

Table: Blue, Green, Gray and Turquoise Hydrogen and their feedstocks, outputs and uses. Hermesmann, M. and Müller, T.E. (May 2022). *Green, Turquoise, Blue, or Grey? Environmentally friendly Hydrogen Production in Transforming Energy Systems.* Progress in Energy and Combustion Science, pp. 3.

Blue hydrogen uses the same SMR process except it is considered a lower intensity fuel because the production is coupled with Carbon Capture and Storage (CCS), which uses technology to physically capture carbon dioxide byproducts from the air to then store and transport to a sequestration site or in some cases inject liquified carbon back into the ground. Blue hydrogen production is touted for resulting in "zero or low greenhouse gas emissions," but, as documented by Howarth and Jacobsen 2021 study this is not the case. In their study, they examine the lifecycle of GHG for both carbon dioxide and unburned fugitive methane emissions (leaks and other irregular releases). Considering the entire lifecycle of energy production, there are additional emissions from blue hydrogen production coming from the fracking required for natural gas, fugitive methane, post-SMR carbon dioxide, and natural gas to power the CCS process plus transportation for CCS. According to Howarth and Jacobsen 2021 study, blue hydrogen's greenhouse gas footprint is twenty percent (20%) more than burning natural gas for heat and sixty percent (60%) more than burning diesel oil for heat in the study (1676).

Gray and blue hydrogen are both produced using SMR but blue is considered the clean standard due to CCS. Regardless, this study estimates that total emissions for blue are only 9-12 percent less than gray hydrogen (1682). The study also looks at greenhouse gas emissions compared to other fuels (per unit of energy produced when burned) considering coal, diesel, and natural gas; and although carbon dioxide is lower than conventional fossil fuels, the methane produced is higher (1683). The *clean energy* and *zero-low greenhouse gas emissions* labels that blue hydrogen is given is not accurate and amounts to greenwashing.



Graph: Comparison of carbon dioxide equivalent emissions from gray hydrogen, blue hydrogen, natural gas burned for heat generation, diesel oil burned for heat, and coal burned for heat. (Howarth & Jacobson)

Furthermore, CCS needs more testing and development on a large scale to capture the emissions from power plants and has not shown to effectively store carbon dioxide (Schlosberg & Hart, 2021). It also requires large amounts of energy to capture carbon, which requires more electricity generation and more fuel. Data from a blue hydrogen plant, Shell in Alberta, Canada shows that daily rates of carbon capture efficiency range from fifty-three to ninety percent (53%-90%) with outliers as low as fifteen percent (15%) (1680). Blue hydrogen may build upon existing fossil fuel infrastructure in place, but would require additional investments in this infrastructure and the continuation of fossil fuel extraction.

Green hydrogen is becoming a popular energy investment in the just transition conversation because it is considered *carbon neutral* as the process uses electrolysis to split water (H_2O) to produce hydrogen while the process is powered by renewable energy sources like wind and solar. Green hydrogen has fewer GHG emissions with the exception of nitrous oxide (NOx) resulting from the process, but requires large amounts of water which is of concern in the arid Southwest. Critics suggest that companies should invest in renewable energy infrastructure and storage rather than invest in energy to produce a different type of carrier.

Other types of hydrogen to be cognizant of include pink hydrogen (sometimes also referred to as red hydrogen). Pink hydrogen also uses electrolysis to split up water molecules, however, the energy used for this process is sourced from nuclear energy. The International Atomic Energy Agency (IAEA) is a

body of the UN with a "mandate to work with its Member States and multiple partners worldwide to promote safe, secure and peaceful nuclear technologies (IAEA, 2022). In the same fashion of top-down authority, the IAEA is present at every COP pushing for more nuclear, both existing and unproven technologies. At COP27, the IAEA held a large exhibition pavilion promoting both nuclear energy and nuclear-hydrogen energy development. "Nuclear plants … produce heat, not just electricity. For that reason, they can be paired with a … high-temperature steam electrolyzer (HTSE)...[and] advanced reactors that operate at very high temperatures can produce hydrogen thermochemically, without the use of electrolyzers" (IAEA, 2022). Nuclear energy uses both heat and electricity, which the industry considers "carbon-free" or "carbon-neutral," as IPCC discounts the processes before and after the nuclear power plant. Opponents of nuclear energy argue that the entire footprint of nuclear energy development must include uranium extraction, fuel development, transport, and waste storage. Nuclear energy requires fossil fuels to process and transport the uranium, and it emits carbon and other pollution, as well as heat, therefore, it is not carbon-free or carbon-neutral.

Aside from the dangers of a hydrogen as a flammable gas and risks of possible explosions spreading radionuclides, uranium mining in the United States, near and on Tribal lands–and in NM–has a long, unresolved history with legacies of detrimental impacts on human health, radioactive wastes, and unremediated pollution lingering in communities and water sources. Given the issues of radioactive contamination resulting from nuclear weapons and energy development, pink hydrogen is also a source to be wary of despite its reputation as a so-called "clean" energy, which it is not. The DOE has committed funding and support for pink hydrogen research and development through various bills and projects sited in the U.S. (Office of Nuclear Energy, 2022). Black, brown, and turquoise hydrogen are produced with fossil fuel inputs and are less common and are not included in energy and infrastructure legislation.

Colors of Hydrogen	Processes/formations of hydrogen energy production
Blue Hydrogen	Hydrogen production from fossil fuels through steam methane reformation; coupled with CCS
Gray Hydrogen	Hydrogen production from fossil fuels through steam methane reformation
Green Hydrogen	Produced using electrolysis powered by renewable energy sources like solar, wind and biomass (although some may argue biomass is not a renewable energy)
Pink Hydrogen	Using nuclear energy to produce hydrogen
Yellow Hydrogen	Using wind and solar to produce hydrogen
Turquoise Hydrogen	Methane as a feedstock, but the process is driven by heat produced with electricity rather than through the combustion of fossil fuels
Black Hydrogen	Using coal power to produce hydrogen

Table on the types of hydrogen production processes and colors commonly used to describe them.

The prevailing sources proposed in New Mexico are green and blue hydrogen sourced from water and natural gas, respectively. When looking at new sources of energy during this critical time of climate chaos and energy transitions, it is important to consider the entire fuel chain including input and output processes.

Proposed Hydrogen Production or Manufacturing Sites in New Mexico

Bernalillo County

Hydrogen is key for New Mexico. The state and industries have eyed New Mexico for blue and green hydrogen production and distribution. Universal Hydrogen is a California-based company that picked Albuquerque as its next manufacturing and distribution hub set to begin full scale manufacturing

by 2024 and bring products to market by 2025 for small hydrogen-powered aircrafts. The company is utilizing green hydrogen fuel cells and technology with the goal to retrofit regional aircrafts to use this fuel source. Press releases from the company do not state if the site has future plans to produce hydrogen onsite on its Albuquerque adjacent site, but currently plans to transport green hydrogen from production sites in the U.S. The company is utilizing private and federal investment in addition to a 10 million dollar commitment from the state of New Mexico via the Local Economic Development Act (LEDA). The City of Albuquerque is also planning to commit two million dollars via investment from its local economic development fund.

BayoTech Inc. is an Albuquerque-based company with an eye towards building out hydrogen hubs in five different states with their mobile hydrogen generators, storage, and high pressure gas transport systems (Robinson-Avila, 2022). BayoTech, Inc. is a blue hydrogen company. The company's systems tap into existing natural gas pipelines or biogas resources (BayoTech, 2022).

Taos County

In Taos County, Questa, NM is being considered as a site for green hydrogen production. Questa has been home to a molybdenum-rhenium mine formerly owned by Molycorp and now owned by Chevron Mining Inc. Since the mine's closure in 2014, the Questa mine is in the process of remedial and reclamation activities and is on the Superfund National Priorities List (Questa del Rio, 2022). This site, the former tailings location, currently is the subject of a feasibility study to determine if it is a possible location to build a green hydrogen production facility with an expected report in 2023. The study is underway in partnership with the National Renewable Energy Laboratory, Sandia National Labs, Los Alamos National Labs, Chevron and Kit Carson Electric Cooperative, the Village of Questa and the Questa Economic Development Fund. Kit Carson Electric Cooperative is a key partner in this possible endeavor as it has increased its renewable energy portfolio rapidly in recent years (KCEC, 2022). Of concern is the site's proximity to the Village of Questa and water resources. Chevron has been in dispute with the Office of the State Engineer over water rights. Others say that water for production might also be sourced from treated wastewater produced by the ongoing remediation of the underground workings at the old mine or a municipal wastewater treatment plant (Plant, 2022), however, it is still yet to be determined.

San Juan County

Like the Permian Basin in Southeast NM, the San Juan Basin in Northwest NM has been and continues to remain one of two epicenters for hydrocarbon extractivism in New Mexico.[1] Socio-economic trends related to hydrocarbon extractivism in the Basin are perhaps most stark in San Juan County, which includes, the City of Farmington, as well as smaller cities such as Bloomfield and Aztec, the Town of Kirtland, and numerous unincorporated communities both within and without the Navajo Nation reservation boundaries.

After an initial oil boom in 1921 that lasted until 1925 precipitated another, hydrocarbon extractivism became the lifeblood of San Juan County beginning in 1950, when "El Paso Natural Gas laid a transmission line extending the San Juan Basin to California" and when the County consequently saw a

[1] The San Juan Basin is a geological feature known as an "asymmetrical structural depression" within the Colorado Plateau—it is, in other words, a very large valley of sorts within a vast elevated plane. The Basin encompasses much of Northwest New Mexico and part of Southwest Colorado. On the New Mexico side of the border, nearly the entirety of San Juan County, the majority of McKinley County, significant chunks of both Rio Arriba and Sandoval Counties, and part of Cibola County are within the bounds of the Basin; in Colorado, the Basin comprises nearly half of Montezuma County and the majorities of both La Plata and Archuleta Counties.

huge influx of workers ("Aztec History Since 1100 A.D.," n.d.) The population of Farmington increased by roughly sixfold between 1950 and 1960, from 3,600 residents to 23,800 residents ("Farmington, New Mexico Population 2022," n.d.)." Two coal-fired power plants were commissioned in the county soon after "along either side of the San Juan River" according to Jonathan Thompson, a writer for *High Country News*—the Four Corners Power Plant and the San Juan Generating Station began operating in 1963 and 1973, respectively (Thompson, 2022; "Four Corners Generating Station, 2021; "San Juan Generating Station," 2022).[3] The oil and gas industry, power plants, and the mines supplying coal to the power plants bolstered a middle-class and eventually became the economic backbone of County/municipal infrastructure and public services (Thompson, 2022). The second boom lasted until 1959, and a third lasted around 40 years, that is, until 2008, when "abundant natural gas supplies from the Bakken and Marcellus shale formations glutted the market, causing prices to crash (Thompson, 2022; Dugan, 1977)." The San Juan Basin saw an overall decrease in 5,000 jobs as a result of this third bust; to serve as icing on a rather grim cake, lawsuits against and divestments from San Juan Generating Station and the Four Corners Power Plant forced both plants to shut down generating units, foreshadowing their eventual demise (Thompson, 2022). The San Juan Generating Station officially shuttered its doors this year; Four Corners is set to be decommissioned by 2031 "Thompson, 2022; Four Corners Generating Station, 2021). Both the slump in the region's oil and gas industry and the closure of the San Juan Generating Station have spelled untold socioeconomic effects on the County: the City of Farmington experienced an 8.76% decline in population between 2010 and 2016, and a 13.5% decline in its non-adjusted gross receipts tax collection between 2009 and 2018 (Smith, A. K., 2022).

Enter hydrogen energy, which New Mexico elected officials such as Gov. Michelle Lujan, Senators Martin Heinrich and Ben Ray Luján, and Rep. Teresa Leger Fernández believe that hydrogen energy production infrastructure is suitable for San Juan County not only because of its "experienced energy workforce" and "proximity to major high-voltage transmission lines and natural gas pipelines," but also because of its economic decline (Heinrich, et al., 2021). A letter from Heinrich, Ray Luján, and Fernández to Secretary of Energy Jennifer Granholm reads: "Clean hydrogen investment in Northwest New Mexico is also critical to workforce development and securing good-paying American clean energy jobs in this economically challenged area (Heinrich, et al., 2021)." Heinrich and Granholm actually visited Farmington in 2021 to discuss the potential for hydrogen energy development with "county leaders" such as Farmington mayor Nate Duckett, San Juan County Commission Chairman John Beckstead, and Executive Vice President of Aztec Well Servicing Jason Sandel (Smith, N.L., 2021.) Aztec Well is the San Juan Basin's "largest locally owned oilfield services company (Thompson, 2022).

Measures to manifest federal hydrogen production infrastructure in San Juan County are well underway. Farmington-based oil field equipment supplier PESCO has begun manufacturing reactor units for Bayotech, Inc.; Libertad Power Project LLC plans to initiative to complete a hydrogen-fueled generating station near Farmington as early as 2024; and Utah-based Big Navajo Energy's plan to capture methane from a refinery near Farmington run by the Navajo National Oil and Gas Company (NNOGC) in a way that "would convert the gas into hydrogen to be used for electric generation ("PESCO Builds Portable Hydrogen Production Units," 2021; Robinson-Avila, 2021). Bayotech, Inc. has also partnered with San Juan College,Farmington's community college, to create a "post-graduate credential program that provides the technical skills needed to work safely and efficiently with hydrogen production systems" ("BayoTech and SJC to Create Graduate Program," 2021). In adjacent McKinley County, New Point Gas LLC and New Point Energy Co. have plans to retrofit the currently defunct Escalante Generating Station outside of Prewitt into a "hydrogen production and generating facility" (Robinson-Avila, 2021). As

mentioned earlier, San Juan basin has a historic legacy of extractivism and with the introduction of a new hydrogen energy production economy would continue the life cycle of fossil fuel cultivation and another boom and bust economy.

Why should New Mexico be concerned about Nuclear-Hydrogen Hub development?

In the United States, there have been just over 100 commercial nuclear reactors at 65 nuclear power plants across the country (NRC) producing electricity since the 1970s. Today, many have been closed and decommissioned, whereas several are continuing beyond their original closure dates; and only one nuclear power plant is adding new reactors. There are no nuclear power plants that are currently producing hydrogen, but the DOE is "investing billions to … scale-up the production of clean hydrogen by leveraging the nation's existing energy assets, including nuclear power plants" (DOE, 2022). The DOE is working with utility companies to develop nuclear-powered hydrogen demonstration projects at four sites, including Palo Verde Generating Station in Arizona, of which PNM owns "just over 10%." (DOE, 2022) (PNM,2022). Does this mean that New Mexico ratepayers could possibly become investors of hydrogen development themselves, or liable for any risk?

Also in New Mexico, while there are no nuclear reactors, there are several concerns including a proposal to build and operate the a high-level radioactive waste storage site for all U.S. commercial nuclear power plant waste (Holtec, 2022), coupled with federal financing for research to reprocess that waste. Adrian Hedden of the Carlsbad Current-Argus newspaper reports, "A team of scientists at New Mexico State University earned $8.5 million in federal grant funding from the U.S. Department of Energy to develop a method to recycle spent fuel leftover from decommissioned nuclear power plants" (DOE, 2022). While there is no public discussion of using reprocessed nuclear power waste for pink or red hydrogen development, there is funding in place to start the process.

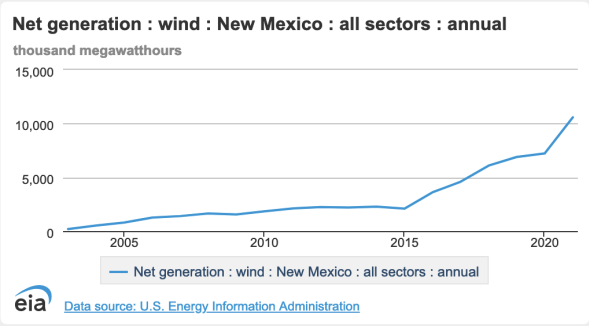
Last and possibly most important, New Mexico depends heavily on federal funding of the two national nuclear laboratories in our state: Sandia National Labs and Los Alamos National Labs. With these federal entities, and existing MOUs, along with several other nuclear facilities in the southeast, New Mexico is considered by some to be a highly-advanced nuclear technology state, and by others it is considered to be a nuclear sacrifice zone. In southeast New Mexico, the state has North America's only uranium enrichment facility (Urenco, 2022), the world's only deep geological repository for nuclear weapons waste, and possibly the largest radioactive waste dump in the world for commercial nuclear power plant waste. The biggest impact to Indigenous peoples of New Mexico is the threat of new uranium mining. Because of the heavy economic dependence on the uranium mining in the past and current nuclear industrial complex, this paper also explores alternative economies as a policy recommendation.

Analysis and Policy Recommendations

NM's Wind and Solar Renewable Energy Potential v. NM's Hydrogen Potential

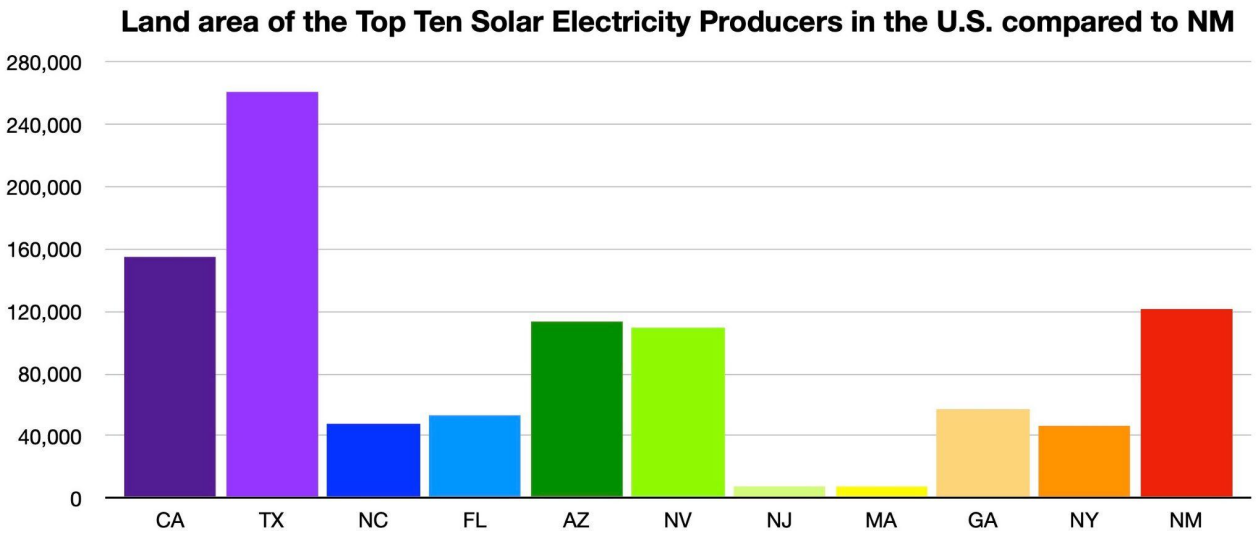
If the goal for hydrogen development is to replace fossil fuels, we can see that the potential of both wind and solar combined can eventually replace electricity generated by natural gas and coal. If we do not account for New Mexico's energy consumption and only focus on what New Mexico produces, we can see from U.S. Energy Information Administration (EIA) data that New Mexico's renewable energy potential exceeds the need to develop hydrogen. "In 2021, renewable resources accounted for the largest share of New Mexico's in-state electricity generation, about 36% of power from utility-scale…For the

first time, renewable energy contributed more to New Mexico's in-state power supply than either coal or natural gas."



According to the DOE Office of Energy Efficiency and Renewable Energy WINDExchange website, while New Mexico currently generates about one third of its electricity from wind power, it only generates about six percent (6%) from solar. In 2021, the energy from wind was more than natural gas and nearly as much as coal, and as seen in the graph, wind is on the rise (DOE, 2022).

According to Ecowatch.com, New Mexico did not develop as much solar energy in 2021, but has great potential compared to states like New Jersey and Massachusetts which were in the top ten solar producing states but have a much smaller land area compared to New Mexico. As we can see in the following graph, which is ordered by largest or first solar producer at the left (California) and declining to tenth largest producer at the right (New York); New Mexico could and should be in the top ten. However, New Mexico came in twenty-sixth, but arguably has more sun than other states. When considering land area and weather patterns, New Mexico could be among the top five. Lastly, in a state with more solar and wind potential, it makes no sense to use precious water resources or fossil fuels to create energy when true renewable energy has not been fully researched or funded in New Mexico.



Ecowatch.com, an environmental newspaper, identifies these states as the ten top national producers "leading solar energy installation in 2022." Comparing land area by square mileage, New Mexico does not make the top ten, but (according to 2010 U.S. Census data) has more land area than most. This graph shows a significant potential for the state of New Mexico or Tribes to develop solar electricity.

Source: https://www.ecowatch.com/top-states-for-solar-energy-2653783171.html
Source: https://www.census.gov/geographies/reference-files/2010/geo/state-area.html

Remediation and Clean up Economy

The rollout of hydrogen energy production in New Mexico and the attendant reality that hydrogen energy is a false climate solution pose yet another iteration of extractivist, undemocratically-determined energy and economic development in the State. The arrivals of coal-fired power generation, nuclear power research and development, oil and gas extraction, and, contemporarily, hydrogen energy production in the state did not stem from democratic deliberation, but out of public-private financial interests. Gov. Lujan Grisham's support for blue and green hydrogen has been premised on evidence from a study conducted by New Mexico Energy Prosperity, which shares an address with Aztec Well, the San Juan Basin's "largest locally owned oil field services company" (Thompson, 2022).

Several policy solutions offer alternatives to particularly the extractivist status quo of energy economic development in New Mexico. As documented by economist Kelly O'Donnell, economic development via remediation and reclamation of oil and gas sites on state trust and private lands is one such alternative to extractivism that is conducive to a regenerative economy. State and federal laws require that private companies plug wells and "restore sites to their original form and function after production ceases," yet their low bonding requirements and the "industry practice of selling off marginal wells to smaller, less financially resilient operators" pose as obstacles to ensuring private industry's accountability for remediation and remediation (O'Donnell, 2021). There were over 28,000 oil and gas production and disposal sites in New Mexico as of June 2021.

Remediation and reclamation projects on state trust and private lands in New Mexico could serve as a significant source of economic stimuli. According to O'Donnell, they could "inject over $8.2 billion into the New Mexico economy and support 65,337 job years (three years of employment for 21,779 New Mexicans) paying $4.1 billion in wages, salaries, and benefits to employees and sole proprietors" (O'Donnell, 2021). Gross receipts and state personal income taxes derived from reclamation projects could generate an additional $541 million in revenue for the state and counties. Reclamation and remediation projects would not completely substitute for the job losses and economic benefits of oil and gas production in the State, but would nonetheless soften the effect of a transition away from hydrocarbon extractivism that is inevitable and would obviously lead to necessary ecological regeneration processes.

Funding for such reclamation and remediation projects would have to come from either a) private companies à la their legal obligation to remediate and reclaim oil and gas infrastructure or, b) the federal government. Exacting pressure on oil and gas companies to fulfill such legal obligations should therefore become a priority for the state and the federal government.

O'Donnell also outlines specific recommendations for economic diversification in historically coal-impacted and economically dependent San Juan, McKinley, and Cibola counties in a report titled "Economic Opportunities for the Four Corners Area" (O'Donnell, 2018). She writes that these counties could pursue economic diversification through prioritizing the following industries and economic sectors: tourism and recreation, solar energy production and storage, mine reclamation, healthcare, and local food systems. These recommendations have a capacity to substitute for the supposed economic stimuli to San Juan County and the San Juan Basin in general via hydrogen energy production infrastructure as advocated for by Martin Heinrich, Ben Ray Luján, and Teresa Leger Fernández.[2] O'Donnell noted that San Juan County is "an excellent site for a commercial scale energy storage facility to serve as a trading hub for southwest utilities," citing the way in which transmission lines from the Four Corners Power Plant

[2] Mine reclamation and remediation, O'Donnell writes, creates 5-33 jobs per million dollars invested, yet, as is the case with oil and gas reclamation and remediation, funding for mine reclamation would have to come from private mining companies or the federal government. Mining companies are responsible for mine reclamation and remediation, but they don't follow through on such responsibilities — "New Mexico coal mines currently have hundreds of millions of dollars in reclamation liability" (O'Donnell 2021).

could transfer solar energy produced throughout the County to a storage facility. She also notes that, given its recent growth, the solar industry could employ almost all workers displaced by coal. The problem is that solar jobs do not generally pay as well as coal jobs, "particularly for workers with only a high school diploma." The State of New Mexico or the federal government should therefore bolster the salaries of solar jobs as an alternative to incentivizing/investing in hydrogen energy production infrastructure.

Safeguards for Communities near Nuclear Facilities

Hydrogen as a flammable gas has many risks as it is combustible and can cause explosions and corrosion of pipes and other infrastructure, weakening them. As explained in the IAEA's 2011 Mitigation of Hydrogen Hazards in Severe Accidents in Nuclear Power Plants, hydrogen was responsible for the expensive and dangerous explosion at the Three Mile Island nuclear meltdown in Pennsylvania in 1979. (IAEA, 2011). Hydrogen is also the cause for explosions at Fukushima in 2011 (Saji, 2016). For the production of hydrogen to be safe, it must be contained and kept away from any risk of exploding radioactive materials. "The U.S. Nuclear Regulatory Commission (NRC) has a checkered history when it comes to requiring measures that would effectively reduce the risk of hydrogen explosions in the event of a severe accident at a U.S. nuclear power plant. This regulatory lapse is rooted in the history of the development of commercial nuclear power in the United States, when the NRC's predecessor agency, the Atomic Energy Commission (AEC), had a dual mandate: both to promote and to regulate commercial nuclear power" (Leyse, 2014). With this "regulatory lapse" and many nuclear facilities and presence of radioactive wastes, New Mexico is too risky a place to develop hydrogen.

Safeguards for Tribal lands: Tribal Air Quality Standards

The Tribal Authority Rule (TAR) is one means through which tribes that are sharing airsheds and are within close proximity to dirty energy production can exercise their tribal sovereignty by designating strong environmental quality standards. In response to any new energy initiative that emits greenhouse gasses, Pueblos and tribes must consider obtaining their own Air Quality Standards under the Tribal Authority Rule (TAR) Under the Clean Air Act. Under section 301(d) of the Clean Air Act tribes air quality standards may be treated in the same manner as states and secures authority over all air resources within the exterior boundaries of a reservation. This rule also notes that Congress provides grant and funding resources for tribes to declare Air Pollution standards through the EPA's Office of Air Quality Planning & Standards currently are accepting proposals for the 2022 Targeted Airshed Grant Program. Qualifications for eligibility for treatment as state status include federal recognition, governing body that will carry out substantial government duties and powers, ability to implement their air quality program consistent with the Clean Air Act, and the ability to identify the exterior boundaries of the reservation. This authority provides tribes' the opportunity to exercise their own sovereignty by designating air quality standards and authority over all air resources within the exterior boundaries of a reservation.

Cumulative Impact Assessments

As mentioned in this analysis, top-down approaches to address energy economic opportunities should include and protect democratic processes for local stakeholders who live near energy production sites. Another means of democratizing deliberations and decisions for future energy production is cumulative impact assessments, which is defined by the EPA as such: "Cumulative Impact Assessment is the process of accounting for cumulative impacts in the context of problem identification and

decision-making. It requires consideration and characterization of total exposures to both chemical and non-chemical stressors, as well as the interactions of those stressors, over time across the affected population" (Julius, et al., 2022).

While the assessment of cumulative impacts is technically required by the Council on Environmental Quality (CEQ) regulations via the National Environmental Policy Act, they, as written by Kiana Courtney of the Environmental Law and Policy Center, "...have yet to be federally codified and instead only appear in guidance and regulations" (Courtney, 2021; "Consideration of Cumulative Impacts, 1999). In light of this, local governments can and should integrate cumulative impact assessment practices into permitting processes. Cumulative impact assessment regulations at the local level are conducive to participatory data collection and aggregation, as "Local governments also have (or at least should have) a more direct line of communication with residents" (Courtney, 2021). The 2016 Environmental Justice and Cumulative Impacts Ordinance adopted by the City of Newark, New Jersey is an example of cumulative impact assessment integration into local regulations/policies (Courtney, 2021; "Chapter 41:20," 2016).

Conclusion

After a condensed review of New Mexico's long legacy of extractivism for fossil fuel energy production, it is not a coincidence for New Mexico to be one of the next regional hydrogen hubs. The fact that New Mexico is still a resource rich state allows for the continuation of extractive energy production that continues to sacrifice and capitalize off of the environment and frontline communities. Actual climate solutions would bolster the solar and wind renewable energy economy, the clean up of historic fossil fuel cultivation, meaningful consultation with sovereign tribal nations, and input from community stakeholders that respects local democratic process. While the nation states are looking to address the impacts of climate change, introducing new energy investments that don't have the teeth to actually lower emissions should be an indicator to look towards renewable technologies that actually work. We cannot deny the crisis that we are enduring as New Mexico experienced the most devastating wildland fire season in 2022. As of December 13, 904,422 acres of land have been burned and climate models suggest that run-off and groundwater recharge will decline by 3-5% each decade and so over the course of 50 years will equate to 16%-27% decline in run-off and groundwater recharge which will result in more fire devastation and poor water and soil quality (Dunbar, Nelia W. et al, 2022; "FAMWeb Data Warehouse, Southwest Area." 2022). The climate realities we face can no longer withstand inaction and must go hand in hand with systematic and radical shifts in economic diversification and opportunities that don't continue old patterns. While hydrogen may be the global initiative for energy development, it can not be a one-size-fits-all solution but real solutions that take into account climate stressors specific to each geography.

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