NATIONAL PETROLEUM COUNCIL

Report

Harnessing Hydrogen

A Key Element of the U.S. Energy Future

April 23, 2024

This is a document approved by the National Petroleum Council as its response to the request for advice from the Secretary of Energy. It was approved subject to final editing and graphics. However, the report's key messages, findings, and recommendations will not substantively change. The final edited report will be posted on this website replacing these drafts.

Appendix C - Executive Summary Findings and Recommendations

APPENDIX C: EXECUTIVE SUMMARY FINDINGS AND RECOMMENDATIONS

The following findings and recommendations have been included as part of the Executive Summary of this study:

Finding 1: LCI hydrogen could account for 8% of Unites States' emissions reductions, primarily in hard-to-abate applications in the Industrial, Transportation, and Power sectors. Addressing these emissions without leveraging LCI hydrogen would cost society approximately an additional 0.5-1% of GDP.

Finding 2: Current policies and anticipated cost reductions for LCI hydrogen could increase total hydrogen demand by nearly 2x by 2050. However, current policies and anticipated economics are not sufficient to catalyze the nearly 7x demand growth required by 2050 to reach LCI hydrogen deployment at scale and support U.S. net zero ambitions at a lower cost to society. Achieving this goal will require significant and immediate action to support the growth and scale-up of all aspects of the hydrogen market: supply, infrastructure, and demand.

Finding 3: The Industrial sector is projected to be the largest demand segment, but deploying LCI hydrogen at scale requires demand growth in hard-to-abate sectors, including heavy-duty transportation and dispatchable power.

Finding 4: The United States has the opportunity not only to secure its own carbon emissions reduction goals via LCI hydrogen but also to be a leader in advancing the global hydrogen economy.

Finding 5: The LCI H2 production mix will be driven by multiple aspects of the various H2 production pathways, including their relative speed-to-scale, delivery cost reductions, and carbon intensities.

Finding 6: Pipelines should connect advantaged production to diverse demand centers to support a regionally optimized infrastructure configuration.

Finding 7: Incorporating large-scale hydrogen storage infrastructure could enable a more cost-effective LCI hydrogen energy system design across the United States.

Finding 8: The LCI hydrogen market in the United States has entered the Activation phase, aided by recent legislation such as the Inflation Reduction Act and Infrastructure Investment and Jobs Act, and is poised to increase LCI hydrogen production in advantaged regions.

Finding 9: A large cost gap exists between incumbent fuels and feedstocks and LCI hydrogen in hard-to-abate applications. Technology advancement will continue to support closing the cost gap; however, current federal and state policies, as well as Modeled system cost re-duction, will not be sufficient to close the cost gap to parity by 2050.

Recommendation 1: Price on Carbon

Recommendation: As more fully described in Chapter 6: Policy, NPC recommends that the administration work with Congress to establish an economy-wide price on carbon well before current incentives, such as 45V, expire. This economy-wide price on carbon should be:

- Phased-in and coordinated to minimize adverse impacts on energy security, reliability, and affordability
- Well-designed to provide predictable signals for decisions about long-lived capital investment
- Economy-wide, market-based, and applicable to imports as well as domestic production, with a rebate for exports
- Visible, predictable, and transparent
- Enabling all technologies to compete and cost-effectively lower carbon emissions intensity by focusing on reducing emissions per unit of energy, while delivering meaningful emissions reductions
- Considering key protections and assurances for communities which are disadvantaged and could be overburdened by climate and air pollution
- An emissions intensity border fee considered in the context of a complementary explicit carbon pricing policy to address/mitigate potential emissions leakage

Recommendation 2: Demand-side incentives for industry: National low carbon intensity industry standard

Recommendation: As more fully described in Chapter 6: Policy, NPC recommends Congress and the administration consider a national low carbon intensity (CI) industry standard to address GHG emissions from the Industrial sector. This transparent, technology-neutral, life cycle-based standard would be funded through carbon credit markets and applied within different segments of the industrial sector to reduce the CI of products by considering well-to-gate** emissions associated with the sector. This policy may require specific CI standards to address various industrial subsegments and provisions will be needed to ensure the industrial sector remains globally competitive. This recommendation would be in lieu of an economy-wide explicit price on GHG emissions, which is the preferred policy approach.

** Well-to-gate shall only include emissions through the point of production (well-to-gate), as determined under the most recent Greenhouse gases, Regulated Emissions, and Energy

use in Technologies model (commonly referred to as the "GREET model") developed by Argonne National Laboratory, or a successor model (as determined by the secretary).

Recommendation 3: Demand-side incentives for transportation: National low carbon intensity transportation standard

Recommendation: As more fully described in Chapter 6: Policy, NPC recommends Congress and the administration establish linked life cycle fuel and well-to-wheels vehicle CO_2 standards*. This policy would include:

- A low carbon fuels standard program, driving down the CI of different fuel pathways (e.g., liquid fuel, H_2, or electricity)
- Vehicle CO_2 standards, which would utilize the well-to-wheels emissions of the vehicle based on the actual/projected LCFS performance of the energy source for the vehicle

As a result, the combined programs funded through carbon credit markets could drive down actual transport emissions in a holistic and efficient way, helping to accelerate emissions reduction and delivering reductions at a lower cost than the current, siloed fuel and vehicle policies. This recommendation would be in lieu of an economy-wide explicit price on GHG emissions, which is the preferred policy approach.

* At this time, NPC does not recommend including vehicle manufacturing emissions due to the current complexity of tracking these emissions across large supply chains but recognizes that other regulatory actions in the future may address these types of emissions and, if implemented, will need to be harmonized with standards such as those described in this recommendation.

Recommendation 4: Production-side incentives

Recommendation: As more fully described in Chapter 6: Policy, NPC recommends:

- To provide further certainty on the investment commitments that developers must take to come to a final investment decision for a LCI H_2 project, the IRS should consider implementing measures to reduce the risk that the "cliff effect" or even concerns over the "cliff effect", which arises due to the steep step changes in 45V between the different CI tiers, may negatively affect the bankability of a LCI H_2 project. To ensure that qualifying LCI H_2 projects are bankable while retaining the structure of 45V tiers, the IRS should consider implementing measures such as:

    - Allowing a reasonable uncertainty range for the 45V tiers, so that true border case projects can qualify for the lower CI tier and have greater financial viability as a result.

    - Allowing companies to have a 6-month period to appeal LCA findings, during which the company can take additional actions to reduce the CI of the project (e.g., purchasing additional renewable natural gas, etc.)

- Congress: Lengthen the 45V credit claiming period to 20 years to more closely match the incentive with the asset life cycle.

- DOE: Improve and fully utilize GREET capability to incentivize emissions intensity reductions by allowing taxpayers to substitute default values in GREET with verifiable values based on coproduct allocation accounting (of methane emissions between oil, gas, and other hydrocarbon products) and reliable measurement, reporting and verification methods (e.g., differentiated natural gas used, efficient electrolyzers).

Recommendation 5: Global trade

Recommendation: As more fully described in Chapter 6: Policy, NPC recommends the administration and Congress:

- Support the development by business and other stakeholders of transparent certification systems on the CI of hydrogen and hydrogen carriers (e.g., ammonia, methanol), and work to ensure their mutual recognition globally

- Support (with technical input and consultations) foreign mutual recognition of U.S. certification schemes (including use of accredited verifiers in different jurisdictions) with key trading partners

- Evaluate trade infrastructure needs and move forward key port, bunkering, transportation, storage, and other related infrastructure—including needed regulatory changes—to meet expected growth, particularly through major trade corridors

- Develop plurilateral agreements to promote trade in low-emissions products, including H_2 and its derivatives, and work to build support beyond the core group of countries that have developed this approach

- Urge the DOE, working with other appropriate U.S. agencies and international organizations, to develop and make public data on the CI of H_2 and H_2 carriers production in the U.S. and globally

- Develop and implement an emissions intensity border fee for H_2 and H_2 derivative products aligned with an explicit price on carbon or, in the absence of an explicit price on carbon, consistent with the effects of the implicit price on carbon

Recommendation 6: Infrastructure incentives

Recommendation: As more fully described in Chapter 6: Policy, NPC recommends Congress create an Investment for Clean Hydrogen Infrastructure Projects program to facilitate access to capital that stimulates LCI H_2 infrastructure. Funding should be made available to qualifying LCI H_2 infrastructure projects in the form of grants, loans and loan guarantees administered through the DOE Loan Programs Office and/or the introduction of an investment tax credit.

Finding 10: Administrative and legal complexity across multiple jurisdictions in the current permitting process could delay development and deployment of necessary facilities and infrastructure.

Recommendation 7: General permitting reform

Recommendation: As more fully described in Chapter 6: Policy, NPC recommends that the administration and/or congress:

- Improve communications related to, and the implementation of, state and/or federal eminent domain; eminent domain should only be used as an option of last resort along with effective community engagement

- Establish an integrated federal, state, and local permitting portal (whole-of-government permitting portal, e.g., expanding on the existing Federal Permitting Improvement Steering Council [FPISC] permitting portal) to avoid duplication and provide efficient coordination and sharing of data amongst permitting authorities and projects

- Expand use of Programmatic Environmental Impact Statements to help accelerate the permitting process for low carbon energy projects and expand permitting agency capacity by adopting the FPISC and ensuring adequate staffing resources

- Consolidate litigation, specifically apply the same two-year or other shorter statute of limitations for filing lawsuits against federal agency actions for all low carbon energy projects and develop a timeline for agencies to act on judicial remands

- Provide adequate funding for appropriate agencies to ensure they have resources and staffing to administer permitting programs

- Expand responsible use of administrative categorical exclusions: Congress should require Federal agencies to examine existing categorical exclusions and consider proposing additional categorical exclusions for LCI H_2/clean energy projects where appropriate

Finding 11: Reaching the Expansion and At-Scale phases of LCI hydrogen deployment will require construction of interstate hydrogen pipelines to cost-effectively move LCI hydrogen from supply to demand centers and will require timely permitting and approvals.

Recommendation 8: Unblended interstate hydrogen pipeline regulatory authority

Recommendation: As more fully described in Chapter 6: Policy, the NPC recommends that Congress deem H_2 infrastructure to be in the public interest and, except as described in bullet "g.", authorize the Federal Energy Regulatory Commission (FERC) to regulate unblended as well as blended (an existing authority) interstate H_2 pipelines, addressing the following key criteria for LCI H_2:

a. Promote regulatory certainty by establishing an unblended federal LCI H_2 interstate pipeline framework in the Activation phase that could then be implemented in the Expansion phase in order to encourage investor certainty

b. Provide a federal framework for eminent domain in conjunction with appropriate stakeholder/community engagement

c. Ensure permits are approved in a timely manner to accelerate industry growth

d. Continue to ensure applicable permit requirements (e.g., National Environmental Policy Act) are met.

e. Develop an unblended LCI H_2 purity definition – clarify the point at which blends of hydrogen and natural gas are classified as "hydrogen" or "natural gas" for regulatory purposes

f. Promote open access and transparency, while ensuring that regulation does not inhibit growth of the nascent LCI H_2 market. Focus FERC jurisdiction to regulation of LCI H_2 transportation rates and service terms for energy. Recognize that H_2 is used as both an energy carrier and as a feedstock for other commodities.

g. Honor the current business model of allowing H_2 systems (not under FERC regulation) that do not seek federal eminent domain rights to remain exempt from any FERC regulation

In addition, Congress and the administration should monitor the development of these changes to encourage a regulatory framework that supports development of a robust, competitive LCI H_2 market.

Recommendation 9: Class VI primacy and well permitting

Recommendation: As more fully described in Chapter 6: Policy, NPC recommends the administration and Congress improve the Class VI primacy and well permitting process as follows:

- Hold EPA accountable to its stated primacy timelines currently in 40 C.F.R. § 145.22 by establishing the following requirements:
    - If EPA has not made a decision on a Class VI primacy application within 90 days of receipt of complete submission, the Administrator should be required by Congress to submit a report to the governor of the state seeking primacy, the state agency seeking primacy, the Chair of the White House Council on Environmental Quality (CEQ Chair), and the appropriate congressional committees explaining why the decision has exceeded 90 days and when the decision should be expected.
    - If EPA has not decided within 365 days of the application being complete, the appropriate congressional committees should consider holding an oversight hearing in which the EPA Administrator and the CEQ Chair explain why a decision has not yet been made.
- Congress, in consultation with EPA, should determine and require minimum staffing levels for Class VI primacy reviews/approvals by statute and enable EPA to meet and maintain these staffing targets until such a time when state requests for primacy have ended.
- Congress should improve the permitting process for individual Class VI wells by determining, in consultation with EPA and state agencies, what is adequate funding to support the Class VI program for states and the EPA in a manner that enables permits to be issued within 18 months. After completing this analysis, Congress should ensure both states and the EPA receive adequate funding for permitting work. Additionally, the EPA shall explain how these funds were used in a report to Congress.

Finding 12: Inadequate community engagement practices have led to distrust of project developers and delays in projects.

Recommendation 10: Commitment to social considerations, transformative community engagement, and net positive outcomes

Recommendation: As more fully described in Chapter 7: SCI and Safety, NPC recommends DOE, decision-makers, corporations, researchers, governments, and regulatory bodies should actively commit to comprehensively consider and equitably address societal, environmental, and public health impacts related to the project during the activation phase of LCI hydrogen deployment.

Recommendation 11: Community engagement improvement opportunities

Recommendation: As more fully described in Chapter 6: Policy and Chapter 7: SCI and Safety, NPC recommends the U.S. government should charter national and/or regional public/private council(s) of excellence in effective industry-community engagement practices to develop and encourage the adoption of best practices that include equitable representations from industry, NGOs, and government.

- These councils should be forums where industry, NGOs, and government would keep community engagement best practices up to date by identifying and disseminating effective community engagement practices, leveraging existing best practice resources (e.g., Permitting Council FY22 Recommended Best Practices Report, API RP-1185, and IPIECA) that are cognizant of regional and local needs and considerations. The governance structures, participation processes, and transparency should be designed to promote engagement of industry, NGOs, local governments, and other interested parties, and enhance the credibility of a council's products.

- These councils should intentionally support less capitalized operators to implement these best practices inclusive of, but not limited to, experienced resources and training.

While acknowledging that many developers already implement community engagement, there is an opportunity to encourage broader adoption of documented best practices across the industry by providing additional motivation to implement robust community engagement. The NPC further recommends the administration and Congress develop government procedural or permitting timeline incentives for companies that consistently meet established best practices (when developed and documented) for community engagement. As part of the joint industry organization, propose a voluntary program to monitor adherence and adoption of recognized best practices that can be considered for eligibility for procedural or permitting timeline incentives.

Recommendation 12: Outreach materials to increase community understanding of LCI hydrogen development

Recommendation: As more fully described in Chapter 7: SCI and Safety, NPC recommends DOE should expand support for programs such as the Environmental Justice Technical Assistance Centers programs and/or should develop funding opportunities for community representatives and experts to support the outreach needed to increase community understanding of advanced energy technologies such as LCI H_2, carbon capture and sequestration (CCS), and direct air capture (DAC); industry and government must ensure a more informed level of community engagement.

Finding 13: Past experiences may have left communities feeling unheard by project developers, resulting in deficit of trust, transparency, tracking, and sharing of outcomes.

Recommendation 13: Role clarity for community benefits

Recommendation: As more fully described in Chapter 7: SCI and Safety, NPC recommends DOE should clarify the roles it and project developers each play in addressing community concerns as early and often as possible in project development (for developers) or throughout listening sessions and roadshows (for DOE).

Recommendation 14: Community benefits planning

Recommendation: As more fully described in Chapter 7: SCI and Safety, NPC recommends DOE should consider expansion of its Community Benefits Plans/Planning approach, which is currently utilized in scoring competitive grant applications, to reach beyond Justice40 covered programs to other funding streams.

Recommendation 15: Tracking and communicating commitments to community engagement to increase public confidence

Recommendation: As more fully described in Chapter 7: SCI and Safety NPC recommends that, as commitments are made to engage with communities associated with LCI H_2 project deployment in the Activation stage, DOE should make the techniques and results available to the public to better educate on effective engagement techniques and to incentivize their use.

Finding 14: Lack of timely workforce development and labor engagement can inhibit the pace of LCI hydrogen growth.

Recommendation 16: Workforce readiness

Recommendation: As more fully described in Chapter 7: SCI and Safety, NPC recommends DOE and Department of Labor should work to create a more broadly inclusive program for apprenticeships that considers input from various groups such as National

Association of Manufacturers, labor unions and trade organizations to enable workforce participation in the H_2 economy.

Recommendation 17: Additional study on societal considerations and impacts

Recommendation: As more fully described in Chapter 7: SCI and Safety, NPC recommends DOE should undertake a stand-alone, comprehensive Societal Considerations and Impacts study, related to energy development, including, but not limited to, LCI H_2 development and GHG emissions reduction value chains, as well as other facets of energy development. It is recommended that this study be conducted with the National Academy of Sciences, Engineering, and Medicine's Division of Behavioral and Social Sciences and Education and the Board on Energy and Environmental Systems, with coordinated input and concerted effort from the NPC and other stakeholders.

Finding 15: Lack of a prioritized investment roadmap for technology is a hindrance to further levelized cost of hydrogen reduction and reliable LCI hydrogen value chain.

Recommendation 18: Technology—reducing the cost gap

Recommendation: As more fully described in Chapter 6: Policy, NPC recommends DOE invest in Research, Development and Deployment (RD&D) in the following areas:

- Demand: Support national laboratory and university research to fast track the development of robust, low-cost materials to enhance the performance of the hydrogen end uses identified to have the highest potential by the MIT Model results (e.g., advanced fuel cells). RD&D should focus on reducing costs, increasing efficiency, improving safety performance, and addressing the environmental impact (e.g., nitrogen oxides emissions) of end use applications.

- Supply: Support materials research for electrolysis, including alternative catalysts and nanotechnology-based solutions to reduce costs, reduce reliance on critical minerals, improve performance, and enable scale. Technology improvements to methane-based production solutions, such as pyrolysis and carbon capture, should be an integral part of DOE's RD&D portfolio.

- Infrastructure: Support national laboratory and university research to understand the effect of hydrogen on natural gas pipeline infrastructure particularly vintage pipelines (embrittlement, corrosion) through the DOE-sponsored Hydrogen Materials Consortium. Perform RD&D on monitoring systems for improved accuracy and cost-reduction of these technologies. Support research to further enhance the properties of nonmetallic, composite pipe for hydrogen and carbon dioxide applications, while improving life cycle emissions.

- Storage: Support research for underground storage of hydrogen (e.g., in engineered caverns, depleted oil and natural gas fields, and deep saline formations). Support on-going national laboratory (Hydrogen Materials Advanced Research Consortium) and university research on hydrogen storage materials to enable cost reduction and increase compatibility with high volume or variable end uses.

Finding 16: Without long-term sourcing and supply of critical materials, a robust and resilient LCI hydrogen value chain may not materialize.

Recommendation 19: Supply chain

Recommendation: As more fully described in Chapter 6: Policy, NPC recommends:

- The government should form a multiagency taskforce to analyze vulnerable supply chains and recommend strategies that focus on ensuring security of supply of critical materials and manufacturing capacity for scaling up hydrogen production. These strategies could and should incorporate supporting U.S. domestic and allied supply and more diversified import options.

- Allow the market to play a role in addressing routine economic challenges and reserve the use of the Defense Production Act for critical and exceptional circumstances to avoid unnecessary intervention in market dynamics.

Finding 17: There is no commercially accessible technology for measuring and mitigating low-flow-rate hydrogen emissions that are relevant to possible climate impacts.

Recommendation 20: Technology—detecting, quantifying and mitigating environmental impact

Recommendation: As more fully described in Chapter 6: Policy, NPC recommends that, in order to better understand the impact of hydrogen emissions, as soon as possible, the DOE should direct the national labs, in conjunction with other public and private researchers, to undertake additional research and development to develop and improve leak detection, prevention and abatement technologies, the accuracy of monitoring technologies, and to measure, quantify, and validate actual hydrogen emissions rates. The EPA can utilize insights to recommend hydrogen emissions reporting standards to develop guidance for monitoring and repair.

Finding 18: The industry requires clear safety standards and guidelines to allow for the safe use of existing or repurposed natural gas lines for the movement of unblended LCI hydrogen or

blends of LCI hydrogen and natural gas. Without clear standards, the deployment of LCI hydrogen could be slowed.

Recommendation 21: Pipeline safety codes and standards

Recommendation: As more fully described in Chapter 3: Infrastructure and Chapter 6: Policy, NPC recommends DOE and PHMSA convene interagency efforts to develop clear requirements for converting existing natural gas pipelines to transport LCI hydrogen or LCI hydrogen and natural gas blends and for converting other infrastructure to hydrogen service including, with industry input, integrity-based quality specifications for hydrogen transported in pipelines.

Finding 19: Integrating LCI hydrogen with the electrical grid and other energy systems can support the grid's transition to a low carbon intensity energy system.

Recommendation 22: Grid integration

Recommendation: As more fully described in Chapter 6: Policy, NPC recommends DOE and the Federal Energy Regulatory Commission (FERC), in consultation with the Independent System Operators/Regional Transmission Operators, commission an energy flow modeling study to assess grid energy system capabilities and resiliency. This study should specifically develop and implement a transmission and distribution grid planning roadmap to assess and support future national grid demands and integrate renewables, hydrogen, storage, natural gas, and the regional electric grid systems. This study should also address the potential benefits, costs, and impacts on accelerating U.S. decarbonization goals by broadly addressing:

- Expanding existing grid capacity
- Interconnection delays
- Long-distance transmission capabilities and transmission planning reform
- Microgrids
- Distributed Energy Resources
- Electrolyzer production and use demand
- Other growing power demands e.g., artificial intelligence, cryptocurrency, battery manufacturing, etc.

Recommendation 23: Grid resiliency

Recommendation: As more fully described in Chapter 6: Policy, NPC recommends:

- FERC, North America Electric Reliability Corporation and Regional Transmission Operators implement available and proven technologies and adopt clear policies to enhance existing grid capacity using Grid Enhancing Technologies, e.g., dynamic line ratings, advanced power flow control, and topology optimization

- FERC continue to expand and improve interconnection reform beyond FERC Order 2023, in order to expand transmission and distribution grid improvements and more rapidly integrate renewables, hydrogen, storage, natural gas, and the regional electric grid systems
- The administration, Congress, FERC, and states work to pass power transmission and distribution grid reforms to incentivize transmission efficiency and capacity development that incorporate new technologies that enhance grid capacity and resiliency e.g., Grid Enhancing Technologies