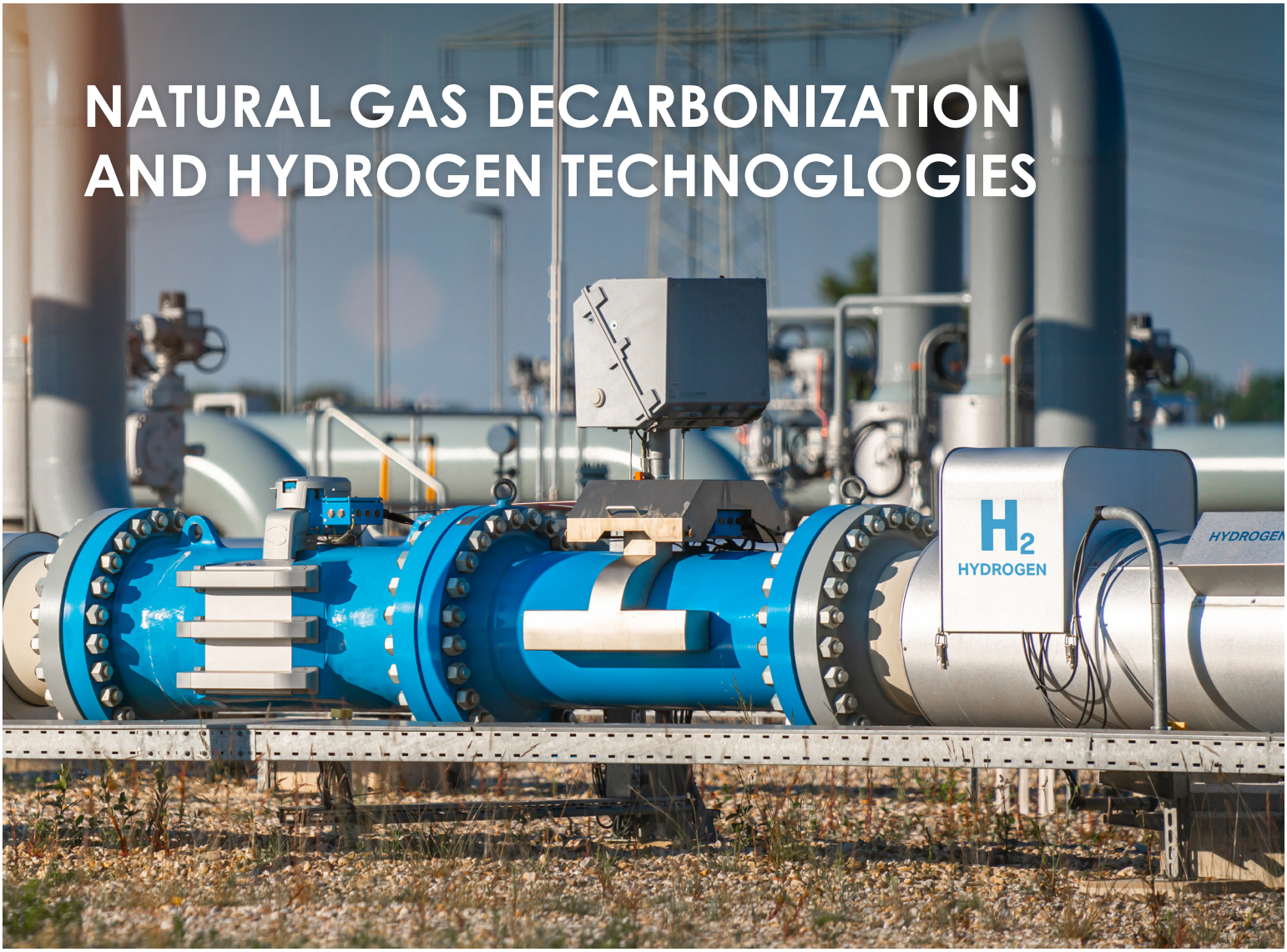
NATURAL GAS DECARBONIZATION AND HYDROGEN TECHNOGLOGIES



NETL

NATIONAL ENERGY TECHNOLOGY LABORATORY

The U.S. Department of Energy's (DOE) Office of Fossil Energy and Carbon Management's (FECM) Natural Gas Decarbonization and Hydrogen Technologies (NG-DHT) Program is pursuing Research, Development, Demonstration, and Deployment (RDD&D) of technologies that decarbonize the domestic natural gas supply chain in support of a clean hydrogen-enabled economy. Technology development and validation efforts under the NG-DHT Program will focus on clean hydrogen production using sustainably sourced fossil fuels and waste streams, the safe and effective transport of hydrogen using the existing natural gas pipeline infrastructure, and the characterization and demonstration of large-scale subsurface geological hydrogen storage infrastructure. The Program will also develop analytical tools and models that are able to evaluate potential advanced technology solutions, monitor technology performance metrics, perform technoeconomic and lifecycle analyses, and conduct resource evaluations.

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NETL implements this effort as part of DOE's Resource Sustainability Program.

Program 093, July 2024

NATURAL GAS DECARBONIZATION AND HYDROGEN TECHNOGLOGIES

Monolith Natural Gas Pyrolysis plant in Hallam, Nebraska

The U.S. DOE's Energy Earthshots Initiative seeks new breakthrough technologies that will enable more abundant, affordable, and reliable clean energy solutions over the next decade and support the Biden Administration's goal of net-zero carbon emissions by 2050. The NG-DHT Program is focused on technologies related to hydrogen, a clean energy carrier that can be used in a fuel cell or combusted for heat or electricity without releasing carbon emissions. Technology development and maturation under the NG-DHT Program will focus on developing advanced analytical tools and validating new technologies related to the production of hydrogen from fossil fuels as well as safe and reliable nationwide hydrogen transport and storage, all in a manner that leverages existing natural gas resources and infrastructure at a mitigated carbon intensity. The NG-DHT Program is advancing along several parallel paths across hydrogen production, transport, and storage:

- Support transformational concepts for clean hydrogen production from domestic natural gas resources with an emphasis on decarbonization opportunities and value tradeoffs within energy markets, and including the effective use of produced water, a significant waste stream for oil and gas wells.
- Develop new materials, catalysts, reactor designs, and alternate chemical pathways that advance the production of clean hydrogen, with the potential to reach the DOE's Hydrogen EarthShot cost target of $1/kg by 2030.
- Ensure the suitability of existing natural gas pipeline materials and associated infrastructure for hydrogen blend transportation while emphasizing hydrogen sensing materials and sensor platform development for leak detection and mitigation.
- Identify basin-specific underground storage infrastructure capable of handling high volumes of hydrogen, while seeking demonstration opportunities for other novel bulk storage mechanisms.
- Develop techno-economic models in support of Hydrogen Hubs to model the full hydrogen value chain, including clean production from fossil sources, the technical performance and cost of nationwide pipeline transport, and regional analyses for the scale up of subsurface storage of hydrogen.

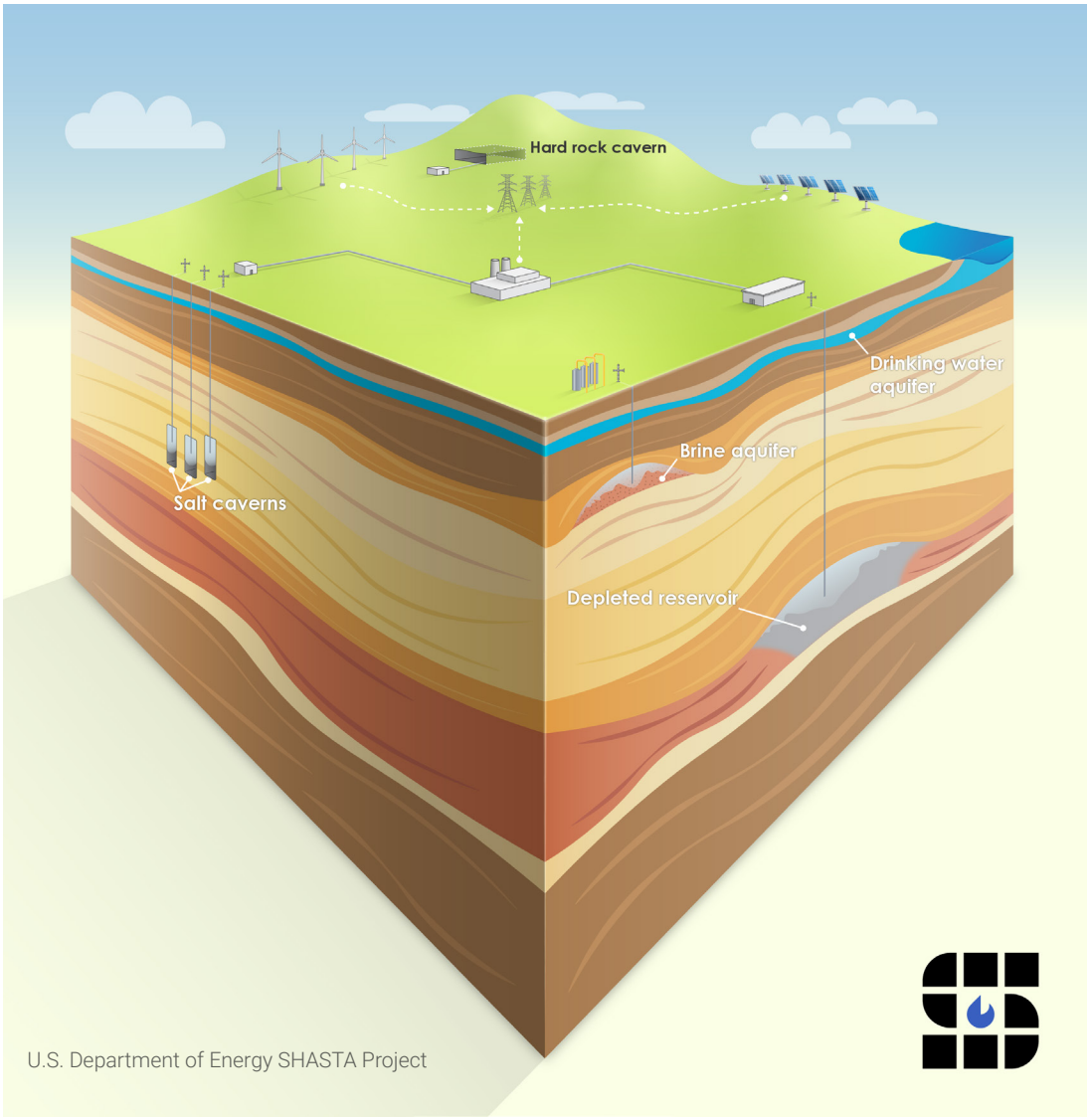
NETL'S RESEARCH WILL DECARBONIZE THE FOSSIL ENERGY SECTOR AND PROTECT THE ENVIRONMENT BY INVESTIGATING:

CLEAN HYDROGEN PRODUCTION AND INFRASTRUCTURE FOR NATURAL GAS DECARBONIZATION — To develop new processes, new catalysts, and novel equipment designs that support transformational decarbonized hydrogen production at volumes that are capable of significantly impacting nationwide decarbonization while sustainably utilizing the United States' natural gas resources.

HYDROGEN PRODUCTION FROM PRODUCED WATER — To develop and validate methods that enable the utilization of produced water waste streams resulting from the fracturing of oil and natural gas-bearing formations by producing hydrogen and leveraging any potential economic benefit of recovering dissolved mineral constituents.

TECHNOLOGIES FOR ENABLING SAFE AND EFFICIENT TRANSPORTATION OF CLEAN HYDROGEN WITHIN THE U.S. NATURAL GAS PIPELINE SYSTEM — To produce materials, sensors, and tools that enable the existing natural gas infrastructure to provide a safe and cost-effective near-term solution for nationwide hydrogen transport and establish optimal hydrogen production, blending, and separation points within the natural gas supply infrastructure.

FUNDAMENTAL RESEARCH TO ENABLE HIGH-VOLUME SUBSURFACE HYDROGEN STORAGE — To develop and demonstrate novel technologies and monitoring systems for effective high-volume long-term subsurface bulk hydrogen storage capable of supporting regional Hydrogen Hubs and the eventual deployment of a nationwide hydrogen supply.



TECHNOLOGY PARTNERSHIPS

The U.S. DOE's Hydrogen and Fuel Cells Technology Office (HFTO) launched the H2@Scale initiative in 2016 to fund projects and activities for national laboratories and industry to accelerate early-stage hydrogen technologies across the areas of hydrogen production, hydrogen surface infrastructure, grind integration, safety, codes, and standards. This funding has advanced several promising hydrogen production technologies building on natural gas technologies, which can be further advanced toward commercialization under the NG-DHT Program.

FECM and the U.S. Department of Transportation's Pipeline and Hazardous Materials Safety Administration (PHMSA) are collaborating to improve reliability and lower the cost of hydrogen transportation and to reduce both the cost and environmental footprint of hydrogen storage. To enable the introduction of hydrogen as an energy carrier, a key initial focus of FECM and PHMSA work is on technical, cost, and institutional challenges for using underground hydrogen storage and hydrogen delivery through local distribution natural gas pipelines.

FECM's collaborative SHASTA project, with twenty-four milestones spread between November 2023 and February 2025, includes seven tasks that are focused on industrial adoption of subsurface hydrogen storage including geologic suitability evaluations, regulatory considerations, monitoring recommendations, hydrogen delivery performance measurements, caprock leakage assessments, gas dynamics considerations within storage caverns, and functional requirements for a web-based analysis tool for existing underground assets.

The National Energy Technology Laboratory is a U.S. Department of Energy national laboratory that drives innovation and delivers technological solutions for an environmentally sustainable and prosperous energy future. Through its world-class scientists, engineers, and research facilities, NETL is ensuring affordable, abundant, and reliable energy that drives a robust economy and national security, while developing technologies to manage carbon across the full life cycle, enabling environmental sustainability for all Americans, advancing environmental justice, and revitalizing the economies of disadvantaged communities.

NETL lends its expertise toward achieving a carbon-free power sector by 2035 and a net-zero economy by 2050 while catalyzing economic revitalization, creating good-paying jobs, and supporting workers in energy communities, especially hard- hit coal, oil and gas, and power plant communities across the country. One of the most rewarding aspects of NETL's research is that our innovations and technologies have the potential to improve people's lives in meaningful ways.

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