MEMORANDUM OF UNDERSTANDING

BETWEEN THE

NATIONAL TECHNOLOGY & ENGINEERING SOLUTIONS OF SANDIA, LLC;

TRIAD NATIONAL SECURITY, LLC;

NEW MEXICO ECONOMIC DEVELOPMENT;

NEW MEXICO ENERGY, MINERALS AND NATURAL RESOURCES; and

NEW MEXICO ENVIRONMENT DEPARTMENT

I. PURPOSE/GOALS/OBJECTIVES

A. PURPOSE

The purpose of this Memorandum of Understanding (MOU) is to facilitate the development of sound science, advance technologies and inform national/state policies that could enable a path to zero carbon hydrogen.

The MOU is between the following entities (collectively referred to as "the Parties"): the National Technology & Engineering Solutions of Sandia, LLC (NTESS), Triad National Security, LLC (Triad), and the New Mexico Economic Development Department (EMNRD), the New Mexico Energy, Minerals, and Natural Resources Department (EMNRD), and the New Mexico Environment Department (NMED).

NTESS is a limited liability company formed under the laws of the State of Delaware that operates Sandia National Laboratories (SNL) pursuant to Contract No. DE-NA0003525 with the United States Department of Energy (DOE).

Triad is a limited liability company formed under the laws of the State of Delaware that operates Los Alamos National Laboratory (LANL) pursuant to Contract No. 89233218CNA000001 with the United States Department of Energy (DOE) National Nuclear Security Administration (NNSA).

B. GOALS

The Parties share common goals around energy development which include catalyzing the timely, material and efficient transformation of energy systems to achieve economic prosperity, reach net zero emissions by 2050 economy wide, and reduce greenhouse gas emissions in New Mexico at least 45% below 2005 levels by 2030, in accordance with Governor Michelle Lujan Grisham's Executive Order 2019-003.

C. OBJECTIVES

In pursuit of these shared goals and pursuant to this MOU, the Parties intend to focus on the science, technologies and policy impacts of hydrogen as it relates to areas of shared interest. Policy impacts include, but are not limited to, climate, economy, energy, environment, equity, research, water, workforce, etc.

II. BACKGROUND

The need for clean, domestically produced energy has never been greater. Climate experts agree that the energy challenges facing the world cannot be solved by any single approach. To this end, the State of New Mexico is developing a portfolio of clean energy solutions: solar, wind, geothermal, hydrogen, etc.

Hydrogen is already a global multi-billion-dollar industry and integral to decarbonizing transportation, manufacturing, the power sector and more. Around the world, governments and industry are partnering to produce, distribute, and use hydrogen to reduce greenhouse gas emissions. Within the United States, zero carbon hydrogen is a strategic pathway to carbon neutrality in context with a broader renewable portfolio of energy sources. While expanding wind and solar energy will continue to reduce emissions from businesses, homes and passenger vehicles, the appropriate use of hydrogen can reduce emissions from industrial sectors (*e.g.*, cement manufacturing, chemical manufacturing, global logistics, mining, petroleum refining) and the transportation industry (*e.g.*, aviation, tractor-trailer trucks, and trains). Emissions from these sectors often affect frontline and underserved communities. Using hydrogen to decarbonize these sources could reduce or eliminate emissions of harmful air pollutants that adversely affect human health *(i.e.*, particulate matter like soot, heavy metals like lead and cadmium, and organic carcinogens like benzene and formaldehyde).

Research on zero carbon hydrogen enabling technologies has been ongoing for decades. While questions remain, a sufficient technology base has been built to enable early projects on the two major aspects of the challenge: the production/utilization of hydrogen and the capture/use/storage of carbon dioxide when hydrogen is produced from fossil resources. Indeed, projects are emerging within western states and New Mexico. However, accelerating zero carbon hydrogen deployment could be facilitated by implementing an applied research effort that addresses remaining challenges through the use of a test bed model.

A test-bed model targets critical research barrier to deployment, building a direct tie between deployment needs and research efforts. In addition, a test-bed model could fill two other needs for accelerated deployment. First, by bringing together diverse businesses and research organizations in the region, test-bed projects will build the coalitions needed for launching new economies. Second, the test-bed projects can be used in building the workforce needed for these new economies, by creating opportunities between the test-beds, higher education institutions and organizations, including community colleges and research universities, and the private sector.

Several New Mexico research academic institutions are actively engaged in various aspects of hydrogen and carbon dioxide capture/utilization/storage. Test-bed projects could provide a platform for faculty and students to collaborate with other institutions on research topics related to New Mexico's energy transition—creating yet another pathway for workforce training. In addition, many of New Mexico's

regional and community colleges are engaged in workforce development in the energy sector and/or in other sectors needed for new energy ecosystems for hydrogen related.

A final component of a strategy to accelerate deployment of zero carbon hydrogen is to facilitate coordination of technology and policy between New Mexico and various similar federal objectives and initiatives. New Mexico's national labs can provide data and science to help inform policy choices by the State of New Mexico executive agencies party here to necessary to further zero carbon hydrogen technologies.

III. AREAS OF COOPERATION

The Parties intend to focus on the production, storage, distribution, and use of zero carbon hydrogen opportunities, including the following areas:

A. Production:

1. Zero-Carbon Hydrogen Generation from Methane and Biomass. This focus area involves the production of zero carbon hydrogen from a hydrocarbon-based feedstock; hence, it inherently requires CO_2 capture. Technology considerations include efficient conversion (including the use of distributed sources), CO_2 capture, life-cycle greenhouse gas emissions and waste, infrastructure needs. In addition to conventional conversion routes (*e.g.*, steam reforming—which is optimized on cost minimization tied to energy and no emissions considerations), new conversion pathways are needed that are optimized for future scenarios that require both cost/energy minimization (*e.g.*, via CO_2 capture), zero emissions, and potential for distributed small-scale production (as opposed to centralized production). Potential feedstocks could include natural gas, methane captured from agriculture or other fugitive sources, or methane derived from biomass (*e.g.*, algae, woody feedstocks, etc.).

2. Zero-Carbon Hydrogen Generation using Concentrating Solar Thermochemical Methods. This approach uses heat generated from concentrated sunlight to split hydrogen from steam through thermochemical processes. Advances in material systems are required to increase production yield.

3. Zero-Carbon Hydrogen Generation from Brackish and Saline Waters. This focus area involves the challenges of producing zero carbon hydrogen from non-fresh water with impure-water feedstocks. Treating brackish and saline waters may allow for zero carbon hydrogen production and could include renewable energy resources, like wind and solar, in the production process.

B. Storage and Distribution:

1. Large-Scale Hydrogen Storage. This area focuses on how large-scale storage of hydrogen plays a fundamental role in a future zero carbon hydrogen economy to ensure supply and demand are balanced and to minimize the delivery costs. Although the storage of gaseous hydrogen in various geologic formations, like salt caverns, is already used on a full industrial scale, additional storage methods are needed.

2. Hydrogen Distribution. This area focuses on the transport of zero carbon hydrogen from production or storage to its end-use applications. This includes analyzing pipelines, rail, vehicles, and other means to transport hydrogen to ensure supply and demand are balanced.

C. Utilization

1. Production of Carbon-neutral Alternatives to Petroleum-based Products. This focus area involves the production of sustainable, carbon neutral alternatives to synthetic fuels and other products/feedstocks/materials that are traditionally derived from petroleum. Routes could include (1) use of hydrogen and CO_2 (*i.e.*, from DAC), and (2) use of algae and other such biomass.

2. Direct Air Capture (DAC) of CO_2. This hydrogen-adjacent focus area involves improving the efficiency of capturing CO_2 from the atmosphere. Deployment at scale could provide adequate DAC CO_2 as a feedstock for combination with green hydrogen in the production of petroleum alternatives.

3. Fit for Purpose End Use Applications. This area is focused on establishing the best use of zero carbon hydrogen applications in New Mexico. Fit for purpose end use applications of zero carbon hydrogen will ensure appropriate speed and scale of the zero-carbon hydrogen economy while accelerating progress towards New Mexico's climate goals. Fit for purpose end use applications will help establish markets for zero carbon hydrogen and develop export markets for New Mexico produced zero carbon hydrogen within the U.S. and abroad.

D. Cross-cutting:

1. Safety, Codes and Standards. This area is focused on creating or revising the standards and protocols that will be needed for safe and reliable use of hydrogen in these new energy economies.

2. Monitoring. This focus area involves monitoring for two concerns: safety and greenhouse gas emissions. In the case of safety, concerns range from local point source leakage (e.g., at a distribution point) to distributed leakage (particularly in conjunction with co-transport of hydrogen and methane). Monitoring approaches might integrate one or more technologies like sensors, various platforms (including ground based, airborne, and satellite), and machine learning.

3. Lifecycle Analysis of Zero Carbon Hydrogen Emissions. This focus area involves standardizing approaches and validating methodologies to evaluate and quantify greenhouse gas emission profiles of hydrogen production. Tangential issues include legal ones surrounding pore space, ownership and control and the long-term ownership of and responsibility for permanently sequestered greenhouse gas emissions associated with zero carbon hydrogen production, distribution, end-use, and recycling.

IV. FORMS OF COOPERATION

A. Pursuant to this MOU, subject to any limitations placed upon the Parties by other applicable requirements outside of the MOU, the Parties anticipate the following:

1. the Parties will designate lead coordinators to facilitate the overall planning and implementation of the activities occurring pursuant to this MOU;
2. lead coordinators will schedule, convene, and facilitate quarterly meetings of the Parties to further their collaborative efforts under this MOU;
3. the Parties, through the formation of technical workgroups, will further the areas of focus discussed in this MOU as mutually agreed upon during their quarterly meetings;
4. lead coordinators will actively seek out strategic opportunities to build capacity and promote technology transfer within the public and private sectors;
5. lead coordinators will strengthen partnerships to build the zero-carbon hydrogen workforce within the public and private sectors; and
6. lead coordinators will periodically update interested stakeholders on outcomes and outputs related to this MOU.

V. AUTHORITIES

A. NTESS enters into this MOU under the terms and conditions of the prime contract for operation of SNL by NTESS.

B. Triad enters into this MOU under the terms and conditions of the prime contract for operation of LANL by Triad.

C. The EDD, EMNRD, and NMED enter into this MOU pursuant to the following laws:

1. NMSA 1978, Section 9-15-7(C) which provides EDD with the authority to enter into contracts with state, federal or private entities;

2. NMSA 1978, Section 9-5A-4, which provides EMNRD with the authorities to administer all laws assigned to its divisions and provide funds for physical projects utilizing clean energy technologies and clean energy education, technical assistance and training; Section 71-7-7(A), which provides the department the authority to collaborate with the New Mexico Economic Development Department in establishing public-private partnerships between the state and national laboratories to provide guidance and support for hydrogen initiatives; and NMSA 1978, Section 9-5A-4, which provides EMNRD with the authorities to administer all laws assigned to its divisions; and

3. NMSA 1978, Section 74-1-6(C), which provides NMED the authority to enter into agreements with environmental and consumer protection agencies of other states and the federal government pertaining to duties of the department.

VI. LIMITATIONS

A. Funding Prohibition.

This MOU does not, and shall not be used to, obligate or commit funds nor does this MOU provide the basis for the transfer of funds. This MOU does not commit any of the Parties to take any actions, and the actions of each Party are independent of the actions of the other Parties.

This MOU is intended to document the relationship between the Parties without creating legally enforceable obligations upon the Parties. All actions documented in this MOU are subject to available funding from DOE to NTESS for work at SNL and from DOE/NNSA to Triad for work at LANL, and no liability shall be imposed upon a Party for failure to undertake any activity documented. This MOU does not create a legally binding contract between the Parties.

Prospective projects or activities that involve the transfer of funds, services, property, and/or anything of value between the Parties require the execution of separate written instruments and are contingent upon numerous factors, including availability of appropriate funds and other resources, and administrative and legal requirements (including agency authorization by statute). Any commitments made pursuant to this MOU on behalf of EDD, EMNRD or NMED are also subject to available appropriations, and no liability shall be imposed upon a Party for failure to undertake any activity documented.

B. No Private Right of Action.

This MOU does not create any right or benefit, substantive or procedural, enforceable by law or equity, by persons who are not party to this MOU, against the Parties, their officers or employees, or any other person. This MOU does not direct or apply to any person outside of the Parties.

C. Conditions for SNL Participation.

1. It is understood that any work done by, or actions taken at, SNL must be in accordance with the terms and conditions of the prime contract between NTESS and the DOE for the operation of SNL; and must be in accordance with any successor contracts for the operation of SNL. In the case of any conflict between this MOU and the prime contract for the operation of SNL, the prime contract shall take precedence.

2. It is further understood that NTESS is required by the DOE to include certain terms and conditions in all implementing agreements it enters with third parties. To the extent applicable to this MOU, such terms and conditions shall be included in such implementing agreements.

D. Conditions for LANL Participation.

1. It is understood that any work done by, or actions taken at, LANL must be in accordance with the terms and conditions of the prime contract between Triad and the DOE/NNSA for the operation of LANL; and must be in accordance with any successor contracts for the operation of

LANL. In the case of any conflict between this MOU and the prime contract for the operation of LANL, the prime contract shall take precedence.

2. It is further understood that Triad is required by the DOE/NNSA to include certain terms and conditions in all implementing agreements it enters with third parties. To the extent applicable to this MOU, such terms and conditions shall be included in such implementing agreements.

E. The Parties may make factual statements to the public which describe the MOU. However, nothing in this MOU allows the Parties to endorse the purchase or sale of specific products or services. The Parties agree not to make statements to the public in news releases, product brochures, on web sites or in any media that imply endorsement of any specific commercial products or services.

VII. PROPRIETARY INFORMATION and IMPLEMENTING AGREEMENTS

To carry out the collaboration from this MOU, the Parties may need to disclose proprietary information to each other. To the extent allowed by law, separate non-disclosure agreement will be executed if proprietary information will be shared amongst the Parties.

The details of the levels of support that may be furnished to one Party by another with respect to funding will be developed in specific implementing agreements subject to availability of funds or appropriations as applicable. Agreements or project plans that set forth specific arrangements for program implementation will be separately developed and agreed to by the Parties in implementing agreements facilitated by this MOU. Appropriate patent and other intellectual property provisions will be included as appropriate in implementing agreements entered into by the Parties.

The DOE patent and intellectual property policies shall apply to any work performed by a contractor (including any subcontractors) that is funded in whole or in part by DOE under an implementing agreement. The Parties acknowledge that no claims for consequential damages, incidental damages, claims for lost profits, or other indirect damages arising out of, or resulting from, the work conducted under implementing agreements facilitated by this MOU shall be allowed.

VIII. INTELLECTUAL PROPERTY

The NTESS, Triad, EDD, EMNRD, and NMED shall retain exclusive right, title, and interest to their individual underlying technologies. None of the Parties warrants that any information or technology disclosed to the other Parties shall be merchantable or fit for a particular purpose or free of claims of infringement from other third parties.

IX. POINTS OF CONTACT

The following individuals are designated lead coordinators for the purposes of Section IV of this MOU:

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X. MODIFICATION/DURATION/TERMINATION

The effective date of this MOU is the date of the last signature affixed to it. This MOU may only be amended by the mutual written consent of the Parties. The Parties will review this MOU every five (5) years to determine whether it should be revised, renewed, or terminated. Any individual Party may withdraw from this MOU at any such time by notifying the other Parties in writing 90 days in advance of the withdrawal date. In that instance, the MOU will remain in effect as to the remaining parties, which may continue collaborating under this MOU.

XI. APPROVAL

By signature below, each Party certifies that the individuals listed in this document as representative of the individual Parties are authorized to act in their respective areas for matters related to this MOU. In witness whereof, the Parties hereto have executed this MOU as of the last date written below.

DocuSigned by:
Andrew McIlroy
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Signature and Date 1/12/2022

Dr. Andrew McIlroy
Associate Laboratories Director
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