The Wyoming Energy Diversification and Geo-asset Digitalization Initiative

A strategic partnership among the Sate of Wyoming,

Thermo Fisher Scientific, and the University of Wyoming

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I. EXECUTIVE SUMMARY

The University of Wyoming's Center of Innovation for Flow Through Porous Media (COIFPM) and Thermo Fisher Scientific (TFS) alliance presents this proposal to foster pioneering research and technological advancements in the geo-energy and environment sectors, driving sustainable innovation in Wyoming.

TFS and COIFPM will tightly integrate their cutting-edge, proprietary technologies and know-hows to conceive sets of new capabilities and expand capacities. These will play a pivotal role in developing innovative solutions to real-world problems important to the future of Wyoming. The initiative will benefit from the exceptionally successful blueprint of the two entities' Phase-I partnership. *Phase-II is designed to substantially broaden Wyoming's capabilities and capacities to meet the increasingly complex challenges of fossil energy production and the needs of energy transition while creating solutions for the water-energy nexus.* Accordingly, the project is organized into five focus areas: oil and gas production optimization; digitalization of the state's geo-assets; hydrogen storage; carbon sequestration; and water resource management. Through multi-scale experimental and computational research in flow through porous media, the project will deliver groundbreaking technologies for maximizing value in development of Wyoming's geo-assets. The alliance will establish *an entirely new division* under UW's COIFPM to launch the new capabilities and form an innovative ecosystem that will entice convergence research. It will promote multidisciplinary and transdisciplinary collaborations to develop effective solutions for complex problems and conceive, foster, and deploy innovative technologies needed to accomplish each focus area objectives.

This proposal seeks a total of $75 million in funding, with dollar-for-dollar matching from TFS. As indicated in an attached document, TFS has **formally committed** their $75 million contribution.

II. AREAS OF FOCUS

A. Oil and Gas Production Optimization

i. **Problem Statement:** Oil and gas operations are critical to the economic engine of Wyoming. The industry creates skilled jobs and generates tax revenues. The State's conventional hydrocarbon assets, however, are partly in the mature stages of their tenure with declining productions, while its unconventional resources show low primary recoveries. Both, therefore, provide a strong value case for the development and deployment of new recovery improvement technologies.

ii. **Desired Outcomes:** Improving recovery requires developing a deeper understanding of the physics governing the simultaneous flow of multiple fluid phases (oil, gas, and water) through complex pore and fracture spaces formed in the subsurface rocks at multiple spatial and temporal scales. Utilizing TFS' and COIFPM's technologies and know-hows, researchers can probe reservoir rock characteristics, rock-fluid interactions, and flow dynamics at macro, micro, nano, and atomic scales to devise effective hydrocarbon production enhancement techniques tailored for Wyoming assets. The proposed partnership creates the new capabilities and the capacities needed to de-risk the recovery enhancement technologies and support Wyoming in its future field-scale initiatives. An example is the current Wyoming Gas Injection Initiative (WGII). WGII is led by COIFPM and establishes a unique public-private partnership (with a nearly $50 million investment) to

enable field pilot testing of innovative oil recovery improvement technologies in Wyoming's oil fields (see https://www.uwyo.edu/research/coifpm/index.html).

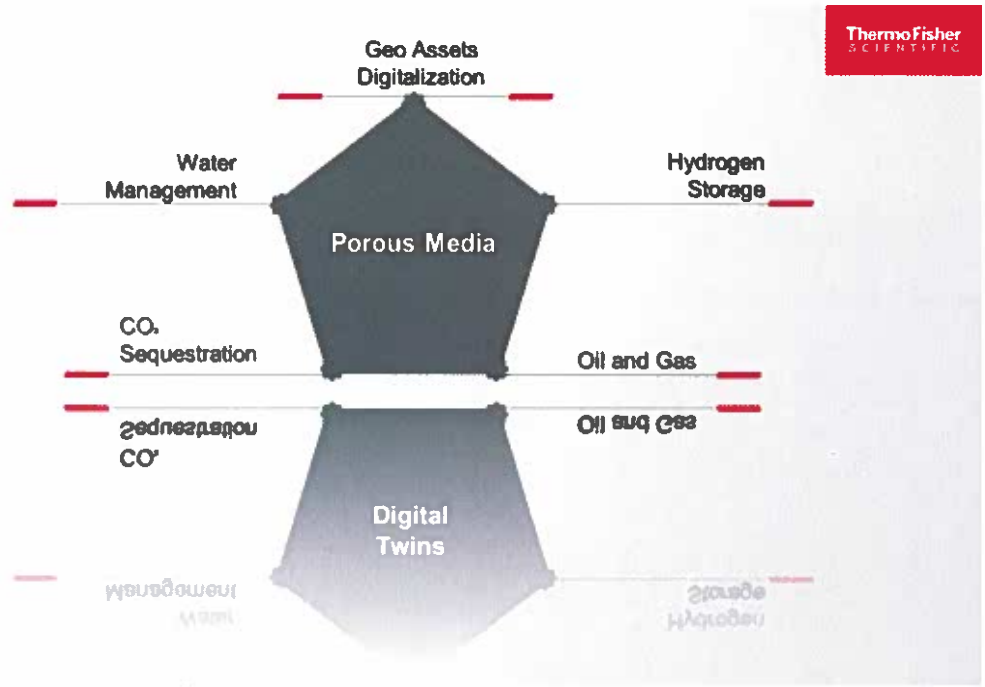

Figure 1. Digital Twins of Wyoming's subsurface assets to facilitate their optimal exploitation and management ultimately shaping a more sustainable energy and environment future for Wyoming.

B. Digitalization of the State's Geo-assets (Digital Twins)

i. **Problem Statement:** An integral objective of our initiative, and common, connecting element among all areas of focus, is the digitalization of the state's geological assets, aiming at providing the critical data needed (when employing computational technologies such as Artificial Intelligence [AI]) to effectively optimize the utilization of its pore spaces for different applications.

ii. **Desired Outcomes:** Leveraging the profound expertise and unparalleled hardware and software capabilities of TFS in advanced multi-scale imaging, image processing, data analytics and management, together with COIFPM's unique experimental and computational capabilities, we aim to revolutionize the way in which geosystems and their pore spaces are evaluated and utilized. A cornerstone of this goal is capitalizing on the power of Digital Rock Technology (DRT) and AI to construct fast and reliable digital solutions to challenging flow problems in geomaterials. With the aid of DRT and AI, we will effectively analyze the expansive datasets generated, enabling us to predict and optimize fluid recovery and geo-storage in digital replicates. The outcomes will directly accelerate the advances in the other four focus areas (see **Figure 1**).

C. Hydrogen Storage

i. **Problem Statement:** Hydrogen is a clean energy alternative that emits only water during combustion and can be produced using major energy resources such as natural gas, nuclear power, solar, and wind. The endeavors for technical and infrastructural development to exploit the full potential of this resource are still in the initial stages and are partly constrained by limitations in fundamental understanding of storage. There are critical challenges associated with: large-scale hydrogen storage in geological systems, effective use of nanoporous materials in hydrogen batteries, cost-effective and safe transportation, and the onboard capacity and pressure of hydrogen tanks, which must be addressed. While Wyoming benefits from ongoing initiatives (e.g., Wyoming's Hydrogen Roadmap, Pronghorn H_2 project, etc.), there is less focus on the storage aspect of this resource.

ii. **Desired Outcomes:** This partnership will produce transformative advances toward tackling such issues. COIFPM possess the know-how and unique Intellectual Properties (IPs) in testing nanoporous materials that can be integrated with TFS' material research technologies to optimize the dynamics of hydrogen storage in natural and synthetic porous materials. This will lead to the development of game-changing hydrogen batteries that would store the fluid at lower pressures, allowing safer and substantially more effective hydrogen energy deployment.

D. Carbon Sequestration

i. **Problem Statement:** Among various methods of carbon capture and storage (CCS), geological sequestration is among the most economically viable options. One of the key parameters that inform sanctioning of CO_2 sequestration projects is the amount of the fluid that can be safely stored in the subsurface (e.g., saline aquifers, depleted hydrocarbon reservoirs, etc.) and its fate over different time periods.

ii. **Desired Outcomes:** COIFPM and TFS will develop technologies for selecting, characterizing, and monitoring sequestration sites. This includes elements such as (i) characterization of CO_2 capacity in site-specific rocks, (ii) testing of new technologies such as CO_2-based foams to enhance conformance control, and thereby increasing storage capacity, as well as preventing potential leakage from fractured formations, and (iii) development of real-time monitoring instruments, gas analyzers, and remote sensing technologies to ensure safe and effective storage. The establishment of experimental and computational platforms in this domain will directly support Wyoming in de-risking its future carbon sequestration projects.

E. Water Resource Management

i. **Problem Statement:** Our technologically advanced partnership is uniquely positioned to explore innovative methods to support the sustainable exploitation of the State's water resources. This involves researching and developing technologies relevant to, for instance,

groundwater remediation and treatment as well as management of brine produced by oil and gas operations and CCS initiatives. Progress in these domains requires an in-depth understanding of pore-scale physics governing the co-existence of water and other phases (air, hydrocarbon gas, CO_2, nonaqueous phase liquids, contaminants, etc.) in the pore space of soils and various geological formations.

ii. **Desired Outcomes:** We will integrate COIFPM's advanced experimental and computational techniques in interrogating porous systems with TFS' advanced material science expertise to carefully examine geomaterials hosting the brines to develop a significantly improved fundamental understanding of the mechanisms governing brine transport in the pore space. This will then lend itself to developing effective solutions for the problem at hand as briefly outlined under the Problem Statement section.

III. EXAMPLES OF METRICS FOR SUCCESS

A. Establishment of a new COIFPM division which will launch new capabilities and expanded capacities and form an innovative ecosystem for transdisciplinary collaborations.
B. Development and testing of new technologies and know-hows for multi-scale characterization of porous martials (e.g., reservoir rocks, hydrogen batteries, etc.) and fluids.
C. Creation of no fewer than 10 corporate partnerships to initiate access to new technologies and promote deployment for real-world applications with emphasis on Wyoming job creation.
D. Harvesting, protecting, and making available at least 30 new IPs for licensing, commercialization, and royalty generation.
E. Introduction of the initial versions of cost-effective hydrogen storage batteries.
F. Development of DRT models for key facies of 5-10 Wyoming geological formations. Completion of a massive, first-in-the-world database with comprehensive digital representations of Wyoming geo-assets.
G. Training at least 50 highly skilled graduates prepared to contribute to the geo-energy production industries.
H. New technologies and/or processes for conformance control and more effective CO_2 storage in different geo-systems.

IV. PROBABILITY OF SECURING NON-EMF FUNDS

The WEA energy matching funds are the best fit for this initiative, as each focus area of the project connects directly to a compelling interest for Wyoming. Substantial funding from other sources at this time is not available, to the best of our knowledge.

V. OTHER PROJECT PARTNERS

This initiative will create synergies across UW through significant collaboration with the School of Computing, the Colleges of Engineering and Business, and others. Cross-disciplinary engagement will include graduate student researcher funding as well as funding across departments for research-active faculty and post-doctoral scientists.