U.S. Department of Energy (DOE)
Hydrogen and Fuel Cell Technologies Office (HFTO)
2025 ARIES H2@Scale Cooperative Research and Development Agreement (CRADA) Call supporting Advanced Research on Integrated Energy Systems (ARIES)

Timeline

- **October 9, 2024:** 12 Noon ET H2IQ Webinar announcing the partnership opportunity
- **November 1, 2024:** Deadline for Letters of Interest submission 5 p.m. MT
- **November–December 2024**: NREL POC review of submissions, evaluation, partner collaboration to develop scope, statement of work (SOW), timeline, deliverables, budget
- **January–March 2025**: Review panel assessment of full proposals, ranking, down select, announcement of awards and CRADA documentation execution

Contact/Questions: Letters of Interest and questions related to the Call should be directed by email to ARIES@nrel.gov. All questions and their respective answers will be posted here: https://www.nrel.gov/hydrogen/h2-at-scale-crada-call.html. To ensure fairness for all applicants, please do not contact individual HFTO or NREL staff member directly. Additionally, please do not include proprietary information in the Letter of Interest or questions.

Proposal Submission: A two-part proposal submission and evaluation process will be used. Applicants must first submit a brief (2 page maximum) Letter of Interest (template provided) by email attachment to NREL at ARIES@nrel.gov. The submission deadline is **5 p.m. MT, November 1, 2024**. A confirmation email will be sent within 2 days.

NREL research leads will review the letters based on specific criteria and will prioritize potential research proposals. Letters will be evaluated based on the following criteria:

- The extent to which the letter addresses the challenges of the specific topic.
- Importance of the described effort to inform industry.
- Alignment of project goals with HFTO and H2@Scale technical objectives.

A set of interested partners will be contacted and encouraged to further develop their proposals with the support and guidance of the NREL lead to best leverage NREL expertise and capabilities as well as H2@Scale priorities and ARIES research goals. Partners will be encouraged to collaborate with their

responsible NREL leads to develop the SOW, actionable research activities, timeline, budget, and deliverables.

Fully developed proposals will be reviewed by the NREL ARIES and Hydrogen Fuel Cell Leadership team evaluation panel based on specific criteria. The review panel will assess fully defined proposal packages and evaluate and rank them based on evaluation criteria. A final review and down select will be made to arrive at the final list of selected projects.

Notification of Selection: Once selections are finalized and announced, successful parties will receive an email from NREL detailing immediate next steps regarding the execution of a cooperative research and development agreement (CRADA) and additional required documentation. The CRADA template is posted for review.

Modifications Summary

Date	Modification
Mod. 1 10/17/2024	Page 8: Updated the "Letters of Interest Preparation" section to clarify the number of submissions per partner.

H2@Scale and ARIES Background and Overview

Building a clean and equitable energy economy and addressing the climate crisis is a top priority of the Biden Administration. This CRADA call will advance the Biden Administration's goals to achieve carbon pollution-free electricity by 2035 and to "deliver an equitable, clean energy future, and put the United States on a path to achieve net-zero emissions, economy-wide, by no later than 2050" to the benefit of all Americans. DOE is committed to pushing the frontiers of science and engineering, catalyzing clean energy jobs through research, development, demonstration, and deployment (RDD&D), and ensuring environmental justice and inclusion of underserved communities.

The activities to be funded under this CRADA call will support the government-wide approach to the climate crisis by driving the innovation that can lead to the deployment of clean energy technologies, which are critical for climate protection. Specifically, this CRADA call will support the H2@Scale initiative, illustrated in Figure 1, by enabling wide-scale hydrogen production, storage, transport, and utilization across multiple applications and sectors in the United States. In addition, this CRADA call will emphasize increasing diversity of research staff, increasing diversity of voices in research design, and/or increasing quantification and emphasis on supporting underserved communities.

The intent of H2@Scale is for hydrogen to enable—rather than compete with—energy pathways across applications and sectors. The H2@Scale effort supports collaborations between various industry stakeholders and national laboratories to accelerate research, development, and demonstration of applicable hydrogen technologies. For more information, visit the DOE and H2@Scale websites at:

- https://www.energy.gov/eere/fuelcells/hydrogen-and-fuel-cell-technologies-office
- https://www.energy.gov/eere/fuelcells/h2scale.

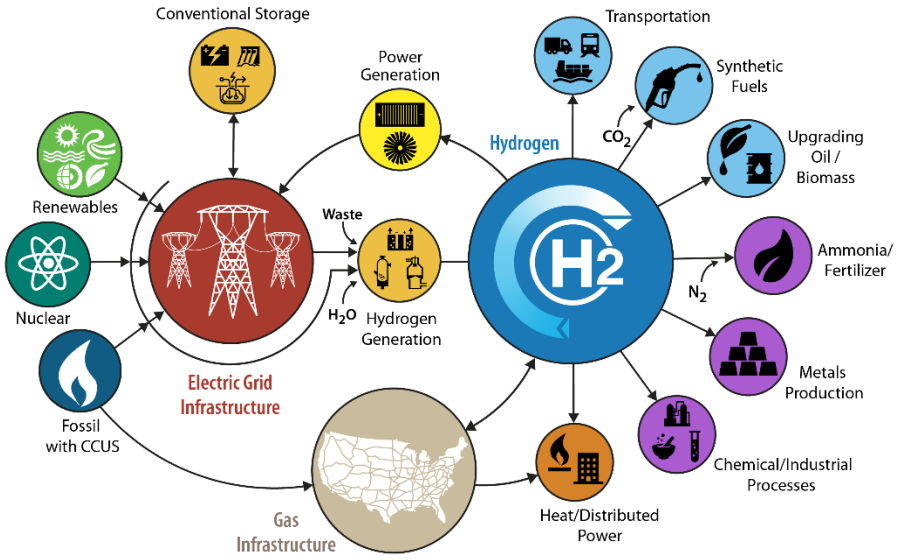

Figure 1. The H2@Scale vision: hydrogen can be produced from diverse domestic resources and is a central input to many important end uses in the industrial, chemical, and transportation sectors

The U.S. power grid is transitioning away from large, centralized power plants and is increasingly reliant on variable generation and distributed energy resources such as renewable energy sources like wind and solar. To realize future energy systems that are clean, secure, reliable, safe, and affordable, it is critical to address the challenges of how to scale up the physical size of these new energy technologies. Determining how to integrate multiple diverse technologies into the bulk power systems by seamlessly incorporating storage, load management, and dynamic controls is also vital and hydrogen can be a key part of the solution.

ARIES is a research platform that can match the complexity of the modern energy system and conduct integrated research to support the development of groundbreaking new energy technologies. ARIES is designed to de-risk and optimize current energy systems, and provide insight into the design and operation of future energy systems by addressing the fundamental challenges of:

- Variability in the physical size of new energy technologies being added to energy system.
- Controlling large numbers (millions to tens of millions) of interconnected devices.
- Integrating multiple diverse technologies that have not previously worked together.

The ARIES platform is intended to be highly flexible to study the impact of, and how to get the most value from, the millions of new grid-connected devices, such as electric vehicles, renewable generation, hydrogen systems, energy storage, and grid-interactive efficient buildings. ARIES addresses the risks and opportunities of widescale integration across six research areas:

1. **Energy storage** to balance variable renewable generation and demand.
2. **Power electronics** to control and integrate rapidly increasing electronics-based technologies.
3. **Hybrid energy systems** to achieve enhanced coordinated capabilities beyond isolated technologies.

4. **Future energy Infrastructure** to adapt existing energy infrastructure for safety, monitoring, and controls.
5. **Cybersecurity** to secure operations to prevent disruption, damage, and loss of functionality.
6. **Industrial decarbonization** to identify pathways for the decarbonization of transportation and manufacturing industries.

ARIES brings together state-of-the-art research assets and capabilities at NREL's Energy Systems Integration Facility (ESIF) and Flatirons Campus to support integrated energy research, analysis, modeling, and hardware experiments. Unique research capabilities at multiple scales and across sectors create a platform for understanding the full impact of energy systems integration and represent a substantial scale-up in experimentation capability from existing research platforms.

Key hydrogen capabilities and research assets currently available at NREL include:

Electrolyzer and fuel cell generator systems

- Can be directly AC-coupled with any permutation of wind turbines, solar PV, lithium battery, load bank, controllable grid interface, utility grid, or Virtual Emulation Environment (digital real time simulation and cyber range)
- Hybrid grid controller controls all power assets on campus including closed loop power point control of the electrolyzer and fuel cell generator and can be customized per project
- 1.25 MW PEM electrolyzer and 1 MW PEM fuel cell generator
- Electrolyzer power gain (up) rate of ~6%/sec and slew (down) rate of ~15%/sec
- Fuel cell can grid follow as well as black start/grid form (near instantaneous 100% power response)
- Fuel cell turns down to 0%, electrolyzer turns down to 20% (including balance of plants)
- 1 Hz standard data acquisition and control rate with 50 kHz data acquisition possible for AC grid

600 kg of hydrogen storage available (including compression)

- Enables nearly 27 hours of full power electrolyzer operation or 10 hours of fuel cell generator operation
- Hydrogen storage system maximum operating pressure of 3,000 psig
- Hydrogen purity of 99.9995% (meets or exceeds SAE 2719 specifications)
- 500 kg of additional metal hydride storage soon to be online (currently undergoing commissioning)

Additional information on NREL's existing infrastructure is provided in the July 25, 2024, H2IQ Hour presentation at https://www.energy.gov/eere/fuelcells/2024-h2iq-hour-webinar-archives#07252024, at https://www.nrel.gov/hydrogen/, and at https://www.nrel.gov/aries/.

2025 ARIES H2@Scale CRADA Call Supporting Advanced Research on Integrated Energy Systems (ARIES)

Overview

The U.S. Department of Energy (DOE) seeks qualified partners to participate in collaborative projects in one of the topics areas described below. Each selected collaborative project will be conducted under a cooperative research and development agreement (CRADA) between the National Renewable Energy Laboratory (NREL) and qualified partners.

Objective

Realizing future energy systems that are clean, secure, reliable, safe, and affordable, requires addressing critical technical challenges of how to scale up the physical size of these new energy technologies while maintaining performance, and how to integrate them within the evolving energy system. NREL, in partnership with the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy, developed a visionary research platform called Advanced Research on Integrated Energy Systems (ARIES) to accelerate solutions for this energy future.

NREL ARIES hydrogen research capabilities include renewable hydrogen generation and energy systems integration, through electrolysis, compression, storage, fuel cells, and modeling. This announcement invites new CRADA partnerships that will utilize ARIES capabilities for innovative research on H2@Scale integration with electrolysis, hydrogen for industrial end uses, and translational proton exchange membrane (PEM) and alkaline electrolysis stacks.

Through this DOE-funded CRADA call, supported by NREL, DOE's Hydrogen and Fuel Cell Technologies Office (HFTO) seeks proposals to support the ARIES H2@Scale vision and NREL's ARIES research goals. Joint partnerships between NREL and qualified partners selected under the three topic areas below will enable the integration of hydrogen technologies in future energy systems.

Topic Area 1: Validating Hydrogen System Integration with Renewables and the Grid

Under this topic, DOE seeks proposals to advance integrated hydrogen systems utilizing current ARIES hydrogen research capabilities to derisk technology and system deployments through validation and testing, with an emphasis on generating impactful experimental and modeling results that reveal how electrolyzers and fuel cells interact with a grid that includes electricity from intermittent sources

NREL's ARIES capabilities will be used to evaluate the integration of hydrogen energy systems with renewables and the grid. Areas of particular interest include, but are not limited to:

- Systems integration/hybridization (including electrolyzer testing/integration)
- Renewable hydrogen production (e.g., wind to hydrogen)
- Grid services (including peak and resource adequacy services)
- Energy storage
- Control systems (e.g., economic dispatch models for hydrogen resources)
- Power electronics
- Innovative and expanded hydrogen end-use applications.

Estimated number of projects: 1–3 projects

Period of performance (POP): 12–36 months

Estimated DOE funding available (to cover NREL staff, services, and facilities): $500K–$3M total

Cost share: Federal funding to NREL must be cost shared by the partners at a minimum of 30% in kind and/or cash. All federal funds will be costed by NREL.

Topic Area 2: Analyzing/Modeling/Validating Hydrogen Systems for Industrial Applications

Using the GreenHEART modeling tools and analysis expertise, NREL will work with industry partners to site and optimize location-specific integrated energy systems. These integrated energy systems will be closely coupled from electricity generation through end use for clean hydrogen production using renewable electricity (behind the meter or grid connected), to supply industrial end uses like green steel or green ammonia.

Deliverables will include analysis and reporting to DOE and industry partners on siting specific parameters (e.g., water availability, land restrictions, wind resource, solar resource, and underground hydrogen storage options); reference designs and use cases with site-specific optimized mixes of equipment, renewable energy mix, battery storage, and electrolyzer capacity; as well as site-specific levelized cost of hydrogen, levelized cost of green steel, or levelized cost of green ammonia.

Estimated number of projects: 1–3

Period of performance: 12–24 months

Estimated DOE funding available (to cover NREL staff, services, and facilities)**:** $100K–$500K total

Cost share: Federal funding to NREL must be cost shared by the partners at a minimum of 30% in kind and/or cash. All federal funds will be costed by NREL.

Topic Area 3: PEM and Alkaline Electrolyzer Validation

This topic will support R&D and provide independent performance validation of PEM and alkaline electrolyzer stacks on advanced balance of plants at NREL. Successful applicants will provide their PEM or alkaline electrolyzer stacks to be operated under a range of operating profiles typical of renewable power supply profiles (e.g., wind, solar) and power levels (25 kW–1 MW).

Applicants will work closely with NREL staff to specify temperature, pressure, flows, current, and break-in, durability, and conditioning sequencing and may propose their own desired operating profiles for technology validation. In addition, NREL will test all selected electrolyzers under standard operating profiles. Electrolyzer response times and degradation rates will be measured to inform HFTO models and to validate electrolyzer performance and durability.

Participants are requested to note in their Letter of Interest the minimum kW power level for the alkaline electrolyzer and it if will be operated under pressurized or non-pressurized conditions.

Estimated number of projects: 1–3

Period of performance: 12 months

Estimated DOE funding available (to cover NREL staff, services, and facilities)**:** $100K–$500K total

Cost share: Federal funding to NREL must be cost shared by the partners at a minimum of 30% in kind and/or cash. All federal funds will be costed by NREL.

Funding Summary by Topic Area

Topic Area	Total Federal Funding per Award	Anticipated Number of Awards	Project Duration (years)	**Min** Required Non-Federal Cost Share %
Topic 1: Validating Hydrogen System Integration with Renewables and the Grid	$500K–$3M	1 to 3	1-3	30% (including in-kind labor, funding, or equipment)
Topic 2: Analyzing/Modeling/Validating Hydrogen Systems for Industrial Applications	$100K–$500K	1 to 3	1-2	30% (including in-kind labor, funding, or equipment)
Topic 3: PEM and Alkaline Electrolyzer Validation	$100K–$500K	1 to 3	1	30% (including in-kind labor, funding, or equipment)
Total:	Up to $5M*	3 to 9		

* Total funding to NREL includes approximately $5M in FY25, subject to appropriations.

Anticipated Impactful Progress and or Results in FY25 (and beyond):

- Multiple prioritized CRADA projects and partnerships ready and capable of delivering results and data in FY 2025/2026.
- Impactful experimental and modeling results that assess how alkaline and PEM electrolyzers respond to variable operation conditions associated with electricity from intermittent sources, with an emphasis on the impact on performance and degradation/lifetime where possible.
- Translational liquid alkaline electrolysis capability established, initial stack evaluations performed, and ready for larger number of international stacks to be evaluated in FY 2026.
- A targeted list of partners for future ARIES hydrogen validation activities and novel innovative demonstration research.
- Data to inform and derisk large scale hydrogen system deployment.
- Siting reports and replicable models for design specifications.
- Operational data sharing to inform models and validate electrolyzer performance and durability expectations for industry and manufacturers.

Eligibility

Participant eligibility is limited to: (1) for-profit entities, educational institutions, and non-profits that are incorporated (or otherwise formed) under the laws of a particular state or territory of the United States and have a physical location for business operations in the United States and (2) U.S. state, local, and tribal government entities. Participation by foreign entities may be allowed if approved by DOE. The approval process may extend the award selection and approval timeframes for projects with foreign involvement. The applicant must identify how they meet the eligibility requirements in the Letter of Interest. Selected partners must enter into a CRADA based on the H2@Scale Template CRADA.

Funding Requirements

DOE funds supporting each CRADA project are to be used for activities undertaken by NREL for services, staff time, and facilities necessary to support each selected project. DOE funds provided to national labs for CRADA projects may not be costed outside of the national laboratories. The DOE funding will be

provided directly to NREL in support of their work under the H2@Scale initiative. The CRADA projects' budgets may vary but must include a minimum of 30% cost share. Cost share from other DOE offices or other federal sources is not permitted.

CRADA Documentation Execution Requirements

For each CRADA project, the participant must enter into a CRADA based on the H2@Scale Template CRADA. Only changes to incorporate optional or alternate language approved in the DOE CRADA Order (DOE O 483.1B) and changes considered non-substantive can be made to the H2@Scale Template CRADA. No changes are allowed to the U.S. competitiveness provision. If the participant fails to agree to the terms of the CRADA with the national laboratories within thirty (30) days from selection, the offer to participate in the CRADA may be rescinded. Template language of the CRADA (covering both single and multi-partner options) are posted in the documentation section of this call. Each applicant should review the H2@Scale Template CRADA carefully to understand the general terms, including intellectual property rights and requirements and the U.S. competitiveness provision, that will apply to its CRADA project.

Proprietary Information

Applicants should not include proprietary information in the Letter of Interest or in any of the questions submitted for clarification.

Letters of Interest Preparation

More informal in nature than a proposal, Letters of Interest should follow the format provided in the template and should be no more than two single-spaced pages using 11-point font. Attach the Letter of Interest template as a .pdf to an email to ARIES@NREL.gov. **Please note "ARIES H2@Scale" in the subject line** to streamline screening. Brief introductory email text or cover/title pages will not be considered part of the two-page Letter of Interest template requirement.

Emails must be received prior to the deadline on November 1, 2024, at 5 p.m. Mountain Time to be considered for participation in the FY25 CRADA call.

Submissions are limited to one submission per partner per topic area. If a partner is interested in more than one topic, they should submit a separate Letter of Interest for each topic. If multiple submissions are received from a partner for the same topic, only the first to be received will be reviewed.

Letter of Interest Evaluation and Selection Process Criteria

A team of NREL ARIES and Hydrogen Fuel Cell Program staff will conduct the full submission evaluation process. The primary categories and relative ranking criteria used to evaluate submission proposals are:

Technical (60%)

- Relevance of objectives, anticipated outcomes, impacts and alignment with the H2@Scale Call Topics and ARIES programmatic goals
- Overall technical merit and benefits achieved through this research opportunity
- Potential impact of collaboration on the technical challenges being addressed and on interested stakeholders through data sharing and publication

- Significance and impact of outcomes to marketplace and industry

Project Management/Programmatic (40%)

- Adequacy and feasibility of proposed work to meet goals of the project and call topic
- Appropriate use of NREL and ARIES capabilities, resources, and expertise
- Project can deliver impactful results in FY25 and meets the POP expectation identified for the topic
- Partner cost-share budget is clearly explained (in kind and/or cash, minimum of 30%)
- Outcomes are realistic considering asset utilization, timing, duration, configurations, and resources
- Commitment to publication and data sharing with industry and academia
- The project addresses measures to encourage diversity, equity, and inclusion and the extent to which the project may benefit underserved communities
- Partner's acceptance of existing H2@Scale Template CRADA