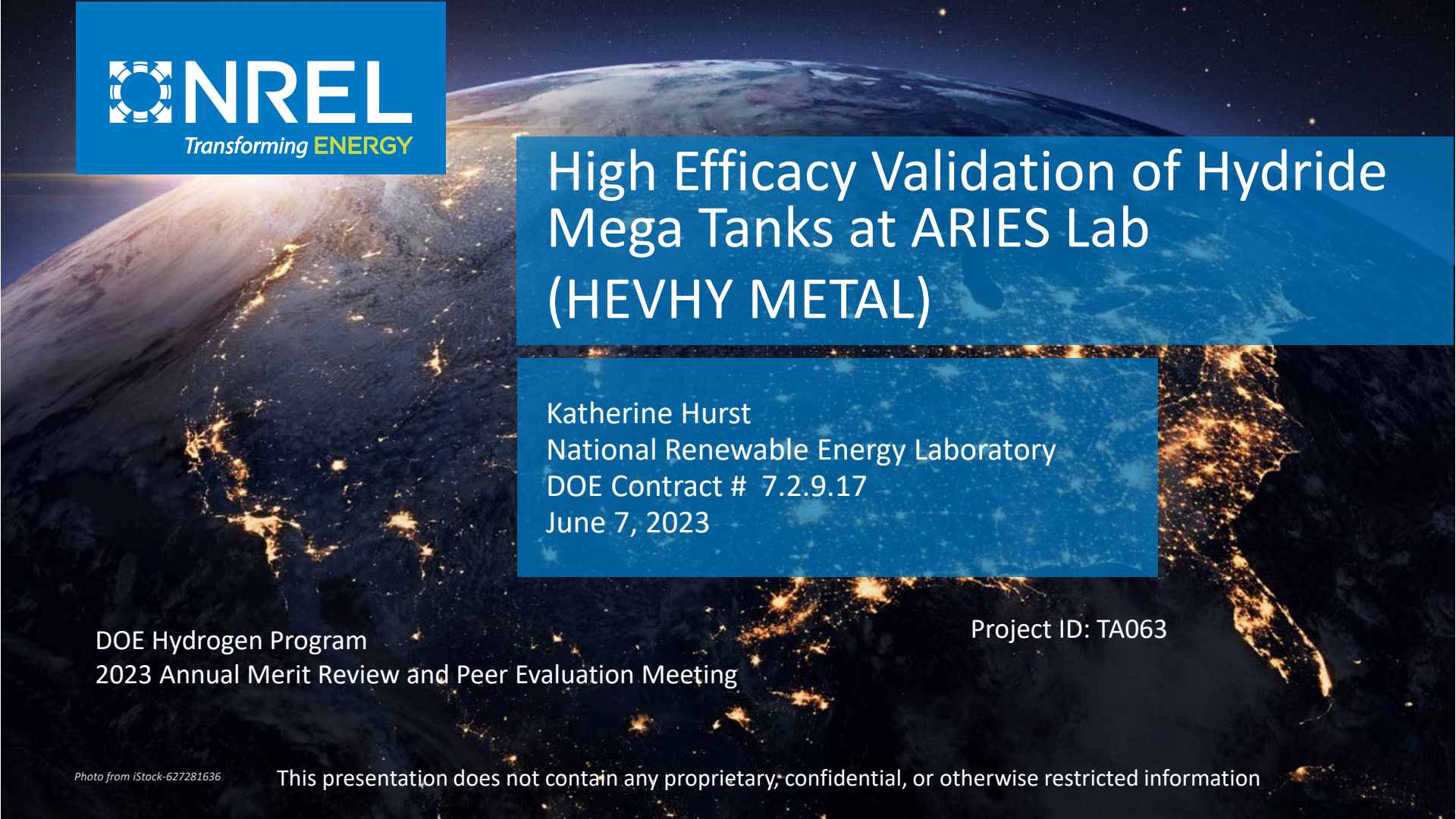

High Efficacy Validation of Hydride Mega Tanks at ARIES Lab (HEVHY METAL)

Katherine Hurst
National Renewable Energy Laboratory
DOE Contract # 7.2.9.17
June 7, 2023

DOE Hydrogen Program
2023 Annual Merit Review and Peer Evaluation Meeting

Project ID: TA063

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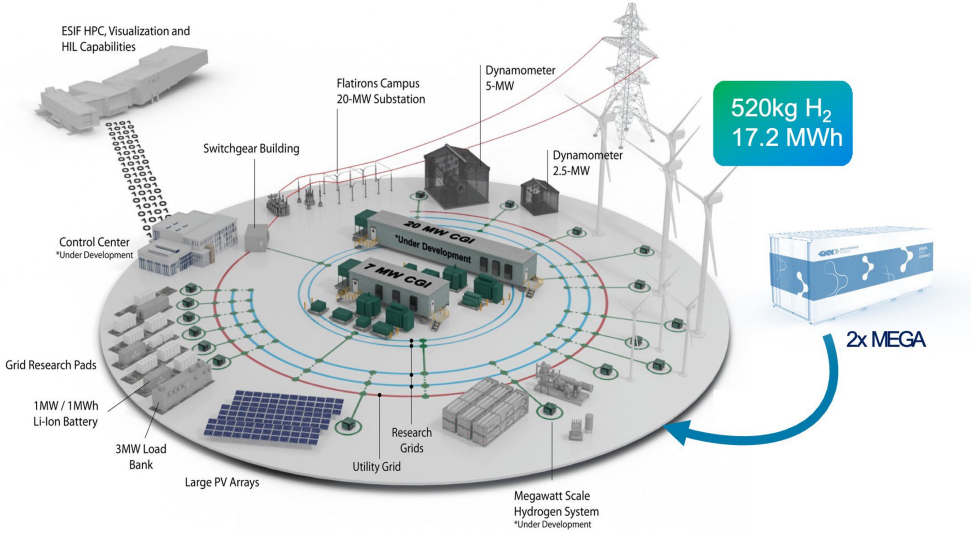
Project Goal

This project will advance materials-based hydrogen storage technologies by large-scale demonstration and identification of deployment pathways

- Demonstrate how two metal hydride HY2MEGA subsystems are installed with megawatt-scale green H_2 infrastructure
- Validate performance: Rates, capacities, efficiencies
- Investigate supply & demand side techno-economics



The ARIES platform is uniquely suited to demonstrate and validate new technologies like the GKN Hydrogen, HYMEGA, metal hydride storage systems

Overview

Timeline and Budget

- Project Start Date: 7/01/23
- Project End Date: 12/31/25
- Total Project Budget: $2,983,229
  - Total DOE Share: $1,722,089
  - Total Cost Share: $1,261,140
  - Total DOE Funds Spent*: $36,795
  - Total Cost Share Funds Spent*:

  Costs based on end of FY22

- ➢ GKN Hydrogen contributes $860,140 in-kind cost share
- ➢ SoCalGas provides $400,000

Total cost share for the project is 42% of the total project value which exceeds the required 30%

Barriers

- Need for sufficient infrastructure
- Need for technology advancements
- Demonstration of technology at-scale

Partners

- Project lead: Katherine Hurst, Daniel Leighton, Jeffrey Mohr, Mark Chung, Evan Reznicek, Karin Wadsack Tom Gennett, Philip Parilla NREL
- Partner: Ivo Gough Eschrich, Michael Cox, GKN Hydrogen technology developer
- Partner: Joe Leiva, Southern California Gas Company Industry application
- Brian Hunter, Jesse Adams, Zeric Hulvey, Ned Stetson - DOE

Potential Impact

- Green hydrogen storage is essential to capturing renewable power that would eliminate green house gas emissions from the electric power sector. This project will demonstrate a new metal hydride technology with benefits in storage vessel size, efficiency, agility and safety. Specific areas of impact for this project include:
- Support of the Hydrogen Shot goal by providing low-cost, agile storage
- Technology that can provide underserved groups with the benefits of stored renewable energy
  - Remote communities that can use low-cost renewable energy versus depending on importing fossil fuels
  - Broadband power infrastructure for rural communities
  - Positive outcomes for green hydrogen that build on diversity, equity and inclusion
- GKN Hydrogen has committed to a manufacturing facility in the United States for the metal hydride technology and the HY2MEGA platform is 100% recyclable
- SoCalGas has ambitious plans for green hydrogen which will benefit the workforce through adoption of new technology for gas infrastructure

Approach

Tasks

1. Integration & Installation

   Produce a guide for integration of metal hydride storage subsystems with green hydrogen infrastructure using information from the site design-plan, safety assessment, and practical considerations. The results will be communicated in a technical publication(s) and presentations(s) that can reach stakeholders, technology adopters and the research community

2. Operational & Performance

   Apply the principles of hydrogen storage (materials) best practices to validate charging/discharging rates and capacity. Measure the storage and roundtrip efficiency for optimization of the two-tank system. Compare performance to relevant tests of compressed hydrogen storage and report results through channels that resonate with technology adopters and the research community.

3. Commercial Demonstration Use Cases

   Design demonstration “experiments” with inputs from stakeholders in telecommunications, utility and underserved communicates to identify the most promising application s for materials storage. Elements of the use cases may include grid resilience, load following power, datacenters, and remote microgrids powered by renewables. Report on the benefits of hydrogen storage and the capability to serve as long duration energy storage.

4. Supply & Demand Techno-economics – CRADA with SoCalGas

   Perform techno-economic analysis of the green hydrogen connected to HY2MEGA storage system that includes: Comparison to other technologies, levelized cost of storage, levelized cost of returned energy, and other metrics. Apply learnings from the commercial use cases to identify drivers and benefits that would motivate adsorption of the technology.

Milestones

Charge and discharge capacities and times to quantify readiness are:
Charge: 400 +/- 30 kg H_2
Discharge:20 +/- 30 kg H_2
Duration to achieve full charge :
72 hours or less

Achieve optimized power response:
Maximum fuel cell output (1MW AC equiv. 20 minutes)

Discharge:10 +/- 5 kg H_2, -25 +/- 5 kg/h

Validate, optimize capacity and rates:
Charge: 520 +/- 40 kg H_2, +25+/- 5kg/h
Discharge:10 +/- 5 kg H_2, -25 +/- 5 kg/h

Accomplishments and Progress: Response to Previous Year Reviewers' Comments

- The project was not reviewed last year.
- The project kicked off with all partners present in person:

  Michael Cox and Ivo Gough Eschrich, GKN Hydrogen

  Jeff Chase, (for Joe Leiva) SoCalGas

  Brian Hunter, DOE

Accomplishments and Progress

Diversity equity and inclusion focus areas are “seeds” and are expected to build channels to serve underserved groups, promote inclusive habits for the project team, and disseminate project impact to wider groups. in each of the following focus areas:

- Diversity of research team
- Integrated outreach
- Technology transfer to underserved communities
- Guest researchers
- Communication with community
- Procurement

DEI project plan was submitted (Milestone 1.0)
Equity was considered in avoiding the use a toxic substance in the cooling system.

Diversity, equity and inclusion are integrated throughout the project

Accomplishments and Progress
Design Interface Plan

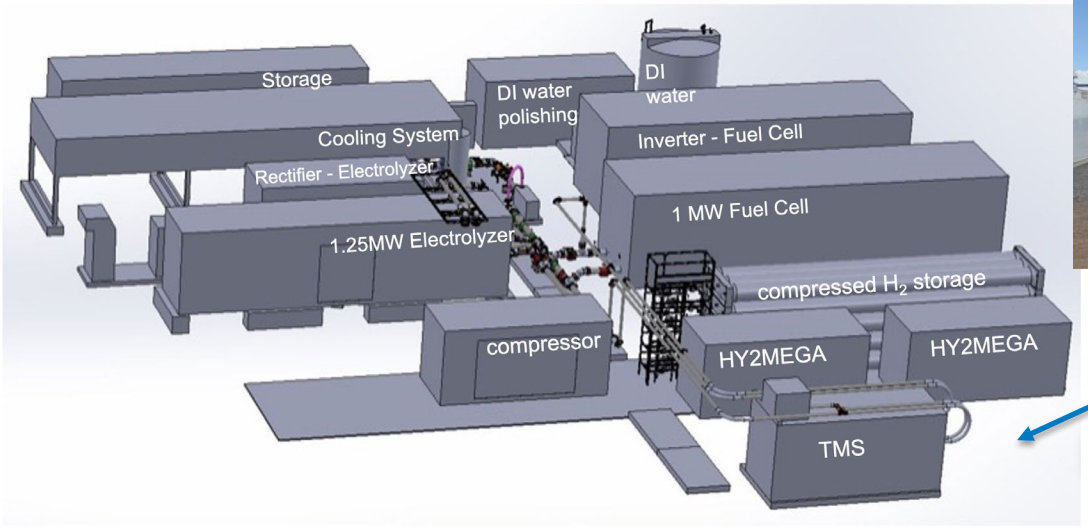
Designing the interface between GKN systems and NREL systems

P&ID drawings were completed for the incorporation of GKN HY2MEGA tanks and thermal management system (TMS) to the hydrogen systems at ARIES Flatiron site Pad 6.

- Designed hydrogen gas connections/venting procedures & fittings
- Determined pressure/valving measurements
- Planned coolant integration design design
- Addressed Codes and Safety Regulations
- Classification of HY2MEGA tank as a hydrogen enclosure and required ventilation
- Siting restriction for HY2MEGA tanks and TMS at Pad 6 Flatirons campus
- Planned to U.S. electrical code requirements and NFPA2 code compliance

Detailed engineering and design communication between NREL and GKN prior to delivery will ensure safe operation and safety regulations are addressed

Accomplishments and Progress
Design and Interface Plan



The site preparation is complete, including thermal, electrical, hydrogen systems connection points established.

Accomplishments and Progress
Design Interface Plan

Systems operations and compliance interface between GKN systems and NREL systems

- Material and installation requirements for each component in the GKN system have been reviewed according to electrical and materials standards used at NREL
- NREL and GKN established measurement and data collection needs to monitor the performance of the metal hydride system
- Currently establishing methods for
  - data collection systems
  - real time communication of system status and performance
  - data transfer to NREL SCADA system
  - controls strategies for interfacing systems to enable integrated operation

Planning component and system details will facilitate efficient installation and commissioning upon delivery.

Accomplishments and Progress

The project has been highlighted in presentations to a variety of audiences

- Fuel Cell Seminar 2/9/2023 – *Scientific audience/industry stakeholders*
- NCLS Legislative Energy Horizon Institute Washington D.C. 11/17/2022 *government officials*
- Denver City Council Task force - *government officials*
- Panel discussion at Hydrogen North America 2022 Conference – *Industry stakeholders*
- Task 41 IEA experts meeting (along with NREL-HyMARC) – *scientific audience*
- Numerous tours and business development presentations – *industry stakeholders/government officials*

Dissemination of project scope and technology is shared with a diverse audience including academic, national laboratory, government and industry stakeholders.

Collaboration and Coordination

CRADA Partners:

GKN Hydrogen

Roles:

Technology developer, system operations & performance, commercial use cases

Southern California Gas Company:

Gas expertise

Commercial Use cases

Collaborative relationship with NFPA2 members to discuss the siting requirements for metal hydride systems resulting in modification of code recommendation

Remaining Challenges and Barriers

Potential Challenges / *Strategies to Mitigate*

- Supply chain delays could affect timeline
  - *Complete designs and determine safety requirements for all components*
- System delivery delayed
  - *GKN team working to reach build milestones*
- Delivery issues with hardware shipped from Italy to Golden resulting in leaks or damage
  - *Consider shipping 3 components (HY2MEGA tanks and TMS) separately (Route forward will be determined by GKN in consultation with NREL)*
- Activation of metal hydride upon delivery could require heater work at maximum temperature rating.
  - *Consider activating metal hydride prior to shipping*
  - *Consider adding additional temporary heat to system during activation*
  - *Investigate lower activation temperature through materials characterization (Route forward will be made by GKN Hydrogen in close consultation with NREL team).*
- Adhering to schedule for integration of HY2MEGA subsystems with ARIES under pressure from global supply change disruptions and construction timetables
- Differences in requirements for designated materials and component safety ratings for Europe versus at NREL could cause time delays due to non-compliant documented materials, components and installation.
  - *Addressed through comprehensive review of certification of each part prior to system build/delivery*
  - *Identify components that need to be approved upon delivery*

Proposed Future Work

- FY23: Integration & Installation for HY2MEGA subsystems
  - Continue safety discussions with EHS. Order 50% of the interface hardware interface hardware Installation of equipment (Milestone 1.3 6/30/23)
  - Accept delivery of 2 HY2MEGA tanks and one TMS (Milestone 1.3 6/30/23)
  - Connect HY2MEGA tanks and TMS to infrastructure at Pad 6 and leak check
  - Activate the HY2MEGA Tanks using hydrogen onsite
  - Commission the system (Milestone 12/31/23)

- FY24: Operation and performance
  - Confirm measurement and controls accuracy and readability
  - Characterization of thermal response to drive discharging and charging operation
  - Single tank processes

  *Any proposed future work is subject to change based on funding levels

Summary

- This project began 7/1/2022

Milestone for Task 1	Due Dat	Status
1.0 Project DEI Plan. A report will be submitted detailing DEI elements in the project team and planned approaches to serve as a baseline metric to help measure the impact. Each quarterly progress report will include a section on DEI. (included in quarterly report FY22 Q4)	9/30/2022	Completed
1.1 Design-plan. Develop P&ID drawings for tanks, thermal management system, and integration to the ARIES-Flatirons Campus.	12/31/2023	Completed
1.2 Equipment Acquisition. Procurement plan that captures long lead time acquisitions. This will also include a report of efforts made to acquire goods and services with a DEI guided approach.	3/31/2023	Completed
1.3 Equipment Acquisition. Complete safety siting work, including discussions with EHS. Order 50% of the interface hardware.	6/30/2023	On track - 50% complete
1.4 Tank Installation. Preparation of NREL Flatirons pad #6 site, receiving of two GKN HY2MEGA tanks with a total storage capacity of 520 kg H_2 and connection to hydrogen infrastructure (1.25 MW PEM Electrolyzer, 1.0 MW Fuel Cell, 600 kg Compressed H_2).	6/30/2023	On track

Task 2 expected start 1/1/24

Task 3 expected start 7/1/24

Milestone completion is on track

Summary

- Important engineering and design work has been accomplished to interface the GKN and NREL systems
- The site at Pad #6 is nearly prepared for delivery of HY2MEGA tanks, and TMS

This is a unique combination of the capabilities of ARIES, a new technology in a field HFTO has made significant investment, the largest materials-based demonstration of hydrogen storage and a partnership between national lab technology developer and industry stake holder.

Thank You

www.nrel.gov

This work was authored by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by U.S. Department of Energy Office of Energy Efficiency and Renewable Energy Hydrogen and Fuel Cell Technologies Office. The views expressed in the article do not necessarily represent the views of the DOE or the U.S. Government. The U.S. Government retains and the publisher, by accepting the article for publication, acknowledges that the U.S. Government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for U.S. Government purposes.

Technical Backup and Additional Information

(Include this "divider" slide before your technical backup slides [maximum 20]. These technical backup slides will be available for oral presenters to use for Q&A and will be included in the published web PDFs for oral and poster presentations.

*Note there is **one required slide** in this section and several suggested slides.)*

DEI Plan

Deliverables: (to be completed at the end of each time period)

Year 1:

1.1 Participate in 1 hydrogen, or energy-storage focused community meetings ✓ Attended Colorado Hydrogen Network Meeting

1.2 Document price and availability comparison for businesses operated/owned by underserved groups.

1.3 Identify a disadvantaged community for case study and to engage communication with.

Year 2:

2.1 Invite a guest researcher to the team for 3 months

2.2 Participate in 1 hydrogen, or energy-storage focused community meetings

2.3 Document price and availability comparison for businesses operated/owned by underserved groups.

Year 3:

3.1 Invite guest researcher to the team for 3 months.

3.2 Participate in 1 hydrogen, or energy-storage focused community meetings

3.3 Write a summary report of DEI efforts, outcomes, and impacts of efforts undertaken.

3.4 Communicate with community through discussions, writing newsletter project descriptions, reader polls, or email to community officials.

3.5 Provide analysis on cost and resilience impacts of deploying project technology with one community, based on their provided energy demand.

Technology Transfer Activities

- This is a CRADA which captures potential development of intellectual property by the partners
- No patent, licensing, or potential licensing information has been developed
- Efforts to address differences in codes and standards for Europe vs United States are important aspect of this work

Publications and Presentations

This project has been highlighted in:

- "Investigating Large-Scale Hydrogen Technology RD&D" Fuel Cell Seminar 2/9/2023 - K. Hurst et al. – *Scientific audience/industry stakeholders*
- "Hydrogen Overview" NCLS Legislative Energy Horizon Institute Washington D.C. 11/17/2022 - K. Hurst et al. – *government officials*
- Hydrogen Overview Denver City Council Task force - *government officials*
- Panel discussion at Hydrogen North America 2022 Conference – *Industry stakeholders*
- "HyMarc Hydrogen Materials update" IEA meeting – S. Shulda (NREL-HyMARC) – *scientific audience*
- Numerous tours and business development presentations – *industry stakeholders/government officials*