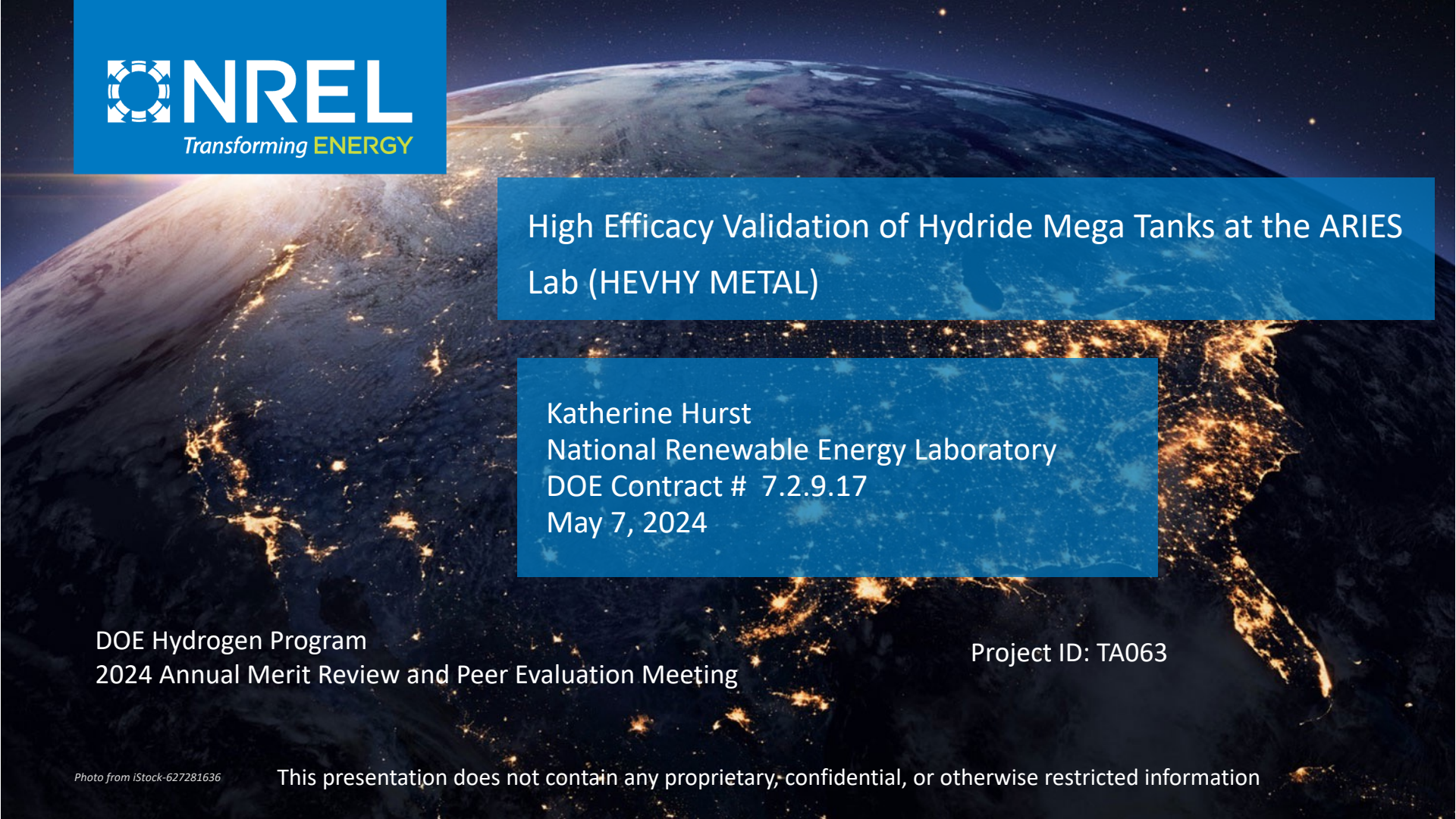

High Efficacy Validation of Hydride Mega Tanks at the ARIES Lab (HEVHY METAL)

Katherine Hurst
National Renewable Energy Laboratory
DOE Contract # 7.2.9.17
May 7, 2024

DOE Hydrogen Program
2024 Annual Merit Review and Peer Evaluation Meeting

Project ID: TA063

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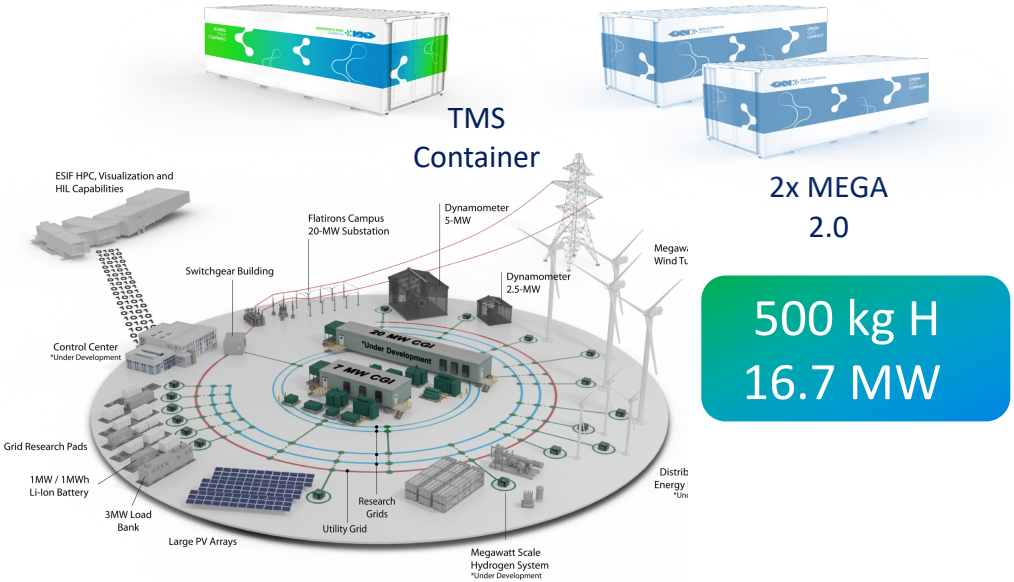
Project Goal

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



500 kg H
16.7 MW

Demonstrate how two HY2MEGA subsystems are installed with MW – scale **green H_2** infrastructure

- Validate performance: Rates, capacity, efficiency
- Investigate supply, demand side techno-economics
- Identify potential deployment pathways

This project is uniquely suited to demonstrate and validate new hydrogen storage technology with integration of MW-scale H_2 systems and renewable energy

Overview

Timeline and Budget

- Project Start Date: 07/01/2023
- Project End Date: 12/31/2025
- Total Project Budget: $2,983,229
  - Total DOE Share: $1,722,089
  - Total Cost Share: $1,261,140
  - Total DOE Funds Spent*: $687485
  - Total Cost Share Funds Spent*: $5,357

    * As of 03/01/2024

  - 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
- Need for long duration energy storage

Partners

- Project lead: Katherine Hurst (PI), Jeffrey Mohr, Daniel Leighton, Phil Parilla, Mark Chung and Evan Reznick, NREL
- Partner: Ivo Gough Eschrich, Matthew Weaver, Michael Cox, GKN Hydrogen (Technology provider)
- Partner: Joe Leiva, Southern California Gas Company, (Industry Application)
- Brian Hunter, Jesse Adams, Zeric Hulvey

Potential Impact

- Green hydrogen storage is essential to capturing curtailed renewable energy
  - This project **demonstrates a new metal hydride technology** with benefits in storage vessel size, efficiency and safety.
- Specific areas of impact for this project include:
  - **Supports the Hydrogen Shot** goal by providing low-cost, safe storage
  - Technology that can provide underserved groups with the benefits of stored renewable energy
    - **Remote communities can use low-cost renewable energy** versus 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**

The project creates impacts in resiliency and energy security, supports rural & impoverished communities, could lead to increased workforce development

Approach 1 (of 2)

Go/No Go Milestone 9/30/2024 on track

Task 1. Integration, Installation & Commission

- Integrate a metal hydride storage subsystems with green hydrogen infrastructure considering site design-plan, safety assessment, and practical considerations.

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

Task 2. Operational & Performance

Go/No Go Milestone 9/30/2025

- Apply best practices of hydrogen storage (materials) 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

Validate, optimized capacity and rates:
Charge: 500+/-40 kg H_2, +25+/-5kg/h
Discharge: 10+/-5 kg H_2, -25 +/-5kg/h

Approach 2 (of 2)

Task 3. Commercial Demonstration Use Cases

Go/No Go Milestone 9/30/2026 on track

- Design demonstration “experiments” with inputs from stakeholders in telecommunications, utility and underserved communities to identify the promising applications
- Report the benefits of hydrogen storage capability to serve as long duration energy storage.

Demonstrate optimized power response to the maximum fuel cell output: 20 minutes
and charge duration at max fuel cell output: 8hrs

Task 4. Supply & Demand Techno-Economics

- Compare techno-economic analysis of green hydrogen connected to HY2MEGA storage system and other storage technologies
- Identify drivers and benefits from the commercial use cases

Approach: Safety Planning and Culture

World-class expertise from Research Engineers and Safety Personnel

- Systems are **designed with safety prioritized**
- **Personnel training** - hydrogen and pressurized gas hazards, electrical safety
- Detailed **documentation** of hazards, procedures, and maintenance

Making Safety a priority:

- Used **complex lift plan** for crane lift of containers
- **Process Hazard Analysis (PHA)** completed
- Confirmed **electrical compliance**, detailed check of the bill of materials
- **Consulted with the NFPA2 committee**

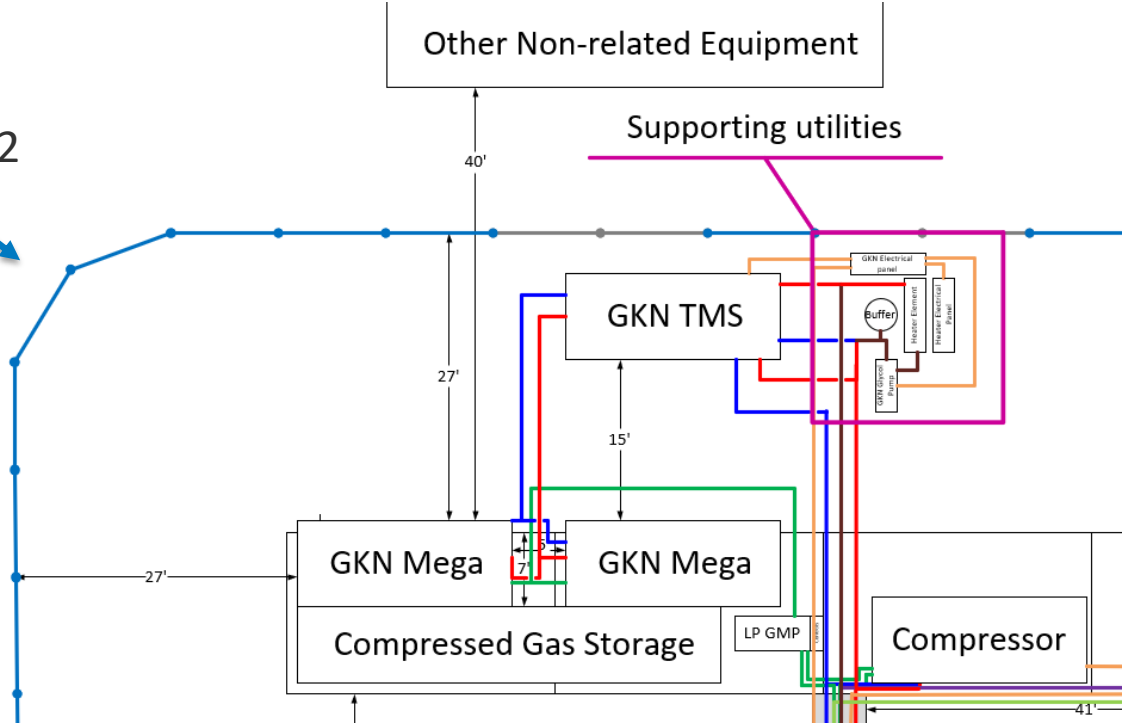
The established safety processes required per NREL's prime contract with the DOE exempted this project from Hydrogen Safety Panel review

Safety is prioritized by planning, expertise, training and detailed attention to work execution

Accomplishments and Progress: Physical Site Design is Finalized

Worked with NFPA Committee to have a Group 2 setback distance reduced to reflect actual storage pressure and reduce setback from 58 feet to 27 feet.

Fence is just outside Group 2 boundary



Accomplishments and Progress: Physical Site Preparation

Gravel was spread and precast concrete was placed to prepare site for arrival of GKN containers.

Accomplishments and Progress

GKN HY2MEGA tanks and the TMS delivered 12/6/2023.

Accomplishments and Progress: Physical Site Preparation

- GKN equipment was unloaded over 2 days
- 1 day of crane work to place containers in final location

GKN Containers in final site location

Accomplishments and Progress: Thermal Utility Connection

Thermal utility connections are designed (CAD model), and buildout is in progress.

- Thermal utility will use waste heat from 1 MW Fuel Cell from ARIES installation.
- Auxiliary heater will be used for initial metal hydride activation onsite at NREL and for high temperature experiments.

Accomplishments and Progress: Electrical Utility Planning

- Detailed **coordination** between NREL and GKN for electrical integration produced a confirmed list of electrical components that satisfy NREL requirements.
- **Certification prior to arrival at NREL**, the system will reduce inspection time necessary by NREL Electrical Safety Team.
  - GKN system was pre-inspected before shipping by TUV and will undergo TUV field inspection once operational at NREL.
- **Utility parts** needed for installation, (distribution panel and conduit) **have been purchased.**

The electrical utility coordination is in progress

Accomplishments and Progress: Communication System Configuration

- NREL and GKN established measurement and data collection needs to monitor the performance of the H2MEGA tanks and the TMS.
- Detailed discussions about data transfer and controls strategies to interface systems will enable integrated operation
  - Establish MODBUS and SCADA communication channels
  - Create control strategies for interfacing systems for integrated operation
  - Determine frequency of system status and performance communication

The system control and data transfer communication in progress

Accomplishments and Progress:
Response to Previous Year Reviewers' Comments

Project was not reviewed last year, no comments to address.

Collaboration and Coordination

CRADA Partners:

GKN Hydrogen

Southern California Gas Company

Roles:

Technology developer, system operations & performance, commercial use cases

Gas expertise
Commercial Use cases

Collaborative relationship with NFPA2 members to discuss siting requirements for metal hydride systems resulted in a modified setback distance recommendation

DEIA/Community Benefits Plans and Activities

1. Obtained quotes for pre-cast concrete pads from diverse group of businesses:
   - Local family-owned business
   - Veteran and woman owned business
   - Establish suppliers to NREL
2. Outreach Efforts
   - Presentation to early-career audience at National Institute in Standards and Technology
   - Educational presentation to officers from National Defense University
   - Participated in two community based H_2 groups – Colorado, Alaska
3. Diverse Research Group
   - Plan to reach out to Metro State University (MSI) to bring on student/intern for data analysis. (Program with MSU established by HyMARC and H2NEW)

Remaining Challenges and Barriers/ *Strategies*

- Supply chain delays still affects timeline (heater, electrical panel).
  - *Flexibility in completing installation of other system components in parallel*
- Adhering to schedule for integration of HY2MEGA subsystems with ARIES under pressure from global supply change disruptions and construction timetables.
  - *Well-managed, agile team will adjust to changing timelines*
- Weather can impact possible work time for installation.
  - *Flexibility in work prioritization*

Flexibility and agility are key aspects to addressing uncertain scheduling

Future work for FY24

- Complete the mechanical/electrical interface between:
  - ❑ HY2MEGA tanks and the TMS
  - ❑ HY2MEGA tanks and the TMS with the core NREL system.
- Complete the integration of two HY2MEGA tanks and TMS with the NREL electrical and glycol systems
- Activation of two H2YMEGA tanks
- Commission HY2MEGA tanks systems
- Define and calculate system energy efficiency for a one tank system

Summary

- This project will advance materials-based hydrogen storage technologies by **large-scale demonstration** and identification of deployment pathways.
- Extensive **safety planning** and safe **project design** are complete.
- **Designing thermal, electrical and communication integration** of GKN HY2MEGA tanks and TMS **is complete.**
- The GKN HY2MEGA tanks and TMS were **placed in position** at Flatirons Campus.
- **Integration** of thermal and electrical utility connections are **underway.**
- Configuration of the communication system is **in progress**.

Thank You

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