NREL/PO-5900-87654

Visit the HydroGEN website to learn more

Visit the H2NEW website to learn more

HydroGEN Advanced Water Splitting Materials

Clean Hydrogen Production: A Consortium Approach

H2NEW Hydrogen from Next-generation Electrolyzers of Water — U.S. DEPARTMENT OF ENERGY

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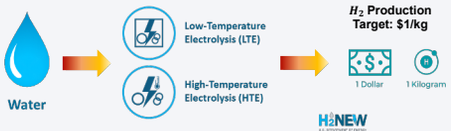
CONSORTIA VISION

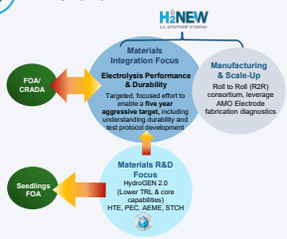
Accelerate R&D of advanced water splitting (AWS) technologies to enable clean, sustainable, and low-cost ($1/kg H_2) hydrogen production.

The **HydroGEN** consortium is focused on early-stage R&D in H_2 production and fosters cross-cutting innovation using theory-guided applied materials R&D to advance all emerging water-splitting pathways for hydrogen production.

Hydrogen (H2) from Next-generation Electrolyzers of Water (**H2NEW**) addresses components, materials integration, and manufacturing R&D to enable manufacturable electrolyzers that meet required cost, durability, and performance targets, simultaneously.



Electrolysis materials discovered and developed in HydroGEN are fed to H2NEW consortium for materials integration, optimization, manufacturing and scale-up.



HydroGEN COLLABORATION

- **Labs collaborate on early-stage materials R&D projects.**
- **Lab-FOA project collaboration: HydroGEN lab capabilities and experts support projects**

HydroGEN PARTNERSHIPS

- **Partnerships with 11 labs, 10 companies, 39 universities supporting over 30 projects (more to come in 2023)**

H2NEW COLLABORATION

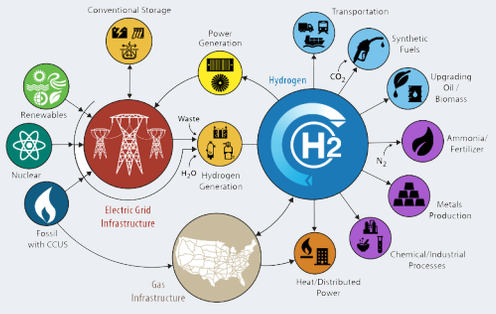
- **Labs collaborate on core R&D projects.**
- **Lab-FOA project collaboration: H2NEW lab capabilities and experts support projects**

H2NEW PARTNERSHIPS

- **Leveraging across other consortia:**
  - **HydroGEN 2.0**
  - **ElectroCat 2.0**
  - **Million Mile Fuel Cell Truck**
  - **Roll to Roll**
- **Numerous industrial, academia, and international interactions: (IEA, ASTWG, materials suppliers, informal collaborations)**
- **Stakeholder advisory board: OEMs, Tier 1 suppliers, analysis and manufacturers)**

H2@SCALE VISION

The HydroGEN and H2NEW Consortia support the H2@Scale vision, demonstrating how hydrogen can couple diverse, domestic resources with difficult-to-decarbonize industrial applications to enable affordable, reliable, clean and secure energy and ultimately help the U.S. meet the net-zero carbon goal by 2050.



TECHNICAL APPROACH

HydroGEN

HydroGEN focuses on materials R&D of the lower TRL AWS technologies:

Alkaline exchange membrane (AEM) electrolysis
Improve AEM electrolysis performance and durability by determining the role of supporting electrolyte and the limiting factors behind DI water operation

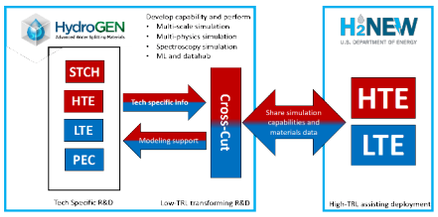
Metal-supported solid oxide electrolysis (MS-SOEC)
Improve performance and durability w/a scale-up cell

Proton-conducting solid oxide electrolysis (p-SOEC)
Understand the proton conduction and electronic leakage mechanisms of electrolyte materials in proton-conducting SOEC

Photoelectrochemical (PEC) water splitting
Understand materials stability and device durability

Solar thermochemical (STCH) water splitting
Identify and understand how structural features, composition, and defect dynamics engender high capacity–high yield behavior in materials

Cross-Cutting Modeling
Conduct theory-guided design to analyze performance and durability of materials under simulated operating conditions



H2NEW

U.S. DEPARTMENT OF ENERGY

H2NEW focuses on component, materials integration and manufacturing R&D of higher TRL AWS technologies:

- **Polymer electrolyte membrane (PEM) electrolysis**
- **Liquid alkaline electrolysis**
- **Oxygen-conducting solid oxide electrolysis (o-SOEC)**

H2NEW PEM Electrolysis Targets

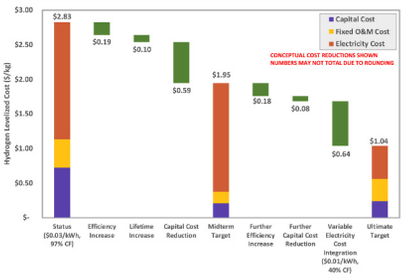
Stack Targets	Status	2026	Ultimate
Cell (A/cm²)	2.0	3.0	3.0
Cell voltage (V)	1.9	1.8	1.6
Lifetime (khr)	40	80	80
Degradation (mV/khr)	4.8	2.3	2.0
Capital Cost ($/kW)	450	100	50
PGM loading (mg/cm²)	3	0.5	0.125

https://www.energy.gov/eere/fuelcells/technical-targets-proton-exchange-membrane-electrolysis

The strongest levers for addressing stack costs are the areas below and are the primary focus of H2NEW:

1. Increased efficiency/current density
2. Decreased PGM loading
3. Scale-up

Potential Impact: Hydrogen Levelized Cost



Collaborative HydroGEN and H2NEW Data Hub Making Digital Data Accessible

https://datahub.h2awsm.org/

Data repository
Storage and sharing of research data: public vs. private data

DOI/Publication of data
Internal vs. external data

Provide security mechanisms
User login and project level access management

Maintain security compliance

Visualization and analysis capabilities

Community Approach to Benchmarking and Protocol Development for AWS Technologies

Goal: Develop best practices in materials characterization and benchmarking—critical to accelerate materials discovery and development

Outcomes:

- Strong community engagement & participation, national & internationally
- Disseminated information to AWS community via HydroGEN website, SharePoint site, email, quarterly newsletters, workshops
- Hosted 5th Annual AWS community-wide benchmarking workshop
- Developed high-level roadmap by AWS technology
- 19 test protocols published in *Frontiers in Energy Research* special issue

19 test protocols published in Frontiers in Energy special issue (7 LTE, 4 THE, 5 PEC, 3 STCH)
4,912 total downloads, 36,000 views (9/19/2023)

H2NEW Cross-Technology Methodology

Task 1: Durability

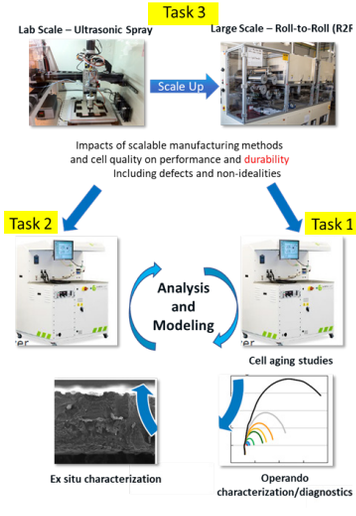
- Establish fundamental degradation mechanisms
- Develop accelerated stress tests
- Determine cost, performance, durability tradeoffs
- Develop mitigation

Task 2: Performance

- Benchmark performance
- Novel diagnostic development and application
- Cell level models and loss characterization

Task 3: Scale-up

- Transition to mass manufacturing
- Correlate processing with performance and durability
- Guide efforts with systems and technoeconomic analysis



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