

Hydrogen Education for a Decarbonized Global Economy (H₂EDGE)

(DE-EE0009253)

Project ID: SCS028

DOE Hydrogen Program
2023 AMR Review & PE Meeting

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Project Goal

- Primary Goal – Build a sustainable infrastructure for developing a workforce for the emerging hydrogen economy as a part of the decarbonized global economy by:
 - Establishing and building partnerships with universities and industries
 - Developing course material at both the university and professional level
 - Creating a university network
 - Evaluating and measuring course and overall program effectiveness
 - Assessing the job needs for the hydrogen economy



H₂EDGE will increase workforce readiness within the growing hydrogen industry

Project Overview

Timeline

- Project Start Date: 10/1/20
- Project End Date: 3/31/25

Budget

- Total Project Budget: \$3,336,000
- Total DOE Share: \$2,686,000
- Total Cost Share: \$650,000
- Total DOE Funds Spent*: \$570,002
- Total Cost Share Funds Spent*: \$159,401

* As of 03/31/2023

Barriers and Targets

- **Barrier:** An increasing number of well-qualified professionals are needed for the growing hydrogen economy
- **Target:** Establish a sustainable workforce development infrastructure at the university and industry level that is responsive to meeting the anticipated needs of the growing hydrogen economy

Partners

- GTI Energy
- Oregon State University
- University Delaware
- University of Houston
- Embedded Assessments
- Industry Partners

Relevance

The hydrogen industry is expected to grow, and thus, create more jobs within the industry

- This workforce should:
 - span across the entire hydrogen value chain: production, delivery, storage, and end use
 - be well-qualified in their respective areas especially when it comes to safety considerations
 - be developed at both the academic and professional level
- DOE goals
 - Create good-paying jobs in the United States
 - Support and improve social justice
 - Strengthen U.S. manufacturing
 - Build clean energy infrastructure
- DOE Report – Pathways to Commercial Liftoff: Clean Hydrogen
 - By 2030, the hydrogen economy could create
 - ~100,000 net new direct and indirect jobs
 - ~450,000 cumulative job-years
 - ~120,000 additional jobs in operations and maintenance of hydrogen assets
 - The Inflation Reduction Act and the Infrastructure Investment and Jobs Act will have an impact in the hydrogen economy and support job creation
 - Since job will not perfectly map from incumbent industries and locations, there should be a focus in workforce development for individuals in those industries in order to ensure a just transition

Approach – Developing Industry Professionals

Creating a short course program

Develop

- Create materials that address multiple DOE H₂ Program areas
- Coordinate with SMEs to ensure high-quality content
- Coordinate with HSP to conduct reviews of all safety info

Deliver

- Schedule and advertise courses
- Offer multiple delivery mechanism (e.g., live-in-person, live-online, computer-based trainings, e-learning videos)

Evaluate

- Work with Embedded Assessments to establish metrics to monitor KPIs
- Create a gaps assessment and training roadmap
- Make iterative improvements to content and delivery

Sustain

- Develop a plan in consultation with project partners for sustainability of the training initiative
- Establish and maintain repository of materials

Current Status

- Developed the professional short course program
- Coordinated Hydrogen Safety Panel reviews for every course
- Creating a gaps and training roadmap
- Delivering the professional short courses

Approach – Advancing University Curriculum

Creating a university network and driving student engagement

Develop

- Select Partner Universities
- Develop course material, tech transfer programs, and student sponsorship programs
- Create an Affiliate University network (includes HBCUs)

Deliver

- Teach new/revised courses and lab materials to students
- Execute regional workshops to “train the trainer” for Affiliate Universities
- Establish internships and capstone projects

Evaluate

- Work with Embedded Assessments to establish metrics to monitor KPIs
- Create an academic gaps assessment
- Make iterative improvements to content and delivery

Sustain

- Develop a plan in consultation with project partners for sustainability of the initiative
- Establish a university network

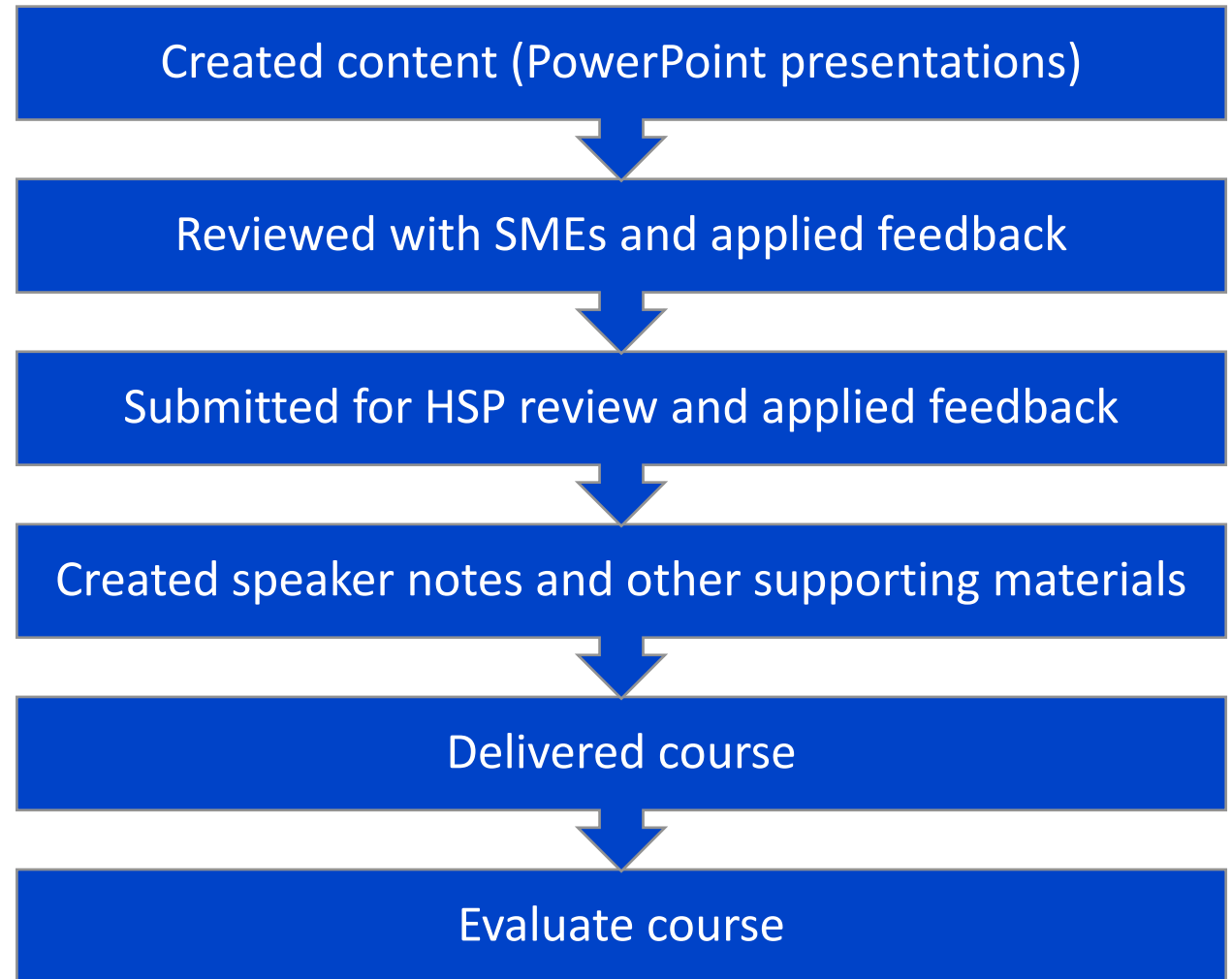
Current Status

- Selected Partner Universities
- Developed course material
- Creating a gaps and training roadmap
- Recruiting and identifying Affiliate Universities (including HBCUs)
- Delivering and evaluating new and revised courses

Accomplishments

Developing a Professional Short Course Program

1. **Basic Hydrogen Science**
2. **Trends in Electrolyzer Technology**
3. **Hydrogen Sources and End-Uses**
4. **Hydrogen Storage and Delivery**



Content has been developed for four short courses that cover the hydrogen value chain

Accomplishments

Partner Universities – Oregon State



Oregon State University
College of Engineering

Teaching

- Chemical Plant Design II (CHE 432)
 - Flowsheeting in Aspen, pressure vessel design, P&ID diagrams, material selection, and safety analysis
 - **Company partnerships in H₂-related design projects**
 - 2022: 42 students on H₂-related capstone projects
 - 2023: 58 students on H₂-related capstone projects
- Sustainable Engineering (ENGR 350)
 - Analyze relationship between society-environment-technology
 - Overview of energy technologies
 - H₂ Economy (Production, Storage/Distribution, Use)
 - In context of low/zero carbon economy
 - **Course offered 3x since 2021 to ~200 students**

Accomplishments

Partner Universities – Oregon State



Oregon State University
College of Engineering

Capstone Projects

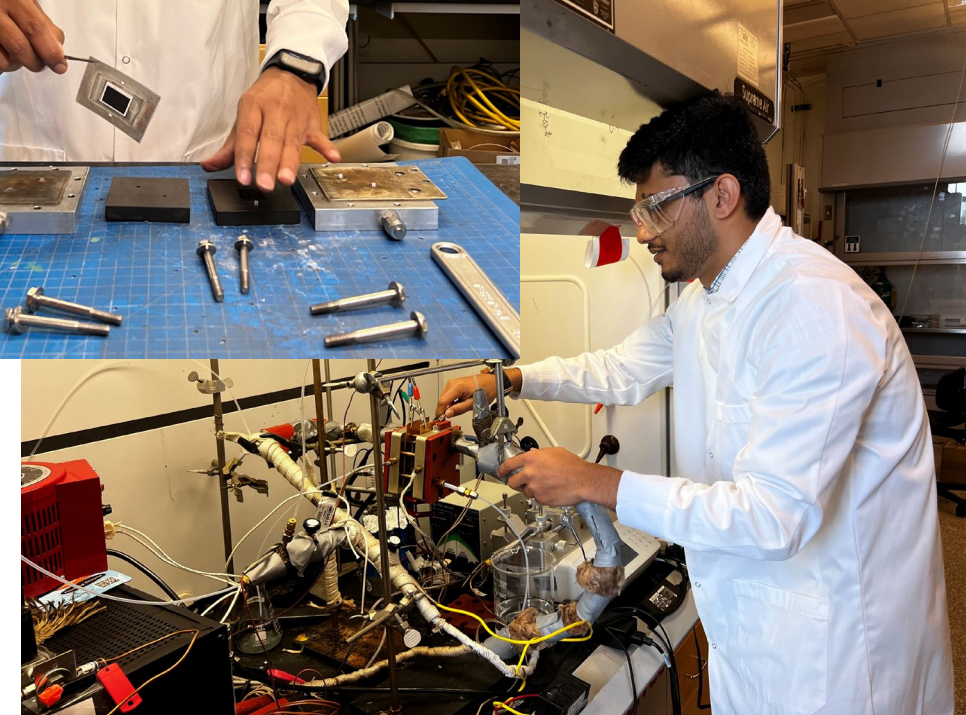
Project Title	Sponsor
H ₂ for Amazon Distribution Centers	Plug Power
Nuclear Hydrogen	Oregon State – School of Nuclear Science & Engineering
Compression Strategy for Modular Electrolysis	E9 Hydrogen
Steel Production Using a H ₂ Plasma (3 projects)	Hertha Metals
Accelerating Decarbonization via Augmentation of Green Methanol Production Using Renewable H ₂	Obsidian Renewables
Repurposing Existing/Abandoned Concrete Structures for H ₂ Storage	Obsidian Renewables
H ₂ Storage Gap	NREL
NREL Advanced Research on Integrated Energy Systems (ARIES) Platform (2 projects)	NREL
Hydrogen for Aviation	NREL

There is a substantial increase in commercial activity in the H₂ sector (especially low-carbon H₂), thus, they are trying to engage new players and build their industrial network through capstone projects

Accomplishments

Partner Universities – University of Delaware

- **Course:** Intro to Fuel Cells (MEEG442/642) has been taught during the Spring 2023 semester
- **Laboratory:** 6 lab experiments pertaining to fuel cell assembly and testing are being developed
 1. Assemble a fuel cell and measure polarization curve
 2. Measure the impedance of a fuel cell using electrochemical impedance spectroscopy
 3. Performance evaluation on the effect of relative humidity on a fuel cell
 4. Performance evaluation of the effect of operating temperature on a fuel cell
 5. Performance evaluation of an electrochemical hydrogen pump
 6. Performance evaluation of an electrochemical hydrogen compressor



A safety plan has been developed for the laboratory activities using HSP's Simplified Safety Planning for Low Volume Hydrogen and Fuel Cell Projects

Accomplishments

Partner Universities – University of Houston



Technical course will be offered through the Chemical Engineering Department

- Hydrogen: Technical attributes and technology developments (CHEE 5390/6390)
 - Will be taught in the Fall 2023 semester
 - Will cover modern energy technologies and their impact on the environment
 - Topics include:
 - Generation, storage, delivery, and end use
 - Increases in performance and efficiencies
 - Future developments in the H₂ economy

Business course will be offered though the College of Business

- The Business of Hydrogen (BUSI 4397)
 - Will be taught in the Fall 2023 semester
 - Will cover all the business, policy, and regulatory aspects of a low carbon H₂ industry
 - Topics include:
 - Net zero global energy scenarios
 - Costs
 - Key regulations
 - International considerations

This approach, that includes both technical and business elements, has been a perspective that U of H has followed with its evolving overall vision to energy solutions

Accomplishments

University Course Evaluation from Embedded Assessments

Metrics Scorecard - University Courses – Dec. 2022

		==== Project End Goals ====			
Key Performance Indicators		Current	Threshold	Target	Distinguished
University Curriculum	# of Enriched courses offered	2	4	6	8
	# of Relevant course offered	2	4	6	8
	Average student enrollment	32	5	10	15
	Satisfaction with course	93%	80%	85%	92%
	Satisfaction with instructor	96%	80%	85%	92%
	Student motivation	92%	80%	85%	92%
	Student confidence	87%	80%	85%	92%
	Student engagement	85%	80%	85%	92%
	Student knowledge	90%	80%	85%	92%

On-target for all Level 1 & Level 2 metrics

Accomplishments

Response to Reviewer Comments

- Project has not been previously reviewed at an AMR

Collaboration and Coordination

Lead



Advisory Board



Supporting Professional Course Creation



University Partners



Remaining Challenges and Barriers

Challenges and Barriers

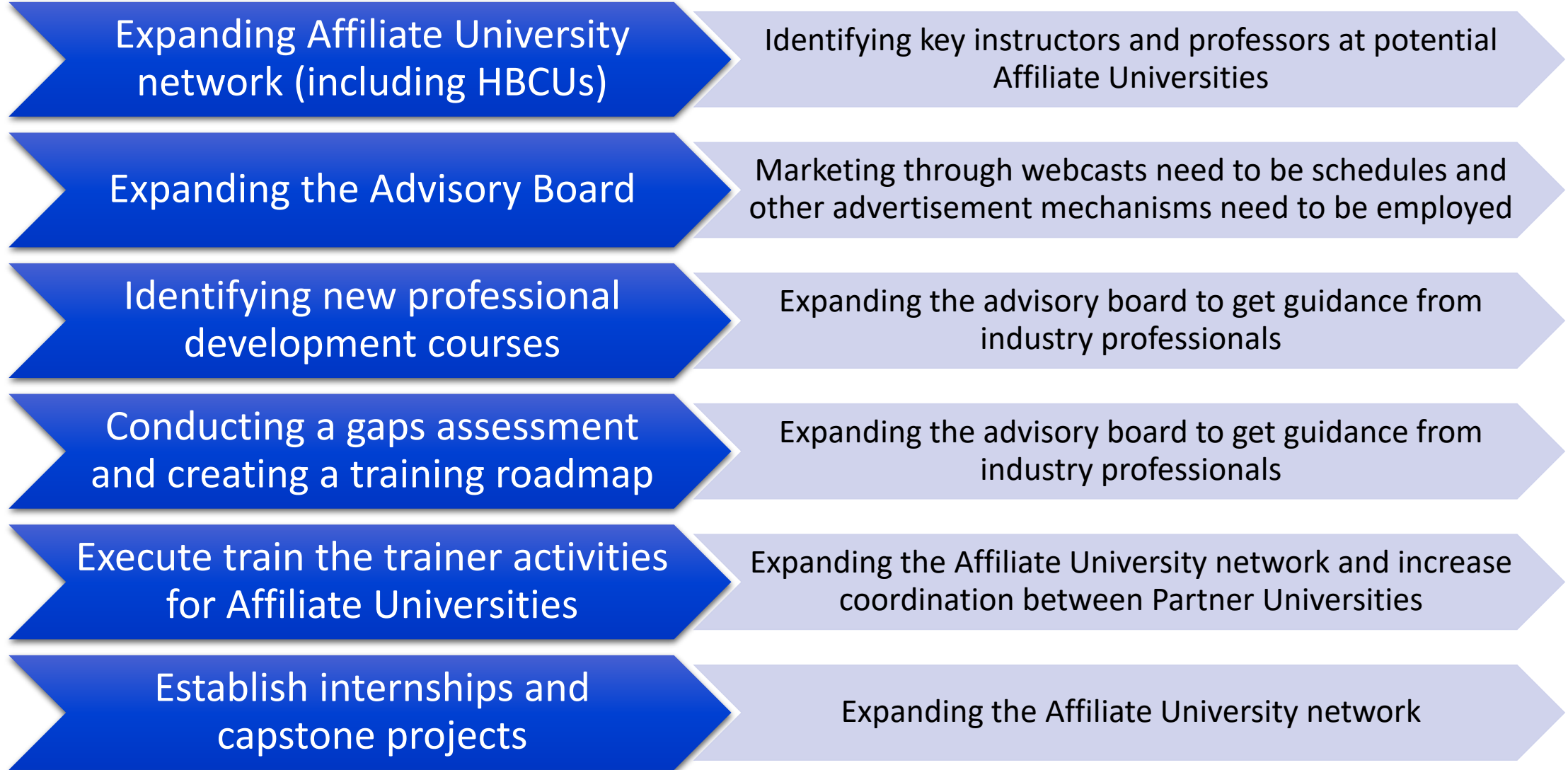
- Change in Principal Investigator (PI)
 - Original PI retired
- Improve outreach of the H₂EDGE program to reach appropriate audiences for expanding the Affiliate University network
- Change in one of the original three Partner Universities

Addressing Challenges

- Eladio Knipping has taken over as the PI of H₂EDGE
- Published a Supplemental Project Notice (SPN) to recruit more industry participants to join and elect Affiliate Universities
- University of Houston has been completely onboarded and is on track to teach two courses in the Fall 2023 semester

Proposed Future Work

FY 2023 – FY 2024



Supporting Historically Black Colleges and Universities

A New DOE Task under H₂EDGE

- Engage with historically black colleges and universities (HBCUs) to provide opportunities to this potentially large underrepresented labor market by:
 - Identifying and recruiting HBCU institutions into the H₂EDGE project through industry sponsorship
 - Facilitating collaboration among participating institutions to meet the fundamental needs of the emerging economy
 - Providing HBCU students with hydrogen industry experience through capstone design projects and broad access to benefits through H₂EDGE's Affiliate University program

Ensuring that 40% of benefits will flow to faculty, students, and research staff

Publishing the Supplemental Project Notice

- Supplemental Project Notice (SPN) has been published on epri.com
 - Offers the opportunity for stakeholders to join H₂EDGE as an advisory role
 - Offers the opportunity to expand the affiliate university network
 - <https://www.epri.com/research/products/000000003002027469>

Training and Educating a Workforce for the Emerging Clean Hydrogen Industry via the *H₂EDGE* Initiative



The diagram illustrates the H₂EDGE initiative's workforce development model. It features a central graphic with a university building, a person, and a progression of four human figures representing career stages: New Hires, Entry-Level, Mid-Level, and Senior-Level, leading to Retirement. Below this, a box labeled 'GridEd The Center for Grid Engineering Education' is shown with arrows indicating the flow of 'Capture Existing Technical Know-How' and 'Research Results' into the workforce pipeline.

Background, Objectives, and New Learnings
Clean hydrogen technology is rapidly developing as an option to help decarbonize our energy system, potentially leading to vast new employment opportunities across a wide variety of industries with a range of skills and earnings potential. Many of these jobs do not currently exist and do not have occupational titles defined in official classifications. In addition, many of these roles would require different education and skills than current jobs. As a result, training requirements must be assessed so that this rapidly growing part of the economy has a sufficient supply of qualified, educated, trained workers. Educating a hydrogen industry workforce in new practices, equipment, and standards is essential for enabling hydrogen's potential role in decarbonization.

An EPRI team, known as **The Center for Grid Engineering Education (GridEd)**, was recently granted a U.S. Department of Energy (DOE) award titled Hydrogen Education for a Decarbonized Global Economy (*H₂EDGE*) for developing a workforce for the emerging clean hydrogen economy. *H₂EDGE* has teamed with the Low Carbon Resources Initiative (LCRI) which provides augmenting assets to enhance the value of this important workforce development activity. Furthermore, universities and industry partners complete the *H₂EDGE* partnership.

GridEd is a self-sustaining program that features eight years of DOE supported initiatives by establishing an ongoing enterprise for workforce development. With this continuation, EPRI is expanding its technical reach to the clean hydrogen economy. GridEd's *H₂EDGE* initiative will work with industry, government, and universities to train a hydrogen industry workforce. Training a cadre of engineers and technicians will poise the industry for success. The result will be educational

material in many forms suited to train both existing and new hydrogen industry professionals, as well as educating university students.

Benefits
Companies joining *H₂EDGE* will benefit from the principles and practices of the program as characterized by the following:

- Advancing workforce knowledge through a robust professional training/retraining program for individuals entering or shifting their skills to the hydrogen industry marketplace.
- Building collaborative relationships between hydrogen industry organizations and local universities to contribute to a national university network that is committed to advancing a curriculum that supports the growing hydrogen economy.
- Contributing to university and college infrastructure, with an integral focus on Historically Black Colleges and Universities (HBCUs), to prepare a workforce for the emerging hydrogen economy.
- Engaging university/college students to expand the talent pool of qualified hydrogen energy workforce participants.

Project Approach and Summary
GridEd is expanding its scope with the *H₂EDGE* award from DOE. The new team of **Partner Universities** consists of Oregon State University, University of Delaware, and the University of Houston. These universities and the *H₂EDGE* technical team will utilize knowledge of hydrogen technology, industry R&D results, and specialized expertise to meet the objectives of *H₂EDGE*. The **Low Carbon Resources Initiative (LCRI)** will provide vital knowledge from its research

Summary

Overview/**Accomplishments**

- The H₂ industry is expected to grow, and thus, create more jobs within the industry
- H₂EDGE has:
 - established and built partnerships with universities and industries
 - developed course material at both the university and professional level
 - begun to create an Affiliate University network
 - measured university course effectiveness

Progress towards key targets

- Continuing to deliver all professional short courses
 - Expand course offering to new topics
- Continuing to teach new/revised courses at universities
- Expanding the Affiliate University network
 - The anticipated expansion of the Advisory Board will lead to an expansion of the Affiliate University network

H₂EDGE is working to build a sustainable infrastructure to develop a workforce for the emerging hydrogen economy as a part of a global decarbonized economy