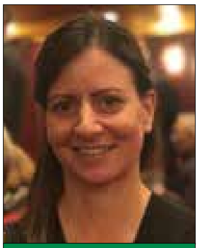
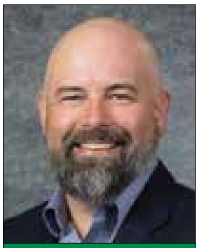
H_2CIRC Closes the Loop on Fuel Cells and Electrolyzers

H_2CIRC is the newest of AIChE's Industry Technology Alliances (ITAs), starting up officially on Jan. 1, 2025. H_2CIRC is funded by $50 million of federal funding from the Hydrogen Fuel Cell and Technology Office (HFTO) in the Energy Efficiency and Renewable Energy Office (EERE) at the U.S. Dept. of Energy (DOE), plus $13 million of cost share over five years. In addition to AIChE, the consortium consists of 15 member organizations — eight companies, four universities, and three national labs. H_2CIRC is led by co-directors Michelle Bryner of AIChE as the Business Director and Todd Toops of Oak Ridge National Laboratory (ORNL) as the Technical Director. A Technical Advisory Board (TAB) made up of a representative from each member organization provides technical guidance to the Directors, and an External Stakeholder Advisory Board (ESAB) has been formed to provide additional perspective on overall direction.

In this Q&A, co-directors Bryner and Toops discuss the consortium's mission, technical challenges, and innovative approaches, all aimed at strengthening U.S. manufacturing, energy security, and the hydrogen economy.



Michelle Bryner



Todd Toops

What are the mission and key goals of H_2CIRC?

H_2CIRC's mission is to recover and recycle the critical materials used in fuel cells and electrolyzers. The recycling of critical materials contributes to expanding Americans' access to reliable, affordable, and secure energy. By developing processes to recycle fuel cells and electrolyzers, the U.S. can develop robust manufacturing and secondary critical material production without relying on foreign supply.

Fuel cells and electrolyzer devices also play a critical role in U.S. manufacturing. Fuel cells are broadly used as a power source for multiple applications, including material handling, and are being demonstrated as backup power sources for data centers and low-noise power sources in military applications. Electrolyzers produce hydrogen, which is used in a range of industries, including oil refining, ammonia production, fuel cells, and methanol production. Its use is growing in other industries, such as steel and cement manufacturing, and in supporting nuclear power.

Why is it critical to develop recycling solutions specifically for hydrogen electrolyzers and fuel cells at this stage of the energy transition?

The critical materials in fuel cells and electrolyzers include precious metals, platinum and iridium, as well as other essential materials such as fluorine, titanium, and graphitic carbon. Recovering the graphite and the fluoropolymer membranes are unique features of H_2CIRC, as the current recycling process of pyrolysis destroys these materials. Recovering these materials from components that are already in the U.S. protects the domestic supply chain and reduces the reliance on mining and processing that occur in other countries like China.

What are some of the biggest technical or logistical challenges involved in recycling these systems, and how does H_2CIRC plan to address them?

Developing a cost-effective, scalable process that can recover both the fluoropolymer and the precious metals is currently limiting the launch of a domestic recycling industry. This consortium is pursuing multiple recycling pathways in conjunction with rigorous technoeconomic analysis (TEA). Additionally, H_2CIRC is unique in its membership, because most of the industry partners are competitors in the same market or industry. Despite the inherent difficulties in managing intellectual property among competitors, we successfully established a framework of agreements that benefits all parties involved. The importance of this research topic is highlighted by the collaborative spirit that is essential for the success of both the consortium and the industry overall.

The consortium brings together partners from across industry, government, and academia. How are these stakeholders collaborating, and what unique strengths does each bring to the table?

The founding H_2CIRC consortium members have skills and experience that span the value chain of proton exchange membrane (PEM) fuel cells and electrolyzers, including:

- a major domestic fluoropolymer manufacturer — Chemours

• catalyst suppliers/recyclers — Heraeus and Johnson Matthey (JM)

• the leading original equipment manufacturers (OEMs) — Plug Power, Nel Hydrogen, Cummins, and General Motors (GM).

The expertise also spans the research, development, and demonstration (RD&D) range from the industrial scale to the advanced capabilities at the national labs and universities. These partners include ORNL, Lawrence Berkeley National Laboratory (LBNL), National Renewable Energy Laboratory (NREL), Univ. of Delaware (UD), Worcester Polytechnic Institute (WPI), Delaware State Univ. (DSU), and Univ. of Houston (UH). TEA expertise is provided by an industry-leading professional consulting firm, Strategic Analysis Inc. (SA).

What role does AIChE play in leading H_2CIRC?

AIChE is the Prime organization of the award and is responsible for the success and compliance of the consortium. This role allows AIChE to lean into its ability to convene diverse stakeholders to work together toward a shared vision. H_2CIRC complements AIChE's landscape of ITAs that also include the Center for Hydrogen Safety (CHS), the Center for Chemical Process Safety (CCPS), the Design Institute for Physical Properties (DIPPR), and our RAPID Manufacturing Institute.

What are some early success stories or milestones the consortium has already achieved — or hopes to achieve within the next year?

The consortium is on track to demonstrate a complete recycle process within the first year of the project that meets at least 50% of the end-of-project goals: 99% platinum, 95% iridium, and 75% fluoropolymer recovery. This includes re-manufacturing membrane electrode assemblies (MEAs) for both fuel cells and electrolyzers and then evaluating their performance and durability.

How does H_2CIRC plan to ensure that the processes developed are scalable and economically viable in real-world supply chains?

Scalability and economic viability are designed into every aspect of the project and will be captured through the TEA. To ensure viability, each of the approaches considered must be performed at speeds commensurate with the speed of manufacturing fuel cells and electrolyzers. Projections for fuel cell manufacturing rates include approximately 1–2 seconds per ~350 cm^2 fuel cell MEA; and for electrolyzer MEAs, approximately 1 electrolyzer MEA per minute for 1 m^2 cells.

The TEA will guide decision points about the most impactful technology to further pursue. Additionally, H_2CIRC is promoting material traceability through the development of a unique digital passport for fuel cell and electrolyzer materials. This aims to track materials and the costs incurred through the recovery process while providing a quantitative value to the manufacturer.

What excites you personally about being involved in H_2CIRC, and what do you hope the long-term impact of this work will be?

What excites us most about this consortium is the significant impact that we will have on U.S. manufacturing and the country's energy security. Additionally, seeing the collaboration that the consortium members are bringing to the program gives us a lot of hope that we will be successful in launching a new recycling industry that will strengthen America's energy security and access to critical material supplies. CEP