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Energy Quarterly

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"Future energy, fuel cells, and solid-oxide fuel-cell technology" title image shows a 2.8-MW molten carbonate fuel-cell system on the University of California, San Diego (UCSD) campus that operates on waste methane gas from a wastewater treatment plant. The fuel cell provided about 7% of UCSD's total energy needs. Credit: UCSD.

"Electrolysis for hydrogen production" title image credit: Luz Adriana Villa, Flickr Creative Commons.

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MRS Bulletin

Time is critical for fuel-cell resurgence

Fuel cells have had an on-again/off-again romance with the public and with policymakers. When I started graduate school, oh so long ago, battery research was considered old and stodgy; solar-cell research was the realm of the dreamers; and nuclear-reactor research had suffered a devastating blow from the Chernobyl disaster. Fuel cells, on the other hand, were the young upstarts—eliciting optimism, grounded in reality, and free of a worrisome safety record. They were sure to revolutionize the energy delivery infrastructure and usher in a sustainable future. And the technology could be embraced across the political spectrum. The oil and automotive industries anticipated a future in which hydrogen for transportation could be derived from fossil fuels and in which consumer habits would be completely unchanged. On the other end of the political divide, environmentalists could imagine hydrogen produced directly from solar energy. Years later, the latter would spawn tremendous global activities under the banner of "solar fuels."

As research efforts pushed on, however, technical barriers to bringing fuel cells out of the laboratory and into the marketplace became increasingly evident. High power density, manufacturability, long-term stability, and cost-competitiveness all proved more difficult to attain than anticipated in those heady days. But the real culprit may well have been the recognition that a hydrogen infrastructure would require an immense financial investment and yet might still not reduce carbon emissions. In 2008, the Obama administration in the United States swept in and, under pressure of a financial crisis, took a cold hard look at the fuel-cell hype. The administration concluded that the hydrogen obstacle was financially insurmountable, and that the reliance by entrenched interests on a distant fuel-cell future was a ploy to stave off real, near-term solutions. Federal programs were canceled, venture capitalists pulled out of fuel-cell startups, and researchers turned their attention elsewhere. Even though the practitioners knew that fuel cells come in different flavors, and only some require hydrogen, it would take several years before a national commitment to fuel cells would be rekindled.

Today, we see that exceptional progress is being made in fuel-cell research, and the excitement surrounding this technology has returned. The number of publications on solid-oxide fuel cells, for example, which peaked in 2011 (a trailing indicator of funding priorities) and then waned, has largely recovered. Significantly, the results reported in these publications reflect major breakthroughs in fuel-cell power outputs and stability, critical factors that ultimately feed into cost-effectiveness and market viability. Peak power densities now routinely exceed 1 W/cm^2 at 600°C, and lifetimes exceed several thousand hours with negligible degradation. However, we don't need wild swings in attention. With just a few years to go before the damage of climate change becomes irreparable, we don't have time for another research lull. We need sustained efforts that create deep knowledge and support innovative problem solving. Fuel cells, particularly when operated reversibly using excess electricity to generate hydrogen or other compounds of high-energy content, can fill an important role for long-term energy storage and electricity production on-demand. They can complement batteries in a sustainable energy future fueled by solar and wind and perhaps even nuclear resources. I am fully convinced that with focus and determination, fuel cells will follow the breathtaking development path taken in the last decade by solar cells and wind energy. All hands on deck.

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