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The Origin of Hydrail and the *International Journal of Hydrogen Energy*

By Stan Thompson, Co-Founder, The Mooresville Hydrail Initiative

In 2004, the Mooresville South Iredell Chamber of Commerce had, for a couple of years, been pursuing with limited success the creation of an inevitable, but yet-to-be-born revolution in railway traction—hydrogen fuel cells. Working with the Charlotte Area Transit System (CATS), Mooresville was seeking to pioneer the world debut of hydrogen commuter trains for pollution and climate change abatement. Our immediate priority was to attract federal innovation funding to help fund Mooresville's portion of a proposed Charlotte-Mooresville commuter line.


Hydrogen powered Coradia iLint train

The players in this audacious game were the rising Chairman of the Chamber (and soon to be Mooresville's Mayor) Bill Thunberg; an engineering wizard from Ingersoll-Rand named Jim Bowman; and myself—a recently retired long-range planning engineer, corporate planner, and futurist from what is now AT&T.

Our efforts had met with some interest by a railcar company and with strong interest by the U.S. Department of Transportation's "think tank" at the Volpe National Transportation Systems Center in Cambridge, MA. In August, 2003, I was invited to Volpe by Senior Engineer Gary Ritter to present "The Mooresville Hydrail Initiative" to a US Department of Defense and Industry team designing a hydrogen switching locomotive.

Our top priority was making government agencies and the public aware that a new, potentially carbon-free, and non-polluting railway technology was possible.

I realized that it would be a challenge to convince industries with massive capital assets that hydrogen was the way to go because change can be extremely expensive.

To make hydrail credible, I surfed the internet for fuel cell rail projects around the world. One day, I found that some Cal Tech Scientists were concerned that hydrogen leakage might exacerbate the Antarctic ozone hole problem, but that a Dr. T. Nejat Veziroglu of the University of Miami disagreed. I contacted Dr. Veziroglu and told him about Mooresville's hydrail initiative. He was intrigued by the rail angle and, as President of the IAHE, asked me to submit a story about it for the non-peer-reviewed "News and Views" section of the IJHE. I did, and it appeared in the February 2004 issue.

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IAHE Objective

The objective of the IAHE is to advance the day when hydrogen energy will become the principal means by which the world will achieve its long-sought goal of abundant clean energy for mankind. Toward this end, the IAHE stimulates the exchange of information in the hydrogen energy field through its publications and sponsorship of international workshops, short courses, symposia, and conferences. In addition, the IAHE endeavors to inform the general public of the important role of hydrogen energy in the planning of an inexhaustible and clean energy system.

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This introduced "hydrail" into the English language. Thanks to the internet, hydrail soon became the generic term used for all wireless rail vehicles carrying electric energy onboard as hydrogen.

"Hydrail" was coined in the IJHE to provide a unique searchable target word and helped integrate work on the subject by scientists and engineers around the world.

By far, the biggest hurdle for hydrail implementation was making the public aware that familiar 19th century trolley technology was no longer the future of railway electrification. To prove to Charlotte that it was OK to consider a new option, we wanted to show that we were not alone.

To that end, on May 5, 2005, we organized the First International Hydrail Conference (1IHC) in Charlotte. The USA, Canada, Denmark, and Japan participated in the conference. The EnviroTeam at the Bank of America's headquarters was the primary funding sponsor.

Because of hydrail's air quality improvement potential (Charlotte was faced with draconian US EPA sanctions), Charlotte's Chamber of Commerce, the Centralina Council of Governments and the State of North Carolina's Energy Office also helped fund the hydrail conference. Jason W. Hoyle of Appalachian State University's Energy Center produced the event and created the hydrail web site, which remains hydrail's academic clearing house.

In 2006, Denmark hosted 2IHC and in 2007, 3IHC was held at Catawba College in North Carolina. 4IHC was held in Valencia Spain, and by then the focus was getting actual hydrail trains on the ground as early as possible. In 2010, with help from Dr. Veziroglu, 6IHC was hosted in Istanbul by the United Nations Industrial Development Organization. 7IHC was held at the University of Birmingham's Centre for Railway Research and Education.

At 8IHC in 2013, at Ryerson University in Toronto, Canada, the keynote presenter was Hydrogenics CEO, Daryl Wilson. There he connected with train builder Alstom Transport of France and, after a year of quiet planning, Alstom and Hydrogenics announced in Berlin at InnoTrans 2014 that the first fleet of forty hydrail trains would be in service in four German states by 2020.

Just as planned, the international hydrail conferences had birthed a new, green, fuel cell rail industry.

In 2013, I went to Shanghai as a guest of the Southwest Jiaotong University for the Fifth World Hydrogen Technology Conference, dedicated to Dr. Veziroglu. There I spoke and chaired the hydrogen locomotive session. Two years later, Chinese hydrail trams were being manufactured by CSR Sifang Co., Ltd. and Tangshan Railway Vehicle Company.

In September 20, 2016, eleven years after 1IHC, I was invited to Berlin for the unveiling of the prototype of Alstom Transport's first full-scale hydrail train, the Coradia iLint.

Today the international hydrail conferences' climate protection goal is to supplant diesel railway traction with wind, solar, hydroelectric, and other carbon-free sources as rapidly and as widely as possible and to forestall stranded investment in "wired" railway electrification.

Just as diesel trains replaced steam, hydrail has begun replacing diesel. The Twelfth International Hydrail Conference will be in Graz, Austria, June 27-28, 2017.

China and Japan have inquired about hosting in the future.

Mooresville's hydrail vision in the February 2004 issue of the IJHE has now been realized.

Hydrail Photo Gallery

Inside of the Coradia iLint hydrail train

Alexander Dobrindt—Minister of Transportation, the Federal Republic of Germany—with Stan Thompson aboard Alstom Transport's first Coradia iLint hydrail train at InnoTrans 2016, Berlin, September 20, 2016.

CSR Qingdao Sifang tram

Tangshan Railway hydrogen-powered tram

Stan Thompson, at InnoTrans 2016 in Berlin, with the hydrail train he described in the IJHE's February, 2004, issue.

DOE announces $30 million investment in hydrogen and fuel cells as industry continues unprecedented growth rates

In commemoration of National Hydrogen Day (Oct. 8), aptly chosen for the atomic weight of hydrogen (1.008), the Energy Department (DOE) released a new report showing continued momentum and growth in the fuel cell industry. The 2015 Fuel Cell Technologies Market Report shows that hydrogen and fuel cells continue to grow at an unprecedented rate, with more than 60,000 fuel cells, totaling roughly 300 megawatts (MW), shipped worldwide in 2015. The number of MW shipped grew by more than 65% compared to 2014. 2015 also saw the world's first fuel cell vehicles for sale. To further expand on this emerging market, the Department today announced a notice of intent to invest $30 million, subject to appropriations, to advance fuel cell and hydrogen technologies. These projects will leverage national lab consortia launched under DOE's Energy Materials Network (EMN) this past year, and will support the President's Materials Genome Initiative and advanced manufacturing priorities.

"DOE-supported fuel cell and hydrogen research have helped reduce the cost of transportation fuel cells by 50% since 2007 by quadrupling durability, and reducing the amount of platinum by a factor of five," said Acting Assistant Secretary for Energy Efficiency and Renewable Energy David Friedman. "We are pleased to highlight the progress and significant potential of this emerging technology by recognizing National Hydrogen and Fuel Cell Day on October 8."

Applicants to the Energy Department's Fuel Cell Technologies Office's fiscal year 2017 funding opportunity will collaborate with national lab consortia stemming from the EMN initiative. The EMN consortia have been launched to make unique, world-class capabilities at the national laboratories more accessible to industry and academia, facilitating collaborations that will expedite the development of advanced materials. National lab consortia that will be leveraged include:

- Electrocatalysis Consortium (ElectroCat)–will accelerate the development of catalysts made without platinum group metals (PGM-free) for use in transportation fuel cell applications.
- HydroGEN Consortium (HydroGEN)–will accelerate the development of advanced water splitting materials for hydrogen production, with an initial focus on advanced electrolytic, photoelectrochemical, and solar thermochemical pathways.
- Hydrogen Materials—Advanced Research Consortium (HyMARC)–aims to address unsolved scientific challenges in the development of viable solid-state materials for storage of hydrogen onboard vehicles.

Fiscal year 2017 funding will also be targeted at the development of low-cost, high-strength precursors for carbon fibers that can be used in vehicular hydrogen storage vessels. Applicants for this topic will be encouraged to collaborate with LightMat, an EMN consortium launched by the DOE Vehicle Technologies Office to enable lightweighting of vehicles through the development of high-strength steels and carbon fiber. In addition to transportation applications, hydrogen has the potential to decarbonize multiple sectors by enabling renewable, energy storage, and low carbon industrial applications.

To further support hydrogen and fuel cell innovation, the DOE's Federal Energy Management Program (FEMP) is partnering with the Fuel Cell Technologies Office (FCTO) to develop training modules, including safety and outreach modules, as part of FEMP's training program. This collaboration will continue to grow FEMP's diverse offerings of training courses and build on FCTO's existing outreach efforts to various stakeholders. For example, more than 36,000 emergency responders and code officials have been reached through on-line and in-person trainings. This partnership will allow for broad dissemination of information and increased awareness of hydrogen and fuel cell technologies.

All of this points to a hydrogen and fuel cell market that continues to grow rapidly. According to the DOE's 2015 Fuel Cell Technologies Market Report, many U.S. state efforts during the year focused on encouraging the growth of fuel cell electric vehicles (FCEVs) on state roadways, particularly in California, where two commercial FCEVs are available to customers (Hyundai Tucson Fuel Cell and Toyota Mirai), as well as the development of hydrogen fueling infrastructure. These efforts, in California, Hawaii, Connecticut, Massachusetts and New York, include grant funding for station development and rebates for the

purchase of FCEVs.

Source: http://energy.gov/eere/articles/doe-announces-30-million-investment-hydrogen-and-fuel-cells-industry-continues

Energy Department highlights top three hydrogen and fuel cell states with more focus on domestic manufacturing

The Department of Energy's (DOE's) Fuel Cell Technologies Office (FCTO) has announced the top three states in hydrogen and fuel cell industry activities while now seeking stakeholder feedback to improve standardized manufacturing in the industry. According to the newly released *State of the States: Fuel Cells in America 2016* report, the top three hydrogen and fuel cell states are California, Connecticut, and New York. California is home to the greatest number of stationary fuel cells, while Connecticut and Delaware are home to the largest installations (roughly 15 MW and 30 MW, respectively—equivalent to power approximately 15,000 houses and 30,000 houses, respectively).

While hydrogen cars hit the streets and hydrogen stations spring up around the country, the industry has seen a consistent growth rate of 30% per year since 2010. According to the report, the northeast hydrogen and fuel cell supply chain contributed nearly $1.4 billion in revenue and investment, supported more than 6,550 direct and indirect jobs, and industry labor reported income of approximately $620 million just in 2015 alone. The report also shows that California's advanced energy economy is growing six times faster than the overall economy and represents 3% (500,000) of workers across the state.

Meeting the demand in certain markets in the U.S. and around the world is helping contribute to a resurgence of manufacturing. In an effort to streamline manufacturing, DOE has issued a request for information (RFI) to obtain feedback from stakeholders regarding how and which components in the hydrogen and fuel cell manufacturing process can and should be standardized. The intent of the RFI is to identify manufacturing pathways to reduce costs in both the near and long-term, as well as how to address any critical barriers regarding manufacturability and supply chain development.

While not all components can or should be standardized, the cooperative development of certain components with universal sizes, functions, and materials will encourage competition and advanced manufacturing to drive down costs and increase product durability. Standardization can also help to maximize compatibility, interoperability, safety, repeatability, and quality.

These announcements were made at the 2016 Hydrogen and Fuel Cell Industry Forum hosted by the Northeast Electrochemical Energy Storage Cluster (NEESC) and the Connecticut Green Bank. The forum brought together investors and stakeholders in the hydrogen and fuel cell industry, including original equipment manufacturers, suppliers, and service providers in the Northeast, to facilitate business connections, expand market opportunities, and explore hydrogen and fuel cell technology that can effectively address our nation's pressing energy and climate concerns.

The Office of Energy Efficiency and Renewable Energy accelerates development and deployment for energy efficiency and renewable energy technologies and market-based solutions that strengthen U.S. energy security and economic vitality. Learn more about the Energy Department's broader efforts to develop affordable, efficient fuel cell and hydrogen technologies on EERE's Hydrogen and Fuel Cells website.

Source: http://energy.gov/eere/articles/energy-department-highlights-top-three-hydrogen-and-fuel-cell-states-more-focus

It's all about building a clean energy economy

By: Mindy Lubber

Last week, while U.S. voters were casting their ballots, Walmart announced plans to double its renewable energy goals—to 50%, by 2025—and to buy half of its electricity from a Texas wind farm. On Wednesday, one day after the election, General Mills, Staples and a half-dozen other companies sent a letter to Michigan lawmakers urging them to boost the state's renewable portfolio standard, which has already attracted $3 billion in clean energy investment in the state.

These examples are important reminders that, no matter

who the president is, business leaders are committed to a clean energy future. While this week's U.S. election is creating legitimate distress, we should refrain from thinking it will completely thwart climate action and the clean energy economy in the U.S. and around the world.

But we should also learn from the election. The voting results are a clear signal that we must do a better job communicating with the American public and others around the world about complex issues like climate change. We need to find more common ground and inclusiveness in tackling this global threat and its far-reaching job and technology-related implications.

With the economy at stake and the facts on our side, I remain optimistic.

As it relates to building a clean energy economy—there is no confusion. It is now cheaper to cut carbon emissions and use renewable energy than it is to continue to rely on fossil fuels. It is true in Minnesota and Colorado, where wind power is out-competing fossil fuel power plants. It is also true in Morocco and Kenya, where solar and wind power is far cheaper than importing oil.

What is especially important now is that leading investors, businesses and world leaders continue seizing on these enormous opportunities by following the visionary path forged by COP21.

The drive to decarbonize the U.S. energy economy will continue regardless of the actions that our next president takes—or doesn't take—because of the rapidly expanding deployment of clean energy solutions by states, cities, and businesses across the country.

While there are divisions between Democrats and Republicans on climate policy, there has been bipartisan support for investments in clean energy as well as in climate resilience. Working with investors and companies in our networks, we will be moving swiftly to make the case for such investments to the new administration and Congress, including support for new infrastructure initiatives that President-elect Donald Trump has already pledged to put forward.

Source:
http://www.forbes.com/sites/mindylubber/2016/11/10/its-all-about-building-a-clean-energy-economy/#79dc9ee06bd1

EDF Renewable Energy Signs Agreement with Otter Tail Power Company

EDF Renewable Energy and Otter Tail Power Company announced the signing of an Asset Purchase Agreement by which EDF RE will construct the 150 megawatt (MW) Merricourt Wind Project. Upon completion, the wind project will be turned over to Otter Tail Power Company. The transaction closing is subject to conditions.

Merricourt Wind Project, located on approximately 13,700 acres south of Edgeley, North Dakota, in McIntosh and Dickey Counties, will consist of 75 Vestas V110-2.0MW wind turbines. The wind turbines are expected to be manufactured in Vestas' Colorado-based facilities. The Project further will create 150+ construction jobs and 10 long-term, full-time positions as well as inject millions of dollars in economic benefits to the local area. Upon commercial operation in 2019, renewable energy will be provided to approximately 65,000 homes in the Otter Tail Power Company service territory.

"We are excited to be partnering with Otter Tail Power Company to deliver competitively priced, clean energy to OTPC's customers through the Merricourt Wind Project," said Ryan Pfaff, Executive Vice President at EDF Renewable Energy. "The Project will also provide an economic boost to the North Dakota economy, through new construction and operations jobs, expanded tax base, and recurring, long-term income for participating landowners."

Today wind energy supplies approximately 19 percent of the Otter Tail Power Company's electricity generation. With this addition, customers will receive nearly 28 percent of their energy from wind. Otter Tail Power Company President Tim Rogelstad said, "Our North Dakota service area has some of the best wind resources in the country to produce low-cost energy. And, because of advances in technology, this wind farm will have a high energy output—even by North Dakota standards."
Source:
www.businesswire.com/news/home/20161117005797/en/EDF-Renewable-Energy-Signs-Agreement-Otter-Tail

Hydrogen Vehicle News

Honda's Clarity fuel cell can drive 366 miles on a single tank of hydrogen

By: Andrew Hard

Hydrogen-fueled vehicles remain a controversial subject, but proponents of the technology just picked up a serious feather for their zero-emission caps. Honda has announced that its upcoming Clarity Fuel Cell sedan will feature an Environmental Protection Agency driving range of 366 miles, which gives it the best rating of any electric vehicle without a combustion engine range extender. That means if you're looking to take a road trip without spewing any additional carbon into the atmosphere, hydrogen might just be your best bet.

Of course, there are major drawbacks to cars like the Clarity. The most obvious is the lack of a nationwide fueling infrastructure, which is why Honda's hydrogen vehicle will only be sold at 12 California dealerships when it arrives at the end of 2016. The brand is working hard to expand the reach of hydrogen, and eventually, the automaker believes owning a fuel cell car will be just as convenient as owning the gas-powered equivalent.

"Not only does the Clarity Fuel Cell fit five passengers and refuel in three to five minutes, it offers customers a driving range on par with gasoline-powered cars," said Steve Center, vice president of Honda's Environmental Business Development Office. "The Clarity leads the pack with a 366-mile driving range rating, and with a growing network of hydrogen stations and fast fueling time, the zero-emissions family road trip is no longer science fiction."

As for the vehicle itself, the Clarity Fuel Cell is slated to arrive by year's end and will start at around $60,000. However, Honda will lease the cars, at first, with a monthly rate of less than $500, keeping it right in line with the Toyota Mirai and Hyundai Tucson. Speaking of the competition, both the Mirai and Tucson Fuel Cell include three years of complimentary hydrogen fill-ups, however Honda didn't say whether it would offer the same.

Plug-In Hybrid and Electric variants of the Clarity will go on sale in 2017 after the Fuel Cell launches, but unlike its more exclusive siblings, the Plug-In Hybrid will be available in all 50 states.

Source: http://www.digitaltrends.com/cars/honda-clarity-hydrogen-fuel-cell-has-366-miles-of-range/

Lexus Hydrogen fuel cell car planned for 2020

By: Larry E. Hall

Following in the tire tracks of the Toyota Mirai hydrogen fuel cell car, Lexus is planning its own luxury version to arrive by 2020.

Speaking with British car magazine *Auto Express*, Alain Uyttenhoven, head of Lexus Europe said that Lexus is adapting the hydrogen fuel technology developed by parent company Toyota and that there are only a few hurdles left to overcome.

"The problem is packaging the technology into a normal sized car," he said. "It will fit into an SUV. We just need to get the right level of performance for a premium car."

The new fuel cell car could be similar to the large fuel-cell flagship sedan LF-FC that debuted at last year's Tokyo Motor Show.

The show car was powered by fuel cells that sent energy to all four wheels, with two in-wheel motors.

The fuel-cell stack is mounted in the rear of the vehicle, with a control unit in front and a T-shaped arrangement of hydrogen tanks.

Uyttenhoven's comments indicate that the new car would have a significant bump in power compared to the Mirai, which produces 152 horsepower.

Lexus could launch a fuel cell LS in time for the 2020 Tokyo Olympic Games, which Toyota is sponsoring.

The Olympics have long favored using zero-emission electric vehicles to accompany events, given concerns over the quality of the air athletes must breathe.

A fuel cell LS would be a "statement" car, a way for Lexus to show off to the world its forward-thinking technology

and get the jump on competition.

Source: http://www.hybridcars.com/lexus-hydrogen-fuel-cell-car-planned-for-2020/

Lack of cheap, clean hydrogen slows fuel-cell cars

By: Umar Irfan

It's been a good year for fuel cells.

In September, the HY4, the first hydrogen fuel-cell-powered passenger aircraft, took flight in Germany. French industrial giant Alstom also unveiled a fuel-cell-powered train.

Several automakers in the United States now offer fuel-cell-powered cars for sale as hardware costs have plummeted. Toyota Motor Corp. ramped up production of its hydrogen fuel-cell-powered car, the Mirai, from 700 units last year to 2,000 this year, and is aiming to make 3,000 in 2017.

California now has more than 20 hydrogen fueling stations, and the Department of Energy and the National Park Service unveiled a hydrogen fueling demonstration facility in Washington, D.C., as the agencies have added hydrogen-powered cars to their fleets.

On Oct. 8, DOE celebrated hydrogen and fuel-cell day (the date was chosen to symbolize the atomic weight of hydrogen: 1.008), highlighting how the agency's research efforts have driven fuel-cell costs down.

"This is a really exciting time," said Sunita Satyapal, director of the fuel-cell technologies office at DOE. "Through our independent analysis, we've seen costs come down by 50 percent since 2007."

Yet hydrogen fuel-cell vehicles still lag far behind electric cars, and the hydrogen economy hasn't blossomed, even though the technology has been around since the 1970s.

Since 2008, Americans have bought more than 500,000 plug-in electric cars, but fewer than 500 fuel-cell cars.

The cells themselves have made dramatic improvements in efficiency and cost, but the infrastructure needed to support them remains a weak point, researchers and analysts say.

Fuel cells use a fuel to generate electricity via an electrochemical conversion process. In a hydrogen fuel cell, a catalyst separates electrons and protons in hydrogen atoms to generate a current, releasing water as the only by-product. The process is two to three times more efficient than combustion, according to DOE.

This makes fuel cells an appealing energy system for vehicles, especially since fuel cells closely match how people already drive. A hydrogen fuel tank can fill up in a few minutes, compared to several hours for a battery.

But there are some caveats: Like a battery-powered car, fuel cells are only as clean as the fuel that powers them. Hydrogen can be generated from splitting water molecules, but the most common and cheapest way to make hydrogen is steam reforming methane, the major component of natural gas. This process produces greenhouse gases.

Satyapal said researchers are now developing ways to produce hydrogen cheaply from renewable sources. "Our target is $4 per gallon of gasoline-equivalent cost," she said. Current retail prices for hydrogen fueling stations are between $13 and $16.

The other challenge is the fueling stations. Places that can provide hydrogen to fuel-cell cars are expensive to build and have fewer cars with which to recoup their costs at the outset.

Fueling stations need large storage tanks that can hold hydrogen at very high pressures, and much of the hardware is being developed for the first time, further raising prices.

"It's a very limited supply chain," said Satyapal. "Even a single nozzle can be very expensive."

Electric cars, on the other hand, can charge up at a wall outlet, albeit slowly. This gap in infrastructure means it's going to be hard to convince people to buy fuel-cell-powered cars for a while.

"Really, we see the outlook for fuel-cell vehicles is pretty grim," said Chris Robinson, a research associate at Lux

Research Inc. "It's going to be really hard for a consumer to justify this."

There is one potential outlier: Japan.

"Japan is the one area where fuel-cell vehicles could really catch on," said Robinson. "Japan doesn't really have another viable option [for fuel] other than imports."

With limited natural resources and high energy prices, an island country like Japan can make a better case for a hydrogen economy. "You can, with a smaller number of stations, provide coverage to the entire island," Robinson said.

The Japanese government seems to agree and is investing heavily in hydrogen infrastructure.

And Satyapal is still optimistic about fuel cells catching on. While passenger cars may be a tough sell, fuel cell vehicles may make more sense for fleet vehicles that travel the roads during the day and return to a central station. Several automakers, including Toyota, have announced projects to develop fuel-cell-powered buses.

"This is not a laboratory curiosity anymore," she said. "We just have to keep up the momentum."

Source: https://www.scientificamerican.com/article/lack-of-cheap-clean-hydrogen-slows-fuel-cell-cars/

Hydrogen-powered ferry? National lab says it's possible, though costly

By: Erin Baldassari

It started with a simple question: Is it possible to build a commuter ferry capable of competing for customers crossing San Francisco Bay in a vessel completely powered by hydrogen fuel?

Tom Escher wanted to know. He's been at the helm of tour boat company Red and White Fleet since 1997, after he bought the company his grandfather founded in 1892. Thinking about the world he was leaving his grandchildren, Escher said he was tired of talking merely about reductions in emissions for diesel engines. He wanted to go to zero.

"It's great to reduce pollution by 10 percent, but we're never going to get rid of pollution unless we take an aggressive step," he said.

What followed next was a two-year quest involving a premier research laboratory, over two dozen government agencies and more than a dozen private companies. The result was a feasibility study released late last month, concluding that, yes, it is possible from a regulatory and technical standpoint, but costly.

Where that feasibility study will ultimately lead remains to be seen, but in a region and state on the leading edge of green technology, hope is growing that zero-emissions commuter ferries could one day be plying the bay.

Escher was familiar with hydrogen fuel cells—a nascent but growing industry emerging in California's personal automobile sector—which, if produced from renewable sources, is truly a zero-emissions technology. So, he brought his question to Livermore's Sandia National Laboratories, a federally funded research lab focused on national security.

Joe Pratt, a mechanical engineer for Sandia, had heard the question before. And he was accustomed to the same "no thanks" response after laying out the requirements and additional expense that accompany today's hydrogen fuel-cell technology. But instead of balking, Escher agreed.

"And I said, 'Well, I don't know if it's possible. No one has ever looked at powering a big vessel entirely with hydrogen fuel cells,' " Pratt recalled.

There had been small tour boats built with the technology but nothing quite like the workhorses that crisscross the bay, shuttling hundreds of passengers sometimes 20 nautical miles or more each way, several times a day. As luck would have it, the federal Maritime Administration was willing to invest $500,000 to fund Sandia's study. It was important to everyone involved that the resulting product be as practical as possible. That meant it had to be durable.

Unlike most automobiles, which tend to last an average of roughly 20 years, most vessels can last up to 40 or 50 years, said John Quinn, the Maritime Administration's

associate administrator for the environment and compliance, and they are a major expense for vessel operators.

"If you can't show (vessel operators) it works, they are hard-pressed to spend the kind of money to get the technology and change the fuels," said Michael Carter, director of the agency's Office of Environment.

With that in mind, Pratt assembled a team of experts in hydrogen technology and naval boat design and began reaching out to regulatory agencies and others, ultimately including nearly 50 offices, departments and companies. Their marching orders: design a commuter ferry that would travel at speeds of up to 35 knots, carry 150 passengers, and traverse four, 50-nautical mile round-trip routes each day.

The team had some important questions to answer, such as, "Would it even float?" said Sandia scientist Lennie Klebanoff.

"Could it carry a decent number of passengers? Would it meet the speed requirements of a ferry operating in this highly competitive ferry environment?" he said. "Would it achieve its goals of reducing not only criteria pollutant emissions like smog but also greenhouse gas emissions? That's just a handful of some of the feasibility questions that were completely unknown going into it."

And, perhaps more importantly, where would it refuel?

California leads the nation in hydrogen fueling stations with 22 stations operating statewide, another 26 under construction and a goal to reach 100 by 2024, according to the California Energy Commission. But unlike refueling stations for personal vehicles, which have an average daily capacity of 180 kilograms of liquid hydrogen, a hydrogen fuel-cell-powered ferry would need some 2,000 kilograms each day, said Phil Cazel, an air pollution specialist for the commission.

In a stroke of serendipity, a 2016 report by the Air Resources Board found that one of the highest-priority areas in the state for a hydrogen fueling station (or two) is San Francisco. Private operators approached the port earlier this year expressing their interest in applying for a state grant, said Rich Berman, the port's utilities specialist. And, Elaine Forbes, the port's interim executive director, issued a letter saying any fueling station, if approved, would also need to support maritime uses.

With the technical and regulatory questions largely out of the way, the final hurdle was cost. Hydrogen ferries cost 2 to 3.5 times as much to build, and are three to five times as expensive to operate as comparable diesel-powered ferries today.

Those estimates threatened to sink the dream, even though the researchers argued that as more people and companies adopt the technology, production would accelerate and costs would decrease. But just to ensure the project moves forward, the Maritime Administration awarded Sandia a second $250,000 grant to further optimize the design and bring down both the capital and operating expenses.

As researchers work on the final stage of analysis, Escher said he is beginning to fund-raise for the money to build it—a boat called the SF Breeze. That, Escher said, will just be the beginning.

"It will be a 30-meter ferry boat, then it will be a 40-meter tugboat and a 70-meter supply boat and a 300-meter ship trading between the U.S. and Hawaii," he said. "Somebody has to be bold."

Source:
http://www.eastbaytimes.com/2016/11/14/hydrogen-powered-ferry-national-lab-says-its-possible-though-costly/

Toyota Mirai hydrogen fuel-cell car wins Monte Carlo e-Rally

By: Stephen Edelstein

The Toyota Mirai hydrogen fuel-cell car can now add a motorsport victory—of sorts—to its resume of accomplishments.

A Mirai sedan won the 2016 e-Rally Monte Carlo, a rally exclusively for zero-emission vehicles held earlier this month in Monaco.

The winning Mirai was one of three in the event, which required competitors to cover more than 1,000 kilometers (621 miles).

A second car—co-driven by the mayor of Monaco—finished sixth, while a third car driven by a group of French journalists finished eleventh.

The 2016 e-Rally Monte Carlo is one of several races for zero-emission cars held in recent years by the Automobile Club de Monaco, the same organization behind the iconic Rallye Monte Carlo and Formula 1 Monaco Grand Prix.

In addition to the e-Rally, the group hosts an ePrix for the Formula E electric-car race series, on a modified version of the street circuit used for the Formula One race.

The 2016 e-Rally attracted 35 teams from nine countries, most of whom used battery-electric cars.

This is the first time a fuel-cell car has participated in this type of event, according to Toyota of France, which entered the winning vehicle.

The trio of Mirai fuel-cell cars was supported by a mobile fueling station, provided by infrastructure company Air Liquide.

Air Liquide has built 75 hydrogen fueling stations globally, and plans to install a small network in the Northeastern United States.

While the Mirai is by no means a performance car, it has appeared quite a few times at races over the past couple of years.

Prior to its competition debut at the e-Rally Monte Carlo, the Mirai appeared at a 2014 Japanese Rally Championship event, driving the course as part of a pre-race safety check.

Remarkably, a Mirai also served as the pace car for a NASCAR race last year.

Source:
http://www.greencarreports.com/news/1106870_toyota-mirai-hydrogen-fuel-cell-car-wins-monte-carlo-e-rally

An extra 60 Hyundai ix35 hydrogen fuel cell taxis for Paris—will grow to a fleet of hundreds

A taxi fleet of five Hyundai ix35 Fuel Cell electric taxis run by Société du Taxi Electrique Parisien is about to grow by 60 and will reach hundreds.

Hyundai's latest pitch for 'Green' motoring has focused around the new Ioniq and its choice of Hybrid, plug-in hybrid or BEV [battery electric vehicle] powertrains.

But even if it looks like Hyundai is playing the BEV game, despite eschewing it back in 2011, that's because they really have no choice but to pursue what others are pursuing, even if the core belief in BEVs is missing. A bit like Toyota, really.

But alongside the Ioniq BEV and hybrids, Hyundai is still producing the world's first mass-produced, commercially available hydrogen fuel cell electric vehicle in the Hyundai ix35 FCEV, and we're about to see a chunk more on the roads of Paris.

The world's largest FCEV taxi fleet currently consist of five ix35 FCEVs run by Société du Taxi Electrique Parisien (STEP) in Paris, but at the opening of a new hydrogen refueling center at Hyundai's European HQ in Germany, an MOU has been signed to deliver a further 60 ix35 FCEVs as Paris taxis.

Thomas A. Schmid, Hyundai's COO in Europe, said:

"STEP and Hyundai Motor have committed to bring 60 additional ix35 Fuel Cell taxis to the streets of Paris. Not only will the fuel cell taxis provide a clean transportation solution for the city, they are also a practical, comfortable and reliable choice for drivers and passengers."

It's a drop in the ocean of replacing the 17,000 predominantly diesel taxis roaming Paris streets in search of a fare, but even if you're skeptical about the amount of damage CO_2 does, you can't deny it's good to get rid of particulates from the atmosphere in cities produced by diesel-

engine transport.

Paradoxically, despite long believing hydrogen power is the future, we've long believed the best place for BEVs is as taxis in city environments.

Still, next best must be FCEVs.

Source: http://www.carsuk.net/an-extra-60-hyundai-ix35-hydrogen-fuel-cell-taxis-for-paris-will-grow-to-a-fleet-of-hundreds/

Flint MTA to test proterra hydrogen fuel cell bus in pilot program

By: Lauren Tyler

Flint's Mass Transportation Authority (MTA) has unveiled a Proterra hydrogen fuel cell vehicle to be deployed on different routes in the City of Flint, MI over a one-year pilot/test program.

According to the MTA, the study will test how the bus fares in a cold environment, as it has only been run in warmer climates, and will also monitor the vehicle's fuel consumption. As reported, the vehicle is highly technical and will be monitored by an on-site Proterra mechanic.

The MTA says this new bus is the result of a collaborative partnership under the National Fuel Cell Bus Program, a Federal Transit Administration program aimed at energizing the transit industry by investing in zero-emission hydrogen fuel cell buses.

Built on top of Proterra's standard electric recharge, the onboard batteries keep the bus running throughout the service day. The MTA notes that each fuel cell system can independently power the bus on a majority of transit routes, providing additional system reliability.

According to the transportation authority, the hydrogen fuel used is produced through steam reforming natural gas, which can have a well-to-pump energy efficiency of 75%. Combined with a bus efficiency approaching 50%, this bus uses the energy in natural gas more efficiently than a conventional bus running on natural gas—reporting a top speed of 55 mph and a range of 280 miles, with both the onboard batteries and hydrogen fuel cell stack.

Source: http://ngtnews.com/flint-mta-to-test-proterra-hydrogen-fuel-cell-in-pilot-program/

Nikola readies electric semi-truck, battery pack and hydrogen charging station plans

By: Tiffany Hsu

Electric semi-truck startup Nikola Motor Co. is ratcheting up anticipation for its upcoming launch event by teasing the reveal of three products key to its vision of an emissions-free freight future.

On Dec. 1 in Salt Lake City, the private company plans to show off its Nikola One electric truck as well as a model-agnostic battery pack and a hydrogen fueling station, it said Thursday.

Industry watchers hope that the debut will shed more light on plans that, so far, have been substantial in scope but light on specifics. The company is competing with more established manufacturers such as Daimler, Tesla, Mack and BYD that are also planning to develop heavy-duty electric vehicles.

The company has described the Nikola One big rig as the most fuel-efficient Class 8 truck ever built. North American models will purportedly be powered by a custom-made 800 V hydrogen fuel cell, capable of traveling 800 to 1,200 miles between fill-ups while achieving 15 to 20 miles per gallon with a full load.

The truck's zero emissions pedigree would allow it to exceed all government greenhouse gas mandates in effect over the next decade, including the Environmental Protection Agency's recently announced Phase 2 standards.

Interest in the truck has been high. The company said it scored nearly $3 billion in reservations within 30 days of accepting requests. The vehicle, slated for road-readiness by 2019, has even been imagined as a replacement postal delivery truck.

But skepticism is also pervasive. In August, Nikola made an abrupt about-face from earlier plans to operate the semi using natural gas-fueled turbines. Instead, the company said, the technology will be developed later abroad to sidestep difficult emissions testing domestically.

Come December 1, though, the company also plans to display an example of the hydrogen stations it hopes to scatter across the continent. Initially, 56 stations will go up around North America, with more than 300 planned stations eventually making up the largest hydrogen network in the world, Nikola said.

Using hydrogen created on solar hydrogen farms built by Nikola as part of a vertically-integrated supply system, the stations will sell the fuel to non-Nikola customers for $3.50 a kilogram—nearly half the current market price, according to the company.

Rounding out its suite of products set for Salt Lake City, Nikola also intends to exhibit its 107-kilowatt-hour lithium battery pack. The pack is designed for the company's Nikola Zero electric utility task vehicle but will go on sale next year as an option for other vehicle models and as an upgrade option for Nikola Zero owners.

Nikola chief executive Trevor Milton said the company's engineers made major advances in power storage and battery cooling. He said the battery packs are "more energy dense and weigh less than any vehicle production pack in the world."

Source: https://www.trucks.com/2016/11/03/nikola-readies-electric-semi-truck/

Al-Futtaim Motors, Toyota to test hydrogen fuel cells in UAE

Al-Futtaim Motors, the exclusive distributor of Toyota in the UAE, in collaboration with Toyota Motor Corporation has proposed to conduct a new study in the field of sustainable mobility for the feasibility of establishing a hydrogen-based society in the UAE.

As part of the study, a pilot plan will be put in place to test Toyota's zero-emission fuel cell technology through a number of hydrogen-powered fuel cell Toyota Mirai vehicles, in order to check their viability in the UAE, said a statement from the company.

Al-Futtaim Motors also made another major announcement about the signing of a partnership with Air Liquide, one of the most established suppliers of hydrogen stations in the world, who will support Al-Futtaim Motors and Toyota Motor Corporation in their assessment of hydrogen as a clean energy solution for the UAE, and who are currently setting up the first hydrogen fueling stations in Dubai, to enable the pilot program, it said.

The announcement was made at the 2nd International Conference on Future Mobility, where Len Hunt, president of Automotive Group at Al-Futtaim, said: "This is a significant step forward in our journey towards contributing to the possible development of a hydrogen society, in which everything from vehicles to work and living places are powered by the zero-emission hydrogen."

"More importantly for the UAE, using hydrogen as a primary source of fuel considerably expedites achieving the sustainability targets set by the UAE Government, and helps the country significantly reduce its CO_2 footprint in the coming decades," he added.

Hunt compared the UAE to other forward-thinking countries around the world, such as Japan, the US and several European states, all of which have implemented a hydrogen fueling infrastructure to support the deployment of hydrogen fuel cell electric vehicles, said a statement.

"The UAE is an exemplary country to pioneer new green technologies such as the fuel cell electric vehicles,

particularly given the environmental goals set by the government such as the ones set by the Dubai Clean Energy Strategy 2050, aiming at making Dubai a global center of clean energy and green economy," Hunt added.

Kiyotaka Ise, senior managing officer, Toyota Motor Corporation, reiterated that his company's commitment to the "Toyota Global Environmental Challenge 2050", an initiative that dictates not only to go beyond zero environmental impact, but also achieve a net positive impact.

The goal is to reduce vehicle CO_2 emissions by 90 per cent in comparison with 2010 levels, by 2050. To realize this, Toyota will promote the development of next-generation vehicles with low or zero CO_2 emissions—hybrid, plug-in hybrid, electric, and hydrogen fuel cell electric vehicles—and further accelerate the spread of these vehicles," he added.

Ise explained how hydrogen fuel cell electric vehicles are driven by an electric motor, but instead of being powered by a battery, they create the electricity through an on board fuel cell stack, using oxygen from the air with the stored hydrogen to power the car, resulting in the release of water instead of CO_2 as a by-product. He detailed the many advantages of fuel cell electric vehicles compared to battery-powered electric cars, mainly in relation to fuel economy and driving range, fueling time and environmental impact.

Also speaking at the conference, François Darchis, senior vice president, member of the Air Liquide Group's executive committee, said: "The world of energy is in the midst of deep change and hydrogen is the missing link for a successful energy transition. Hydrogen constitutes one of the solutions for clean transportation, allowing to shift towards a low carbon society, reduction of greenhouse gas emissions as well as pollution in cities."

"The new pilot allows us to further demonstrate the benefits of hydrogen-powered vehicles and equipment and the impact they can have on creating a more sustainable society, allowing all parties to contribute in meeting energy and environmental targets," he concluded.

–TradeArabia News Service

Source:
http://www.tradearabia.com/news/IND_316668.html

Hyundai opens first public hydrogen filling station in Germany

South Korean car manufacturer Hyundai has inaugurated the first public hydrogen refueling station in Germany. The station has been built and operated by Air Liquide in Hyundai's European headquarters in the German city of Offenbach.

The new station's daily capability of 200 kilograms of hydrogen can power more than 30 vehicles a day and refuel a Hyundai ix35 Fuel Cell car in three to five minutes.

The construction and maintenance of the station has received a 1-million euro funding from the German Ministry of Transport and Digital Infrastructure under the Clean Energy Partnership (CEP), a European Union initiative aimed at reducing emissions by 80% by 2050.

"The new station installed and operated by our partner Air Liquide underscores our commitment to democratizing zero-emission driving with fuel cell cars, making this future technology accessible to as many people as possible. Hyundai Motor was the first car company in the world to offer a mass-produced fuel cell electric vehicle for the general public with the ix35 Fuel Cell," said Thomas A. Schmid, Chief Operating Officer at Hyundai Motor Europe.

Source:
http://www.petrolplaza.com/news/industry/MiZlbiYyMDY4NyYmMSYzMCYx

Hydrogen News of Interest

AFC Energy enters agreement with Peel Environmental for Assessment of UK's largest hydrogen fuel cell precinct

AFC Energy (AIM: AFC), the industrial fuel cell power company, is pleased to announce it has signed an agreement with Peel Environmental Limited ("Peel") to assess the techno-economic feasibility of the UK's largest hydrogen fuel cell precinct at Peel's Protos industrial park.

Protos is located between Manchester, Liverpool and Chester and will deliver 250 hectares of industrial development in the North West of England. It represents a strategic cluster of businesses encompassing energy intensive industries with associated supply chains and importantly, reflects Peel's vision for an energy generation hub that provides secure, low carbon and low cost energy generation to its onsite facilities.

AFC Energy will conduct the assessment in collaboration with Peel and other third party partners to review a range of hydrogen sources and offtake arrangements and work with local stakeholders that will see a proposed phasing of fuel cell projects at Protos commencing at 1MW through to an estimated 35MW to 50MW of installed capacity at the site.

The installation of a fuel cell project of the scale proposed could see a range of new investment and potential employment creation opportunities consistent with the UK Government's Northern Powerhouse initiative. The Northern Powerhouse has been recognized by the UK Government for several years as a major player in the country's energy sector. The focus on low carbon generation technologies clearly identifies the region as a national hub for nuclear power, onshore and offshore wind, biomass and associated supply chains. The integration of hydrogen fuel cells into the regional energy mix creates further opportunities for decarbonization of the national power sector and utilizes surplus hydrogen available in the area to generate clean energy on a long term basis.

A positive outcome from the techno-economic assessment for the development of a 35MW to 50MW fuel cell project at Peel's Protos site could see the development of the UK's largest stationary fuel cell project and one of the largest in the world, confirming a growing transition towards a hydrogen based economy, and thereby positioning Protos and AFC Energy at the forefront of this movement.

The feasibility study will be conducted over several months into 2017.

Myles Kitcher, Managing Director of Peel Environmental and Protos, said:

"We are delighted to partner with AFC Energy in investigating the feasibility of this commercial scale hydrogen fuel cell techno-economic feasibility study, working towards a fuel cell project of scale. AFC's hydrogen fuel cell precinct study will complement the existing low carbon energy generation technologies on site at Protos. This type of technology demonstration at Protos, exemplifies the industrial strategy which the UK government is promoting. A successful hydrogen fuel cell project of this scale will be a first for the UK and we hope to be able to support more new technologies in the future to provide regional economic growth and competitive low carbon domestic energy.

Mr. Adam Bond, AFC Energy's Chief Executive Officer, said:

"AFC Energy is proud to be collaborating with Peel Land & Property Group. This techno-economic feasibility study will see a proposed phasing of fuel cell projects at Protos commencing at 1MW through to an estimated 35MW to 50MW of installed capacity at the site, delivering the first phase of an industrial fuel cell power company. Following recent advances in the development of the AFC Energy fuel cell, the Board now believe the Company is well positioned to capitalize on these project deployment opportunities and hope to make further such announcements in the near future. Protos will provide the ideal opportunity for a scaled and commercial hydrogen fuel cell facility that will play an important part in the long term and sustainable powering of the UK's Northern Powerhouse. I'm confident that with the mix of skills and capabilities of AFC and Protos, we will deliver a world class innovative fuel cell project right here in the UK".

Source: https://fuelcellsworks.com/news/afc-energy-enters-agreement-with-peel-environmental-for-assessment-of-uks-largest-hydrogen-fuel-cel

Hydrogen News of Interest

HES Energy Systems Hywings drone flies up to 500km and 10 hours non-stop

By: Chris Griffith

HES Energy Systems says it has successfully developed hydrogen fuel cell technology that generates electricity to power its Hywings drone. It says its aerospace-grade fuel cell technology is 3 to 5 times lighter than lithium batteries. And it sees UAVs flying 50 to 80 hours continuously on hydrogen fuel as around the corner.

"At a total takeoff weight of just 7kg, hydrogen UAVs such as Hywings can cover larger areas of land faster, while removing the need for catapult launchers or runways typically required by larger, heavier and more expensive systems," says chief executive Taras Wankewycz.

Wankewycz says the UAV is available now to buy with everything included—choice of power system, choice of sensor and ground control station included. He would not disclose the cost, but he says it has two levels. One version of the UAV is fueled by hydrogen stored as a gas (lower cost), the other by hydrogen made on demand from chemicals (higher cost).

"We are currently working to increase the endurance further, beyond 10 hours, and (we) may be able to achieve another 30-50 per cent longer duration," he told *The Australian*.

The UAV flies at about 50 km/hr.

We interviewed Wankewycz 18 months ago in Singapore when HES was building a prototype of a hydrogen fuel cell drone.

At the time he had his sights on selling the UAVs to an Australian operator for activities such as rail and road inspections. Yesterday he said there were several interested parties in Australia but he wouldn't name names.

Wankewycz is also an executive director of HES's parent firm Horizon Fuel Cell Technologies, which began working in the general hydrogen fuel cell space 13 years ago. He originally cut his teeth working for Eastman Chemical.

The fuel cells work by taking stored hydrogen and mixing it with air to produce water and electricity. According to Wankewycz, the most efficient system for drones is to use batteries (charged by fuel cells) for peak power and energy surges, and fuel cells directly for continuous lower power.

Wankewycz said Hywings' technology had skipped months or years of testing in the lab, reducing development costs while accelerating go-to-market.

"Hywings is also a step towards enabling larger platforms. With further improvements to its technology in combination with new aircraft designs, HES sees the feasibility of 50 to 80 hour electric flight durations in both unmanned and manned aircraft configurations."

Hywings is part of a product line-up which includes Hycopter, a hydrogen-electric multi-rotor platform, and a remotely operated drone charging station called Dronebox, which can operate in the field for up to 2 years. The drone is charged remotely using solar energy.

He said HES was designing small and portable refueling systems that could fill up 1 kWh storage tanks, which is enough to fly Hywings for 6 hours.

HES is a subsidiary of H3 Dynamics which is based in Singapore and Austin, Texas.

Australians interested in the Hywings should contact the Civil Aviation Safety Authority to discuss the viability of flying this type of drone.

Source:
http://www.theaustralian.com.au/business/technology/hywings-drone-flies-up-to-500km-and-10-hours-nonstop/news-story/84c24df5ec76fe8ee22bb33a617f8bd2

Hydrogen News of Interest

Hydrogen Hub launches new website and announces new Chairman

The Hydrogen Hub announces today the official launch of its website www.hydrogenhub.org and a new Chairman—Kevin Fothergill.

The Hydrogen Hub is devoted to establishing the UK as a global leader in hydrogen and fuel cell technology. The Hub brings together industry, businesses, stakeholders and local authorities to develop and deploy hydrogen and fuel cell projects, meeting current energy and transportation needs and driving industry investment at a local and national level.

The website outlines the objectives and approach of the Hydrogen Hub and demonstrates the benefits both of hydrogen and fuel cell technology and also of the Hydrogen Hub model.

Hydrogen Hub's new Chairman, Kevin Fothergill said:

"We're really excited about the launch. The Hydrogen Hub Initiative will work to facilitate the introduction of hydrogen and fuel cells as a key part of the UK's transition to a low carbon economy. We look forward to working with the government and other stakeholders to shape energy and transportation policy and supporting UK businesses in the practical deployment of these new technologies."

Kevin Fothergill is an expert in hydrogen and fuel cell technologies having provided leadership to the industry over the past 12 years.

Clare Jackson, Hydrogen Hub Manager:

"With the new website we hope to showcase some of the exciting projects and work that the Hydrogen Hub is undertaking and encourage more organizations and businesses to join our community and support this valuable opportunity to cost-effectively deliver secure energy whilst significantly reducing pollution and greenhouse gas (GHG) emissions."

For more information, visit their website at www.hydrogenhub.org.

Stanford engineers set record for capturing and storing solar energy in hydrogen fuel

By: Tom Abate

Solar energy has the potential to provide abundant power, but only if scientists solve two key issues: storing the energy for use at all hours, particularly at night, and making the technology more cost effective. Now an interdisciplinary team at Stanford has made significant strides toward solving the storage issue, demonstrating the most efficient means yet of storing electricity captured from sunlight in the form of chemical bonds. If the team can find a way of lowering the cost of their technology, they say it would be a huge step toward making solar power a viable alternative to current, more polluting energy sources.

The basic science behind the team's approach is well understood—use the electricity captured from sunlight to split water molecules into hydrogen and oxygen gas. That stored energy can be recovered later in different ways: by recombining the hydrogen and oxygen into water to release electricity again, or by burning the hydrogen gas in an internal combustion engine, similar to those running on petroleum products today.

Although the process is well understood, the challenge has been turning this science into an efficient industrial process. That's where a team led by Thomas Jaramillo, an associate professor of chemical engineering and of photon science, and James Harris, a professor of electrical engineering, has made a significant improvement. In work published in *Nature Communications*, they were able to capture and store 30 percent of the energy captured from sunlight into stored hydrogen, beating the prior record of 24.4 percent.

"This milestone brings us much closer to a sustainable and practical process to use water-splitting as a storage technology," Jaramillo said. "Improving efficiency has a remarkable impact on lowering costs. We have to continue work on finding more ways to lower the costs to compete with conventional fuels."

Improved energy storage

The starting point of their system is the solar cell they used in their experiments, one that is very different—and more expensive—than the typical rooftop solar arrays. While typical rooftop arrays are based on silicon, the Stanford team employed solar cells pioneered by Harris' lab that use three less-common semiconductor materials. They are called triple-junction solar cells because each material is tuned to capture blue, green or red light, respectively. Through this precision, triple-junction solar cells convert 39 percent of incoming solar energy into electricity, compared with roughly 20 percent for silicon-based, single-junction solar cells found on rooftops worldwide.

The most important question for the team, though, was not how much energy they captured, but how much energy was stored through water splitting. To solve that question, Jaramillo and his collaborators built on research they have been conducting on how to improve the performance of catalysts—materials that speed up chemical reactions but are not consumed in the process. To store electricity captured from sunlight, the team looked in particular at water-splitting catalysts, in which electrons flow through the catalytic materials to break apart the stable H_2O molecule.

Much of the catalytic process in the Stanford experiment is built on their previous advances in the area, with one particularly important approach to achieve their record energy capture. Most photovoltaic-powered water-splitting reactions use a single electrolysis device, but this team was able to combine two identical electrolysis devices in such a manner to produce twice as much hydrogen, making use of their higher-efficiency solar cells and putting them to work.

"Tuning all the elements, electronics and the chemistry was critical," Harris said. "The entire system has to be perfectly balanced or the process wouldn't work at all."

When their experiment was done, their measurements showed that 30 percent of the energy originally collected by the triple-junction solar cells had been stored in the form of hydrogen gas.

Addressing costs

Now that the Stanford team has demonstrated this record-setting efficiency in the use of water-splitting to store solar power, the focus shifts to costs: the triple-junction solar cells and catalysts they used, which included platinum, are fine for proof-of-principle experiments, but not for an industrial process. "But what we've done is demonstrate how a systems approach can vastly improve storage efficiency," Jaramillo said. "Now we have to find ways to get similar results with less expensive materials and devices."

Jaramillo and Harris say that one big reason for the success of this research is the collaboration among different engineers and scientists. The team brought in 11 researchers, including collaborators from the SLAC National Accelerator Laboratory and experts in chemistry, process engineering and electronics to achieve two goals—first to squeeze the utmost in power from sunlight, and then to store as much of this as possible through water-splitting chemistry.

"It took specialists in different fields to do what none of us could have done alone," Harris said. "That's one of the lessons of this result: There is no single fix. How everything links together is the key."

Harris is also the James and Elenor Chesebrough Professor in the School of Engineering, professor, by courtesy, of applied physics and of materials science and engineering, a member of Stanford Bio-X and of the Stanford Neurosciences Institute, and an affiliate of the Precourt Institute for Energy and the Stanford Woods Institute for the Environment. Jamarillo is also an affiliate of the Precourt Institute for Energy.

Source: http://news.stanford.edu/2016/10/31/stanford-engineers-set-record-capturing-storing-solar-energy-hydrogen-fuel/

Prefecture, firms tie up on solar-derived hydrogen

By: Kenji Kaneko

Yamanashi Prefecture, Toray Industries Inc, Tokyo Electric Power Company Holdings Inc and Takaoka Toko Co Ltd have concluded an agreement to jointly promote the

technological development and experimental study of a "P2G (Power to Gas) system" for realizing a CO_2-free "hydrogen energy society."

A P2G system produces hydrogen by using renewable energy-derived electricity and stores and uses it. The system is expected to stably utilize renewable energy-derived electricity, which fluctuates in accordance with weather changes, by exploiting the characteristics of hydrogen, which can be stored for a long period of time and transported.

Yamanashi Prefecture and Tokyo Electric Power jointly run "Komekurayama Solar Power Plant," a 10MW solar power plant, in Kofu City. In addition, at "Yume Solar Kan Yamanashi," which adjoins the plant, it has been operating a verification facility that produces hydrogen with a 20kW on-roof solar power generation system, stores it and uses it for a fuel cell system.

The four organizations that have formed the agreement aim to establish a P2G system that produces, stores and uses 450,000Nm^3 (planned value) of hydrogen per year by using solar electricity in the Komekurayama area, where such verification facilities are located. They jointly applied for a project commissioned by New Energy and Industrial Technology Development Organization (NEDO), and the application was adopted Sept 27, 2016. Then, they started to consider basic issues including the clarification of technological problems.

In the verification project, the shift to the technological development phase will be judged through the "stage gate examination" planned in June 2017. Based on the results of the examination, the four organizations plan to engage in technological development and experimental study until the end of fiscal 2020.

Through the project, Yamanashi Prefecture will promote the introduction of renewable energy by promoting the development of power storage technologies as a measure to stabilize a power grid. At the same time, by building bases for technological development and experimental study related to P2G systems in the prefecture, they aim to stimulate industrial development.

Among the participants in the project, Toray is responsible for the development of materials for fuel cells and water electrolysis such as electrolyte films and electrode substrates. Takaoka Toko will design power equipment that uses renewable energy to produce hydrogen and deal with an energy management system.

Source: https://www.japantoday.com/category/technology/view/prefecture-firms-tie-up-on-solar-derived-hydrogen

Nel enters Californian market with first solar-driven hydrogen production plant

By: Rhea Healy

The US looks set to get its first solar-driven hydrogen production plant as a dedicated H_2 company Nel ASA announces plans to build and operate the site in California.

The Norwegian company revealed that it has signed a Letter of Intent to establish a joint venture with a leading global solar corporation, which will help to engineer the solar-driven facility. The partner was not identified.

The project is thought to be the first step towards large-scale commercial renewable H_2 production, which will help to meet expected demand for renewable H_2 in California and throughout the US.

The agreement is expected to be finalized before the year is through, with the joint venture aiming to being production and delivery of renewable H_2 during the second half of 2017.

Nel's CEO Jon Andre Lokke, commented on the importance of the project and said, "Given the requirement from the government in California for 33% renewable H_2 in the transport sector, we are confident that this will become an attractive market for our joint technology solutions.

It is understood that the parties are already exploring additional sites in California for renewable H_2 production on a larger scale.

Source: https://www.gasworld.com/us-gets-first-solar-driven-hydrogen-production-plant/2011755.article

Hydrogen News of Interest

Safe new storage method could be key to future of hydrogen-powered vehicles

Hydrogen is often described as the fuel of the future, particularly when applied to hydrogen-powered fuel cell vehicles. One of the main obstacles facing this technology—a potential solution to future sustainable transport—has been the lack of a lightweight, safe on-board hydrogen storage material.

A major new discovery by scientists at the universities of Oxford, Cambridge and Cardiff in the UK, and the King Abdulaziz City for Science and Technology (KACST) in Saudi Arabia, has shown that hydrocarbon wax rapidly releases large amounts of hydrogen when activated with catalysts and microwaves.

This discovery of a potential safe storage method, reported in the Nature journal *Scientific Reports*, could pave the way for widespread adoption of hydrogen-fueled cars.

Study co-author Professor Peter Edwards, who leads the KACST-Oxford Petrochemical Research Centre (KOPRC), a KACST Centre of Excellence in Petrochemicals at Oxford University, said "This discovery of a safe, efficient hydrogen storage and production material can open the door to the large-scale application of fuel cells in vehicles."

Co-author Dr Tiancun Xiao, a senior research fellow at Oxford University, said "Our discovery—that hydrogen can be easily and instantly extracted from wax, a benign material that can be manufactured from sustainable processes—is a major step forward. Wax will not catch fire or contaminate the environment. It is also safe for drivers and passengers."

Co-author Professor Hamid Al-Megren, from the Materials Research Institute at KACST, said "This is an exciting development—it will allow society to utilize fossil fuels or renewable-derived wax to generate on-board hydrogen for fuel cell applications without releasing any carbon dioxide into the air."

Hydrocarbons are natural, hydrogen-rich resources with well-established infrastructures. The research team has developed highly selective catalysts with the assistance of microwave irradiation, which can extract hydrogen from hydrocarbons instantly through a non-oxidative dehydrogenation process. This will help unlock the longstanding bottleneck hindering the widespread adoption of hydrogen fuel technology.

Co-author Professor Angus Kirkland, from the Department of Materials at Oxford University and Science Director at the new electron Physical Science Imaging Centre (ePSIC) at Harwell Science and Innovation Campus, described the breakthrough as an example of how Oxford is able to respond to key academic and industrial problems by using interdisciplinary resources and expertise.

Co-author Professor Sir John Meurig Thomas, from the Department of Materials Science and Metallurgy at the University of Cambridge, said the work could be extended so that many of the liquid components of refined petroleum and inexpensive solid catalysts can pave the way for the generation of massive quantities of high-purity hydrogen for other commercial uses, including CO_2-free energy production.

Professor Edwards added, "Instead of burning fossil fuels, leading to CO_2, we use them to generate hydrogen, which with fuel cells produces electric power and pure water. This is the future—transportation without CO_2 and hot air."

Source: https://www.sciencedaily.com/releases/2016/10/161020102540.htm

New biofuel cell with energy storage

Researchers have developed a hybrid of a fuel cell and capacitor on a biocatalytic basis. With the aid of enzymatic processes, what's known as a biosupercapacitor efficiently generates and stores energy. The trick: the enzymes are embedded in a stable polymer gel, which can store a large amount of energy. The scientists at the Ruhr-Universität Bochum and the Swedish Malmö University describe their development in the journal *Angewandte Chemie*.

Societal challenge

Generating energy and saving it with as little loss as possible is one of the major challenges for today's society. Energy production and storage usually take place in different systems—which is inefficient. This is different in the

new biosupercapacitor, which combines both processes.

"Such a technology could, for instance, be interesting for miniaturized devices, which should even supply themselves with energy wirelessly. This is particularly important for implantable miniaturized sensors," says Prof Dr. Wolfgang Schuhmann from the Bochum Institute for Analytical Chemistry. He was involved in the development with his colleagues Dr. Felipe Conzuelo, Dr. Piyanut Pinyou and Sabine Alsaoub.

Enzymes at both electrodes

With the aid of an enzyme, the biosupercapacitor burns glucose as a fuel at one electrode. At the other electrode, an enzyme converts oxygen into water. Both enzymes must be embedded in an electron-conducting gel in order to establish the electrical contact to the electrodes. For the first time, the team used the same gel, also called a redox polymer, for both electrodes.

When charging up and storing the energy, this redox polymer at one electrode gives off electrons and is thus positively charged. At the other electrode, it takes in the electrons and is thus negatively charged. "During the discharging process, the charges equal out and a current flows," explains Schuhmann.

High capacity

The system set up in this manner showed itself to be stable in the researchers' tests and can serve as a permanent source of energy. It has a low weight and a high capacity, so it can hold a large charge. "We see this work as a starting point for future strategies in the development of new, highly functional and also affordable electrical sources of energy on bioelectrochemical basis," summarize the authors.

Source:
https://www.sciencedaily.com/releases/2016/11/161115083716.htm

Novel catalyst design opens possibility to hydrogen vehicle

In their study, published in the November issue of the *Journal of the American Chemical Society*, Professor Sang Hoon Joo of Energy and Chemical Engineering and his team have devised a new synthetic strategy to boost the activity of iron- and nitrogen-doped carbon (Fe-N/C) catalyst that can realize low-cost hydrogen fuel cell.

Hydrogen fuel cells generate electricity with hydrogen and oxygen, producing water as a byproduct. Precious platinum(Pt) has been used in commercialized fuel cells. However, the high cost of Pt (>40$ per g) hampers widespread application of the fuel cell.

The research team has attempted to develop a high-performance non-precious metal catalyst, which can substitute for the state-of-the-art Pt-based catalysts. In this research, they focused on carbon-based catalysts with iron and nitrogen due to low cost and high activity (Fe-N/C catalyst). During the preparation of the Fe-N/C catalysts, high-temperature heat-treatment at over 700^{o}C is commonly required to endow high catalystic activity, but unfortunately this treatment also diminishes the number of active site. The active site refers to the place where the rate-determining catalytic reaction occurs.

To solve the problem, they have introduced 'silica-protective-layer' approach. The silica layer effectively preserved the active site at high-temperature, preventing the destruction of the active site.

The novel Fe-N/C catalyst prepared by the 'silica-protective-layer' approach showed very high oxygen reduction reaction (ORR) activity, which is comparable to the Pt catalyst. ORR is an electrochemical reaction at the cathode of the hydrogen fuel cell. Due to 1-million-times slower reaction kinetics of ORR at the cathode compared with hydrogen oxidation reaction at the anode, ORR is a major factor for a large drop of the efficiency of the fuel cell. Up to date, expensive Pt has been used primarily as an efficient ORR catalyst.

The research team realized a record high activity by employing their catalyst as the cathode catalyst of an alkaline membrane fuel cell (one type of hydrogen fuel cell). The team also demonstrated very high performance in the proton exchange membrane fuel cell (PEMFC), in which the developed catalyst showed the activity of 320 A cm^{-3}, exceeding 2020 US Department of Energy (DOE) activity target for non-precious metal catalyst (300 A cm^{-3}).

"Our novel strategy for high-performance catalysts is expected to hasten the commercialization of hydrogen fuel cells, and the catalyst design can be also applied to other

energy storage and conversion devices." says Prof. Joo.

Source: http://phys.org/news/2016-11-catalyst-possibility-hydrogen-vehicle.html

How sand holds its breath

The popular Middle Park beach is under the international spotlight following a world-first study by Monash University chemists who have discovered how sand 'holds its breath'.

The discovery, published in Nature Geoscience, has major implications and potential uses in the biofuels industry, according to lead authors Associate Professor Perran Cook and PhD student Michael Bourke from the Water Studies Centre, School of Chemistry.

Sand is full of algae called diatoms, but this environment is mixed about continuously so these organisms might get light one minute then be buried in the sediment with no oxygen the next.

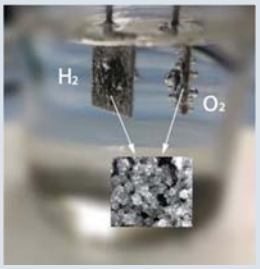
Sand often has high concentrations of algae, which are highly productive and an important food source for food webs in the bay. It is important to understand how these organisms survive in the harsh environment in which they live. In this work, scientists present the first study of the importance of anoxic micro-algal metabolism through fermentation in permeable sediments. They combined flow-through reactor experiments with microbiological approaches to determine the dominant contributors and pathways of dissolved inorganic carbon production in permeable sediments.

They show that micro-algal dark fermentation is the dominant metabolic pathway, which is the first time this has been documented in an environmental setting.

"The finding that hydrogen is a by-product of this metabolism has important implications for the types of bacteria present in the sediment," said Associate Professor Cook.

"It is well known that bacteria in the sediment can 'eat' hydrogen, however, these hydrogen eating bacteria may be more common than we previously thought."
Source: www.sciencedaily.com/releases/2016/11/161128131328.htm

Improved water splitting advances renewable energy conversion



Washington State University researchers have found a way to more efficiently create hydrogen from water — an important key in making renewable energy production and storage viable.

The researchers, led by professors Yuehe Lin and Scott Beckman in the School of Mechanical and Materials Engineering, have developed a catalyst from low cost materials. It performs as well as or better than catalysts made from precious metals that are used for the process.

Energy conversion is a key to the clean energy economy. Because solar and wind sources produce power only intermittently, there is a critical need for ways to store and save the electricity they create. One of the most promising ideas for storing renewable energy is to use the excess electricity generated from renewables to split water into oxygen and hydrogen; the hydrogen can then be fed into fuel-cell vehicles.

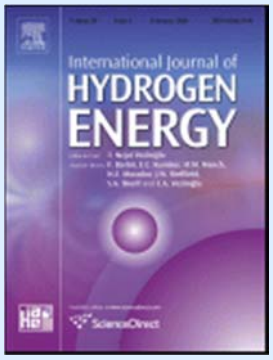
Industries have not widely used the water splitting process, however, because of the prohibitive cost of the precious metal catalysts that are required, usually platinum or ruthenium. Many of the methods to split water also require too much energy, or the required materials break down too quickly. Instead, industries generally use a fossil-fuel based process to produce hydrogen for fuel cells, which generates harmful greenhouse gas emissions.

For their catalyst, the WSU research team added nanoparticles of relatively inexpensive copper to a cobalt-based framework. The new catalyst was able to conduct electricity better than the commonly used precious metal catalysts. It produced oxygen better than existing commercial catalysts and produced hydrogen at a comparable rate.

The researchers used both theoretical modeling and experimental assessments to demonstrate and fine tune their catalyst's effectiveness.

Source:
www.sciencedaily.com/releases/2016/10/161025125747.htm

International Journal of Hydrogen Energy Highlights



The *International Journal of Hydrogen Energy* provides scientists and engineers throughout the world with a central vehicle for the exchange and dissemination of basic ideas in the field of hydrogen energy. The emphasis is placed on original research, both analytical and experimental, which is of permanent interest to engineers and scientists, covering all aspects of hydrogen energy, including production, storage, transmission, utilization, as well as the economical, environmental and international aspects. When outstanding new advances are made, or when new areas have been developed to a definitive stage, special review articles will be considered. As a service to readers, an international bibliography of recent publications in hydrogen energy is published quarterly.

Most Cited IJHE Articles (past 5 years)

1. **A comprehensive review on PEM water electrolysis**
   Carmo M, Fritz DL, Mergel J, Stolten D. Int J Hydrogen Energy 2013;38(12):4901–34.
2. **Nanoscale and nano-structured electrodes of solid oxide fuel cells by infiltration: Advances and challenges**
   Jiang SP. Int J Hydrogen Energy 2012;37(1):449–70.
3. **Non precious metal catalysts for the PEM fuel cell cathode**
   Othman R, Dicks AL, Zhu Z. Int J Hydrogen Energy 2012;37(1):357–72.
4. **Hydrogen from renewable electricity: An international review of power-to-gas pilot plants for stationary applications**
   Gahleitner G. Int J Hydrogen Energy 2013;38(5):2039–61.
5. **An overview of hydrogen safety sensors and requirements**
   Buttner WJ, Post MB, Burgess R, Rivkin C. Int J Hydrogen Energy 2011;36(3):2462–70.
6. **Pd-Ni electrocatalysts for efficient ethanol oxidation reaction in alkaline electrolyte**
   Zhang Z, Xin L, Sun K, Li W. Int J Hydrogen Energy 2011;36(20):12686–97.
7. **Ammonia and related chemicals as potential indirect hydrogen storage materials**
   Lan, R, Irvine, J.T.S., Tao, S. Int J Hydrogen Energy 2012;37(2):1482–94.

Top IJHE Downloads (Sept.-Nov. 2016)

1. **Hydrogen and fuel cell technologies for heating: A review. Int J Hydrogen Energy**
   Dodds PE, Staffell I, Hawkes AD, Li F, Grünewald P, McDowall W, et al. Int J Hydrogen Energy 2015;40(5):2065–83.
2. **A comprehensive review on PEM water electrolysis**
   Carmo M, Fritz DL, Mergel J, Stolten D. Int J Hydrogen Energy 2013;38(12):4901–34.
3. **Changing the fate of Fuel Cell Vehicles: Can lessons be learnt from Tesla Motors?**
   Hardman S, Shiu E, Steinberger-Wilckens R. Int J Hydrogen Energy 2015;40(4):1625–38.
4. **Metal hydride materials for solid hydrogen storage: A review**
   Sakintuna B, Lamari-Darkrim F, Hirscher M. Int J Hydrogen Energy 2007;32(9):1121–40.
5. **Review of the proton exchange membranes for fuel cell applications**
   Peighambardoust SJ, Rowshanzamir S, Amjadi M. Int J Hydrogen Energy 2010;35(17):9349–84.
6. **Study on method of domestic wastewater treatment through new-type multi-layer artificial wetland**
   Lu S, Pei L, Bai X. Int J Hydrogen Energy 2015;40(34):11207–14.
7. **Hydrogen from renewable electricity: An international review of power-to-gas pilot plants for stationary applications**
   Gahleitner G. Int J Hydrogen Energy 2013;38(5):2039–61.

Treated Nanolayered Mn Oxide by potassium fluoride: An improvement for nanolayered Mn oxide toward water oxidation

-Mohammad Mahdi Najafpour, Seyedeh Maedeh Hosseini, Mohadeseh Zarei Ghobadi, Parvin Rafighi, Robabeh Bagheri, Zhenlun Song. Int J Hydrogen Energy 2016:41(46): 21203-21211

Water splitting has received much attention in recent years in the context of a means for generating hydrogen as an energy carrier for renewables. Slow kinetics for water oxidation, however, has been identified as the limiting process that renders electrolysis prohibitively inefficient in this context. Pt, Ru and Ir compounds have been shown to be efficient catalysts, but their low earth abundance has rendered them impractical for implementation on a large scale. This study examines the role of fluoride on water oxidizing activity of nanolayered Mn oxide. Mn is both earth abundant (low cost) as well as environmentally friendly. While Mn (III) has previously been demonstrated to reduce the onset potential of water oxidation by ~500 mV, it proved to be unstable in extended use. This study demonstrates the effect of F^- in increasing water oxidizing activity of nanolayered Mn oxide at acidic conditions (pH ~ 1) by stabilizing Mn(III) ions. Mn oxide was synthesized and treated with potassium fluoride (KF) and then characterized and tested. SEM and TEM were used in qualitative analysis, while XPS, EDX, BET, Raman spectroscopy and UV-Vis spectroscopy were used for quantitative analysis. While SEM and TEM showed negligible changes in surface morphology, EDX showed 5-7% F^- on the surface and the Raman results showed sharp bands related to Mn-O, K-O, and K-Mn. XPS and UV-Vis indicated an increase of Mn(III) for the treated Mn oxide by F^-. The amounts of F^- observed here are expected to have a low effect on water oxidizing activity, but in the context of Mn nanolayers this amount of F^- has a significant effect on the stability of Mn(III).

http://www.sciencedirect.com/science/article/pii/S0360319916323692

-By Cyrus Daugherty

Identification of critical parameters for PEMFC stack performance characterization and control strategies for reliable and comparable stack benchmarking

-Jens Mitzel, Erich Gulzow, Alexander Kabza, Jurgen Hunger, Samuel Simon Araya, Piotr Piela, Iker Alecha, Georgios Tsotridis. Int J Hydrogen Energy 2016: 41(46): 21415-21426.

Several challenges still need to be overcome for the widespread commercialization of polymer electrolyte membrane fuel cells (PEMFCs). At the moment, the required investments for PEMFC stacks and systems are still too high due to the overall cost and the complexity of the system. Apart from the costs, the main challenges for competitive fuel cell systems are stack performance and durability. All these aspects are examined in many laboratories and improvements are ongoing by component and stack design modifications. The reliability of the stack characterization and of the benchmark result is thereby crucial because many parameters have significant impact on the results and may vary using different test hardware and test procedures. Therefore, the use of standardized procedures and clear definitions of all influential parameter sensors are of high importance to assure reliable and comparable test results for different test objects as well as for different test facilities. Consequently, the harmonization of PEMFC tests at the stack level is important in order to accelerate stack development and to benchmark stacks. The resulting procedures are of high interest for stack manufacturers, system integrators and for academia.

This paper is focused on the identification of critical parameters and on the development of reliable methodologies to achieve comparable benchmark results. Possibilities for control sensor positioning and for parameter variation in sensitivity tests are discussed and recommended options for the control strategy are summarized. This ensures result comparability as well as stable test conditions. E.g., the stack temperature fluctuation is minimized to about 1°C. The experiments demonstrate that reactants pressures differ up to 12 kPa if pressure control positions are varied, resulting in an average cell voltage deviation of 21 mV. Test parameters simulating different stack applications are summarized. The stack demonstrated comparable average cell voltage of 0.63 V for stationary and portable conditions. For automotive conditions, the voltage increased to 0.69 V, mainly caused by higher reactants pressures. A benchmarking concept is introduced using “steady-state” polarization curves. The occurring 20 mV hysteresis effect between the ascending and descending polarization curve can be corrected calculating the mean value of both voltages. This minimizes the influence of preceding load levels, current set points, and dwell times.

http://www.sciencedirect.com/science/article/pii/S0360319916324235

-By Yasser Ashraf Gandomi

From the Bookshelf

Sensors for Safety and Process Control in Hydrogen Technologies

by Thomas Hübert, Lois Boon-Brett and William J. Buttner

Sensors for Safety and Process Control (CRC Press 2016) provides practical, expert-driven information on modern sensors for hydrogen, other gases, and physical parameters for the safe and efficient implementation of hydrogen technologies. Various facets of sensors are covered, including both an introduction to fundamental sensor principles and practical aspects on the use of sensors relevant to hydrogen technologies. There is an extensive discussion on the role of sensors in specific hydrogen applications. The limitations of existing sensors with respect to current performance requirements are also presented along with emerging technologies that might alleviate the impact of these gaps. The authors provide guidance on sensor selection for different applications. Overall, the book was written to provide a balance between detailed technical descriptions and simple but more practical explanations. The timely release of this book fills a critical need in the hydrogen community and will help assure the safe implementation of hydrogen systems. The book is suitable for both technical and non-technical readers who have either an interest in or need to implement hydrogen sensors. This book gives invaluable insight into the role sensors play as key enabling devices for both control and safety in both established and emerging hydrogen technologies.

https://www.crcpress.com/Sensors-for-Safety-and-Process-Control-in-Hydrogen-Technologies/Hubert-Boon-Brett-Buttner/p/book/9781466596542

Become a Member of IAHE

The International Association for Hydrogen Energy (IAHE) has four categories of membership:

- **H-Members:** Scientists, engineers, and laypersons who are interested in fields relating to Hydrogen Energy. They receive IAHE e-Newsletter, hard copies of the International Journal of Hydrogen Energy (IJHE), and reduced registration for IAHE conferences.
- **E-Members:** Scientists, engineers and laypersons who are interested in fields relating to Hydrogen Energy. They receive IAHE e-Newsletter, access to electronic copies of the International Journal of Hydrogen Energy (IJHE), and reduced registration for IAHE conferences.
- **Student Members:** They are students who are interested in hydrogen energy. They receive the IAHE e-Newsletter. The student membership is free.
- **IAHE Fellows:** Long-time IAHE members who have significantly impacted society by promotion of Hydrogen Economy through research, education and/or service.

If you are interested in becoming a member of IAHE, please visit the membership page at www.iahe.org. You can sign up for membership directly on the membership page.

Research Group Highlight

Hashemi Lab, Bio Microfluidics and Optofluidic Systems

Hashemi Lab is located in Iowa State University and the ongoing projects concerned with the design and fabrication of microfluidic/optofluidic devices with applications to clinical diagnosis, renewable energy, and environmental monitoring.

The primary research objective is to understand how microfluidic transport could provide a fundamental science base for novel fabrication of polymer microfibers with controlled size, shape, and molecular alignment. Computational fluid dynamics and experimental techniques are usually employed to design and study characteristics of highly structured microfibers.

The major ongoing research in the lab includes the following topics.

Energy Microdevices

Miniature microbial fuel cells have recently drawn lots of attention as portable power generation devices due to their short startup time and environmentally-friendly process, which could be used for powering small integrated biosensors.

In Hashemi's Lab, microbial fuel cells in a microfluidic platform are being engineered. The miniature microbial fuel cell generates a maximum current of 2.59 μA and has a significantly short startup time.

3D Paper-Based Microfluidic Devices for Healthcare Applications

The first step in curing a disease is being able to detect the disease effectively. The paper based microfluidic devices are biodegradable and can make diagnosing diseases cost effective and easy in almost all environments.

In Hashemi's Lab, 3D paper devices using wax printing fabrication technique and basic principles of origami are built. This design allows for a versatile fabrication technique over previously reported patterning of SU-8 photoresist on chromatography paper by employing readily available wax printer. The design also utilizes multiple colorimetric assays, which can accommodate one or more analytes including urine, blood, and saliva.

Microfluidic Organ-on-a-Chip Technology for Advancement of Biological Studies

Drug testing targeted at the placenta has lacked reliable in vitro testing designs to mimic in vivo situations. With the plethora of different birth defects occurring around the world, attention needs to be drawn to finding a potential alternative to testing live subjects. Organ-on-a-chip technology has seen a vast increase in popularity, as the understanding of utilizing the properties of microfluidics has become more prevalent. Additionally, they are cost effective, use minimal product to create, and dodge the ethical dilemma of using in vivo animal models.

In Hashemi's Lab, the goal is to create a microfluidic 3D cell culture system representing a "placenta-on-a-chip" in order to mimic the nutrient/waste transfer between maternal blood and fetal blood that occurs in the cotyledon section of the placenta, and to test and observe the effects of ethanol within the maternal bloodstream and compare it to a similar in vivo situation.

Biosensor for Optofluidic Characterization of Cells and Particles

Analysis of the intrinsic fluorescence profiles of individual marine algae can be used in general classification of organisms based on cell size and fluorescence properties.

In Hashemi's Lab, Microflow Cytometers on a chip for characterization of phytoplankton are being designed and fabricated. The Microflow Cytometer measures distinct side scatter and fluorescence properties of Synechococcus sp., Nitzschia d., and Thalassiosira p. The Microflow Cytometer is sensitive enough to detect and characterize picoplankton with diameter approximately 1 μm and larger phytoplankton of up to 80 μm in length. The wide range in size discrimination coupled with detection of intrinsic fluorescent pigments suggests that this Microflow Cytometer will be able to distinguish different populations of phytoplankton on unmanned underwater vehicles.

Contact Information:

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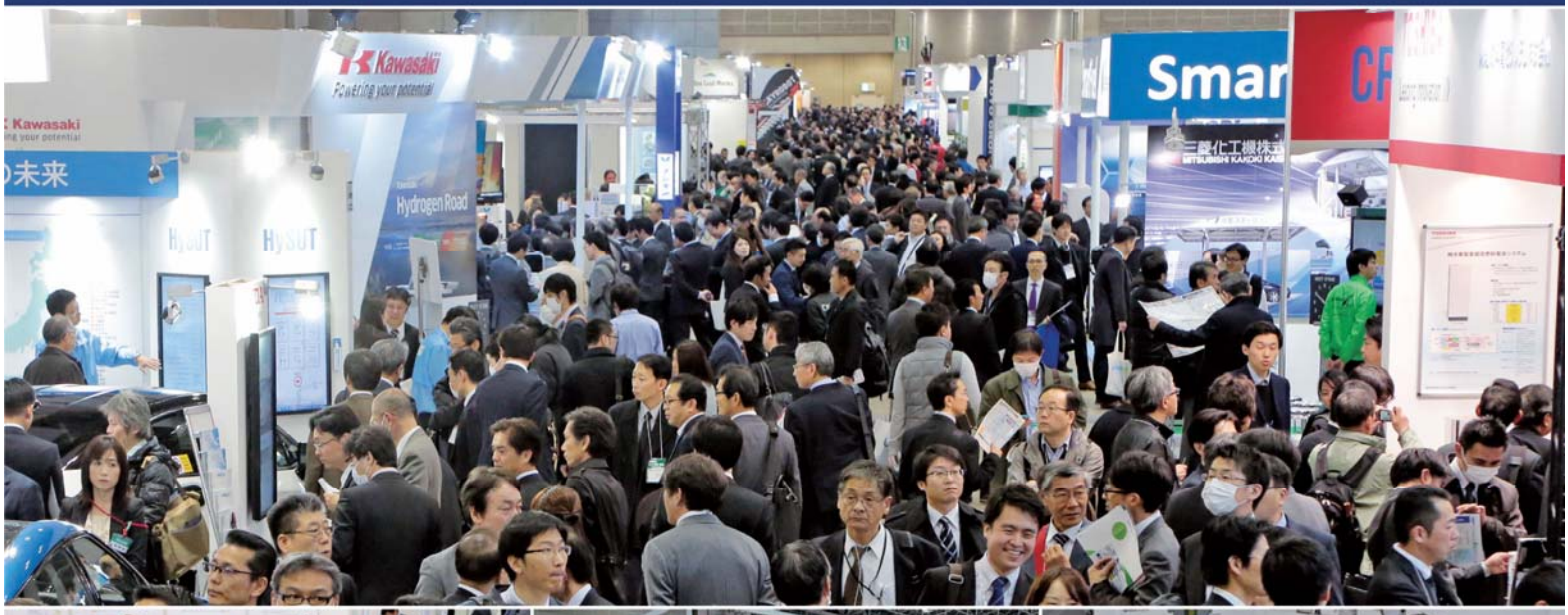
Department of Mechanical Engineering
Email Address: nastaran@iastate.edu
Link: http://web.me.iastate.edu/hashemi/Index.htm

Your Key Show in the Hydrogen & Fuel Cell Industry!



Held inside **World Smart Energy Week 2017**

13th Int'l Hydrogen & Fuel Cell Expo

FC EXPO 2017

Mar. 1 [Wed] – 3 [Fri], 2017 **Tokyo Big Sight, Japan**

Organised by: **Reed Exhibitions Japan Ltd.**

Co-organised by: **Hydrogen Energy Systems Society of Japan (HESS)**
Fuel Cell Development Information Center(FCDIC)

Exhibiting Information? >>> FC EXPO

Upcoming Meetings & Activities

February 2017

Energy, Utility & Environment Conference
February 8-10, 2017
San Diego, CA
http://www.euec.com/

7th Annual Next-Generation 2017 Energy Storage
February 14-16, 2017
San Francisco, CA
http://www.knowledgefoundation.com/next-generation-energy-storage/

March 2017

FC EXPO 2017, 13th Int'l Hydrogen & Fuel Cell Expo
March 1-7, 2017
Tokyo, Japan
http://www.fcexpo.jp/en/

Eevc-2017: European Battery, Hybrid & Fuel Cell Electric Vehicle Congress
March 14-16, 2016
Geneva, Switzerland
http://www.eevc.eu/page/exhibition/

April 2017

6th International Conference on Fuel Cell & Hydrogen Technology
April 13-17, 2017
Putrajaya, Malaysia
http://www.ukm.my/icfcht2017/

Hannover Messe: Hydrogen+Fuel Cells+Batteries
April 24-28, 2017
Hannover, Germany
http://www.h2fc-fair.com/

WCX 17: SAE World Congress Experience
April 4-6, 2017
Detroit, Michigan
http://www.wcx17.org/

May 2017

All-Energy Exhibition and Conference 2017
May 10-11, 2017
Glasgow, Scotland (UK)
http://www.all-energy.co.uk/

231st ECS Meeting
May 28-June 2, 2017
New Orleans, LA
http://www.electrochem.org/231

June 2017

International Hydrogen + Fuel Cells 2017 Summit
June 5-6, 2017
Vancouver, BC
http://www.hfc2017.com/

5th Workshop on Ion Exchange Membranes for Energy Applications
June 26-28, 2017
Bad Zwischenahn, Germany
http://www.next-energy.de/en/research-areas/fuel-cells/fuel-cells-workshops/fuel-cells-workshop-emea2017/

July 2017

The 7th World Hydrogen Technology Convention
July 9-12, 2017
Prague, Czech Republic
http://www.whtcprague2017.cz/

Gordon Conference on Hydrogen-Metals Interactions : Making the Hydrogen Economy Work-New Developments and Recent Applications
July 16-21, 2017
Stonehill College, Easton, MA
http://www.grc.org/programs.aspx?id=11603

Do you have a hydrogen-related meeting, workshop, or activity you would like us to include in the next issue of the IAHE Newsletter? If so, please email a description and web link to Kathy Williams at williamk@utk.edu.

Get Connected—Internet Groups of Interest

LinkedIn Connections

Hydrogen Group

Hydrogen Group is a global specialist recruitment business, placing exceptional, hard to find candidates in over 70 countries.

Global Hydrogen Ambassadors Network

Their goal is to exchange opinions on a topic, which may look easy at first glance, but is rather complex. All questions are allowed. A wealth of answers can be expected.

World EcoEnergy Forum: Driving Innovation in the Energy Storage and Smart Grid Industry

The aim of this group is to bring together executives responsible for R&D to discuss about new product development and sustainable development in the energy storage and smart-grid industry.

Hydrogen Pathway

This is a very active group-page within LinkedIn that includes discussions and latest news regarding hydrogen energy.

Renewable Energy Solutions

I.R.E.S. platform to create bridges between international based investors, manufactures and wholesale companies in the Renewable Business Industry. Solar power, wind energy, tidal power, geothermal power, air power, hydrogen, waste management.

Global Renewable Energy Network

Global Renewable Energy Network (GReEN) is the premier business network for professionals and companies involved in the development, commercialization, and utilization of renewable energies (e.g. bioenergy, geothermal, hydro, hydrogen, ocean, solar, and wind), worldwide.

Fuel Cell & Hydrogen Network

Bringing together professionals and enthusiasts alike, the Fuel Cell & Hydrogen Network serves to connect those advocating fuel cell and hydrogen technologies. The group welcomes people who are interested in all types of fuel cell technologies as well as the wide variety of hydrogen technologies, and is not exclusive of hydrogen fuel cells.

Fuel Cells

Welcomes those who are interested in clean energy fuel cell applications and technologies. Encourages members to start discussions that are relevant to fuel cells, to post promotions and jobs, and to use this group to develop their professional network.

Fuel Cell Energy

The Fuel Cell Energy Group advocates the use of Fuel Cell Energy & the promotion of its Technology and for those interested in learning more about Fuel Cell Technology. Fuel Cell Professionals, Renewable Energy, Clean Technology, and Environmental Advocates are welcome. Solar, Wind, Biomass, Biofuel, Tidal Power & Wave Professionals also welcome to learn about this emerging technology.

Facebook Connections

Horizon Fuel Cell Technologies

Horizon Fuel Cell Technologies was founded in Singapore in 2003 and currently owns 5 international subsidiaries, including a new subsidiary in the United States. Having started commercialization with small and simple products while preparing for larger and more complex applications, Horizon already emerged as the world's largest volume producer of commercial micro-fuel cell products, serving customers in over 65 countries.

International Association for Hydrogen Energy

Facebook community for sharing the information regarding advances in hydrogen energy.

Blogs

Fuel Cell Nation

Fact-Based Analysis and Discussion of Clean Energy
http://blog.fuelcellnation.com/

H2-International

Offers a blog and newsletter that contains articles which are published in the German magazine HZwei. Offers detailed information on hydrogen and fuel cells, and is a respectful attempt at continuing the work of Peter Hoffman, the author of *Hydrogen & Fuel Cell Letter*.
http://www.h2-international.com/

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