international association for hydrogen energy
Clean and Abundant Energy for Sustainability

April 2017 • Volume 9 • Issue 2 Electronic Newsletter

How is the United States doing in the global hydrogen fuel-cell game?

Hydrogen fuel-cell vehicles (FCVs) are coming to a lot near you, and fuel stations aren't far behind—they're already there in small numbers on the West Coast.

"The U.S. is making progress on the development of a hydrogen station network, especially in California," said Toyota Advanced Technologies Group national manager Craig Scott. "Today there are about 25 retail locations in California, with about 17 more in various stages of development."

Funding currently exists for 100 hydrogen fuel stations across California. Scott admitted that widespread adoption and development of hydrogen fuel-station infrastructure is necessary for technology to truly take hold. The brand has a major interest in doing so: Toyota has released the Mirai, one of the first commercially sold hydrogen vehicles in the country.

"Hydrogen is an important long-term technology initiative for Toyota," Scott said. "When we launched Mirai, our president, Akio Toyoda, explained that hydrogen represents the next 100 years for us. The transition to carbon-free fuels and zero-emission-vehicle technology will happen over a period of time measured in decades, not years."

While the implementation of hydrogen infrastructure in the United States is still largely contained to California (there are three stations on the Eastern seaboard), other countries have already committed major resources to the green energy source.

As home to the largest concentration of hydrogen car manufacturers, Japan not surprisingly has a more robust network of hydrogen fueling stations than other countries. The Japanese Ministry of Economy, Trade and Industry recently set a goal of having 40,000 FCVs on the road by 2020, just in time for the Olympic Games in Tokyo. There are currently 80 fueling stations across that country, but the government is aiming to double that by the time the torch is lit.

The island nation plans to make its hydrogen dream a reality through public/private partnerships with both energy companies and automakers. By investing big in its own infrastructure and production, Japan hopes it can create an economy-of-scale effect that drives down the price of both FCVs and hydrogen infrastructure.

Meanwhile, in Europe, similar plans to cooperatively develop both FCVs and the infrastructure to go with them are underway. Two major German automakers are in the final stages of developing production versions of FCVs.

By 2023, Europe's largest economy plans to have 400 stations across the country (currently fewer than 50 are in operation), creating an environment where economies of scale can take effect for automakers and suppliers.

Elsewhere in Europe, population-dense nations that place

-Continued on page 3

Contact Us:
IAHE, 5794 SW 40 St. #303, Miami, FL 33155, USA
Any questions on the E-Newsletter or IAHE? Email Matthew Mench at mmench@utk.edu

Table of Contents

Newsletter Production

Published by IAHE through
The University of Tennessee
Mechanical, Aerospace, and Biomedical Engineering Department
414 Dougherty Engineering Building
Knoxville, TN 37996

Editor-in-Chief Dr. Matthew M. Mench, Head and Condra Chair Professor
Designer/Editor Kathy Williams
Writers/Contributors Yasser Ashraf Gandomi, and Cyrus Daugherty

THE UNIVERSITY OF TENNESSEE KNOXVILLE
BIG ORANGE. BIG IDEAS.

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.

Get Connected with IAHE

International Association for Hydrogen Energy

International Association for Hydrogen Energy

-Continued from page 1

a high value on green energy already have robust functioning networks of hydrogen stations. Denmark—where approximately a dozen stations are currently operating, with more on the way—has partnered with its neighboring Nordic states Norway and Sweden, as well as Germany, to ensure that travel routes between major cities are outfitted with fueling stations.

No discussion of hydrogen infrastructure is complete without mentioning the green elephant in the room: battery-electric vehicles (BEVs). The demand and technology for BEVs have soared in recent years, and many critics are quick to suggest that consumers and indeed infrastructure developers must choose one or the other.

"People often pit BEVs against FCVs, but I say that's silly—this is not a zero-sum game," Scott explained. "Any technology that drives society toward less carbon in our transportation system should be embraced. BEVs work for some customers, while FCVs, I believe, can work for many more. The idea is to make the transition easy and seamless for the customer."

With the exception of California, the United States is far from having a robust hydrogen infrastructure, but developments in the Golden State, Japan, and Europe suggest this could change quickly. A recent independent market research report posited that by 2020, enough infrastructure will be in place around the globe to jump-start the FCV market. By 2050, the report argued, FCVs will dominate the auto industry. As more stations are built and FCVs become cheaper, it's only a matter of time before hydrogen is a standard option on the road.

Source: http://blog.caranddriver.com/how-is-the-united-states-doing-in-the-global-hydrogen-fuel-cell-game/

Hydrogen Vehicle News

First drive: Honda Clarity soars with hydrogen

Honda was green before green cars were cool, but the automaker gets less credit than late-comers to environmental awareness.

Over the next few weeks, Honda will launch a new bid to be considered one of the auto industry's leaders in environmental technology and alternative energy.

The first step is a slick and luxurious car powered by a hydrogen fuel cell: The Accord-sized Clarity sedan. Two other versions of the Clarity will debut at the New York auto show in mid-April: an electric car that goes 80 miles on a charge and a plug-in hybrid with a 40-mile battery range and longer range on gasoline.

It's strange Honda isn't already recognized as a green leader, but the mantle of environmental leadership slipped away from the company in the 21st Century, despite a history that includes selling America's first hybrid, building millions of highly fuel-efficient vehicles and having hydrogen fuel cell cars on the road for nearly two decades.

Honda executives and engineers gnash their teeth whenever another company wins accolades for hybrids and alternate fuel vehicles. They were there first, and initially best.

The easy-to-drive Clarity fuel cell reasserts that status. It's a legitimate five-seater, with a range of 366 miles on a tank of hydrogen, thanks to high-pressure storage of hydrogen gas and a quick refueling time of 3-5 minutes, far less than battery-electric cars. Fuel cells generate electricity by combining hydrogen from their tank with atmospheric oxygen. The only exhaust is an invisible waft of steam that's vented below the vehicle.

It takes just three to five minutes to fill the tanks at a hydrogen pump, a significant advantage versus even the quickest-charging battery-powered electric cars.

The Clarity's interior is roomy and richly appointed, with soft materials and advanced features including. The fuel cell creates electricity nearly soundlessly and the car is ready to drive a few seconds after the driver pushes the start button.

I enjoyed a brief drive in a Clarity on highway and surface streets in suburban Detroit. The fuel cell delivers power with the smooth ease all electric vehicles offer. The electric motor's output of 174 horsepower and 221 pound-feet of torque is pretty mild for a 4,134-pound midsize sedan, but the Clarity accelerates confidently. A sport setting increases acceleration and regenerative braking.

The steering is well tuned and direct, as you'd expect in any good midsize sedan. The ride is smooth.

The Clarity comes in one, well-equipped trim level, with leather upholstery, a head-up display, touch screen, adaptive cruise control, lane-keeping assist and other features.

The sticker price is $58,490, but Honda subsidizes 36-month leases to $369 a month with a $2,800 deposit. Owners also get $15,000 to buy fuel and 21 days' free rental of a luxury car to use in areas without hydrogen filling stations.

If hydrogen were widely available, it's easy to imagine thousands of people all over the country choosing the Clarity as their everyday vehicle.

Of course, hydrogen isn't widely available, even in California, the only state where the all-new 2017 Clarity is on sale. A couple dozen gas stations in the Bay Area and from Santa Barbara to San Diego have hydrogen pumps. Honda expects the network to grow to 36 this year and 100 by 2020, filling gaps up the coast and moving east into the valleys.

Honda has delivered about 80 Clarity fuel cell cars so far this year. The company won't make sales projections, but Steven Center, vice president of Honda's environmental office, says there's a waiting list for every one that arrives from the assembly plant in Sayama, Japan. Supply will increase when the electric and plug-in hybrid models arrive later this year.

The Clarity uses an all-new structure that was developed specifically to accommodate fuel cell, battery and hybrid vehicles. Few automakers have accomplished that level of engineering flexibility.

The electric motor and fuel cell fit under the hood, in the same space Honda's 3.5L V6. That clever packaging is a first step toward creating a fuel cell that can be dropped into a variety of vehicles as an alternative to gasoline engines, the same way many current vehicles can accommodate a V6 or four-cylinder engine as needed.

A battery to store electricity goes under the front seats. Hydrogen compressed to 10,000 psi goes in two tanks, a small one under the rear seat and a larger one behind the rear seat. The larger tank intrudes into the trunk, reducing luggage space to 11.8 cubic feet, far less than a conventional midsize sedan.

We're years away from having nationwide network of hydrogen stations, if one ever develops. Honda makes a strong argument for one with the fuel cell Clarity, though. The automaker hopes the battery-only and plug-in hybrid Clarity models will win plenty of buyers before then, rebuilding its reputation as an environmental hero.

Source: http://www.freep.com/story/money/cars/mark-phelan/2017/03/25/2017-honda-clarity-hydrogen/99517678/

First in NJ: Hydrogen filling station for fuel cell cars get one town's OK

If hydrogen-fueled cars and trucks are the wave of the future, this Bergen County borough will be a proud first: the first in New Jersey to approve installation of a hydrogen gas dispensing station for vehicle owners dealing with a fuel cell low on juice.

There are dozens of these stations throughout the country — mostly in California — but zero in the Garden State. It's expected the Northeast is the next target for these stations that combine hydrogen and oxygen to generate power. Hydrogen-powered vehicles are considered electric, but don't need to be plugged in for hours. Instead, a "fill-up" would take minutes.

Lodi's hydrogen fuel station will set up shop in the months ahead at an existing Shell gas station on Essex Street. The proposal was approved by zoning officials at the end of February.

"New Jersey is a corridor state, so if you were to put five stations in New Jersey, you could cover the whole length of the state where people would be able to get to a refueling station," said Mike Strizki, president of Hydrogen House Project, a nonprofit in Hopewell.

Strizki described fuel cell vehicles as "the next generation," likening them to cell phones in favor of landlines. Water is the only emission.

"And hydrogen is 80 percent of every molecule in the universe so it can be made from everything," he added. Hydrogen fuel cell vehicles are not currently sold in New Jersey. Dealerships in California are selling the Mirai, Toyota's fuel cell car.

Source: http://nj1015.com/first-in-nj-hydrogen-filling-station-for-fuel-cell-cars-get-one-towns-ok/

Hyundai's FE fuel cell concept car previews hydrogen's future

Hyundai beat Toyota and Honda to the punch with a hydrogen fuel-cell car, but the South Korean carmaker also took a shortcut. That's because the current Tucson Fuel Cell is a derivative of an existing model, rather than a clean-sheet design like the Toyota Mirai and Honda Clarity Fuel Cell.

But Hyundai is now thinking ahead to its next generation of fuel-cell cars. At the 2017 Geneva Motor Show, it unveiled the FE Fuel Cell concept, which shows what a Hyundai fuel-cell vehicle based on a dedicated platform could look like. That's exactly the kind of vehicle Hyundai will launch sometime next year as a replacement for the Tucson Fuel Cell.

The FE (for "Future Eco") Fuel Cell is a crossover like the Tucson Fuel Cell, but with styling that's radically different from any current Hyundai production model. Because fuel cell cars don't require large radiators, Hyundai ditched the traditional grille for a smooth front fascia. The rest of the body continues that motif, with relatively simple surfaces that contrast with the sculpting and heavy lines of many current cars. Hyundai says the shape is supposed to reference the flow of water — the fuel-cell powertrain's only emission.

Speaking of the powertrain, Hyundai says it's an improvement over the one used in the Tucson Fuel Cell. The FE Fuel Cell concept's setup is 20 percent lighter and achieves 10 percent greater efficiency, according to the automaker, with a 30-percent increase in the power density of the fuel cell stack. That allows for more power to be produced from the same volume, in theory providing greater range. Hyundai says the FE Fuel Cell can drive 800 kilometers (497 miles) between hydrogen fill-ups.

The FE Fuel Cell concept doesn't just use fuel cells to propel itself. Water emitted by the fuel cell stack is cycled through a humidifier to make the cabin more comfortable, and electricity is sent to portable battery packs that can charge electrical devices, including a scooter stored in the cargo area.

Hyundai plans to launch its next-generation fuel cell crossover next year, and says that the production model will incorporate some features from the FE Fuel Cell concept. Fuel-cell cars still face major challenges, including limited hydrogen infrastructure and relatively high prices. But Hyundai is hedging its bets: it's devoting resources not only to fuel cells, but also to hybrids, plug-in hybrids, and battery-electric cars in a bid to become a major green-car player.

Source: http://www.digitaltrends.com/cars/hyundai-fe-fuel-cell-concept/

Gov't pushes hydrogen fuel cell cars

The Ministry of Environment and the Gwangju Metropolitan Government launched a renewable energy-powered car rental service in the city Monday, including 15 hydrogen fuel cell vehicles, in an attempt to raise awareness on eco-friendly transportation.

This is the first time hydrogen fuel cell vehicles have been available to rent.

In addition to the 15, 27 others run on electricity.

The Car Sharing project is for those who need vehicles for less than one hour. Customers must make reservations online and pick up the vehicle from a designated parking lot. The rent will cost ₩3,950 per 30 minutes.

"Hydrogen fuel cell vehicles usually cost more thus making it more difficult for people to experience them," said Environment Minister Cho Kyeung-kyu. "I hope this service will give people a chance to ride in a fuel cell vehicle and become motivated to buy one."

The fuel cell car is the Tucson IX made by Hyundai Motor Co. It has a range of 415 kilometers with a full battery, a big advantage compared to electric vehicles.

Electric vehicles are popular for their zero-emission feature. Jeju Island's rental service sets a good example to raise awareness of electric vehicles among the public. Other provinces and metropolitan cities are following Jeju's lead.

Around the world, electric and fuel cell vehicles are gaining traction. Their popularity has also increased in Korea, but they've got a lot of catching up to do as people still prefer gas powered vehicles. The government is adopting different measures to encourage the public to purchase electric cars.

Source: http://www.koreatimes.co.kr/www/nation/2017/03/371_225181.html

Hydrogen fuel cells get a boost from Tesla's Elon Musk

Tesla Motors CEO and co-founder Elon Musk is famous for blowing off hydrogen fuel cell vehicles, but it looks like he may have stirred a hornet's nest. Spurred in part by the success of Tesla's zero-emissions, battery-operated EVs, oil companies are helping to build out a fueling infrastructure for fuel cell vehicles.

That's not necessarily a clear win for the environment, because the primary source of hydrogen for fuel cells is natural gas. However, hydrogen from renewable sources is already inching into the market, and some oil companies — Royal Dutch Shell being one notable example — are beginning to transition into lower-carbon business models.

Where are all the hydrogen stations?

Hydrogen fuel cell vehicles run on electricity, just like Tesla's popular Model S. The difference is that the Model S stores an electrical charge in a battery. Fuel cell vehicles generate electricity through a chemical reaction between hydrogen and oxygen. The only emission is water.

Fuel cell EVs have one big advantage over battery EVs: They can be refueled in a few minutes just like a conventional car.

The problem is that very few hydrogen fuel stations are available.

On the bright side, several interesting collaborations have popped up to fix that problem.

The Shell-Toyota hydrogen collaboration

Shell is mapping a hydrogen transition. Back in 2015 the company announced big plans for a hydrogen fueling network in Germany, leveraging locations at existing gas stations.

In the latest development, Shell is banking on a $16.4 million grant from the California Energy Commission to help fund the construction of seven fuel stations. Shell and Toyota — manufacturer of the Mirai fuel cell EV — will chip in the remaining $11.4 million.

The eventual goal for California is 100 public fueling stations by 2024.

In consideration of the natural gas issue, Shell's interest in the California market is a step in the right direction. The Air Resources Board requires 33 percent renewable hydrogen to be dispensed in any fuel station that it funds.

Shell may shrug off oil, eventually

Shell also appears to recognize that, just as zero-emission vehicles are nudging out combustion engines, renewable hydrogen will eventually push fossil fuel aside. Here's a snippet from the company's website:

"When driven, the vehicle's fuel cell converts compressed hydrogen from the fuel tank into electricity that powers the motor. FCEVs produce no emissions from the tailpipe, only water. When renewable electricity is used to make the hydrogen, the vehicle can effectively be driven without generating any carbon emissions."

Helping that initiative along, last year Shell created a division devoted to wind energy investments.

As cited by Bloomberg, the company's chief financial officer let word out that Shell foresees demand for oil peaking in about five years.

Toyota is also active in the renewable hydrogen field, and the company is confident that hydrogen will compete with batteries for the EV market. Bloomberg's Craig Trudell, Yaki Hagiwara and John Lippert explain why Elon Musk's success with Tesla spurred Shell and other companies to start looking at new technologies:

"Musk may be inadvertently helping Toyota's cause. Early on, Big Oil wasn't convinced cars could make the zero-emission switch in droves. Then Tesla took about 373,000 pre-orders for its Model 3 sedan last year. The oil industry was 'a bit scared' by the feverish reception, said Katsuhiko Hirose, a Toyota project general manager."

The hydrogen economy has many fans

Despite the environmental issues involving natural gas, the U.S. is forging ahead with plans for the hydrogen economy of the future, as is Japan.

Europe is another hotbed of fuel cell activity. Earlier this year, Shell partnered with a dozen other industry stakeholders to form the Hydrogen Council: a new organization with a mission to help guide policymakers toward best practices and encourage an efficient transition to fuel cells.

The new partnership leaves plenty of wiggle room for hydrogen sourced from natural gas, but it also emphasizes the role of renewable hydrogen in the decarbonized economy of the future:

"Efforts to decarbonize the energy system need to pull on four main levers: improving energy efficiency, developing renewable energy sources, switching to low/zero carbon energy carriers, and implementing carbon capture and storage (CCS) as well as utilization (CCU). This will radically change energy supply and demand."

As for Mr. Musk, about two years ago he had this to say about fuel cell EVs:

"I just think that they're extremely silly … It's just very difficult to make hydrogen and store it and use it in a car," Musk said at the time. "If you, say, took a solar panel and use that … to just charge a battery pack directly, compared to split water, take hydrogen, dump oxygen, compress hydrogen … It is about half the efficiency."

It looks like hydrogen may get the last laugh after all.

Source: http://www.triplepundit.com/2017/03/hydrogen-fuel-cell-elon-musk/#

Texas positioned to lead hydrogen revolution

For decades Texas has been the largest producer of transportation fuels in the United States. Our refineries have produced gasoline, diesel and jet fuel that mobilized the nation and made the state rich. But based on current projections, demand for gasoline will decrease significantly in the coming decades because of a combination of fuel economy improvements and the dramatic shift to electric vehicles.

These trends could give Texas cause for worry because they might undercut global demand for gasoline. But Texas industry can also play a key role in the era of electrified transportation.

In the U.S., electric vehicles are expected to account for up to 35 percent of new car sales by 2030. Because of performance, energy diversity and environmental- and climate-related benefits and the impending arrival of autonomous vehicles, the surge in electric vehicles will continue worldwide. Furthermore, an increasing number of cities are proposing to ban diesel vehicles — most recently, Athens, Madrid, Mexico City and Paris, adding uncertainty to the future of light-duty diesel vehicles.

Hydrogen Vehicle News

Currently, there are two ways to electrify vehicles — with fuel cells or with batteries. Most attention today is focused on battery electric vehicles, and given recent improvements, rightly so. However, fuel cell electric vehicles, which derive their electricity by combining hydrogen and oxygen from the air over a catalyst, with water being the only emission, are gaining traction with manufacturers. Fuel cells have been used by NASA for decades, so they just might be a space-age technology whose time has come.

Texas is ideally situated to be a leader in producing hydrogen for the new energy system and for the next generation of electrically powered vehicles. Texas is the largest producer in the nation of hydrogen and has accumulated excellent knowledge of the production, storage, transport and safe handling of hydrogen.

Texas also has excellent resources of natural gas — the main feedstock for manufacturing hydrogen — and of solar and wind, which can be used to produce renewable hydrogen by electrolyzing water. Hydrogen production and storage also can help to stabilize the electricity grid as more intermittent renewables come on line.

More broadly, hydrogen can be used to power turbines to create heat and electricity, as a feedstock in several industrial applications such as the production of steel and chemicals including ammonia for fertilizers, and in the semiconductor industry.

It seems clear that an energy transition is afoot, and hydrogen might play a key role in multiple sectors simultaneously.

The hydrogen society has been talked about for decades, but its potential has gained attention recently. For example, 13 major international companies recently created a Hydrogen Council to pool their resources to promote hydrogen in the energy transition. These companies invest about $2 billion per year on hydrogen and fuel cells.

To put it in context, that level of research investment is on par with traditional research and development budgets for the U.S. Department of Energy for all nonnuclear forms of energy combined.

Of the 13 companies in the council, three have significant operations in Texas — Air Liquide, Shell and Toyota. Air Liquide already is a major hydrogen producer in Texas. Shell has its U.S. corporate headquarters in Houston and has major oil and gas production and exploration, refinery and gas station network operations in the state. Toyota has a manufacturing plant in San Antonio and recently moved its U.S. corporate headquarters to Plano.

Texas has a great opportunity to join with these companies not only to be the leader for today's fuel but to keep making money while the energy sector reduces its environmental footprint and gets transformed. This is where Texas has excelled — not through mandates but in partnering with industry to create an environment to attract business and create jobs.

Source: http://www.mysanantonio.com/opinion/commentary/article/Texas-positioned-to-lead-hydrogen-revolution-11010208.php

Buy an electric car, get a NY rebate

A total of $70 million has been allocated for electric car rebates and outreach initiatives in New York, Gov. Andrew Cuomo announced this week.

The program has been launched with the intentions of increasing the number of clean and non-polluting electric cars in the state through the "Drive Clean Initiative" as well as promoting efforts to reduce carbon emissions within the transportation sector.

"Reducing vehicle emissions is a critical part of this administration's efforts to fight climate change and reduce New York's carbon footprint," Cuomo said in a statement. "These highly-anticipated rebates will make electric vehicles more affordable and accessible and support this state's nation-leading efforts to build a cleaner, greener New York for generations to come."

The Drive Clean rebates Cuomo referred to will become available to New York residents who buy eligible cars through participating new car dealers and are valued up to $2,000. That's in addition to a federal tax credit of up to $7,500.

The initiative is a $55 million government investment that will provide rebates for the purchase of a new plug-in hybrid electric car, all-electric or hydrogen fuel cell car.

The other $15 million will go towards improving consumer awareness of electric cars and their benefits, as well as installing more charging stations and improving electric car-enabling technologies.

The transportation sector is the largest contributor to the state's greenhouse gas emissions, according to Cuomo's office, Additionally, electric cars are not only more energy efficient than gasoline-powered cars, but they also cost 50 to 70 percent less to operate per mile.

Last fall, Cuomo's office also announced $3 million in rebates through the Environmental Protection Fund for municipalities to purchase or lease zero-emission vehicles, such as battery electric and hydrogen vehicles, for their fleets.

Source: http://www.lohud.com/story/news/politics/politics-on-the-hudson/2017/03/22/buy-electric-car-get-ny-rebate/99502168/

CARB finds vehicle standards are achievable and cost-effective

On March 24, California re-affirmed its commitment to clean air, protecting public health and continuing the fight against climate change when the California Air Resources Board voted unanimously to continue with the vehicle greenhouse gas emission standards and zero-emission vehicle program for cars and light trucks sold in California through 2025.

The action ensures that California and 12 other states that follow its vehicle regulations, together accounting for a third of the U.S. auto market, will move forward greenhouse gas emission standards adopted in the 2012 process involving the federal government, California and the automakers.

The Board also voted to support the expansion of the zero-emission vehicle marketplace before 2025, calling for redoubling current efforts underway to support market growth and paving the way for new regulations to rapidly increase the number of zero-emission vehicles required to be sold in California after 2025.

"Today ARB affirmed the technical reviews done by our own and EPA staff, as well as the work of independent analysts," said CARB Chair Mary D. Nichols. "We invite the global industry to bring us their best cars and trucks and take advantage of the willingness of our leaders to provide a broad range of incentives to help make these vehicles affordable. And we also invite them to come sit down with us if they have specific concerns about implementation of the existing regulations that can be addressed without weakening the impact overall. The program is delivering cleaner cars that save consumers money and are fun to drive: That's how we do it in California."

The Board vote was supported by representatives from the 12 states that have adopted California's standards. Those states together have a population of 113 million and constitute roughly 30 percent of the nation's new car sales. Senior environmental officials from Connecticut, Massachusetts, New York and Oregon testified at today's hearing to urge the Board's approval.

The Board action affirmed the comprehensive, multi-year staff assessment and analysis that concluded that the standards for model years 2022-25 are appropriate and feasible. The staff assessment found that the technology to achieve them is not only currently available, but has exceeded the original expectations, both for level of development and cost, when the standards were adopted with automaker support in 2012.

The Board's vote reached the same conclusion as the U.S. Environmental Protection Agency in its final determination in January on the federal greenhouse gas emission standards for model years 2022-25. Last week, however, the Trump administration rescinded that decision at the request of automakers, and announced that it intends to reconsider the final determination in coordination with the National Highway Traffic Safety Agency, which is responsible for setting the Corporate Average Fuel Economy standards.

Governor Edmund G. Brown Jr., Attorney General Xavier Becerra, Senate President pro Tempore Kevin de Leon and Assembly Speaker Anthony Rendon criticized the move by the Trump administration.

The Board's decision to stay the course on standards to cut greenhouse gases and smog-forming emissions was based upon the findings of a comprehensive, 637-page staff report that included an analysis of the Technical Assessment Report developed by California and the federal agencies, which was released last July. The CARB staff report also includes the first comprehensive, in-depth analysis of the zero-emission vehicle market in California, including valuable new consumer research to assess the benefits and use profiles of ZEVs now operating in California.

Based on these findings, the Board also voted to pursue policies to support more than 4 million zero-emission vehicles in California by 2030, and established a goal to continue reducing average fleet-wide greenhouse gas emissions from new vehicles by 4-5 percent per year between 2025 and 2030.

"With the midterm review now in the rearview mirror, we look forward to accelerating our efforts to develop the next set of California vehicle standards," said CARB Deputy Executive Officer Alberto Ayala. "California is also moving forward to accelerate deployment of fuel cell and battery electric cars. That will put us on track to meeting our clean air and climate goals for 2030 and also align California with current advanced vehicle technology research and investment in the global auto marketplace."

California, with nearly half of all zero-emission vehicles in the nation, has several programs in place to further support the growing electric car marketplace. The state offers rebates to new buyers or lessees of zero-emission vehicles, is rapidly scaling the infrastructure for charging electric cards and fueling hydrogen fuel cell vehicles, and agencies are pursuing nearly 200 actions to support the market, as identified in the Governor's 2016 ZEV Action Plan.

The Board expressed its commitment to support the ZEV marketplace by continuing complementary programs such as the Low Carbon Fuel Standard, and redoubling efforts on continued state incentives, utility infrastructure programs, and expanded public education programs, such as the newly established initiative through Veloz, formerly the California Plug-in Electric Vehicle Collaborative.

The staff Midterm Review report is here: https://www.arb.ca.gov/msprog/acc/acc-mtr.htm

Source: https://yubanet.com/california/carb-finds-vehicle-standards-are-achievable-and-cost-effective/

Air Liquide's new hydrogen station fuels 1,000th fuel cell vehicle

Air Liquide, a hydrogen supply-chain company, says that its first hydrogen station installed in California – in the city of Anaheim – has achieved its 1,000th hydrogen fuel cell vehicle fill-up after just 100 days in operation.

Opened to the public since December 2016, this station has already enabled hydrogen-powered vehicles to cover 250,000 kilometers, avoiding about 56 tons of atmospheric CO_2 emissions.

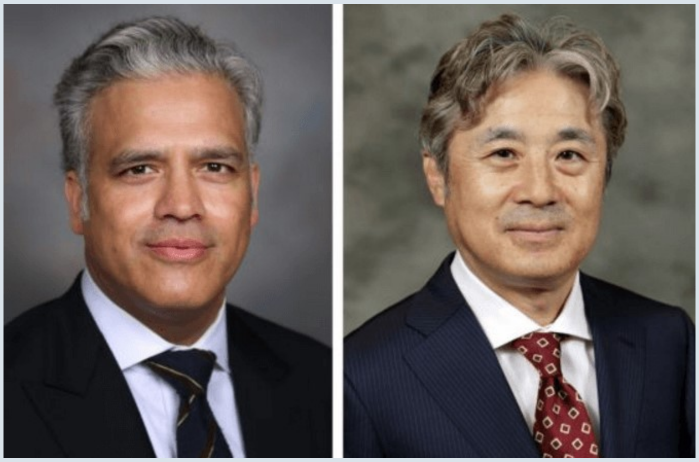
As reported, this new station installed and operated by Air Liquide is part of a state of California program designed to support the deployment and use of hydrogen vehicles, with about 50 hydrogen stations planned in California by the end of 2017.

The Anaheim station, like all of the stations designed and installed by Air Liquide, is able to recharge hydrogen-powered electric vehicles in less than five minutes for a driving range of around 500 kilometers. Used in a fuel cell, the hydrogen combines with the oxygen in the air to produce electricity without generating any byproduct other than water and offering an extended range capacity.

To date, 75 hydrogen stations have already been designed and installed by Air Liquide worldwide.

Source: http://ngtnews.com/air-liquide-touts-1000th-fuel-cell-vehicle-fill-calif-hydrogen-station

GM, Honda name leaders for hydrogen fuel cell joint venture



General Motors Co. (GM) and Honda have announced the executive structure for their recently established joint venture company, Fuel Cell System Manufacturing LLC (FCSM), which will develop hydrogen fuel cell propulsion systems.

According to the companies, Suheb Haq of GM will serve as the first president of FCSM, and Tomomi Kosaka of Honda will be the new company's vice president. Together, Haq and Kosaka will be responsible for operations, overseeing the start-up of the joint venture and ongoing manufacturing operations.

GM and Honda note that they plan to rotate the positions of president and vice president every two years.

Haq most recently was director of GM operational excellence. Kosaka was president and CEO of Honda of America Mfg. Inc., responsible for manufacturing operations of three auto plants and an engine plant in Ohio.

Further, FCSM will include a board of directors consisting of three executives from each company that will include a rotating chairperson.

Representing Honda on the FCSM board of directors are the following:

- Takashi Sekiguchi, managing officer and director/chief operating officer of automobile operations for Honda Motor Co.
- Mitsugu Matsukawa, operating officer/chief operating officer of IT operations/head of production planning supervisory unit in production operations for Honda Motor Co.
- Rick Schostek, executive vice president of Honda North America Inc.

Sekiguchi will serve as the first chairperson of the FCSM board of directors.

Representing GM on the FCSM board of directors are the following:

- Charles Freese, executive director of the global fuel cell business
- David Maday, executive director of corporate development
- Robert Portugaise, executive director in manufacturing engineering.

As previously reported, FCSM was established with equal investments from Honda and GM totaling $85 million, creating the auto industry's first manufacturing joint venture to mass-produce an advanced hydrogen fuel cell system that will be used in future products from each company.

FCSM will operate within GM's existing battery pack manufacturing facility site in Brownstown, Michigan, south of Detroit. Mass production of fuel cell systems is expected to begin around 2020 and create nearly 100 new jobs.

Back in July 2013, Honda and GM established a master collaboration agreement that enabled the co-development arrangement for a next-generation fuel cell system and hydrogen storage technologies. The companies integrated their development teams and shared hydrogen fuel cell intellectual property to create a more affordable, commercial solution for fuel cell and hydrogen storage systems.

Source: http://ngtnews.com/gm-honda-name-leaders-hydrogen-fuel-cell-joint-venture

Rollout begins: Toyota delivers first of 100 fuel cell buses

Toyota Motor Corp. says it has officially delivered the first fuel cell (FC) bus sold under the Toyota brand to the Bureau of Transportation of the Tokyo Metropolitan Government.

Toyota FC Bus (modified for Toei route bus)

According to the automaker, this FC bus will be put into operation as a Toei route bus in March, along with a second bus that is scheduled for delivery in the same month.

As previously reported, Toyota plans to introduce over 100 FC buses mainly within the Tokyo area ahead of the Tokyo 2020 Olympic and Paralympic Games. The increased use of FC buses in urban areas is expected to help raise the level of understanding by the general public regarding the use of FC buses as a form of public transportation.

The Toyota Fuel Cell System, which was developed for the Mirai fuel cell vehicle, has been adopted to provide better energy efficiency in comparison with internal combustion engines, as well as to deliver superior environmental performance, with no CO_2 emissions or substances of concern emitted when driving.

The company says the bus also uses a high-capacity external power supply system. With a power supply capable of a 9 kW maximum output, and a large capacity of electricity supply at 235 kWh, the FC bus can be used as a power source in the event of disasters, such as at evacuation sites, or its electricity supply can also be harnessed for home electric appliance use.

Development and demonstration tests of the Toyota FC Bus were conducted under the Next-Generation Energy and Social Systems Demonstration Project of the Ministry of Economy, Trade and Industry and the Low Carbon Technology Research and Development Program under the Ministry of Environment. It was then introduced under the program for promoting low carbonization of local transportation of the Ministry of Land, Infrastructure, Transport and Tourism.

Toyota says it continues engaging in the technological and product development of FC buses and fuel cell forklifts, as well as stationary fuel cells for use in homes. Going forward, the group intends to accelerate developments to contribute to the realization of a hydrogen-based society.

Source: http://ngtnews.com/rollout-begins-toyota-delivers-first-fuel-cell-bus-to-tokyo-government

Foshan hydrogen fuel cell tram contract signed

China: CRRC Qingdao Sifang is to supply eight hydrogen fuel cell trams for a route being developed in Foshan, the supplier announced on March 9.

Each tram will have capacity for 285 passengers and a maximum speed of 70 km/h. They will be powered by hydrogen fuel cells developed with Canadian company Ballard Power Systems under a C$6m agreement.

The trams will be deployed on the 17.4 km Gaoming Line in Foshan, which will have 20 stops.

In March 2015 seven hydrogen fuel cell trams assembled by CRRC Qingdao Sifang under license from Škoda Transportation entered passenger service on an 8.8 km line in Qingdao.

Source: http://www.metro-report.com/news/single-view/view/foshan-hydrogen-fuel-cell-tram-contract-signed.html

Hydrogen News of Interest

Cambridge scientists use light & plants to make cheap, clean hydrogen

Hydrogen has come into the spotlight for its ability to provide clean fuel source for vehicles. Referred to as *fuel cell vehicles*, they use hydrogen gas to power an electric motor. This is different than conventional vehicles that run on gasoline or diesel, because the fuel cells cars and trucks use a combination of hydrogen and oxygen to produce electricity to run the motor.

Hydrogen is typically made with natural gas, which is less polluting than oil, but isn't completely clean. So why not try to make it cleaner? That was the goal of the University of Cambridge scientists who found a way to make the fuel source using sunlight and biomass like leaves.

To begin, the researchers created clean hydrogen with biomass by suspending the biomass in alkaline water and then adding catalytic nanoparticles. The components were put in light mimicking the sun in the lab, where chemical reactions unfolded, allowing lignocellulose, which is a part of plant biomass, to produce hydrogen. This event is called a photocatalytic conversion process.

Joint lead author Dr. Moritz Kuehnel, from the Department of Chemistry at the University of Cambridge, explains:

"Lignocellulose is nature's equivalent to armored concrete. It consists of strong, highly crystalline cellulose fibers, that are interwoven with lignin and hemicellulose which act as a glue. This rigid structure has evolved to give plants and tress mechanical stability and protect them from degradation, and makes chemical utilization of lignocellulose so challenging"

Up until this point, in order to turn lignocellulose into hydrogen, scientists needed high temperatures in a gasification process. The Cambridge scientists relied on sunlight instead:

"There's a lot of chemical energy stored in raw biomass, but it's unrefined, so you can't expect it to work in complicated machinery, such as a car engine. Our system is able to convert the long, messy structures that make up biomass into hydrogen gas, which is much more useful. We have specifically designed a combination of catalyst and solution that allows this transformation to occur using sunlight as a source of energy with this in place we can simply add organic matter to the system and then provided it's a sunny day, produce hydrogen fuel."

Co-author Erwin Reisner continues:

"Our sunlight-powered technology is exciting as it enables the production of clean hydrogen from unprocessed biomass under ambient conditions. We see it as a new and viable alternative to high temperature gasification and other renewable means of hydrogen production. Future development can be envisioned at any scale, from small scale devices for off-grid applications to industrial-scale plants."

A United Kingdom patent application has been filed, while discussions regarding a possible commercial partnership are underway.

The study's results provide a positive glimpse at what the future may hold if scientists focus on finding cleaner ways to advance the world we live in. In a time when natural resources are declining and waste products accumulating, using waste for energy may prove to be the most reliable, sustainable, and efficient route for both governments and businesses to follow.

It will be interesting to see how their findings affect fuel sources for vehicles.

Source: http://www.collective-evolution.com/2017/03/18/cambridge-scientists-use-light-plants-to-make-cheap-clean-hydrogen/

Solar and hydrogen fuel state-of-the-art electric ship

Swiss-based charity, Race For Water Foundation, wants to turn the PlanetSolar catamaran into a floating display of emerging hydrogen technologies.

"That's unprecedented on a boat," says Alexandre Closset, CEO of Swiss Hydrogen. "For the first time, a full hydrogen chain will be installed on a boat."

The electric vessel, the first to circle the globe on solar power in 2012, will be departing from the French city of Lorient on April 9, to raise awareness about plastic pollution in oceans.

Covered with solar panels, the catamaran contains eight tons of batteries to store energy. "Enough for two days," says Closset. "With our hydrogen system, we've added six to eight days of autonomy."

So how does it work? The vessel pumps seawater, which is then desalinated and purified. "Electrolyzers" powered by solar panels split H_20 molecules into oxygen and hydrogen, which is then stored and compressed in bottles, ready to be injected into fuel cells. Thus, the vessel produces energy, but emits nothing but water vapor.

Swiss Hydrogen recently presented the "Hy-Rex10" kit, a built-in electric generator on a fuel cell of 10 kilowatts that was installed for demonstration on a Renault Kangoo ZE. The system made it possible to double the electric car's autonomy. For Closset, there's no doubt about it: Hydrogen has the potential to become a fuel source for the future.

Source: http://www.worldcrunch.com/tech-science/solar-and-hydrogen-fuel-state-of-the-art-electric-ship

Hydrogen production breakthrough could herald cheap green energy

Scientists have taken a major step forward in the production of hydrogen from water, which could lead to a new era of cheap, clean and renewable energy.

Chemists from the University of Glasgow report in a new paper in *Science* on a new form of hydrogen production that is 30 times faster than the current state-of-the-art method. The process also solves common problems associated with generating electricity from renewable sources such as solar, wind or ocean wave energy.

Hydrogen is easily produced from water by electrolysis, a process which uses electricity to break the bonds between water's constituent elements, hydrogen and oxygen, and releases them as gas. Hydrogen gas can be burned to produce power with no negative impact on the environment, unlike power produced by burning fossil fuels.

One of the problems of generating electricity via renewable power is that the output either needs to be used immediately or stored. Using renewable power to produce hydrogen allows the capture of electricity in an environmentally-friendly state, which is easily stored and distributed.

Currently, industrial production of hydrogen relies overwhelmingly on fossil fuels to power the electrolysis process. The most advanced method of generating hydrogen using renewable power uses a method known as proton exchange membrane electrolysers (PEMEs). To reach optimum efficiency, PEMEs require precious metal catalysts to be held in high-pressure containers and subjected to high densities of electric current, which can be difficult to reliably achieve from fluctuating renewable sources.

The new method allows larger-than-ever quantities of hydrogen to be produced at atmospheric pressure using lower power loads, typical of those generated by renewable power sources. It also solves intrinsic safety issues which have so far limited the use of intermittent renewable energy for hydrogen production.

"The process uses a liquid that allows the hydrogen to be locked up in a liquid-based inorganic fuel. By using a liquid sponge known as a redox mediator that can soak up electrons and acid we've been able to create a system where hydrogen can be produced in a separate chamber without any additional energy input after the electrolysis of water takes place," said Lee Cronin, lead researcher, of the University of Glasgow's School of Chemistry.

"The link between the rate of water oxidation and hydrogen production has been overcome, allowing hydrogen to be released from the water 30 times faster than the leading PEME process on a per-milligram-of-catalyst basis."

The research was produced as part of the University of Glasgow Solar Fuels Group, which is working to create artificial photosynthetic systems which produce significant amounts of fuel from solar power.

"Around 95 percent of the world's hydrogen supply is currently obtained from fossil fuels, a finite resource which we know harms the environment and speeds climate change. Some of this hydrogen is used to make ammonia fertilizer and as such, fossil hydrogen helps feed more than half of the world's population," added Cronin.

"The potential for reliable hydrogen production from renewable sources is huge. The sun, for example, provides more energy in a single hour of sunlight than the entire world's population uses in a year. If we can tap and store even a fraction of that in the coming years and decrease our reliance on fossil fuels it will be a tremendously important step to slowing climate change."

Source:
https://www.laboratoryequipment.com/news/2017/03/hydrogen-production-breakthrough-could-herald-cheap-green-energy

New storage method for hydrogen-powered vehicles

An environmentally friendly future must not only encompass a universe where recycled materials are continuously repurposed, but must also involve the complete elimination of pollution from all its sources. One of the largest contributors of air pollution today is the combustion of fuels powering factories and automobiles that produce carbon dioxide (CO_2) as a byproduct.

In an effort to move towards this healthier vision of a universe, the "hydrogen economy" has provided a glimpse into what a sustainable and environmentally friendly future could look like.

The hydrogen economy describes a system that utilizes hydrogen, an attractive chemical for its ability to be stored for later use, as a major carrier for energy supply purposes[1]. As a result of hydrogen's combustibility, it has successfully been used as a fuel, both by itself and in combination with traditional gasoline.

With an estimated 60% efficiency attributed to the use of fuel cells, which is nearly double that of a gasoline internal combustion engine, whose efficiency typically only ranges from 20-35%, these energy conversion devices also exhibit a decreased rate of pollution production as compared to these typical fuel methods. In fact, a hydrogen-powered fuel cell will only produce water, heat and electricity following its use in any type of vehicle or device[1].

As a result of the remarkably eco-friendly effects associated with hydrogen-powered vehicles, an increased interest in developing enhanced methods of storing hydrogen for these energy purposes is captivating the attention of many researchers around the world.

A recent collaboration between scientists from Lawrence Livermore and Sandia National Laboratories has successfully developed an efficient hydrogen storage system placed under nanoconfinement. The method of nanoconfinement describes the infiltration of a metal hydride with the matrix of another material, typically carbon[2].

By placing a high-capacity lithium nitride (Li_3N) hydrogen storage system under this process of nanoconfinement, these researchers have shown that both the uptake and release of hydrogen within its given pathways were changed dramatically[2]. These changes occurred as a direct result of the presence of nanointerfaces present on the lithium nitride nanoparticles, which measured at a width of only 3 nanometers, which allows for a unique control of the hydrogen storage reaction chemistry to occur[2].

By undergoing a series of hydrogenation reactions, the application of lithium nitride nanoparticles to this system completely avoids the production of unfavorable intermediates, therefore increasing the efficiency of the hydrogen fuels[3]. Typical hydrogen fuel used in combination with air can cause a subsequent production of harmful nitrogen oxides (NO_x) intermediates, which can be damaging to the vehicle or device, as it can slow down the ability of the material to perform adequately[1]. By enhancing the storage capacity of this system through the utilization of these confined nanoparticles, a completely new paradigm for hydrogen storage methods has been established.

While the use of solid-solid nanointerfaces is not new to the world of battery applications, this is the first time that the role of these interfaces has shown to be successful for hydrogen storage purposes[3].

As a result of changing the chemical reactions occurring at the internal microstructures within the hydrogen storage systems, researchers in this study have been able to further understand the importance of considering not only this internal microstructure, but also the certain morphological properties that can greatly affect the performance of a given material.

By understanding the function of hydrogen-induced phase transitions in the presence of complex metal hydrides, future engineering materials are now able to take this work further in future energy storage endeavors.

References

1. Bennaceaur, Kamel, Brian Clarke, Franklin M. Orr, Jr., T. S. Ramakrishnan, Claude Roulet, and Ellen Stout. "Hydrogen as a Future Energy Carrier." *ECLIPSE 300* (2005): 30-41. Web.

2. "Nano-sized Hydrogen Storage System Increases Efficiency." *ScienceDaily*. ScienceDaily, 24 Feb. 2017. Web. https://www.sciencedaily.com/releases/2017/02/170224133918.htm.

3. "Researchers Use Confined Nanoparticles to Improve Hydrogen Storage Materials Performance." *Phys.org*. 24 Feb. 2017. Web. https://phys.org/news/2017-02-confined-nanoparticles-hydrogen-storage-materials.html.

Source:
http://www.azocleantech.com/article.aspx?ArticleID=635

Hydrogen on demand

Technion-Israel Institute of Technology researchers have developed a new approach to the production of hydrogen from water using solar energy. In findings published in *Nature Materials*, the researchers explain that this approach will make it possible to produce hydrogen in a centralized manner at the point of sale (for example, at a gas station for electric cars fueled by hydrogen) located far from the solar farm. The new technology is expected to significantly reduce the cost of producing the hydrogen and shipping it to the customer.

The study was led by Avigail Landman, a doctoral student in the Nancy & Stephen Grand Technion Energy Program (GTEP), and Dr. Hen Dotan from the Electrochemical Materials & Devices Lab. Ms. Landman is working on her doctorate under the guidance of Prof. Avner Rothschild from the Faculty of Materials Science and Engineering, and Prof. Gideon Grader, Dean of the Faculty of Chemical Engineering.

Hydrogen is considered one of the most promising energy carriers for vehicles and various other uses because of its salient advantages:

1. Hydrogen can be produced from water, and therefore production does not depend on access to non-renewable natural resources.

2. Using hydrogen fuel would reduce the dependence on fossil fuels such as oil and natural gas, whose availability depends on geographical, political and other factors, and would increase the energy available to Earth's population.

3. Unlike diesel and gasoline engines that emit considerable pollution into the air, the only byproduct of hydrogen fuel utilization is water.

Because of the advantages of hydrogen fuel, many countries -- led by Japan, Germany and the United States -- are investing vast sums of money in programs for the development of environmentally friendly ("green") technologies for the production of hydrogen. Most hydrogen is currently produced from natural gas in a process that emits carbon dioxide into the air, but it is also possible to produce hydrogen from water by splitting the water molecules into hydrogen and oxygen in a process called electrolysis. However, since electricity production itself is an expensive and polluting process, researchers at the Technion and around the world are developing a photoelectrochemical (PEC) cell that utilizes solar energy to split water into hydrogen and oxygen directly, without the need for external power source.

The main challenges in the development of PEC solar farms for the production of hydrogen are 1.) keeping the hydrogen and the oxygen separate from each other, 2.) collecting the hydrogen from millions of PEC cells, and 3.) transporting the hydrogen to the point of sale. The Technion team solved these challenges by developing a new method for PEC water splitting. With this method, the hydrogen and oxygen are formed in two separate cells -- one that produces hydrogen, and another that produces oxygen. This is in contrast to the conventional method, in which the hydrogen and oxygen are produced within the same cell, and separated by a thin membrane that prevents them from intermixing and forming a flammable and explosive mixture.

The new process allows geographic separation between the solar farm consisting of millions of PEC cells that produce oxygen exclusively, and the site where the hydrogen is produced in a centralized, cost-effective and efficient manner. This was accomplished with a pair of auxiliary electrodes made of nickel hydroxide, an inexpensive material used in rechargeable batteries, and a metal wire connecting them.

"In the present article, we describe a new method for producing hydrogen through the physical separation of hydrogen production and oxygen production," says Ms. Landman. "According to our cost estimate, our method could successfully compete with existing water splitting methods and serve as a cheap and safe platform for the production of hydrogen."

But that's not all. As stated, the vision of the Technion researchers is geographic separation between the sites where the oxygen and hydrogen are produced: at one site, there will be a solar farm that will collect the sun's energy and produce oxygen, while hydrogen is produced in a centralized manner at another site, miles away. Thus, instead of transporting compressed hydrogen from the production site to the sales point, it will only be necessary to swap the auxiliary electrodes between the two sites. Economic calculations performed in collaboration with research fellows from Evonik Creavis GmbH and the Institute of Solar Research at the German Aerospace Center (DLR), indicate the potential for significant savings in the setup and operating costs of hydrogen production.

In October, Ms. Landman won first place in the energy category in the Three Minute Thesis (3MT) competition held in Australia. At the competition, held on the initiative of the University of Queensland, participants are required to present groundbreaking research in just three minutes.

The method developed at the Technion for separating hydrogen production and oxygen production was the basis for the development of new two-stage electrolysis technology. This technology, which was developed by Dr. Hen Dotan, enables hydrogen production at high pressure and with unprecedented efficiency, thus significantly reducing hydrogen production costs. The new technology is now in its pre-industrial development stage.
Source:
https://www.sciencedaily.com/releases/2017/03/170313192723.htm

Four-stroke engine cycle produces hydrogen from methane, captures carbon dioxide

When is an internal combustion engine not an internal combustion engine? When it's been transformed into a modular reforming reactor that could make hydrogen available to power fuel cells wherever there's a natural gas supply available.

By adding a catalyst, a hydrogen separating membrane and carbon dioxide sorbent to the century-old four-stroke engine cycle, researchers have demonstrated a laboratory-scale hydrogen reforming system that produces the green fuel at relatively low temperature in a process that can be scaled up or down to meet specific needs. The process could provide hydrogen at the point of use for residential fuel cells or neighborhood power plants, electricity and power production in natural-gas powered vehicles, fueling of municipal buses or other hydrogen-based vehicles, and supplementing intermittent renewable energy sources such as photovoltaics.

Known as the CO_2/H_2 Active Membrane Piston (CHAMP) reactor, the device operates at temperatures much lower than conventional steam reforming processes, consumes substantially less water and could also operate on other fuels such as methanol or bio-derived feedstock. It also captures and concentrates carbon dioxide emissions, a by-product that now lacks a secondary use -- though that could change in the future.

Unlike conventional engines that run at thousands of revolutions per minute, the reactor operates at only a few cycles per minute -- or more slowly -- depending on the reactor scale and required rate of hydrogen production. And there are no spark plugs because there's no fuel combusted.

"We already have a nationwide natural gas distribution infrastructure, so it's much better to produce hydrogen at the point of use rather than trying to distribute it," said Andrei Fedorov, a Georgia Institute of Technology professor who's been working on CHAMP since 2008. "Our technology could produce this fuel of choice wherever natural gas is available, which could resolve one of the major challenges with the hydrogen economy."

Hydrogen News of Interest

A paper published February 9 in the journal *Industrial & Engineering Chemistry Research* describes the operating model of the CHAMP process, including a critical step of internally adsorbing carbon dioxide, a byproduct of the methane reforming process, so it can be concentrated and expelled from the reactor for capture, storage or utilization. Other implementations of the system have been reported as thesis work by three Georgia Tech Ph.D. graduates since the project began in 2008. The research was supported by the National Science Foundation, the Department of Defense through NDSEG fellowships, and the U.S. Civilian Research & Development Foundation (CRDF Global).

Key to the reaction process is the variable volume provided by a piston rising and falling in a cylinder. As with a conventional engine, a valve controls the flow of gases into and out of the reactor as the piston moves up and down. The four-stroke system works like this:

- Natural gas (methane) and steam are drawn into the reaction cylinder through a valve as the piston inside is lowered. The valve closes once the piston reaches the bottom of the cylinder.
- The piston rises into the cylinder, compressing the steam and methane as the reactor is heated. Once it reaches approximately 400 degrees Celsius, catalytic reactions take place inside the reactor, forming hydrogen and carbon dioxide. The hydrogen exits through a selective membrane, and the pressurized carbon dioxide is adsorbed by the sorbent material, which is mixed with the catalyst.
- Once the hydrogen has exited the reactor and carbon dioxide is tied up in the sorbent, the piston is lowered, reducing the volume (and pressure) in the cylinder. The carbon dioxide is released from the sorbent into the cylinder.
- The piston is again moved up into the chamber and the valve opens, expelling the concentrated carbon dioxide and clearing the reactor for the start of a new cycle. "All of the pieces of the puzzle have come together," said Fedorov, a professor in Georgia Tech's George W. Woodruff School of Mechanical Engineering. "The challenges ahead are primarily economic in nature. Our next step would be to build a pilot-scale CHAMP reactor."

The project was begun to address some of the challenges faced by the use of hydrogen in fuel cells. Most hydrogen used today is produced in a high-temperature reforming process in which methane is combined with steam at about 900 degrees Celsius. The industrial-scale process requires as many as three water molecules for every molecule of hydrogen, and the resulting low density gas must be transported to where it will be used.

Fedorov's lab first carried out thermodynamic calculations suggesting that the four-stroke process could be modified to produce hydrogen in relatively small amounts where it would be used. The goals of the research were to create a modular reforming process that could operate at between 400 and 500 degrees Celsius, use just two molecules of water for every molecule of methane to produce four hydrogen molecules, be able to scale down to meet the specific needs, and capture the resulting carbon dioxide for potential utilization or sequestration.

"We wanted to completely rethink how we designed reactor systems," said Fedorov. "To gain the kind of efficiency we needed, we realized we'd need to dynamically change the volume of the reactor vessel. We looked at existing mechanical systems that could do this, and realized that this capability could be found in a system that has had more than a century of improvements: the internal combustion engine."

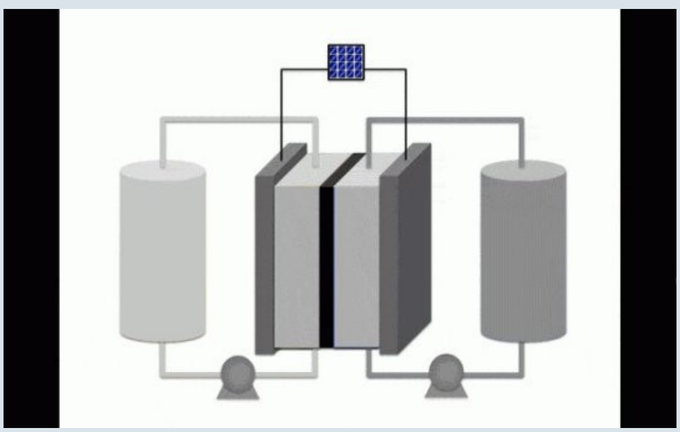
The CHAMP system could be scaled up or down to produce the hundreds of kilograms of hydrogen per day required for a typical automotive refueling station -- or a few kilograms for an individual vehicle or residential fuel cell, Fedorov said. The volume and piston speed in the CHAMP reactor can be adjusted to meet hydrogen demands while matching the requirements for the carbon dioxide sorbent regeneration and separation efficiency of the hydrogen membrane. In practical use, multiple reactors would likely be operated together to produce a continuous stream of hydrogen at a desired production level.

"We took the conventional chemical processing plant and created an analog using the magnificent machinery of the internal combustion engine," Fedorov said. "The reactor is scalable and modular, so you could have one module or a hundred of modules depending on how much hydrogen you needed. The processes for reforming fuel, purifying hydrogen and capturing carbon dioxide emission are all combined into one compact system."

Source: https://www.sciencedaily.com/releases/2017/02/170216130410.htm

Stabilizing energy storage

Because the sun doesn't always shine, solar utilities need a way to store extra charge for a rainy day. The same goes for wind power facilities, since the wind doesn't always blow. To take full advantage of renewable energy, electrical grids need large batteries that can store the power coming from wind and solar installations until it is needed. Some of the current technologies that are potentially very appealing for the electrical grid are inefficient and short-lived.



A diagram of a redox flow battery. An energy source, in this case a solar panel, provides the energy to the central cell to charge the battery. The charge is held in tanks of electrolytes that are pumped back into the cell to discharge the battery.

University of Utah and University of Michigan chemists, participating in the U.S. Department of Energy's Joint Center for Energy Storage Research, predict a better future for a type of battery for grid storage called redox flow batteries. Using a predictive model of molecules and their properties, the team has developed a charge-storing molecule around 1,000 times more stable than current compounds. Their results are reported today in the *Journal of the American Chemical Society.*

"Our first compound had a half-life of about 8-12 hours," says U chemist Matthew Sigman, referring to the time period in which half of the compound would decompose. "The compound that we predicted was stable on the order of months."

Not your ordinary battery

For a typical residential solar panel customer, electricity must be either used as it's generated, sold back to the electrical grid, or stored in batteries. Deep-cycle lead batteries or lithium ion batteries are already on the market, but each type presents challenges for use on the grid.

All batteries contain chemicals that store and release electrical charge. However, redox flow batteries aren't like the batteries in cars or cell phones. Redox flow batteries instead use two tanks to store energy, separated by a central set of inert electrodes. The tanks hold the solutions containing molecules or charged atoms, called anolytes and catholytes, that store and release charge as the solution "flows" past the electrodes, depending on whether electricity is being provided to the battery or extracted from it.

"If you want to increase the capacity, you just put more material in the tanks and it flows through the same cell," says University of Michigan chemist Melanie Sanford. "If you want to increase the rate of charge or discharge, you increase the number of cells."

Current redox flow batteries use solutions containing vanadium, a costly material that requires extra safety in handling because of its potential toxicity. Formulating the batteries is a chemical balancing act, since molecules that can store more charge tend to be less stable, losing charge and rapidly decomposing.

Molecular bumper cars

Sanford began collaborating with Sigman and U electrochemist Shelley Minteer through the U.S. Department of Energy's Joint Center for Energy Storage Research (JCESR), an Energy Innovation Hub dedicated to creating next-generation battery technologies. Sanford's lab developed and tested potential electrolyte molecules, and sought to use predictive technology to help design better battery compounds. Minteer contributed expertise in electrochemistry and Sigman employed a computational method, which uses the structural features of a molecule to predict its properties. A similar approach is widely used in drug development to predict the properties of candidate drugs. The team's work found that a candidate compound decomposed when two molecules interacted with each other. "These molecules can't decompose if they can't come together," Sanford says. "You can tune the molecules to prevent them from coming together."

Tuning a key parameter of those molecules, a factor describing the height of a molecular component, essentially placed a bumper or deflector shield around the candidate molecule.

The most exciting anolyte reported in the paper is based on the organic molecule pyridinium. It contains no metals and is intended to be dissolved in an organic solvent, further enhancing its stability. Other compounds exhibited longer half-lives, but this anolyte provides the best combination of stability and redox potential, which is directly related to how much energy it can store.

Sharing skills to build batteries

Sigman, Minteer and Sanford are now working to identify a catholyte to pair with this and future molecules. Other engineering milestones lay ahead in the development of a new redox flow battery technology, but determining a framework for improving battery components is a key first step.

"It's a multipart challenge, but you can't do anything if you don't have stable molecules with low redox potentials," Sanford says. "You need to work from there." The team attributes their success thus far to the application of this structure-function relationship toolset, typically used in the pharmaceutical industry, to battery design. "We bring the tools of chemists to a field that was traditionally the purview of engineers," Sanford says.

Source: https://www.sciencedaily.com/releases/2017/02/170221102034.htm

Self-sustaining bacteria-fueled power cell created

Instead of oil, coal, or even solar energy, self-sustaining bacterial fuel cells may power the future.

Researchers at Binghamton University, State University of New York have developed the next step in microbial fuel cells (MFCs) with the first micro-scale self-sustaining cell, which generated power for 13 straight days through symbiotic interactions of two types of bacteria.

"This concept of creating electricity through synergistic cooperation is not new. However, much of this work is still in its nascent stages," said Binghamton University Electrical and Computer Science Assistant Professor Seokheun Choi, who is one of the co-authors of "Self-sustaining, solar-driven bioelectricity generation in micro-sized microbial fuel cell using co-culture of heterotrophic and photosynthetic bacteria," along with PhD candidate Lin Liu.

"The evolution of this technology will require additional exploration, but we, for the first time, realized this conceptual idea in a micro-scale device," Choi said.

In a cell chamber about one-fifth the size of a teaspoon -- 90 microliters -- researchers placed a mixed culture of phototrophic and heterotrophic bacteria. Phototrophic bacteria uses sunlight, carbon dioxide, and water to make its own energy, while heterotrophic bacteria must "feed" on provided organic matter or phototrophic bacteria to survive -- think of cows grazing in a grassy field.

While the cell was exposed to sunlight, an initial dose of "food" was added to the chamber to stimulate growth of the heterotrophic bacteria. Through cellular respiration, the heterotrophic bacteria produced carbon dioxide waste, which was used by the phototrophic bacteria to kickstart the symbiotic cycle.

After that cycle was established, researchers stopped adding additional "food" sources for the heterophic bacteria, and there was enough phototrophic bacteria to sustain the metabolic processes of the heterophic bacteria. Those metabolic processes generated an electrical current -- 8 microamps per square centimeter of cell -- for 13 straight days. The power was about 70 times greater than current produced by phototrophic bacteria alone.

"Heterotrophic bacteria-based fuel cells generate higher power, while photosynthetic microbial fuel cells provide self-sustainability. This is the best of both worlds, thus far," Choi said.

The breakthrough is promising, but it is an early step in the development of bacteria-generated power. Overall, the miniature size of the cells allows for a short start-up time and small electrical resistances to overcome. However, a common 42" high-definition television takes about half an amp of electrical current to function which would, theoretically, require roughly 62,500 cells from the experiment. In reality, these cells will be used to provide power in remote or dangerous locations for low-power items like health monitors and infrastructure diagnostic sensors.

"There are some challenges of using this technique," Choi said. "Balancing both microorganisms' growth to maximize the device performance and the need to make sure that this closed system will permanently generate power without additional maintenance are two we have found. Long-term experiments are needed."

The current work is the latest in a series of battery-related and microbial-based power studies Choi has worked on. Last spring, researchers connected nine biological-solar (bio-solar) cells into a working bio-solar panel for the first time ever. The bacteria used in that experiment were phototrophic. That panel generated the most wattage of any existing small-scale bio-solar cells: 5.59 microwatts. Choi has also developed an origami-inspired microbe-based paper battery, a microbe-based battery that can use human saliva as a power source, a battery that can be printed on paper and battery designs inspired by Japanese ninja throwing stars.

The paper will appear in the *Journal of Power Sources* on April 30.

Source:
https://www.sciencedaily.com/releases/2017/03/170322122627.htm

New research urges a rethink on global energy subsidies

The hidden toll that subsidies for electricity, fossil fuels, and transport have on social welfare, economic growth and technological innovation needs to be exposed through better research says a new paper in *Ecological Economics* by Benjamin K Sovacool.

Energy subsidies, which have mostly supported fossil fuels and nuclear power over the previous half century, have historically kept energy prices artificially low, compared to market rates. But they come at a high cost to governments and taxpayers. The Indian government, for example, spends as much as it does on fuel subsidies for kerosene and liquid propane, used to light rural houses, as it does on education. India subsidies fossil energy consumption by $21 billion every year, which works out at $16 per person. Given that 500 million of its people live on less than $2 per day, this is a surprisingly large amount.

Such costs aren't benefiting the poorest households, meant to the key beneficiaries of the subsidies, because they have less money to spend on fuel and electricity in the first place. Of the tens of billions spent on fossil fuel subsidies in India in 2010, for example, less than $2 billion benefited the poorest 20% of the population. Instead, the subsidies benefitted wealthier households, which consume around 20 times more energy services than their poorer counterparts. They also tend to benefit energy companies and equipment suppliers.

Practically every energy system has been subsidized at some point. This results in budget deficits and higher taxes which potentially could have been spent more effectively elsewhere. If the world's projected $1.9 trillion in energy subsidies were repealed tomorrow, that would provide enough money to eliminate worldwide hunger and malnutrition one hundred times over.

Environmentally, energy subsidies tend to have "substantial carbon footprints" because they tend to favor fossil fuels, such as coal and petroleum. As subsidies lower the price of electricity and fuel, they generally lead to higher levels of consumption. They also generally diminish efforts to promote energy efficiency or to conserve energy.

This is why the negative impacts of subsidies need to be better understood. Below are key elements listed in the paper to be improved or reformed so subsidies can better benefit societies and the environment.

Impact studies

The new paper calls for more transparent, complete and comparable data on the impact of subsidies to help bring about further independent analysis. These impact studies could help governments and communities better determine the costs and benefits of particular subsidies, and decide which ones need revising or repealing.

Sunset clauses

Once governments adopt subsidies they tend to become self-replicating with expenditure tending to operate, maintain and improve existing technologies. Adding sunset clauses can put an end to this. By setting an expiration date, subsidies can't operate indefinitely.

Managing the risks

A review of 22 case studies of subsidy reform by the IMF found that only 12 didn't cause major economic or social disruption. Subsidy reforms should aim to ensure that the poorest in society don't lose out from the removal of the subsidies. Adjustment packages targeting those likely to be hit hardest can help. The paper also calls for more research on the political economy dimensions to subsidy reform.

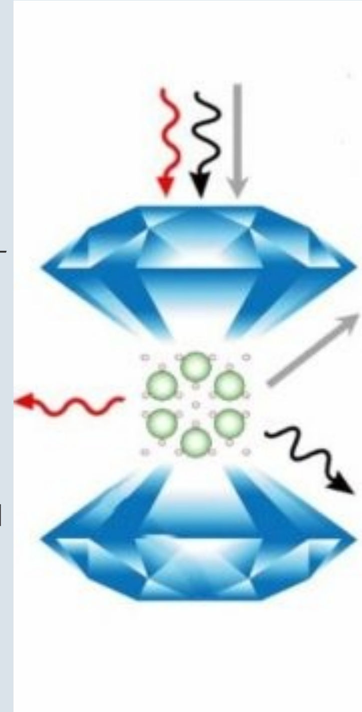
Source:
https://www.sciencedaily.com/releases/2017/03/170313134948.htm

Argon is not the 'dope' for metallic hydrogen

Hydrogen is both the simplest and the most-abundant element in the universe, so studying it can teach scientists about the essence of matter. And yet there are still many hydrogen secrets to unlock, including how best to force it into a superconductive, metallic state with no electrical resistance.

"Although theoretically ideal for energy transfer or storage, metallic hydrogen is extremely challenging to produce experimentally," said Ho-kwang "Dave" Mao, who led a team of physicists in researching the effect of the noble gas argon on pressurized hydrogen.

It has long been proposed that introducing impurities into a sample of molecular hydrogen, H_2, could help ease the transition to a metallic state. So Mao and his team set out to study the intermolecular interactions of hydrogen that's weakly-bound, or "doped," with argon, $Ar(H_2)_2$, under extreme pressures. The idea is that the impurity could change the nature of the bonds between the hydrogen molecules, reducing the pressure necessary to induce the nonmetal-to-metal transition. Previous research had indicated that $Ar(H_2)_2$ might be a good candidate.



Surprisingly, they discovered that the addition of argon did not facilitate the molecular changes needed to initiate a metallic state in hydrogen. Their findings are published by the *Proceedings of the National Academy of Sciences*.

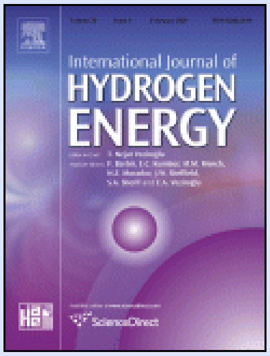
The team brought the argon-doped hydrogen up to 3.5 million times normal atmospheric pressure -- or 358 gigapascals -- inside a diamond anvil cell and observed its structural changes using advanced spectroscopic tools.

What they found was that hydrogen stayed in its molecular form even up to the highest pressures, indicating that argon is not the facilitator many had hoped it would be.

"Counter to predictions, the addition of argon did not create a kind of 'chemical pressure' on the hydrogen, pushing its molecules closer together. Rather, it had the opposite effect," said lead author Cheng Ji.

Source:
https://www.sciencedaily.com/releases/2017/03/170323125511.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. **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.
3. **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.
4. **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.
5. **Ammonia and related chemicals as potential indirect hydrogen storage materials**
   Lan, R, Irvine, JTS, Tao, S. Int J Hydrogen Energy 2012;37(2):1482–94.
6. **Green methods for hydrogen production**
   Dincer, I. Int J Hydrogen Energy 2012, *37*(2): 1954-1971.
7. **A review of gas diffusion layer in PEM fuel cells: Materials and designs**
   Park, S, Lee, J-W., & Popov, B. N. Int J Hydrogen Energy 2012, 37(7): 5850-5865.

Top IJHE Downloads (January-March 2017)

1. **Hydrogen and fuel cell technologies for heating: A review**
   Dodds, PE, Staffell, I, Hawkes, AD, Li, F, Grünewald, P, McDowall, W, et al. Int J Hydrogen Energy 2015;40(5):2065–83.
2. **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.
3. **A comprehensive review on PEM water electrolysis**
   Carmo, M, Fritz, DL, Mergel, J, Stolten, D. Int J Hydrogen Energy 2013;38(12):4901–34.
4. **An Energy Management Stratety to concurrently optimize fuel consumption & PEM fuel cell lifetime in a hybrid vehicle**
   Fletcher, T, Thring, R, Watkinson, M. Int J Hydrogen Energy 2016; 41(46): 21503-2515.
5. **Metal hydride materials for solid hydrogen storage: A review**
   Sakintuna, B, Lamaridarkrim, F & Hirscher, M. Int J Hydrogen Energy 2007;32(9), 1121–1140.
6. **Review of the proton exchange membranes for fuel cell applications**
   Peighambardoust, SJ, Rowshanzamir, S, Amjadi, M. Int J Hydrogen Energy 2017;35(17): 9349-9384.
7. **Study on method of domestic wastewater treatment through new-type multi-layer artificial wetland**
   Lu, S., Pei, L., & Bai, X. (2015). Int J Hydrogen Energy 2015;40(34), 11207–11214.

Numerical analysis of microwave assisted thermocatalytic decomposition of methane

-Siddharth Gadkari, Beatriz Fidalgo, Sai Gu. Int J Hydrogen Energy 2017:42(7): 4061-4068

With the increasing interest in renewable energy in recent years, hydrogen has been an energy carrier that has gotten a great deal of attention. One common method of generating hydrogen is via Steam methane reforming from natural gas, which currently accounts for around 50% of commercially available hydrogen. This paper develops a 3D model for heating of a catalyst in microwave cavity to produce hydrogen via thermocatalytic decomposition (TCD) of methane (the primary component of natural gas). TCD has been identified as a promising alternative to steam methane reforming, which generates large quantities of CO_x. The advantages that microwave heating provides are 1) uniform volumetric heating, 2) comparatively high heating rate, 3) better selectivity, 4) heating without contact and 5) short start-up or stopping time. The paper then goes on to outline the geometric scheme as well as the governing equation used in the model as well as the boundary conditions and the model for reaction kinetics. Comsol Multiphysics was used to simulate the model, analyze different physical phenomena, and give spatial and temporal distributions of electric field, pressure, and temperature inside the microwave cavity. To verify the model, an experimental data set was used for comparison, where there was some disagreement between the transient hydrogen concentration. The authors point to the volumetric hourly space velocity (VHSV), which is defined as the ratio of the total volumetric flow rate at the inlet of the reactor to the mass of catalyst, as a highly influential parameter for the accuracy of their model. Comparing different VHSV values for experimental data versus the model, the disagreement becomes larger for higher for larger VHSV values in terms of the initial transient effect. The model predicted a linear change in the concentration profiles of CH_4 and H_2 across the length of the reactor tube, which was also validated with experimental data.

http://www.sciencedirect.com/science/article/pii/S0360319916328245

-By Cyrus Daugherty

Carbon xerogel as gas diffusion layer in PEM fuel cells

-Alexandra M.I. Trefilov, Athanasios Tiliakos, Elena C. Serban, Catalin Ceaus, Stefan M. Iordache, Sanda Voinea, Adriana Balan J Hydrogen Energy 2017: In Press..

Porous carbonic nanomaterials are emerging as promising catalyst supports and micro-porous layers (MPLs) to reach adequate power densities in proton exchange membrane fuel cells (PEFCs). Such materials (e.g. plasmapyrolyzed carbon black, carbon nanotubes, graphene) are combined with hydrophobic binders to create MPLs at the interface between the catalyst and the macro-porous backing layer (e.g. carbon paper, carbon cloth). However, their associated high costs keep PEFCs' prices at non-competitive levels.

In this work, a novel gas diffusion layer/catalyst/membrane assembly based on low-cost carbon xerogels replacing the expensive plasma-pyrolyzed carbon black MPL was investigated. The tri-layer structure (carbon paper/carbon xerogel/carbon black) of the gas diffusion layer (GDL) was tailored to enhance the bi-phase (gaseliquid) flow dynamics. GDL-synthesis was performed by immersing carbon paper in a resorcinol-formaldehydegraphene oxide precursor solution, followed by thermal treatment. The end product is a carbon xerogel structure with incorporated graphene layers that counter the additional overpotential losses due to conductivity and mass-transfer limitations. MPL structure and porosity were controlled by performing xerogel crosslinking in a centrifugal field at different G-Forces, resulting in a highly conductive material with structural properties tailored to the application of interest.

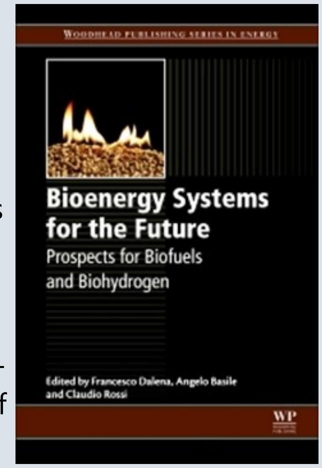
http://www.sciencedirect.com/science/article/pii/S0360319917308765

-By Yasser Ashraf Gandomi

From the Bookshelf

Bioenergy Systems for the Future, Prospects for Biofuels and Biohydrogen

Editors: Francesco Dalena, Angelo Basile, and Claudio Rossi



Bioenergy Systems for the Future: Prospects for Biofuels and Biohydrogen examines the current advances in biomass conversion technologies for biofuels and biohydrogen production, including their advantages and challenges for real-world application and industrial-scale implementation.

In its first part, the book explores the use of lignocellulosic biomass and agricultural wastes as feedstock, also addressing biomass conversion into biofuels, such as bioethanol, biodiesel, bio-methane, and bio-gasoline. The chapters in Part II cover several different pathways for hydrogen production, from biomass, including bioethanol and bio-methane reforming and syngas conversion. They also include a comparison between the most recent conversion technologies and conventional approaches for hydrogen production. Part III presents the status of advanced bioenergy technologies, such as applications of nanotechnology and the use of bio-alcohol in low-temperature fuel cells. The role of advanced bioenergy in a future bioeconomy and the integration of these technologies into existing systems are also discussed, providing a comprehensive, application-oriented overview that is ideal for engineering professionals, researchers, and graduate students involved in bioenergy

Key Features:

- Explores the most recent technologies for advanced liquid and gaseous biofuels production, along with their advantages and challenges
- Presents real-life application of conversion technologies and their integration in existing systems
- Includes the most promising pathways for sustainable hydrogen production for energy applications

https://www.elsevier.com/books/bioenergy-systems-for-the-future/dalena/978-0-08-101031-0

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

National Fuel Cell Research Center

The National Fuel Cell Research Center (NFCRC) at University of California, Irvine, was dedicated in 1998 by the U.S. Department of Energy and the California Energy Commission to accelerate the development and deployment of fuel cell technology, to provide an outreach to the market, to address market hurdles, and to provide leadership in the preparation of educational materials and programs throughout the country.

The NFCRC engages undergraduate and graduate students from all disciplines of engineering and the physical and biological sciences, and collaborates on courses and team projects with both the social sciences and business sciences. The outreach of the NFCRC is conducted with institutions around the world, through the California Stationary Fuel Cell Collaborative (CaSFCC), the California Fuel Cell Partnership (CFCP), the U.S. Fuel Cell Council, the Fuel Cell Seminar, the American Society of Mechanical Engineers (ASME) Annual International Fuel Cell Engineering, Technology, and Science Conference, the Annual International Colloquium on Environmentally Preferred Advanced Power Generation (ICEPAG), and the Pacific Rim Consortium on Energy, Combustion , and the Environment (PARCON).

The Mission of the NFCRC is to facilitate, demonstrate and accelerate the development and deployment of fuel cell technology and fuel cell systems; promote strategic alliances to address the market challenges associated with the installation and integration of fuel cell systems; and to educate and develop resources for the various stakeholders in the fuel cell community.

The application of fuel cell technologies to advanced power generation systems portends a significant advancement in energy efficiency, conservation and environmental protection for this century. The National Fuel Cell Research Center (NFCRC) is principally focused on stationary power and its role as a Distributed Generation and Central Power Plant technology as a Portable Power technology, a Transportation Power and Hoteling technology for aircrafts, ships, locomotives, and long-distance trucks, and as a generation source of Hydrogen for transportation fueling and industrial feed stock. Efforts are in progress that address the components of fuel cell systems, and the development, integration, deployment, and connectivity of fuel cell systems.

The approach of the NFCRC is based on two traditional university activities (Research and Education) and the non-traditional activities (Beta Testing, and Market Dynamics).

In an effort to bridge fuel cell technology development and its successful introduction into the marketplace, the NFCRC is participating in a variety of initiatives through a series of strategic alliances with industry and the public sector. These alliances are critical to facilitate the deployment of fuel cell systems. An excellent example is the NFCRC's role as co-chair and co-administer of the California Stationary Fuel Cell Collaborative.

Contact Info

Professor Scott Samuelsen, Director
National Fuel Cell Research Center
University of California
Irvine, CA 92697-3550
gss@nfcrc.uci.edu

Will Decker
Manager, Program Development and External Relations
National Fuel Cell Research Center
University of California
Irvine, CA 92697-3550
wd@nfcrc.uci.edu

Link: http://www.nfcrc.uci.edu/3/Default.aspx

Upcoming Meetings & Activities

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

Fuel Cell & Hydrogen Technical Conference 2017
May 31-June 1, 2017
Millennium Point, Birmingham, UK
http://www.birmingham.ac.uk/research/activity/chemical-engineering/energy-chemical/fuel-cells/FCH2/index.aspx

June 2017

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

Advanced Automotive Battery Conference
June 19-22, 2017
San Francisco, CA
http://www.advancedautobat.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/

International Hydrail Conference
June 27-28, 2017
Graz, Austria
https://hydrail.appstate.edu/

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

August 2017

China International Hydrogen and Fuel Cell Exhibition
August 28-30, 2017
Beijing, China
http://en.chfce.com/

September 2017

2nd Int'l Hydrogen & Fuel Cell Expo
September 20-22, 2017
Osaka, Japan
http://www.fcexpo-kansai.jp/en/

October 2017

World of Energy Solutions
October 9-11, 2017
Messe Stuttgart, Germany
http://www.world-of-energy-solutions.com/startpage.html

November 2017

Fuel Cell Seminar & Energy Exposition
November 7-9 2017
Long Beach California
https://www.fuelcellseminar.com/

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/

Contacts and Information

Board of Directors

Officers of the IAHE

T. Nejat Veziroğlu
President
John W. Sheffield
Executive Vice President
Ibrahim Dincer
Vice President
David S. Scott
Vice President
E. Caglan Kumbur
Secretary
Juan Carlos Bolcich
Vice President, Argentina
Alexander Y. Ramenskiy
Vice President, Russia
Zong Qiang Mao
Vice President, China
Bruno Pollet
Vice President, Africa
Detlef Stolten
Vice President, Germany
Onkar N. Srivastava
Vice President, India
Hirohisa Uchida
Vice President, Japan
Ayfer Veziroğlu
Comptroller

IAHE Division Officers

Chiara Fiori
President, Young Scientists Division
Patrick Hallenbeck
President, Biohydrogen Division
Yun Hang Hu
President, Hydrogen Storage Division
Greg Naterer
President, Nuclear Hydrogen Division
Andrei V. Tchouvelev
President, Hydrogen Safety Division
Emre A. Veziroğlu
Editor-in Chief, IJHE

Board of Directors of the IAHE

Franco Barbir, Croatia & USA
Juan Carlos Bolcich, Argentina
Eniya Listiani Dewi, Indonesia
Gibril S. Elijrushi, Libya
Inci Eroğlu, Turkey
David Hart, U.K. & Switzerland
Terry Kimmel, Canada
Zong Qiang Mao, China
Cesare Marchetti, Austria
Paulo Emilio de Miranda, Brazil
Nazim Z. Muradov, Azerbaijan & USA
Bruno Pollet, VP, Africa
Alexander Y. Ramenskiy, VP, Russia
Jacques Saint-Just, France
John W. Sheffield, USA
Giuseppe Spazzafumo, Italy
Onkar N. Srivastave, India
Detlef Stolten, Germany
Hirohisa Uchida, Japan
Ayfer Veziroğlu, USA

On the Web

International Association for Hydrogen Energy (IAHE)
http://www.iahe.org
5794 SW 40 St. #303
Miami, FL 33155, USA

International Journal of Hydrogen Energy (IJHE)
The Official Journal of the IAHE
http://www.elsevier.com/locate/he