international association for hydrogen energy
Clean and Abundant Energy for Sustainability

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NREL Establishes World Record for Solar Hydrogen Production

Scientists at the U.S. Department of Energy's (DOE) National Renewable Energy Laboratory (NREL) recaptured the record for highest efficiency in solar hydrogen production via a photoelectrochemical (PEC) water-splitting process.

The new solar-to-hydrogen (STH) efficiency record is 16.2 percent, topping a reported14 percent efficiency in 2015 by an international team made up of researchers from Helmholtz-Zentrum Berlin, TU Ilmenau, Fraunhofer ISE and the California Institute of Technology. A paper in Nature Energy titled Direct Solar-to-hydrogen Conversion via Inverted Metamorphic Multijunction Semiconductor Architectures outlines how NREL's new record was achieved. The authors are James Young, Myles Steiner, Ryan France, John Turner, and Todd Deutsch, all from NREL, and Henning Döscher of Philipps-Universität Marburg in Germany. Döscher has an affiliation with NREL.

The record-setting PEC cell represents a significant change from the concept device Turner developed at NREL in the 1990s.

Both the old and new PEC processes employ stacks of light-absorbing tandem semiconductors that are immersed in an acid/water solution (electrolyte) where the water-splitting reaction occurs to form hydrogen and oxygen gases. But unlike the original device made of gallium indium phosphide (GaInP2) grown on top of gallium arsenide (GaAs), the new PEC cell is grown upside-down, from top to bottom, resulting in a so-called inverted metamorphic multijunction (IMM) device.

This IMM advancement allowed the NREL researchers to substitute indium gallium arsenide (InGaAs) for the conventional GaAs layers, improving the device efficiency considerably. A second key distinguishing feature of the new advancement was depositing a very thin aluminum indium phosphide (AlInP) "window layer" on top of the device, followed by a second thin layer of GaInP2. These extra layers served both to eliminate defects at the surface that otherwise reduce efficiency and to partially protect the critical underlying layers from the corrosive electrolyte solution that degrades the semiconductor material and limits the lifespan of the PEC cell.

Turner's initial breakthrough created an interesting new way to efficiently split water using sunlight as the only energy input to make renewable hydrogen. Other methods that use sunlight entail additional loss-generating steps. For example: Electricity generated by commercial solar cells can be sent through power conversion systems to an electrolyzer to decompose water into hydrogen and oxygen at an approximate STH efficiency of 12 percent. Turner's direct method set a long-unmatched STH efficiency record of 12.4 percent, which has been surpassed by NREL's new PEC cell.

Before the PEC technology can be commercially viable, the cost of hydrogen production needs to come down to meet DOE's target of less than $2 per kilogram of hydrogen. Continued improvements in cell efficiency and lifetime are needed to meet this target. Further enhanced efficiency would increase the hydrogen production rate per unit area, which decreases hydrogen cost by reducing balance-of-system expenditures. In conjunction with efficiency improvements, durability of the current cell configuration needs to be significantly extended beyond its several hours of operational life to dramatically bring down costs. NREL researchers are actively pursuing methods of increasing the lifespan of the PEC device in addition to further efficiency gains.

While an alternative configuration where the device isn't

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IAHE Objective

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

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submerged in acidic electrolyte and instead is wired to an external electrolyzer would solve the durability challenge, a techno-economic analysis commissioned by DOE has shown that submerged devices have the potential to produce hydrogen at a lower cost.

The latest research was funded by the Energy Department's Fuel Cell Technologies Office in the Office of Energy Efficiency and Renewable Energy.

NREL is the U.S. Department of Energy's primary national laboratory for renewable energy and energy efficiency research and development. NREL is operated for the Energy Department by The Alliance for Sustainable Energy, LLC.

Source: http://www.nrel.gov/news/press/2017/41792

Hydrogen Vehicle News

Ricardo partners with Toyota on hydrogen fuel cell system for trucks

UK based auto-component manufacturer Ricardo will collaborate with Japanese auto-maker Toyota for its 'Project Portal' in designing a heavy-duty hydrogen fuel cell system, Ricardo confirmed in a media release.

The class 8 truck is used at the ports of Los Angeles and Long Beach. The company will provide the required technical assistance to the project backed by Toyota and help in areas of design, vehicle building. Currently Ricardo is supporting vehicle trials for the project.

Project Portal is an initiative by Toyota to broaden the application of zero-emission fuel cell technology that can serve a range of industries. It is a fully functional heavy duty class 8 truck with adequate power and torque capacity to conduct port drayage operations while emitting nothing but water vapor.

Heavy duty vehicles make up a significant percentage of the annual emissions output at the San Pedro Bay ports, and the Portal feasibility study may provide another path to further reduce emissions, added the company in a statement.

Ricardo has assisted Toyota on this project across a wide range of engineering functions. These functions include but are not restricted to systems integration and packaging, including the fuel cells, power electronics, hydrogen tanks, cooling systems, batteries, electric motors and transmission.

Many of the ancillary systems that are traditionally driven by the engine were also electrified, including the air compressor, power steering and HVAC system, the controls of which required integration into the vehicle's J1939 CAN BUS.

The Project Portal platform truck generates more than 670 horsepower and 1325 pound feet of torque from two Mirai fuel cell stacks and a 12kWh battery, a relatively small battery to support class 8 load operations.

The concept's gross combined weight capacity is 80,000 lbs., and its estimated driving range is more than 200 miles per fill, under normal drayage operation.

"Ricardo was honored to collaborate with Toyota on this high profile fuel cell demonstration project," commented Chris Brockbank, VP of Vehicle Engineering at Ricardo. "Heavy duty trucks are generally not amenable to the types of electrification used for passenger cars and other light duty vehicles, due to the size and cost of the required battery systems.

"For this reason, Project Portal provides an exciting opportunity to evaluate a further, practical option for a heavy truck ZEV application. We look forward to working with Toyota in the completion of the in-port trials, and to seeing the results of the project which, I believe, may well inform the future vision of heavy duty transportation." Chris concluded.

Source: http://auto.economictimes.indiatimes.com/news/commercial-vehicle/mhcv/ricardo-partners-with-toyota-on-hydrogen-fuel-cell-system-for-trucks/58571105

Brown goes green as UPS introduces hydrogen fuel cell delivery truck

Automakers left and right have been experimenting with hydrogen fuel cells. Some (like Honda and Toyota) have even put them into production and offered them to the public. But passenger cars aren't the only ones on the road, or the only vehicles that could benefit from the clean propulsion technology.

Case in point: UPS, which isn't waiting around for a manufacturer to supply it with greener vehicles, but is developing its own fuel cell-powered delivery trucks as part of its Rolling Laboratory – a fleet of experimental logistics vehicles.

The Class 6 medium-duty delivery truck carries 10 kg of hydrogen fuel, a 32-kilowatt fuel cell, and a 45-kWh battery. The hydrogen fuel cell charges the battery which powers the electric motor to allow the van to travel along its route – even down the highway – with zero tailpipe emissions. Despite the photo above that was clearly taken in New York (the Park Slope neighborhood in Brooklyn if we had to guess), the first prototype is being tested in Sacramento. Once the company has about 5,000 hours of in-service operational data, it plans to start rolling them out more extensively across California, where there's already a (relatively) extensive network of hydrogen fuel stations.

UPS reports that it has invested over $750 million in alternative propulsion and other advanced technologies since 2009, deploying over 8,300 experimental vehicles (from electric bicycles to natural gas and renewable diesel fuel) around the world.

Source: http://www.carscoops.com/2017/05/brown-goes-green-as-ups-introduces.html

Program launched to mass manufacture fuel cell stacks for hydrogen cars

A pan-European program has been launched to drive down the cost of hydrogen cars by developing the mass manufacture of fuel cell stacks.

Like electric vehicles, vehicles powered by hydrogen fuel cells are essential to helping reduce carbon emissions.

Called DIGIMAN, the $3.5 million program will receive funding from the Fuel Cells and Hydrogen Joint Undertaking (FCH JU) under the EU's *Horizon 2020* program.

The aim of the program is to provide a future blueprint to enable fully automated mass manufacturing of fuel cell stacks for the automotive market.

Fuel cell stacks for hydrogen cars are currently manufactured on an individual basis, making them very costly. The program will therefore help ensure that fuel cell technology remains cost competitive for the future and increase consumer uptake.

Bart Biebuyck, Executive Director of the FCH JU, said: "The project will improve manufacturing techniques by reducing the production time and costs, and increase the quality levels of PEMFC stacks. The project, which gathers industry, academia and research centers, is contributing to maintain Europe at the competitive edge on the key technologies for clean transport."

The program's technology lead is provided by British-based clean energy company Intelligent Energy, with overall coordination provided by European innovation laboratory CEA Tech-Liten. Also involved in the three-year program are Freudenberg Performance Materials SE&Co.KG, Warwick Manufacturing Group at the University of Warwick, and Toyota Motor Europe. The latter will be responsible for best practice requirements for fu-

ture automotive stack production.

The program will enable the development of Intelligent Energy's proprietary air-cooled fuel cell architecture, which will also benefit commercialization in other market sectors such as stationary power and drones.

Martin Bloom, Group CEO at Intelligent Energy, said: "With the wealth of experience we have in this area resulting from our ongoing joint manufacturing venture with Suzuki (SMILE), in addition to almost 30 years of fuel cell development, we have the know-how and capability to ensure we support and mobilize this ecosystem of partners."

Once developed, the blueprint design will enable build-to-print machine configurations with ready to scale production capacity to meet future requirements of more than 50,000 fuel cell stacks by 2020.

Source: http://www.eaem.co.uk/news/programme-launched-mass-manufacture-fuel-cell-stacks-hydrogen-cars

Australian Researchers Working to Grow Hydrogen Availability

Australian researchers launch a A$3.4 million ($2.5 million) program to develop technology to supply fuel-cell vehicles globally with low-emission hydrogen.

The 2-year project will build on the Commonwealth Scientific and Industrial Research Organization's expertise in separating pure hydrogen from mixed gas streams, in this case converting ammonia to high-purity hydrogen for use in HFCVs.

The organization's membrane-reactor technology will fill the gap between hydrogen production, distribution and delivery in the form of a modular unit that can be used at or near a refueling station.

The project received A$1.7 million ($1.3 million) from the Australian Science and Industry Endowment Fund, which will be matched by the CSIRO.

The research also is supported by bulk-gas supplier BOC, Hyundai, Toyota and Renewable Hydrogen.

The transportation and storage of hydrogen now are complex and relatively expensive, making export commercially challenging.

The goal of the project is to allow hydrogen to be transported in the form of ammonia – which already is being traded globally – and then converted back to hydrogen at the point of use. The thin metal membrane allows hydrogen to pass, while blocking all other gases.

In the final stages of development, the membrane device is being further refined for commercial deployment.

Recent advances in solar and electrochemical technologies mean renewable hydrogen production is expected to become competitive with fossil fuel-based production, providing an opportunity to decarbonize both the energy and transport sectors while creating new export opportunities.

While Australia is a relatively small hydrogen market, the fuel can be distributed to emerging markets in Japan, South Korea and Europe using existing infrastructure.

CSIRO CEO Larry Marshall sees the prospect of a growing global market for clean hydrogen, and the potential for a national renewable hydrogen-export industry, benefiting Australia.

"This is a watershed moment for energy, and we look forward to applying CSIRO innovation to enable this exciting renewably sourced fuel and energy-storage medium a smoother path to market," Marshall says in a statement.

Renewable Hydrogen plans to export hydrogen to Japan as ammonia and Chairman Brett Cooper believes CSIRO's membrane technology will mean a new export product for Australia that could match the scale of the current liquefied-natural-gas industry.

"With this technology, we can now deliver our renewable energy to Japan, (South) Korea and across the Asia-Pacific region in liquid form, as renewable ammonia, and efficiently convert it back to pure hydrogen for cars, buses, power generation and industrial processes," Cooper says.

This market didn't exist 10 years ago and Cooper says Australia is positioned to be the No.1 renewable-fuel pro-

vider in the global economy's fastest-growing region.

Bernie O'Connor, senior executive advisor to the board of Toyota Australia, says research into making hydrogen more accessible for fuel and energy storage is key to the success of the technology.

Source: http://wardsauto.com/engines/oz-researchers-working-grow-hydrogen-availability

What is the future for fuel cell cars in U.S.?

For years, green car enthusiasts have been heralding the dawn of a new era of pollution-free driving powered by fuel cells, which combine readily available hydrogen with oxygen to fire up the engine. NASA created the first commercial grade fuel cells in the 1960s to power satellites and space capsules, and automakers have been talking up their potential for use in cars and trucks ever since.

But the idea has never gotten beyond the prototype stage, due mostly to the lack of any refueling infrastructure. After all, drivers are used to being able to refill their tanks on almost every corner, while the new generation of electric and plug-in hybrid and electric vehicles (EVs) can be recharged from any electrical outlet.

But FCVs (fuel cell vehicles) may still represent the holy grail of auto travel because they combine the environmental benefits of electric vehicles (no reliance on fossil fuels and no pollution) with the driving range (~300 miles between refueling) of conventional cars. While GM, Hyundai and Daimler are heavily invested in fuel cell vehicle production, Toyota and Honda are already offering fuel cell vehicles for sale or lease to drivers in California, given the Golden State's head start in creating a hydrogen refueling network. According to the California Fuel Cell Partnership, 27 hydrogen refueling stations are already up and running around metro Los Angeles and the Bay Area, with 33 more coming online soon.

Toyota's Mirai FCV seats four and offers all the trimmings of any new car — touch-screen entertainment, dual climate control, steering wheel mounted controls, radar to prevent accidents and help with parking, and a 312-mile range per fill-up. The MSRP on the Mirai is $57,500, but Toyota is currently offering $7,500 back. Another option is a 36-month lease on the Mirai for $349/month plus $2,499 up front.

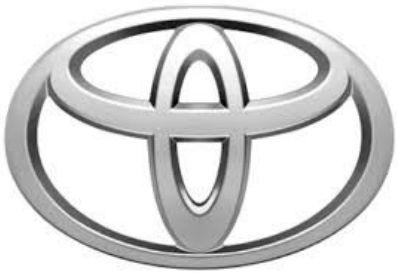
Meanwhile, Honda's new Clarity FCV is similarly appointed but offers a roomier interior (seating for five) and a longer range (366 miles per fill-up). Californians can lease the Clarity (it's not for sale in the U.S.) for $369/month for 36 months plus $2,868 due at signing, with Honda covering the first $15,000 worth of hydrogen fuel.

Drivers behind the wheel of the Mirai or Clarity qualify for a one-time $5,000 tax rebate from California for driving a green car, not to mention access to HOV lanes statewide even with just a single occupant.

Of course, fuel cell drivers won't want to leave California just yet. Outside the Golden State, there are exactly three publicly accessible hydrogen refueling stations (Massachusetts, Connecticut and South Carolina each have one). But later this year Toyota, in partnership with France's Air Liquide, will start to roll-out a new network of hydrogen refueling stations around the northeastern U.S. so drivers there can start to enjoy the benefits of driving the latest, greatest and greenest technology ever to grace the American road.

Source: http://www.fayettetribune.com/community/what-is-the-future-for-fuel-cell-cars-in-u/article_32ca4936-3655-11e7-95f6-ebc8e5fab738.html

Toyota experimenting with natural gas fuel cells



Toyota is one of the biggest proponents of hydrogen fuel cells. In addition to the Mirai fuel cell car, it's building fuel cell-powered buses for Japan, and even experimenting with a fuel cell semi truck. But even Toyota has to admit that hydrogen power still has issues. Specifically, the hydrogen part. Lack of large-scale hydrogen production and the infrastructure to distribute the fuel remains a major drawback for fuel-cell vehicles. So Toyota is investigating a way to power its fuel cells with something different: natural gas.

The automaker recently installed a prototype hybrid fuel-

cell system to provide power at its Motomachi Plant in Japan. Motomachi builds the Mirai, and built the Lexus LFA supercar before that. The system splits natural gas into hydrogen and carbon monoxide, which are then used to provide electrical power.

The prototype hybrid system actually uses both fuel cells and a micro gas turbine to generate power. The turbine provides oxygen to the fuel cell in the form of compressed air. The oxygen reacts with the hydrogen and carbon monoxide to create electricity. Waste heat from the system is used to create additional power, and Toyota says the turbine is powered by leftovers from the process that splits natural gas into hydrogen and carbon monoxide.

Toyota claims the system is capable of generating 250 kilowatts of power, with 53 percent efficiency using only the fuel cell. Factoring in the use of waste heat to create power increases the system's overall efficiency to 65 percent, Toyota says, making it more efficient than a regular fuel cell. The fuel cell features a novel solid-oxide design that doesn't require a platinum catalyst, according to Toyota, and it operates at lower temperatures than conventional fuel cells.

Nissan unveiled a prototype vehicle powered by solid-oxide fuel cells last year. It was a converted e-NV200 van that used the fuel cell stack to provide power to an onboard battery pack. Unlike the Toyota system, Nissan's used ethanol as the base fuel to create hydrogen. But in both cases, the goal was to find an alternative to straight hydrogen in order to make fuel-cell vehicles more practical.

Natural gas is easier to get ahold of than hydrogen, especially in the U.S., where massive quantities of it are extracted from the ground through the controversial "fracking" process. While it produces lower levels of emissions than gasoline or diesel, natural gas still contributes to climate change. Another problem is that, while natural gas is easy to produce, it faces the same fueling infrastructure problems as hydrogen. That's why natural gas passenger cars haven't really taken off.

Toyota did not discuss any plans to use its hybrid fuel-cell system in a vehicle. Right now, it's concentrating on stationary electricity generation. That may prove a more practical use of the technology, as the infrastructure to provide natural gas as a fuel for power plants or to heat buildings already exists.

Source: http://www.thedrive.com/tech/9738/toyota-experimenting-with-natural-gas-fuel-cells

New hydrogen dispenser could signal a brighter future for fuel cell vehicles

Shell works with BMW subsidiary to design new hydrogen dispenser

BMW and Shell have worked together to develop new hydrogen dispenser that is meant to make the fueling process more efficient for drivers of fuel cell vehicles. Shell commissioned Designworks, a BMW subsidiary, to design the new hydrogen dispenser. Designworks specializes in developing solutions for the transportation space. The new hydrogen dispenser aims to create a seamless experience for those fueling their fuel cell vehicles, which are expected to become more common in the coming years.

Fuel cell vehicles could benefit from new hydrogen technologies

Current hydrogen dispensers available on the market are based on the use of conventional fuels. Designworks has worked to change this with the new hydrogen dispenser using a new concept it calls "Oasis." The concept involves using a pillar-like design for the dispenser and making use of clean energy. Shell will be using the dispenser designed by Designworks to provide fuel for fuel cell vehicles that make use of its new hydrogen station. The dispenser may see use in other fueling stations that are part of Shell's network in the future.

Fuel cell vehicles continue to attract popularity

Fuel cell vehicles are still quite rare, but they are beginning to grow in popularity throughout the world. Many automakers have plans to launch more of these types of vehicles in the coming years. In order to ensure their success, however, they must have the support of a comprehensive hydrogen infrastructure. As such, companies like Shell have begun to develop new fueling stations. They must ensure that hydrogen can be supplied in an efficient manner, however, which has led some companies to develop better dispensers ahead of the wide-

spread launch of fuel cell vehicles.

New hydrogen dispensers may make fuel cell vehicles more attractive

The new hydrogen dispenser has received praise from the California Fuel Cell Partnership, which has long worked to improve hydrogen technologies. In the future, the new dispenser may play a prominent role in the development of new fueling stations in many prominent markets. California is one market where fuel cell vehicles are likely to thrive due to the state's prominent interest in clean transportation.

Source: http://www.hydrogenfuelnews.com/new-hydrogen-dispenser-could-signal-a-brighter-future-for-fuel-cell-vehicles/8531985/

BMW producing hydrogen through solar-powered electrolysis

BMW is working on resolving a dilemma faced by backers of fuel cell vehicles – where the hydrogen comes from.

The automaker is showing a 5-Series GT fuel cell prototype that has hydrogen coming from solar-powered electrolysis. It's part of the 2017 Hannover Trade Fair in Germany.

The electrolysis process breaks the hydrogen down into two parts hydrogen, one part water. The only element that's emitted is water, and the power source comes through solar-powered clean energy.

Most hydrogen is extracted through other sources besides solar, including petroleum and natural gas. That takes away some of the environmental benefits of producing hydrogen to run a vehicle's electric motor.

BMW has taken a supportive, yet cautious, approach to endorsing fuel-cell vehicles. In 2013 the company entered a strategic alliance with Toyota to combines their research and development programs on this alternative powertrain and fuel.

BMW officials said that its goal now is to explore hydrogen fuel cell vehicles as another option in its portfolio of emissions-free mobility. The company is pitching the benefits of fuel cell vehicles in Hannover by boasting energy efficiency, fast refueling times, and longer range than battery-electric vehicles have been capable of.

It also supports the German automaker's efforts on the solar energy front.

In 2014, BMW Motorsport forged a partnership with solar equipment supplier GermanPV. It was part of the automaker's M4 DTM race sponsorship, with hints that it will be part of BMW's electrification effort.

BMW conducted calculations on clean energy production with the Fraunhofer Institute for Solar Energy Systems ISE that demonstrate the benefits of using electrolysis. The energy can come from solar, wind, waves, or another alternative power source. The Institute says that going with a clean energy source supports the German government's goal of hitting greenhouse gas reduction targets by 2050.

Oil company Shell joined BMW's Hannover display by demonstrating a hydrogen fueling pump. Shell developed the fuel dispenser with Designworks, a BMW subsidiary. They're showing off how seamless it can be for fuel cell drivers to pull up and refuel in five minutes or less.

Shell is playing a significant role in bringing hydrogen fueling stations to Europe and the U.S.

BMW hasn't laid out plans for commercializing fuel cell vehicles. Toyota, Honda, and Hyundai are taking the alternative powertrain seriously through production-level fuel cell vehicles. General Motors, Daimler, and Kia, along with BMW, are showing interest.

Source: http://www.hybridcars.com/bmw-producing-hydrogen-through-solar-powered-electrolysis/

Hydrogen News of Interest

Ballard's Protonex subsidiary powers successful test flights of boeing Insitu ScanEagle UAV

Ballard Power Systems (NASDAQ: BLDP; TSX: BLDP) announced that the company's subsidiary, Protonex, has successfully powered test flights of the ScanEagle unmanned aerial vehicle (UAV) with the Company's PEM (proton exchange membrane) fuel cell propulsion system. The ScanEagle is manufactured by Insitu (www.insitu.com), a wholly owned subsidiary of The Boeing Company.

"These test flights have successfully demonstrated the integration and operation of our fuel cell propulsion system as well as the high pressure hydrogen fuel tank," said Paul Osenar , President of Protonex. "The tests also documented acoustic footprint reduction that will enable mission routes that take the ScanEagle closer to its targets. In addition, test flights confirm that our fuel cell propulsion system offers power during flight that can be used to support greater payload diversity. When combined with improved reliability and other advantages over internal combustion systems, fuel cells are proving to be a tremendous fit for UAVs."

Advantages of the Protonex fuel cell propulsion modules over traditional internal combustion engine propulsion systems include: significant improvement in the expected MTBF (mean time between failures) of up to 5x; silent operation; 100% throttle flexibility, including mid-air start-stop capability; and use of existing JP8 fuel in ground refueling systems.

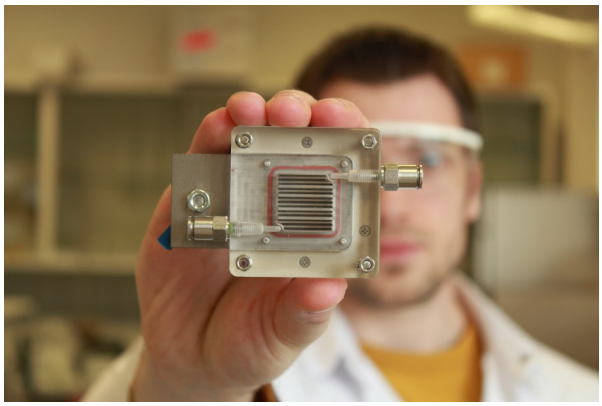
Peter Kunz , Insitu's Chief Technology Officer noted, "Insitu continues to progress toward our goal of offering all-electric power and propulsion system options for Insitu platforms. Now in developmental testing, the Protonex fuel cell system has exceeded our power requirements and has integrated very well with the initial target aircraft systems and with general unmanned aerial system, or UAS, operations. Additional performance tests and customer demonstrations are planned throughout the remainder of this year."

Insitu's ScanEagle is a versatile platform with multiple payload capabilities, including high-definition imaging at a fraction of the cost of larger UAV systems and has logged over 800,000 flight hours in military and civilian applications, making it one of the most successful UAV platforms to date. The ScanEagle is operated in conjunction with Insitu's Mark4 Launcher – a low-maintenance, runway-independent platform – along with its SkyHook® recovery system.

ScanEagle is 1.55 meters (5.1 feet) in length, has a wingspan of 3.11 meters (10.2 feet) and maximum takeoff weight of 22 kilograms (48.5 lbs). The ScanEagle can fly at a maximum speed of 41.2 meters per second (80 knots), reach a ceiling of 5,944 meters (19,500 feet) and has an endurance capability of more than 24-hours. Additional details and images are available at http://www.insitu.com/information-delivery/unmanned-systems/scaneagle.

Source: https://finance.yahoo.com/news/ballards-protonex-subsidiary-powers-successful-210000341.html

Belgian scientists invent device that gets hydrogen from polluted air



Pollution is a global problem, and obtaining energy has been linked to it for decades, without any apparent solution.

Scientists have struggled to devise solutions to the age-old problem of sourcing energy in the most efficient way possible, while also tackling the pollution that can comes from conventional power sources.

According to a recent announcement from Belgium, a team of researchers from the Universities of Antwerp and Leuven has presented a device that can obtain hydrogen from polluted air.

The small appliance, shown on that scale for proof of concept, needs to be exposed to light to be able to operate,

and comes with the bonus of purifying the air while extracting hydrogen from it.

Each of the two "abilities" of the invention has the possibility of being a valuable characteristic, but blending them into a single unit should make this product.

The device does not have a name yet, but it can generate hydrogen gas, which can be used as fuel. Evidently, it will require specific treatment before being suitable for use in fuel cell vehicles, which means that you cannot fit one of these to the roof of a car and hope to drive on as long as there's sunlight outside and you are in a polluted area.

Do not imagine that there's something wrong with the hydrogen it obtains from the air pollution broken down by the particular membranes, but Fuel Cell Vehicles need hydrogen at an appropriate pressure for optimal operation.

Moreover, these vehicles would also require obtaining a well-defined quantity that may not be accomplished by this unit while operating continuously during a drive. However, the existence of the device is more important than the fact that it may not be suitable to fit it on the roof of existing hydrogen fuel cell vehicles when it is ready for consumers.

Researchers have explained on the KU Leuven's website that they are currently working on scaling up the technology and improving its response to sunlight.

Source: https://www.autoevolution.com/news/belgian-scientists-invent-device-that-gets-hydrogen-from-polluted-air-117781.html#

Norway races Australia to fulfill Japan's hydrogen society dream

Norway and Australia are racing each other to show they can supply Japan with hydrogen, hoping to fulfill its ambition to become the first nation significantly fueled by the super-clean energy source.

While Australia has planned to derive liquid hydrogen from brown coal for some time, Norway could steal a march if a pilot project producing the fuel using renewable energy—a climate-friendly method more in keeping with Japan's aims—is cheaper.

Japan is betting heavily on becoming a "hydrogen society" despite the high costs and technical difficulties which have generally slowed its adoption as a carbon-free fuel.

Prime Minister Shinzo Abe is pushing his vision of vehicles, houses and power stations using hydrogen to end Japan's energy crisis since the 2011 Fukushima disaster, which led to a dramatic drop in electricity production from its nuclear plants.

The country's annual hydrogen and fuel cell market is forecast to hit 1 trillion yen ($9 billion) in 2030 and 8 trillion yen in 2050, according to the industry ministry.

Kawasaki Heavy Industries (KHI) is developing a supply chain to back Abe's initiative, which will be showcased when Tokyo hosts the 2020 Olympic games.

KHI has been looking at using brown coal from the Australian state of Victoria, where supplies are plentiful. However, it is hedging its bets with a project in Norway to derive hydrogen using power from hydroelectric dams and eventually wind farms.

Using Australian coal requires removing its climate-changing carbon and burying it in old oil or gas wells there.

In Norway, KHI has teamed up with Nel Hydrogen, a maker of hydrogen plants, with backers including Japan's Mitsubishi Corp and Norway's Statoil. The project aims to demonstrate that liquefied hydrogen (LH_2) can be produced using renewables and delivered to Japan on tankers.

Nel Hydrogen's market development vice-president Bjorn Simonsen told Reuters the company aims to deliver liquefied hydrogen to Japan for a minimum 24 yen per normal cubic meter (Nm^3). A study on the scheme is due to be completed in 2019.

KHI estimates that hydrogen from Australia costs about 29.8 yen/nm^3 and the company plans to establish a global LH_2 supply chain like that for liquefied natural gas, KHI's spokesman Keisuke Murakami told Reuters by email.

"If Norway commercial (production) goes rapidly it might be earlier than Australian commercial," he said.

Study awaited

Both projects still have a long way to go before they could start commercial production.

Under the Australian plan, coal would be converted to gas for processing to remove sulphur, mercury and carbon dioxide, leaving hydrogen. The Norwegian system would use renewable power for high-temperature electrolysis to split water into hydrogen and oxygen, which would be released into the atmosphere. In both cases, the hydrogen would be liquefied for shipment to Japan.

In Australia, a small demonstration ship is being built and KHI plans to build bigger tankers in the 2020s. The firm is also seeking support from the Victorian and federal (Commonwealth) governments, Murakami said.

A hydrogen plant would "contribute to job creation and the acquisition of foreign currencies," he said, adding that a pilot project in Australia is scheduled to start before 2020.

Victoria is looking at the project due to the decline of brown coal mining and power stations burning the polluting fuel.

"The Victorian and Commonwealth Governments have been working with KHI on an engineering study into the possible production of hydrogen from Victorian brown coal," the state's resources minister, Wade Noonan, told Reuters. The government is waiting for KHI's results, he said.

The Japanese government is backing KHI's Australian initiative and budgeting 4.7 billion yen for it and related efforts this financial year, up 70 percent from the previous year. It is spending 22 billion yen backing other hydrogen initiatives.

Earlier this month Abe called on ministers to step up efforts to "lead the world in making the hydrogen society come true". He called for 40,000 fuel cell vehicles to be on the streets by the 2020 Olympics.

So far, the technology has largely been applied to cars, with hydrogen used by a fuel cell to make electricity which in turn powers the vehicle. Toyota Motor Corp launched its hydrogen-fueled Mirai model in 2014.

However, only a few thousand Mirai - which means "future" in Japanese - are on the roads, a figure dwarfed by numbers of technically simpler battery-powered cars worldwide.

Fewer than 100 filling stations sell the fuel in Japan as safety concerns have held back development following hydrogen explosions that rocked the Fukushima nuclear plant.

While Japan has high hopes of developing commercial scale power stations using hydrogen, environmental concerns over the use of brown coal and other fossil fuels may cloud its future.

"Over 95 percent of [hydrogen] today comes from fossil fuels. To speak about clean hydrogen we have to clean the dirty fuel that produces it," said Cédric Philibert, a senior renewable energy analyst at the International Energy Agency.

Source: http://www.reuters.com/article/us-japan-hydrogen-race-idUSKBN17U1QA

Graphane could act as efficient and water-free hydrogen fuel cell membrane

Hydrogen powered fuel cell cars, developed by almost every major car manufacturer, are ideal zero-emissions vehicles because they produce only water as exhaust. However, their reliability is limited because the fuel cell relies upon a membrane that only functions when enough water is present, limiting the vehicle's operating conditions.

Researchers at the University of Pittsburgh's Swanson School of Engineering have found that the unusual properties of graphene could form a type of anhydrous "bucket brigade" that transports protons without the need for water, potentially leading to the development of more efficient hydrogen fuel cells for vehicles and other energy systems.

The principal investigator is Karl Johnson, the William Kep-

ler Whiteford Professor in the Swanson School's Department of Chemical & Petroleum Engineering, and graduate research assistant Abhishek Bagusetty is the lead author. Their work, "Facile Anhydrous Proton Transport on Hydroxyl Functionalized Graphane" (DOI: 10.1103/PhysRevLett.118.186101), was published in *Physical Review Letters*. Computational modeling techniques coupled with the high performance computational infrastructure at the University's Center for Research Computing enabled them to design this potentially groundbreaking material.

Hydrogen fuels cells are like a battery that can be recharged with hydrogen and oxygen. The hydrogen enters one side of the fuel cell, where it is broken down into protons (hydrogen ions) and electrons, while oxygen enters the other side and is ultimately chemically combined with the protons and electrons to produce water, releasing energy.

At the heart of the fuel cell is a proton exchange membrane (PEM). These membranes mostly rely on water to aid in the conduction of protons across the membranes. Everything works well unless the temperature gets too high or the humidity drops, which depletes the membrane of water and stops the protons from migrating across the membrane. Dr. Johnson explains that for this reason, there is keen interest in developing new membrane materials that can operate at very low water levels-or even in the complete absence of water (anhydrously).

"PEMs in today's hydrogen fuel cells are made of a polymer called Nafion, which only conducts protons when it has the right amount of water on it," says Dr. Johnson. "Too little water, the membrane dries out and protons stop moving. Too much and the membrane "floods" and stops operating, similar to how you could flood a carbureted engine with too much gasoline," he added.

Dr. Johnson and his team focused on graphane because when functionalized with hydroxyl groups it creates a more stable, insulating membrane to conduct protons. "Our computational modeling showed that because of graphane's unique structure, it is well suited to rapidly conduct protons across the membrane and electrons across the circuit under anhydrous conditions," Dr. Johnson said. "This would enable hydrogen fuel cell cars to be a more practical alternative vehicle."

Source: https://www.sciencedaily.com/releases/2017/05/170504110558.htm

80 years later, stigma of Hindenburg disaster stills affects hydrogen

Eighty years after the Hindenburg disaster, the airship appears to be finally inching closer to returning to the skies. But it remains unclear whether today's advanced airships will ever resume the use of hydrogen.

The Hindenburg famously crashed and burned in New Jersey on May 6, 1937, killing 36 people. Although it was far from the first crash by a hydrogen-powered airship, the spectacular footage of the disaster essentially ended the era of the zeppelin.

The sporadic use of helium-powered blimps continued in subsequent decades, and a new breed of airships recently took to the skies.

Those airships, however, also use helium rather than hydrogen—a pattern analysts in part attribute to continued public perceptions of hydrogen as a dangerous, flammable gas.

To mark the 80th anniversary of the disaster, the Royal Society of Chemistry examined the suspected causes of the Hindenburg crash—electrostatic discharge, most likely—and noted dramatic advancements in both aviation safety and in the handling of hydrogen.

If hydrogen can move past the stigma of the Hindenburg, it could provide substantial advantages over helium. It's much lighter—and therefore could lift more passengers or cargo—and there are concerns about just how much helium is available on Earth.

Although new airships are touted as ideal for sightseeing, they could prove more important to commerce. The helium-fueled Airlander 10, for example, can carry more than 22,000 pounds with no emissions.

Studies also suggested that airships could provide an alternate way for companies to ship their goods overseas, and e-commerce giant Amazon is even looking at the possibility of airborne warehouses.

Hydrogen News of Interest

Source: https://www.chem.info/news/2017/05/80-years-later-stigma-hindenburg-disaster-still-affects-hydrogen

New, more efficient catalyst for water splitting

University of Houston physicists have discovered a catalyst that can split water into hydrogen and oxygen, composed of easily available, low-cost materials and operating far more efficiently than previous catalysts.

That would solve one of the primary hurdles remaining in using water to produce hydrogen, one of the most promising sources of clean energy.

"Hydrogen is the cleanest primary energy source we have on earth," said Paul C. W. Chu, TLL Temple Chair of Science and founding director and chief scientist of the Texas Center for Superconductivity at UH. "Water could be the most abundant source of hydrogen if one could separate the hydrogen from its strong bond with oxygen in the water by using a catalyst."

Chu and colleagues including physicists Zhifeng Ren and Shuo Chen, both of whom also are principal investigators with the Texas Center for Superconductivity at UH, report their discovery—an efficient catalyst produced without the expensive precious metals most commonly used—this week in the *Proceedings of the Natural Academy of Sciences*.

Other researchers involved in the project include postdoctoral researchers Haiqing Zhou and Fang Yu, and graduate students Jingying Sun and Ran He.

The catalyst, composed of ferrous metaphosphate grown on a conductive nickel foam platform, is far more efficient than previous catalysts, as well as less expensive to produce. "Cost-wise, it is much lower and performance-wise, much better," said Zhifeng Ren, M.D. Anderson professor of physics and lead author on the paper. The catalyst also is durable, operating more than 20 hours and 10,000 cycles in testing.

"Some catalysts are outstanding but are only stable for one or two hours," Ren said. "That's no use."

Although it is simple in theory, splitting water into hydrogen and oxygen is a complex process, requiring two separate reactions -- a hydrogen evolution reaction and an oxygen evolution reaction, each requiring a separate electrode. While hydrogen is the more valuable component, it can't be produced without also producing oxygen. And while efficient hydrogen catalysts are available, Ren said the lack of an inexpensive and efficient oxygen catalyst has created a bottleneck in the field.

Hydrogen has a number of advantages. "Hydrogen (H_2) produced from water splitting by an electrochemical process, called water electrolysis, has been considered to be a clean and sustainable energy resource to replace fossil fuels and meet the rising global energy demand, since water is both the sole starting material and byproduct when clean energy is produced by converting H_2 back to water," the researchers wrote.

And unlike solar power, wind power and other "clean" energy, hydrogen can be easily stored.

Currently, most hydrogen is produced through steam methane reforming and coal gasification; those methods raise the fuel's carbon footprint despite the fact that it burns cleanly.

Chen said oxygen evolution reactions often depend upon an electrocatalyst using a "noble metal"—iridium, platinum or ruthenium. But those are expensive and not readily available.

"In this work, we discovered a highly active and stable electrocatalyst based on earth-abundant elements, which even outperforms the noble metal based ones," she said. "Our discovery may lead to a more economic approach for hydrogen production from water electrolysis."

Water splitting can be triggered either through electric current or through photocatalysis, using the power of the sun. Direct solar-powered water splitting is too inefficient, as water can absorb just a small portion of the light spectrum. Ideally, Ren said, solar power would be used to generate the electric power used to split water.

Source:
https://www.sciencedaily.com/releases/2017/05/170515150734.htm

Hydrogen News of Interest

Sustainable innovations delivers the 1st fully integrated solid-state electrochemical hydrogen compressor system to NASA

Sustainable Innovations has delivered a Hydrogen-Based Energy Conservation System (HECS) for recovering hydrogen from various waste streams at NASA Stennis Space Center (SSC). The first of its kind, this fully integrated, solid state system is designed to recover hydrogen released from cryogenic storage or to separate hydrogen from helium used in rocket test operations. Using a proprietary electrochemical process developed by Sustainable Innovations, the HECS system can purify and compress recovered hydrogen to commercial storage pressures, facilitating its reuse for vehicle fueling and other needs. SI was tapped for this development project because of its success in hydrogen fueling pressure at significant scale while avoiding the unacceptable downtime and maintenance pitfalls that have hampered mechanical compressors. As an electrochemical-based process, energy is not wasted during compression and there are no moving parts. The result is a highly reliable system requiring very low maintenance.

The HECS system delivered to NASA is the culmination of Small Business Innovation Research (SBIR) Phase I and Phase II efforts. The key objective was to develop the components of a large-scale hydrogen recovery and compression system. The components were designed as a modular building block for a scaled-up system to reclaim and compress large amounts of NASA Stennis Space Center's (SSC's) wasted hydrogen and helium. NASA is a major user of both gases, using upwards of 700,000 gallons of cold liquid hydrogen per shuttle rocket flight. As well, NASA uses up to 100 million cubic feet of helium per year, mainly to purge hydrogen fueling lines after firing rocket engines. With the HECS, there is now the ability to recover valuable hydrogen fuel and also separate out and recapture, an extraordinarily valuable and an increasingly scarce resource—helium gas.

Source: http://www.prnewswire.com/news-releases/sustainable-innovations-delivers-the-1st-fully-integrated-solid-state-electrochemical-hydrogen-compressor-system-to-nasa-300457546.html

Safe, efficient way to produce hydrogen from aluminum particles and water for in-flight aircraft energy

Aerospace engineers at the Technion-Israel Institute of Technology have developed and patented a process that can be used onboard aircraft while in flight to produce hydrogen from water and aluminum particles safely and cheaply. The hydrogen can then be converted into electrical energy for inflight use. The breakthrough could pave the way for non-polluting, more-electric aircraft that replace current hydraulic and pneumatic systems typically powered by the main engine.

The groundbreaking work was reported in a recent paper published in the *International Journal of Hydrogen Energy*.

"Hydrogen produced onboard the aircraft during flight can be channeled to a fuel cell for electrical energy generation," said lead researcher Dr. Shani Elitzur of the Technion Faculty of Aerospace Engineering. "This technology offers a good solution to several challenges, such as hydrogen storage, without the problems associated with storing hydrogen in a liquid or gas state."

While the use of hydrogen fuels has been a potential greener energy solution for some time, storing hydrogen has always been a problem. The engineers were able to work around the hydrogen storage problem by using non-polluting Proton Exchange Membrane (PEM) fuel cells and a process of aluminum activation patented by the paper's co-authors, Prof. Alon Gany and Dr. Valery Rosenband.

Dr. Elitzur's research was focused on the reaction between the activated aluminum powder and water (from different types) to produce hydrogen. The foundation for the technology is in the chemical reaction between aluminum powder and water to produce hydrogen. Either fresh water or waste water, already onboard the aircraft, can be used for activation, which means the aircraft does not need to carry any additional water.

The spontaneous and sustained reaction between powdered aluminum and water is enabled by a special thermo-chemical process of aluminum activation the re-

searchers developed. The protective properties of the oxide or hydroxide film covering the aluminum particle surface are modified by a small fraction of lithium-based activator diffused into aluminum bulk, allowing water at room temperature to react spontaneously with the aluminum.

The process does generate heat, which the researchers say can be used for a number of tasks, including heating water and food in the galley, de-icing operations, or heating aircraft fuel prior to starting the engines.

According to the researchers, their technology would provide:

- Quieter operations on board an aircraft
- Drastic reductions in CO_2 emissions
- Compact storage; no need for hydrogen storage tanks onboard aircraft
- More efficient electric power generation
- A reduction in wiring (multiple fuel cells can be located near their point of use)
- Thermal efficiency (fuel cell generated heat can be used for de-icing, heating jet fuel)
- Reduced flammable vapors in fuel tanks (Inert gas generation)

"The possibility of using available, onboard wastewater boosts both the efficiency and safety of the system," explained Dr. Rosenband. "Also, the PEM fuel cells exhibit high efficiency in electric energy generation."

Aircraft manufacturers, including Boeing and Airbus, have already investigated using onboard fuel cells. Boeing has experimented with them in smaller aircraft, in anticipation of using them on its 787-8, the current state-of-the-art electric airplane. According to the Technion researchers, fuel cells can even play an energy saving role in airline and airport ground support operations when they are used for systems such as de-icing and runway light towers.

"Efficient hydrogen production and storage represents the future for efficient and safe aircraft inflight energy needs." summarized Prof. Gany.

Source: https://phys.org/news/2017-04-safe-efficient-hydrogen-aluminum-particles.html

Oil platforms as a part of large-scale North Sea renewable energy generation

The more than 1400 oil and gas platforms currently located in the North Sea might eventually be used to fight the problem they helped to create: unsustainable energy generation. By revamping these installation, they could become part of the energy revolution as hydrogen production and storage facilities.

Multiple organization, including oil giants Shell and Total, but also Siemens and Dutch research institute TNO, are now working together on giving fossil fuel infrastructure in the North Sea a new life within a renewable grid. It is expected that deconstruction of the Dutch share of installations alone would come at a 3.6€ billion price tag, costs which the aforementioned parties hope to prevent.

Shallow waters combined with a lot of wind make the North Sea ideally suited for vast British, Norwegian, and Dutch wind parks. Several gigawatts are already online, and with many more in the pipeline, the North Sea is quickly becoming a vital part of the Western European electricity supply.

As wind power capacity further increases, there will inevitably be more and more moments at which all these turbines produce more than what is needed, engendering a need for storage. That's where the old platforms could come in. They could transform the electricity into hydrogen, in which form the energy can then be stored for times at which the wind is blowing less vigorously or for periods of peak demand.

Other uses are being considered as well. Platforms could be turned into gas-to-wire installations for example, which would convert the last remainders of gas in the North Sea

to electricity that could be brought to land using the grid connections of the wind farms. This could be done with a very low-carbon footprint according to TNO, if combined with carbon capture and storage (CCS). But even connecting those installations that are currently in operation to the grid would already attain a substantial emission reduction. An estimated 1 million tons of CO_2 could be saved that way, as these installations are now dependent on inefficient gas or diesel generators for their electricity supply.

Source: https://cleantechnica.com/2017/05/15/oil-platforms-part-large-scale-north-sea-renewable-energy-generation/

CSIRO hydrogen membrane a gateway to renewable energy exports

A new hydrogen membrane developed by the CSIRO will fill a gap in the global energy technology chain to supply fuel cell vehicles with low-emissions hydrogen sourced from Australia, the agency says.

A two-year project will build on CSIRO's expertise in separating pure hydrogen from mixed gas streams, in this case converting ammonia to high-purity hydrogen for use in fuel cell vehicles (FCVs).

CSIRO's membrane reactor technology will fill the gap between hydrogen production, distribution and delivery in the form a modular unit that can be used at or near to refueling stations.

The project recently received $1.7 million from the Science and Industry Endowment Fund (SIEF), which will be matched by CSIRO.

Currently, the transportation and storage of hydrogen is complex and relatively expensive, making export commercially challenging.

The membrane will allow hydrogen to be transported in the form of ammonia (which is already being traded globally) and then reconverted back to hydrogen at the point of use.

The thin metal membrane allows hydrogen to pass, while blocking all other gases.

The device is in the final stages of development.

Hydrogen's here to help

Recent advances in solar and electrochemical technologies means renewable hydrogen production is expected to become competitive with fossil fuel-based production, providing an opportunity to decarbonize both the energy and transport sectors while creating new export opportunities.

While Australia is a relatively small hydrogen market, the fuel can be distributed to emerging markets in Japan, South Korea and Europe using existing infrastructure.

CSIRO chief executive Dr. Larry Marshall sees a growing global market for clean hydrogen and the potential for a national renewable hydrogen export industry to benefit Australia.

"This is a watershed moment for energy, and we look forward to applying CSIRO innovation to enable this exciting renewably-sourced fuel and energy storage medium a smoother path to market," Dr. Marshall said.

"I'm delighted to see strong collaboration and the application of CSIRO know-how to what is a key part of the overall energy mix."

Renewable Hydrogen chair Brett Cooper believes CSIRO's membrane technology can enable a new, and potentially carbon-free, export industry for Australia that could match the scale of the LNG industry.

"With this technology we can deliver our renewable energy to Japan, Korea and across the Asia-Pacific region in liquid form, as renewable ammonia, and efficiently convert it back to pure hydrogen for cars, buses, power generation and industrial processes," Cooper said.

"This market didn't exist 10 years ago—now Australia is positioned to be the number one renewable fuel provider in the world's fastest growing region."

In addition to its membrane technology, CSIRO will apply its expertise to all stages of the technology chain (including solar photovoltaics, solar thermal, grid management, water electrolysis, ammonia synthesis, direct ammonia utilization via combustion and/or fuel cells, as well as hydrogen production).

Source: http://www.ecogeneration.com.au/csiro-hydrogen-membrane-a-gateway-to-renewable-energy-exports/

A more than 100% quantum step toward producing hydrogen fuel

Efforts to reduce our dependence on fossil fuels are advancing on various significant fronts. Such initiatives include research focused on more efficient production of gaseous hydrogen fuel by using solar energy to break water down into its components of hydrogen and oxygen. Recently, in an article published in the journal *Nature Energy*, lead author Yong Yan, an assistant professor in the Department of Chemistry and Environmental Science, reported a key breakthrough in the basic science essential for progress toward this goal.

The article, "Multiple exciton generation for photoelectrochemical hydrogen evolution reactions with quantum yields exceeding 100%," reports on the investigative work that Yan carried out along with colleagues affiliated with the National Renewable Energy Laboratory, the Colorado School of Mines and San Diego State University. Essentially, they created what is known as a quantum dot photoelectrochemical cell that catalytically achieved quantum efficiency for hydrogen gas production exceeding 100%—in the case of their experiments an efficiency approaching 114%.

Quantum dots are extremely small semiconductor particles only a few nanometers in size. In their device, lead sulfide quantum dots replace semiconductor materials such as silicon and copper indium gallium arsenide. The advantage is that such a photoelectrochemical device can, potentially, convert a greater portion of the solar spectrum into useful energy.

The device described is able to absorb one visible solar photon and produce two, or even more, electrons through a process known as multiple exciton generation, or MEG, which are further utilized to reduce water to generate hydrogen gas. Although many scientists worldwide are engaged in efforts to achieve quantum efficiency as close as possible to 100% for solar hydrogen production, Yan's achievement in directly exceeding this threshold is a significant fundamental breakthrough. It clearly proves that the photoelectrochemical cell design he describes is much more efficient than a quantum dot solar cell with respect to quantum yield.

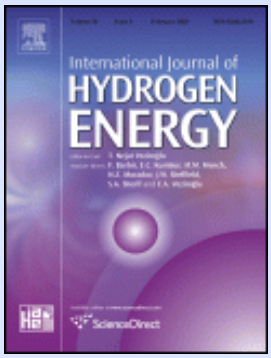
Yan, who joined the NJIT faculty in 2016, emphasizes that this advance is at the level of basic solar science, and that the breakthrough with respect to quantum yield does not equate to a substantial increase in the ultimate solar-to-hydrogen conversion efficiency. Nonetheless, this dramatic increase in quantum yield realized with a uniquely innovative lead sulfide quantum dot photoelectrochemical device is an important development in several ways, and as such is a product of Yan's long-standing interest in renewable sources of energy, especially in novel applications of solar energy.

For Yan, the research reported in *Nature Energy* culminated at NJIT after his previous work as a postdoc at Princeton University and at the U.S. Department of Energy's National Renewable Energy Laboratory in Colorado. The success of this leading-edge effort was made possible with funding provided, in part, by NJIT and the Department of Energy.

Yan says, "These results do present the possibility of generating more energy more efficiently with such a solar-capture device in the future. This could also lead to a fundamental change in the entire process of producing hydrogen fuel. We can now obtain hydrogen fuel from water by using electricity supplied by conventional power plants that consume fossil fuels. But by building on the basic step of achieving such high quantum efficiency for solar hydrogen generation, we could make the process of producing a 'green' fuel much greener as well."

Source:
https://www.sciencedaily.com/releases/2017/04/170425124226.htm

International Journal of Hydrogen Energy Highlights



The *International Journal of Hydrogen Energy* aims to provide a central vehicle for the exchange and dissemination of new ideas, technology developments and research results in the field of Hydrogen Energy between scientists and engineers throughout the world. The emphasis is placed on original research, both analytical and experimental, covering all aspects of Hydrogen Energy, including production, storage, transmission, utilization, enabling technologies, environmental impact, economic and international aspects of hydrogen and hydrogen carriers such as NH3, CH4, alcohols, etc.

The utilization includes thermochemical (combustion), photochemical, electrochemical (fuel cells) and nuclear conversion of hydrogen, hydrogen isotopes and/or hydrogen carriers to thermal, mechanical and electrical energies, and their applications in transportation (including aerospace), industrial, commercial and residential sectors. When outstanding new advances are made, or when new areas have been developed to a definitive stage, special review articles will be considered. Shorter communications are also welcome.

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High-performance ceramic composite electrodes for electrochemical hydrogen pump using protonic ceramics

-Jaewon Choi, Minho Shin, Baek Kim, Jong-Sung Park. Int J Hydrogen Energy 2017:42(18): 13092-13098

With applications in intermediate temperature (IT) fuel cells, protonic ceramics have been reported in recent years to exhibit adequate performance as a separator for hydrogen pump applications where protons are pumped through an electrolyte to synthesize chemicals such as hydrocarbon fuels or ammonia. In this study, a high-performance ceramic electrolyte was developed and characterized with common electrochemical methods such as electrochemical impedance spectroscopy (EIS) and polarization curves. The composition of the protonic ceramic used as the electrolyte was $Ba(Zr_{0.30}Ce_{0.54}Y_{0.15}Cu_{0.01})$ and the article goes into a discussion of the methodology for fabricating the material (infiltration method). Hydrogen pumps have a similar architecture to fuel cells; however, they have different gas compositions at the anode and cathode which dictate what chemicals will be synthesized when the electrodes are polarized. The researchers characterized the ceramic primarily via SEM, I-V polarization curves and EIS. The SEM results showed microstructures as well as the scaffold formed by the chemical composite. The ASR was measured at various bias current densities where it increased gradually at low current densities (0 - .5 A cm^2) then very steeply at the next current density interval (.75 A cm^2). With this nonlinear ohmic resistance, it was observed that the limiting current in the I-V polarization curves had contributions from both concentration polarization as well as this increasing ohmic resistance. The researchers parametrically investigated different partial pressures at the anode and cathode as well as different temperatures. The greatest improvement that was achieved by the researchers was operating at higher temperature (973 K vs. 873 K) where the EIS results showed great improvement in kinetics.

http://www.sciencedirect.com/science/article/pii/S0360319917313812

-By Cyrus Daugherty

Experiments on solid state hydrogen storage device with a finned tube heat exchanger

-Anurag Singh, M.P. Maiya, S. Srinivasa Murthy. J Hydrogen Energy 2017: In Press.

High pressure gas, cryogenic liquid and metal hydrides (MH) are the most common modes of storing hydrogen gas. Among different storage options, MH store hydrogen at practical temperatures and pressures compared to other technologies. However, poor thermal conductivity and high heat of adsorption results in large charging and discharging times. Accordingly, the heat exchangers being used in MH configurations are required to be improved for enhancing the heat transfer rate between MH and heat transfer fluid (HTF).

In this work, the absorption and desorption performances of a solid state MH hydrogen storage device with a finned tube heat exchanger are experimentally investigated. The heat exchanger design consists of two "U" shaped cooling tubes and perforated annular copper fins. Copper flakes are also inserted in between the fins to increase the overall effective thermal conductivity of the metal hydride bed. Experiments are performed on the storage device containing 1 kg of hydriding alloy $LaNi_5$, at various hydrogen supply pressures. Water is used as the heat transfer fluid. The performance of the storage device is investigated for different operating parameters such as hydrogen supply pressure, cooling fluid temperature and heating fluid temperature. The shortest charging time found is 490 s for the absorption capacity of 1.2 wt% at a supply pressure of 15 bar and cooling fluid temperature and velocity of 288 K and 1 m/s respectively. The effect of copper flakes on absorption performance is also investigated and compared with a similar storage device without copper flakes.

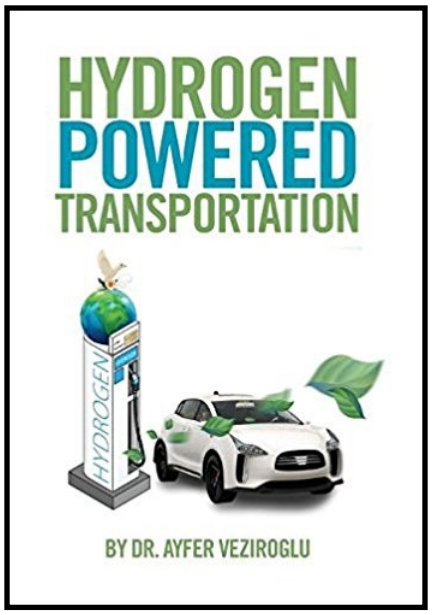
http://www.sciencedirect.com/science/article/pii/S0360319917317949

-By Yasser Ashraf Gandomi

From the Bookshelf

Hydrogen Powered Transportation

By Dr. Ayfer Veziroglu



The current status of fossil fuel and alternative energy is a hot topic of today. Many different sides have many different opinions on the transition strategy that will work best as fossil fuel reserves slowly diminish.

Hydrogen fits into this transition mostly by replacing oil in the transportation sector as the main energy carrier. Natural gas and biofuels seem to be the best short-term solution, but after 2050, hydrogen transportation must become the norm as we move into a sustainable energy sector by 2100. Fuel-cell vehicles will be able to run off hydrogen more efficiently and be far cleaner than conventional gas-powered vehicles.

As production of fossil fuels slows and proven reserves fall, prices will rise and alternative sources will become economically competitive with fossil fuels. Nuclear, geothermal, wind, PV, and wave energy will all be needed to provide for the total global energy demands. A hydrogen platform will also be developed through this century for the transportation sector. Hydrogen will serve as an energy carrier for vehicles and will be used as a form of chemical storage for energy in stationary applications, produced most likely by off-peak excess power.

Based on the above information, all countries in the world can be analyzed to assess their potential to become early adopters for hydrogen energy. Even though a basic statistical approach might not provide very accurate results, it provides an insight on early adopters and the status of countries in terms of several commonly measured properties.

https://www.amazon.com/Hydrogen-Powered-Transportation-Ayfer-Veziroglu/dp/1524582964

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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

Institute for sustainability, Energy, and Environment (ISEE)

Overview:
Institute for Sustainability, Energy, and Environment (ISEE) is located at University of Illinois at Urbana-Champaign. The ISEE's main mission is to explore solutions for food, water, and energy while ensuring a safe, productive, and sustainable environment for all global citizens.

The ISEE is focused on researching solutions for the world's pressing sustainability, energy, and environmental needs. The five different distinct areas of research at ISEE:

- Climate solutions
- Energy transitions
- Sustainable infrastructure
- Water and land stewardship
- Secure and sustainable agriculture

Climate solutions:
The climate change effects are serious in the U.S., however, the impacts pose even greater risks for agriculture, food and water supplies in developing nations—projected to experience the largest percentage of the world's growth from now until 2100. These threats could quickly erase recent gains in the fight against poverty, hunger and disease.

Therefore, the ISEE is taking a comprehensive approach with research and programs to address various aspects of climate solutions including:

- Risk
- Mitigation and adaptation
- Human health
- Social vulnerability, conflict and democracy
- Ecological integrity

Energy Transitions:
As the world's population grows and economies become more industrialized, nonrenewable energy sources will become scarcer and costlier. In fact, some reports caution that the world will need 40% more energy by 2030. That energy will need to be found in renewable sources—quickly and with reliability.

ISEE is fostering path-breaking new works in numerous areas of energy transitions:

- Renewables
- Optimization of supply and demand
- Systems and controls
- Micro grid and storage
- Pollution

Sustainable Infrastructure:
From massive repairs of aging systems for water, sanitation and more, to developing new improvements to preserve natural resources, it's imperative that we harness technology and public policy across engineering and urban planning disciplines to create sustainable solutions.

To address these concerns, ISEE is encouraging and coordinating work in key areas of sustainable infrastructure:

- Transportation
- Built environment
- Risk, resilience and adaptation
- Pollution and waste
- Cities and urban environments

Water and Land Stewardship:
Degradation and loss of natural assets is a major threat to 85% of all species, according to the International Union for Conservation of Nature's Red List. What's more, the impact of chemical pollution is creating a chain reaction that's causing debilitating mutations to fish and animals while imposing unsafe levels of toxins to the human food supply.

To help halt this dramatic situation, ISEE is serving as a unified source for new insight into water and land stewardship including:

- Land use change
- Freshwater resources and purity
- Conservation and biodiversity
- Land and resource tenure
- Health

Secure & Sustainable Agriculture:
With growing populations and higher demand for food, the impact of climate change could result in an increase of 20% of the world's people at risk of chronic hunger, according to a World Health Organization report.

The gap between agricultural production and demand can be closed by expanding agriculture to currently marginal or unused land, substituting new types of crops, and adopting new technologies—particularly in developing nations affected by large variations in rainfall and reduced water availability. ISEE is spearheading initiatives in numerous areas of secure and sustainable agriculture:

- Greenhouse gas emissions and farming practices
- Nutrient management and soil health
- Technology for sustainable agriculture
- Regulation
- Public health, food safety, and policy

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Upcoming Meetings & Activities

June 2017

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

European PEFC & Electrolyser-Forum
July 4-7, 2017
Lucerne, Switzerland
http://www.efcf.com/

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

Hydrogen + Fuel Cells North America
September 10-13, 2017
Las Vegas, NV
http://www.h2fc-fair.com/usa/

Joint European Summer School on Fuel Cell, Electrolyser, and Battery Technologies
September 17-23, 2017
Athens, Greece
http://www.jess-summerschool.eu/Week-1

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

eMove 360° Europe
October 17-19, 2017
Munich, Germany
http://www.emove360.com

November 2017

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

December 2017

European Fuel Cell Conference & Exhibition
December 12-15, 2017
Naples, Italy
http://www.europeanfuelcell.it/

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

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