international association for hydrogen energy
Clean and Abundant Energy for Sustainability

August 2017 • Volume 9 • Issue 4 *Electronic Newsletter*

The US Army's new truck is silent—and driving it is surreal

When you're slinking behind enemy lines, the last thing you want is to be detected.

For the U.S. Army's Tank Automotive Research, Development and Engineering Center (TARDEC), the next step in military vehicle technology marks its location with only a hint of water dripping out of its tailpipe.

The only sound you'll hear as it approaches is the crunch of the ground beneath its big mud tires. And its heat profile is almost invisible to infrared cameras.

The Chevrolet Colorado ZH2 hydrogen fuel-cell electric truck is quite a departure from the rumbling diesel Humvees long emblematic of the Army.

Behind the Chevrolet Colorado ZH2's show-stand looks are a host of goodies that make it a highly capable off-roader for the armed forces. The one-off ZH2 is currently undergoing a year of Army evaluation at several bases spread across the U.S. We caught up with it at Fort Carson, near Colorado Springs, Colorado, where the foothills of the Rocky Mountains approximate the terrain in some of the world's most dangerous places.

Test-bed of technology

GM formally handed the Colorado ZH2 to TARDEC for a year-long evaluation beginning late last year. It may look like a concept, but its chunky looks hide a test-bed of technologies. Chief among them is the 170-horsepower electric motor that receives its juice from a hydrogen fuel cell. This test truck actually uses a Gen 0 (in GM-speak) fuel cell powertrain borrowed from GM's now-discontinued line of fuel cell Chevy Equinox crossovers. It's not the latest and greatest fuel cell setup, but it does serve as a good starting point for military testing in a variety of durability and feasibility situations that simulate everything from reconnaissance to combat.

The hydrogen fuel cell also provides juice to a separate electric generator housed behind a top-hinged trunk where the standard Colorado's bed would be. An electric generator could eventually replace the loud, inefficient diesel generators the armed forces currently lug behind their Humvees to power their communications devices.

Underneath, the ZH2 is basically an off-road ready Colorado ZR2 with a slightly lifted suspension, 37-inch BF Goodrich Mud-Terrain off-road rubber, beefier skid plates, and rocker panel-protecting tubular rails. It's mostly off-the-shelf stuff that makes an already capable four-wheeler more durable.

A production military vehicle with a fuel-cell powertrain isn't likely to look much like this Colorado, but army officials did tell us that the mid-size pickup's dimensions and inherent maneuverability are appealing advantages—if not unique to the ZH2. Instead, the test focuses mostly on the ZH2's instant torque electric motor and the range and reliability of its hydrogen fuel-cell.

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

MECHANICAL, AEROSPACE & BIOMEDICAL ENGINEERING

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

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

Getting hydrogen to Fort Carson is no easy task. At this base just outside Colorado Springs, the Army's closest filling station is the National Renewable Energy Laboratory's (NREL) Wind Test Site near Golden—about 90 minutes away. The Army can extract hydrogen from the JP8 fuel it uses in most of its combustion engines, though doing so on the small scale required for the ZH2 test isn't feasible.

At least the Army has seen up to 200 miles of range out of the ZH2, depending on the type of terrain it's driven through. Our brief ride-along on a sunny day didn't exactly test that range, but it did show off the ZH2's rapid acceleration. Its suspension soaks up boulders the size of Prius wheels reasonably well, softer than a Humvee but not nearly as plush as a Ford F-150 Raptor. There's no noise other than gravel shifting below its big tires and rocks occasionally tapping its skid plates—a surreal experience on its own.

Just how the armed forces are likely to use a hydrogen-fueled vehicle remains up for debate, though this test should help TARDEC gain a lot of insight. The inherent combustibility of hydrogen necessitates extra careful precautions for the ZH2's tank, which is designed to vent upward and outward in the event of a breach.

True, that could limit its use in combat situations, but TARDEC suggested that electric motors fed by hydrogen fuel cells could make a lot of sense as generators capable of powering an entire remote location in silence. In some of the world's most dangerous places, silence may be the best weapon yet.

Source: http://www.businessinsider.com/take-a-look-at-the-us-armys-chevy-colorado-zh2-2017-7

Hydrogen Economy News

US Energy Department announces $15.8 million investment for innovation in hydrogen and fuel cell technologies

On June 8, 2017, the U.S. Department of Energy (DOE) announced approximately $15.8 million for 30 new projects aimed at discovery and development of novel, low-cost materials necessary for hydrogen production and storage and for fuel cells onboard light-duty vehicles. Selected projects will leverage national lab consortia launched under DOE's Energy Materials Network (EMN) this past year, in support of DOE's materials research and advanced manufacturing priorities.

Selections were made under the Office of Energy Efficiency and Renewable Energy's Fuel Cell Technologies Office (FCTO) annual funding opportunity announcement (FOA) in 2017. The 2017 FOA solicited early-stage materials research to advance the Department's goals of enabling economic and efficient transportation via fuel cell electric vehicles that use hydrogen fuel produced from diverse domestic resources.

More than 2,000 fuel cell vehicles have been sold or leased in the U.S. since 2015. These consume 95% less petroleum per mile than conventional internal combustion engine vehicles, have no tailpipe emissions, and offer quiet operation.

The selected EMN consortia projects will leverage unique, world-class capabilities at the national laboratories, facilitating collaborations that will expedite the development of advanced materials.

Selected projects will cover the following topics:

Topic 1: PGM-free Catalyst and Electrode R&D—4 projects will leverage the Electrocatalysis Consortium (ElectroCat) to accelerate the development of catalysts

Hydrogen Economy News

made without platinum group metals (PGM-free) for use in fuel cells for transportation.

Topic 2: Advanced Water Splitting Materials—19 projects will leverage the HydroGEN Consortium to accelerate the development of advanced water-splitting materials for hydrogen production, with an initial focus on advanced electrolytic, photoelectrochemical, and solar thermochemical pathways.

Topic 3: Hydrogen Storage Materials Discovery—4 projects will leverage the Hydrogen Materials—Advanced Research Consortium (HyMARC) to address unsolved scientific challenges in the development of viable solid-state materials for hydrogen storage onboard light-duty vehicles.

Topic 4: Precursor Development for Low-Cost, High-Strength Carbon Fiber—3 projects will reduce the cost of onboard hydrogen storage tanks necessary for fuel cell vehicles. These projects will pursue innovative approaches to developing novel precursors for high-strength carbon fiber at half the cost of current materials. Resources from LightMAT (a DOE Vehicle Technologies Office-managed EMN consortium), and IACMI (an institute for advanced composites research within the Manufacturing USA network managed by DOE's Advanced Manufacturing Office), may also be leveraged by the awardees.

Source: https://www.energy.gov/articles/energy-department-announces-158-million-investment-innovation-hydrogen-and-fuel-cell

Hydrogen Vehicle News

Grant focuses on "Hydrogen Sponge" for use in fuel-cell vehicles

Finding practical hydrogen storage technologies for vehicles powered by fuel cells is the focus of a $682,000 grant from the U.S. Department of Energy, awarded to Mike Chung, professor of materials science and engineering, Penn State.

Chung's recent research on superabsorbent polymers, which shows potential to aid in oil spill recovery and cleanup, may also be a storage vehicle for hydrogen fuel cells.

"My group developed hydrocarbon polymers with a high oil absorption capacity," he said. "The polymers provide an efficient way to separate and store the hydrocarbon molecules—oils—from water during spills."

He hopes to apply similar technology to create a hydrogen adsorbent. Adsorption occurs when thin layers of molecules adhere to the surface of solids or liquids. Chung said the difficulties faced in storing the hydrogen could be overcome with the adsorbent, which would condense the gas into supercritical liquid form. A liquid turns supercritical at the point when distinct liquid and gas phases do not exist.

Hydrogen can then be stored in pores within the adsorbent at ambient temperature and low-pressure conditions. The pores naturally form in the spaces between the polymer's molecules. This would allow more hydrogen to be stored without having to increase the size of the tank.

"The polymer would act as a 'hydrogen sponge' in the storage tanks," Chung said.

His research could be critical given the challenges that researchers face in storing and using hydrogen fuel safely and efficiently.

"We face many difficulties with hydrogen storage technology," he said. "The technology isn't as well established yet as other alternative fuel sources, such as solar and wind power."

Hydrogen gas comes from many sources, including coal gasification and electrolysis. Gasification uses high pressures, temperatures, oxygen and steam to separate the hydrogen from the coal. Electrolysis uses electricity to split water into hydrogen and oxygen.

After obtaining hydrogen, it can be stored either as a gas or liquid. Storing hydrogen as a gas requires tanks that can withstand extremely high pressures of up to 700 times normal atmospheric pressure. To store hydrogen as a liquid requires very cold temperatures—lower than minus

436 degrees Fahrenheit—to prevent the hydrogen from becoming a gas.

"Because of the temperatures that would be required to store liquid hydrogen, our best option right now is compressed hydrogen gas," said Chung. "However, we have to find a way to store it efficiently and economically."

This is where Chung's research comes in, which aligns with the Department of Energy's increased focus on hydrogen storage, technology and capability. One of the department's primary objectives by 2020 is to develop hydrogen storage systems that allow for refueling at ambient temperatures, low pressures and for driving ranges of more than 300 miles.

Hydrogen has the highest energy per mass of any fuel. According to the Department of Energy, motors in fuel cell vehicles that run on hydrogen are often two to three times more efficient than those powered by gasoline.

"Hydrogen-powered fuel cell vehicles have the potential to be quite efficient, which is great because hydrogen fuel is the cleanest fuel available," Chung said.

Fuel cell vehicles, which release zero carbon emissions, generate power for their motors through electrochemical processes that use compressed hydrogen and oxygen—air—while only emitting water through the tailpipes.

Chung's grant is funded through September 2019.

Source: http://www.newswise.com/doescience/?article_id=677854&re-turnurl=aHR0cHM6Ly93d3cubmV3c3dpc2UuY29tL2FydGljbGVzL2xpc3Q=

Hyundai Motor to increase production of hydrogen powered car in an effort to hold off Toyota

The company plans to produce 3,600 units surpassing Toyota's goal of 3,000

Hyundai Motor Co. has announced their intention to increase production of its new "FE" fuel cell electric vehicle (FCEV). The FCEV can travel distances upwards of 500 miles on a single, 3-minute, hydrogen fill-up. The company believes that this technology will ease charging anxiety, as it mimics that of gas consuming vehicles today. When hydrogen is combined with oxygen through a fuel cell, the only emission is water. Hyundai is banking on hydrogen as the future energy source of motive power.

The problem isn't in the technology itself. The problem is the amount of filling stations available to re-fuel the vehicle. It is estimated that it will cost $500 billion to convert conventional gas stations into hydrogen filling stations. The United States, China, and Germany plan to have 100's of filling stations in place by 2025.

Much like the "Space Race", major countries are racing towards the finish line to a hydrogen economy. However, this race won't finish anytime soon.

Source: https://www.h2news.us/single-post/2017/06/21/Hyundai-Motor-to-Increase-Production-of-Hydrogen-Powered-Car-in-Efforts-to-Hold-off-Toyota

Ballard Power to supply fuel cell buses to Sunline Transit

Ballard Power Systems Inc. announced that it has entered into a definitive agreement with SunLine Transit Agency to supply five 150 kilowatt (KW) FCveloCity fuel cell engines. These fuel cell engines will be used toward powering clean energy buses in Palm Desert, CA along with promoting heavy duty transit solutions in the Coachella Valley area.

Per the agreement, Ballard Power will be collaborating with BAE Systems BAESY supplier of electric drive systems, and North American bus OEM, ElDorado National to deliver transit service by supplying fuel cell buses to SunLine Transit Agency.

Ballard's Global Step Forward

Ballard's Technology team and subsidiaries are working progressively to provide clean services to accelerate fuel cell development not only in the U.S but also across other markets including Canada, China, and Europe.

Recently in the month of June, the company entered in to an $18 million supply contract with Zhongshan Broad-Ocean Motor Co., Ltd. to aid the implementation of 400

Hydrogen Vehicle News

FCveloCity fuel cell engines into energy buses and trucks in China. This deal was the extension of a program with Broad-Ocean to deploy Ballard's fuel cell technology in support of China's plan to address environmental issues and adoption of zero-emission vehicles.

The company's subsidiary, Protonex, also signed an agreement to supply fuel cell propulsion system to South African-based FlyH2 Aerospace, a developer of hydrogen fuel cell powered unmanned aerial vehicles (UAVs) for commercial applications.

Source: http://www.nasdaq.com/article/ballard-power-to-supply-fuel-cell-buses-to-sunline-transit-cm817553

How do you service a hydrogen fuel cell car at a dealer?

Honda Clarity being serviced at a dealership

Over the past century, gasoline-powered vehicles have gotten simultaneously more complex and more reliable.

Service intervals have lengthened, drivers no longer check a car's fluids daily or weekly, and many new-car owners will never once open the hood.

Reliability data shows that some of them won't visit a dealer service department except for regularly scheduled services over their first three to five years of ownership.

Hybrids added some new complexity—high-voltage battery packs and electronics—to dealer servicing when they started to arrive in 2000.

Plug-in cars in 2011 added further new elements, including electric-car charging stations at dealers.

With more than 1,000 cars powered by hydrogen fuel cells on California roads, how do *they* change what a dealer's service department has to do? How do they get serviced?

That's a question we've tried to explore for two years. Over time, we turned to Honda, whose Clarity Fuel Cell went on sale in California last December.

What follows is taken from a long and very informative interview with Doug Reed, a training center coordinator who teaches dealer service personnel what they have to do to prepare for the hydrogen-powered Clarity.

The primary factor affecting how a dealership services a Clarity, he said, is a set of safety rules issued by the state of California.

Those regulations were drafted in consultation with various makers that now lease hydrogen vehicles in California or have done in the past.

If the sealed high-pressure hydrogen storage system and fuel-cell stack aren't involved, a hydrogen vehicle has most of the same service needs as any other car driven by an electric motor.

Service personnel use standard procedures for repair or replacement of components like electric accessories or suspension parts, for instance.

But if service work has to touch either the hydrogen storage tanks or the fuel-cell stack itself, or the plumbing that connects those elements, the rules change in a very major way.

First, the service area has to be fitted with hydrogen detectors, curtains around the area in which a hydrogen car is being serviced, and lighting fixtures that are explosion-proof.

And the vehicle can only enter that special service bay once it is in a "minimum-fueled state," meaning the bulk of the hydrogen has been removed from its tanks, stack, and plumbing.

The regulations require that less than 0.5 kilogram of hydrogen, at 600 pounds per square inch, remain in the Clarity's two tanks combined during service. Their total capacity is 5.5 kg at 10,000 psi when full.

To drain the tanks of their hydrogen if a car comes into the dealer with more than that amount of fuel requires a very specific process that takes place outside the service bays.

It's usually done in a designated area of the parking apron that's only accessible to service personnel, Reed said. It will be away from tall buildings, with minimum height and distance requirements that are specified by the state.

In that marked-off 23-foot by 35-foot work area, the car is joined by a large rolling cart full of tools specific to hydrogen vehicles, a battery charger, and a set of components that are assembled into an 11-foot-high vent stack to be connected to the car.

The cart contains two 300-cubic-foot cylinders, one each of pressurized helium and nitrogen, and a portable hydrogen leak detector, along with grounding wires, high-pressure steel hoses, and such tools as a hex driver for the tank valves.

Mechanics position the car within the designated area, put it up on jack stands, electronically switch off the hydrogen supply to the fuel cell (confirmed on a scan tool), and direct the fuel cell to power itself down, which takes 2 or 3 minutes.

It can take "a delicate hand" to switch off the hydrogen supply valves under the car as a backup precaution, Reed said, which takes place during the tightly choreographed timing sequence of steps.

Once those steps have been completed, most of the danger of the fuel-cell stack producing electricity has been alleviated.

The next step is to neutralize the stack, first by filling it with helium at 220 psi and pushing that through the stack and out the exhaust pipe.

The hydrogen fuel-supply line from the tanks in the rear to the stack under the hood is then disconnected, and up to three braided venting hoses are run out of the car to the venting stack, which is grounded via a steel rod.

The next step is to unlock the fuel-tank valves at a "defueling joint"—and leave the car to vent its hydrogen through the tall stack.

That process can take from 30 minutes to 3 hours, Reed said, while service personnel monitor the scan tool connected to the car's control electronics to track its progress.

When the hydrogen is largely gone from the tank itself, the rest of the car's plumbing has to be flushed to remove remaining hydrogen in its fuel lines.

That's done using a nitrogen purge function that pumps pure nitrogen through the plumbing for 5 minutes, after another sequence of valve closings and shutoffs, and vents it through the grounded stack.

That's what it takes to remove hydrogen from a fuel-cell vehicle safely, leaving it with its tank's locks closed and 580 psi or less of hydrogen remaining in them.

After that, Reed told us, the car is removed from the jack stands, pushed into the service bay by mechanics, and work on the system can begin.

Service items might include, for example, replacing a fuel line or valve outboard of the hydrogen tank itself—though Reed stressed that under no circumstances are the valves to the hydrogen tank ever opened during such service items.

The hydrogen sensors within the curtained-off service bay will warn personnel of any hydrogen leaking from the vehicle.

The portable leak detector is employed several times during defueling and refueling processes, he said. Those procedures vary in complexity, with the low-pressure part of the system forward of the tank regulator easier to empty and check for leaks than the high-pressure parts.

Once the repair has been performed, Reed said, mechanics go through a startup procedure consisting of a set of steps to repressurize the fuel system, including more purging again monitored via the scan tool.

Once the car's fueling system is again fully operational, the 0.5 kg of remaining hydrogen in its tanks should be enough to take it to the fueling station nearest the dealership, he said.

This means dealers don't keep stocks of hydrogen fuel on-hand, a frequent question on the topic.

The bulk of hydrogen fuel-cell mechanics, Reed said, have previous experience with natural-gas vehicles, which Honda sold from 2002 through 2015 in three generations of Honda Civic compact sedans.

They're familiar with nitrogen purging, pressure regulators, valves and O-rings, and other hardware associated with high-pressure compressed gaseous fuels.

Source:
http://www.greencarreports.com/news/1111440_how-do-you-service-a-hydrogen-fuel-cell-car-at-a-dealer/page-2

Clean sweep: Dutch town gets hydrogen fuel cell street cleaner

To the untrained eye, this street sweeper looks like a normal municipal vehicle. But underneath, it's a glimpse of the future—it runs on hydrogen.

Launched in the town of Hoogezand in the Netherlands, the machine was originally built to run on diesel. But thanks to Dutch firm Holthausen and Finnish manufacturer Visedo, it now uses a hydrogen fuel cell for propulsion.

That means that the operator fills the tank with hydrogen, which the machine then uses to create the electricity that drives its powertrain. The only emission from this process is pure water.

In the context of street-sweeping, that means a day and a half of work before it needs to be refueled.

More importantly for local residents, the hydrogen fuel cell sweeper is significantly quieter than its diesel-burning former self. The old version emitted 120dBA, while this one emits just 60dBA – from an uncomfortably loud noise, to one comparable to a normal conversation.

"With the old machines producing 120 decibels, a passing diesel street cleaner can shake the windows of your house. Our sweeper is now at 60 decibels so it creates much less noise pollution for the local community," said Carl Holthausen of Holthausen.

Hydrogen fuel cell technology is one of the most promising 'future fuels' possibilities in the automotive sector, and this project demonstrates a possible application. Other cities are showing an interest in the new technology, including Amsterdam, Rotterdam and the Vatican.

Source: http://www.telegraph.co.uk/cars/news/clean-sweep-dutch-town-gets-hydrogen-fuel-cell-street-cleaner/

Surprise! The lack of hydrogen fueling infrastructure is stymieing hydrogen fuel cell car sales

Toyota has tossed around a lot of money in the name of hydrogen, most recently with a project to build a fuel cell-powered big rig truck. But the Japanese automaker has also been trying to boost sales in the U.S. for its car of the future—the Mirai. But as *Bloomberg* reports, sales are sluggish, and it should come as no surprise why: there's barely any infrastructure to support the car.

According to *Bloomberg*, Toyota had a slow start to building "enough" hydrogen fueling stations in California, which undercut sales of the automaker's fuel cell vehicle, the Mirai, which is the Japanese word for "future." The idea was to expand to the east coast of the U.S., with fueling stations in New York, Connecticut and Massachusetts.

As the news outlet reports, however, those states are still waiting. Instead of having a dozen ready on the east coast by the end of this summer, Toyota and its partner Air Liquide SA expect to have three, maybe four, completed by the end of this year.

Toyota sold 708 Mirai fuel cell sedans in the first half of the year in the U.S., with deliveries limited to select California dealerships. GM and Nissan each sold 10 times as

many Chevrolet Bolts and Nissan Leafs, respectively. Tesla, which doesn't report monthly sales, probably delivered about 23,550 of its electric vehicles in the U.S. in that same period, according to an estimate by researcher Autodata Corp.

The leisurely pace of sales for Toyota is in part explained by the fact that only 28 retail fueling stations operate in the lone state where Mirai is being sold, according to the California Fuel Cell Partnership. The state's powerful environmental regulator, the California Air Resources Board, originally estimated back in 2015 that 44 stations would be open by the end of that year.

One of the biggest problems, according to *Bloomberg*, has been the navigation of local fire codes that aren't equipped for hydrogen. But stations in Providence, Rhode Island, and Hartford Connecticut, are currently under construction and a dozen more are expected to come online in 2018.

While slow, the inclusion of more stations is needed for Toyota, an automaker that's bullish on fuel cells. Hydrogen-based cars get better driving range than other zero-emission cars and don't require drivers to deal with the downtime that's found at an electric-vehicle charging station.

Toyota's hoping to boost global fuel cell car sales to 30,000 by around 2020, *Bloomberg* says, and an expansion in the U.S. might make that goal more obtainable.

Fuel cells make for an interesting technology, as we've noted in the past, but whether there's enough quantity to power a substantive fleet of fuel cell-powered vehicles remains an open-ended question. And more importantly, if there's a lack of fueling stations, the convenience of fuel cells and their ability to alleviate range anxiety will keep the technology where it's at now: hypothetical for most, and existing in limited supply for some.

Source: http://jalopnik.com/surprise-the-lack-of-hydrogen-fueling-infrastructure-i-1797191615

Toyota announces start of operations for hydrogen fuel cell demo project

Together with its partners, Toyota Motor Corp. has announced the start of full-scale operations for the

Low-carbon Hydrogen Technology Demonstration Project, which aims to implement and evaluate a low-carbon hydrogen supply chain that will utilize hydrogen produced from renewable energy in facilities along Tokyo Bay to power fuel cell forklifts.

According to Toyota's announcement, a system has been created for using electricity generated at the Yokohama City Wind Power Plant to electrolyze water to create low-carbon hydrogen, which is then compressed and stored. The produced hydrogen will be transported in a hydrogen fueling truck to a fruit and vegetable market, a factory, and warehouses, where it will then be used in fuel cells to power forklifts.

As noted in the corporate release, 12 fuel cell-powered forklifts will operate at the four selected locations to demonstrate their viability in a range of operating conditions.

Toyota says the creation of this hydrogen supply chain in cooperation with local partners is expected to reduce CO_2 emissions by at least 80% when compared with a supply chain using forklifts powered by gasoline or grid electricity.

The automaker says the ultimate goal of the project is to establish a hydrogen supply chain, analyze costs and estimate potential CO_2 reductions that can be achieved with a wider, full-scale supply chain in the future.

Source: https://ngtnews.com/toyota-announces-start-operations-hydrogen-fuel-cell-demo-project

Hydrogen News of Interest

2020 Tokyo Olympics welcome hydrogen technology

Tokyo Olympics to power the 6000-unit athlete village on hydrogen along with transport buses and cars

Japan will invest $330 million to advance hydrogen technology, including fuel cells for buses and cars, with plans of powering the entire athletic village on H_2. Japan has already unveiled plans to quadruple their current hydrogen station infrastructure. The country expects to see 100 hydrogen-powered buses and thousands of fuel cell cars supported by the infrastructure for the Olympic games. The village will also utilize industrial-sized fuel cells that can power the athlete's dormitories.

"Utilizing the Olympic Games as a way to motivate and really transform their infrastructure is really quite exciting," MIT's Shao-Horn says. "Whatever learning they have, I think it will benefit other cities, states, or countries that want to push in this direction."

Japan believes that hydrogen technology will help fight against air pollution, as hydrogen may be the answer to the battle for clean air. Hydrogen combines with oxygen to produce electricity, emitting only water. This technology has the power to push the country into the future, responsibly.

Source: https://www.h2news.us/single-post/2017/06/29/2020-Tokyo-Olympics-Welcome-Hydrogen-Technology

New ship powered by hydrogen fuel cells set to embark

New ship makes use of clean technology, including hydrogen fuel cells

A new boat equipped with hydrogen fuel cells has embarked on a six year voyage to highlight the capabilities of clean technology and how it can be used for transportation. Called the Energy Observer, the boat had once been used for racing. A team of 50 engineers, designers, and architects have refashioned the vessel to be powered by hydrogen fuel cells, solar panels, and even wind turbines. The boat will make several stops throughout the world on its global voyage.

Energy Observer will use solar and wind power during the day and its hydrogen fuel cells at night

The Energy Observer is 100-feet long and will rely primarily on its solar panels and wind turbines during the day. At night, however, the vessel will be powered by hydrogen fuel cells, which consume hydrogen to generate electrical power. The hydrogen that will be used by the fuel cells is produced through the electrolysis of seawater. According to the vessel's developers, it is the first of its kind to combine various forms of renewable energy for the sake of operation. During its adventure, the Energy Observer will make 101 stopovers in 50 countries.

Fuel cells are gaining popularity in transportation

Hydrogen fuel cells are becoming more popular in the transportation space. This is largely due to their performance capabilities and the fact that these energy systems do not produce harmful emissions. These energy systems are somewhat expensive, however, which has slowed their adoption somewhat. Hydrogen fuel cells are quite rare in the world of sea travel, but these energy systems have been seeing use in conventional vehicles. These cars are being developed by some of the world's largest automakers, many of whom are using hydrogen fuel cells to become more environmentally friendly.

New vessel to highlight the capabilities of clean technology

The Energy Observer is meant to showcase how clean technology can be used to power sea travel. Conventional vessels produce a significant amount of carbon emissions. As such, efforts are being made to make more environmentally friendly. Combining various forms of clean pow-

er may be the best way to accomplish this task.

Source: http://www.hydrogenfuelnews.com/new-ship-powered-by-hydrogen-fuel-cells-set-to-embark/8532490/

Fuel cell industry to benefit from new legislation in Connecticut

Legislation could help the fuel cell industry expand

New legislation in Connecticut could have a major impact on the fuel cell industry. The legislation allows state utilities to purchase as much as 30 megawatts of fuel cell systems and encourages the use of fuel cell power plants in order to distribute electrical power. The legislation has been praised by FuelCell Energy, a developer of hydrogen fuel cells based in Connecticut. The legislation is expected to lead to a higher adoption of fuel cells in the state.

Fuel cells may help provide renewable energy to Connecticut

Per the legislation, the Department of Energy and Environmental Protection is also set to issue a request for proposal to obtain clean energy. This proposal is meant to enhance the reliability of the state's energy supply. It is also meant to spur economic development throughout the state, particularly within the fuel cell industry. FuelCell Energy notes that in-state fuel cell projects are capable of generating significant tax revenue, which highlights the economic prospects of these energy systems.

Fuel cells continue to gather momentum in the US

Hydrogen fuel cells have become quite popular in recent years, particularly in the transportation space. These energy systems consume hydrogen to generate electricity, but do not produce harmful emissions. Fuel cells are also being used for distributed energy purposes. Fuel cell power plants are quickly becoming an attractive alternative to traditional energy systems, allowing those that need electricity to distance themselves from fossil-fuels. While these energy systems have been gaining popularity, the fuel cell industry has struggled to attain commercialization. The new legislation may help companies in Connecticut accomplish this elusive goal.

Fuel cell industry expected to continue seeing growth

The fuel cell industry is expected to experience strong growth in the United States in the coming years. Fuel cells have already established a relatively strong position in the auto industry and they are gaining prominence as primary energy systems for data centers and similar applications. State policies have helped the fuel cell industry thrive in many parts of the country.

Source: http://www.hydrogenfuelnews.com/fuel-cell-industry-to-benefit-from-new-legislation-in-connecticut/8532366/

New hydrocarbon fuel cells with high efficiency and low cost

South Korea's Ulsan National Institute of Science and Technology has introduced new low cost, high efficiency hydrocarbon fuel cells.

The commercialization of the 'natural gas fuel cell' has finally come to the fore, thanks to the recent development of electrode materials that maintain long-term stability in hydrocarbon fuels. Advantage of using this material includes that it uses internal transition metal as a further catalyst in a fuel cell operating condition.

This breakthrough comes from research, conducted by Professor Guntae Kim of Energy and Chemical Engineering at UNIST in collaboration with Professor Jeeyoung Shin of Sookmyoung Women's University, Professor Jeong Woo Han of University of Seoul, Professor Young-Wan Ju of Wonkwang University, and Professor Hu Young Jeong of UNIST. Their results, published online in the June issue of the prestigious journal *Nature Communications*, have emerged as the promising candidate for the next generation direct hydrocarbon solid oxide fuel cells (SOFCs) technology.

A solid oxide fuel cell (SOFC) is an electrochemical conversion device that produces electricity by oxidizing a fuel. SOFC is still subject to a fairly intense development for its unforgettable competitive benefits of long-term stability, a high fuel flexibility, low emissions, as well as relatively low cost. SOFCs are a possible next generation fuel cell, as they are capable of raising efficiency higher than 90% when using the exhaust heat. However, successful commercialization of SOFCs has been delayed due to its high production cost mainly related with the development of

electrode materials in hydrocarbon fuel cells.

Professor Kim has solved the problem of securing hydrogen by developing a new anode material (catalyst) which can directly use hydrocarbons, known as natural gas liquids (LGLs) and LPG, as a fuel of SOFC. Using this newly-developed catalyst, SOFC can operate the fuel cell without converting the hydrocarbon into hydrogen externally.

In the study, the research team has proposed that transition metals are exsolved from the new anode material in reducing atmosphere. Generally, the transition metals act as fuel oxidation catalyst in SOFC. They also reported that the exsolved Co and Ni nanoparticles on the surface of the layered perovskite show good stability with no remarkable degradation. Moreover the single cell presents 1.2 W/cm^2 in H_2 at 800 ^{o}C, indicating that the performance is twice as high as that of the conventional electrode material (0.6 W/cm^2).

"Although the existing anode materials demonstrated good initial performance, due to their long-term instability and complex manufacturing process, they could not be reliably operated when using hydrocarbon directly as fuel," says Professor Kim, corresponding author of the paper. "The new anode material reduces manufacturing process and maintains good stability, which is expected to accelerate the commercialization of the SOFC."

According to the research team, their findings provide a key to understand the exsolution trends in transition metals (Mn, Co, Ni and Fe) containing perovskites and design highly catalytic perovskite oxides for fuel reforming and electro-oxidation.

Source: https://phys.org/news/2017-07-hydrocarbon-fuel-cells-high-efficiency.html#jCp

Walmart deepens bet on hydrogen fuel cells at distribution centers

Walmart boosted its commitment to hydrogen energy in its distribution network by agreeing to back a fuel-cell company and acquire more of its products.

The big-box chain plans to adopt Plug Power's fuel cells and hydrogen stations to bolster its energy efficiency at up to 30 more locations. The retailer had already installed Plug Power fuel cells at 22 distribution centers.

The deal jolted Plug Power stock, which rose 10.7% to $2.35 at 10:20 a.m. Friday.

Walmart also received warrants to acquire up to about 55.3 million shares of Plug Power stock, including 5.8 million warrants that were exercised as a result of the latest fuel cell purchasing deal.

The fuel cells help replace lead-acid batteries and power devices such as forklifts to improve warehouse efficiency.

"Our expanding relationship with Walmart validates Plug Power's advanced capabilities in fuel cell products and systems, allowing the world's largest retailer to maintain its leading position as an industry innovator," Plug Power CEO Andy Marsh said in a statement.

Source: https://www.usatoday.com/story/money/2017/07/21/walmart-hydrogen-fuel-cell-plug-power/498862001/

Japan plans wind-driven hydrogen project

A demonstration project designed to create hydrogen from wind power has been launched in Yokohama.

Power will be created by a ten-year-old Vestas V80 2MW turbine, owned by Yokohama City, to electrolyze water and create low-carbon hydrogen.

The hydrogen will then be stored in an on-site tank before being shipped by truck to neighboring Kawasaki City and used to power fuel-cell driven forklifts at a fruit and vegetable market, a factory and warehouses.

Some hydrogen is also likely to be used by fuel-cell cars in Yokohama.

The creation of a hydrogen fuel source is forecast to reduce carbon dioxide emissions by at least 80% compared with gasoline powered forklifts.

The goal of the project is to establish a hydrogen supply chain, analyse costs and estimate potential CO_2 reductions that can be achieved with a full-scale supply chain in the future.

The project is a partnership, consisting of the Kanagawa prefectural government, the cities of Yokohama and Kawasaki, Iwatani, Toshiba, Toyota Motor Corporation, Toyo-

ta Industries, Toyota Turbine and Systems, and Japan Environment Systems.

Source:
http://www.windpowermonthly.com/article/1440164/japan-plans-wind-driven-hydrogen-project

AFC Energy to deploy fuel cells for UK H2 micro-grid

AFC Energy, the industrial fuel cell power company, has executed a term sheet with Dunsfold Park Ltd. to commence front end engineering and design (FEED) work on a landmark hydrogen (H_2) micro-grid at the Dunsfold Park site in Surrey, UK.

Dunsfold Park is home to AFC Energy's head office, and under its site redevelopment masterplan, is scheduling the development of an initial 1,800 new homes and green space, co-existing with light industry, to create one of the UK's largest residential and industrial brownfield redevelopment projects.

AFC Energy and Dunsfold Park have executed a term sheet which seeks to deploy up to 1 – 1.5 megawatts (MW) of the company's fuel cell systems on-site as part of a residential and industrial energy micro-grid to meet the growing needs of the redeveloped site.

The scheme expects to be supplied with green H_2 sourced locally from bio-methane making the proposition an entirely renewable and clean micro-grid which could have applications not only across the UK, but could also be replicated internationally across all brown and green field residential, commercial and industrial developments.

The clean micro-grid is entirely consistent with the Dunsfold Park renewable energy strategy and that of the UK Governments industrial policy and policy of building more stability, flexibility and resilience into local power grids through the decarbonization of the national power grid.

AFC Energy will commence work on the FEED in August 2017 to fully engineer and cost-up the projects.

Power generation from the fuel cell facility in conjunction with the existing solar farm on-site, will make Dunsfold Park the only business Park in the UK with a micro-grid supplied entirely by a combination of H_2/ renewable derived energy, highlighting the importance and prominence of this project in the context of the UK energy market.

The timing for delivery of the project will be divided into multiple phases in recognition of the growth trajectory for new energy demand in conjunction with the sites redeveloping initiatives. Indicatively, the parties hope to deliver the first 0.5 – 1 MW of installed generation capacity in Q4 2018 and the second tranche of installed power capacity by the end of Q3 2019.

Jim McAllister, Chief Executive of Dunsfold Park, said, "We are delighted to be collaborating with AFC Energy, a long-time tenant of Dunsfold Park on this nationally significant H_2 full cell project. We look forward to seeing the results of the FEED study and endorse the initiatives full alignment with Dunsfold's Park's clean energy strategy which has permeated all of our redevelopment activities over the past few years. Initiatives such as this collaboration with AFC Energy further highlight Dunsfold, the Borough of Waverley and the County of Surrey's prominence at the forefront of renewable energy technologies."

Adam Bond, AFC Energy's CEO, said, "As long-term tenants of Dunsfold Park, we are delighted to now be collaborating in the commercial deployment of AFC Energy's fuel cell technology. The introduction of H_2 derived from renewable sources is a particular highlight of the proposed scheme and re-emphasizes the potential innovation in sourcing long-term, sustainable H_2 for our fuel cell projects. This scheme offers the potential for national and international replicability and could become a benchmark in localized H_2 micro-grids. We look forward to working closely with Dunsfold Park in delivering this important clean energy initiative for the region."

Source: https://www.gasworld.com/afc-energy-fuel-cells-for-h2-micro-grid/2013163.article

Red announces $1200 Hydrogen One smartphone with holographic screen coming in 2018

A new device from from high-end video camera producer Red has been announced, that if promises are kept, will be the first holographic display-equipped smartphone not requiring users to wear glasses or headsets for fill three-

dimensional content viewing.

According to an announcement by the company, the Hydrogen One smartphone is powered by Android, and allows users to view all traditional 2D content at full resolution, holograpic content generated by a new Red camera, stereo 3D content, and augmented reality in 2D and 3D. Coupled with the display, a new "H3O algorithm" converts stereo sound into "expansive multi-dimensional audio" to match the 3D content.

The company claims that the Hydrogen System incorporates a new high-speed data bus for a modular component system, to include future, unannounced attachments. Additionally, the Hydrogen One will integrate into the Red camera program and will work with Scarlet, Epic, and Weapon systems as a user interface and camera monitor.

A content store will roll out at the same time as the Hydrogen One. Called the "Red Channel," the store will allow users to find holographic content, upload creations, and download compatible movies, documentaries, games, and other apps.

Connectivity is provided by some form of cellular wireless, Wi-Fi, USB-C, and a Micro SD slot for storage expansion. Other accessories will be available as an additional purchase at launch. The company notes that expansion modules will not be available at launch.

Red is not a new company. It was founded in 2005, with the goal of producing 4K digital video cameras. The first Red One cameras were delivered in 2007, and captured 4K video at 60 frames per second.

Marvel Studios' "Guardians of the Galaxy Vol. 2" was shot on Red's Weapon series of cameras in 8K.

Pre-order pricing is $1195 for the aluminum version, and $1595 for the titanium version, with first orders shipping in the first quarter of 2018.

Source: http://appleinsider.com/articles/17/07/06/red-announces-1200-hydrogen-one-smartphone-with-holographic-screen-coming-in-2018

Apple is building another data center fueled entirely by renewable energy in Europe

Apple announced in July it will spend 6 billion Danish crowns ($921 million) on a new data center in Denmark, its second in the Nordic country to run entirely on renewable energy.

Facebook in January also announced plans to build a data center in Denmark, only its third outside of the United States.

Apple has pledged to back the Paris climate accord by switching to renewable energy and has recently issued a $1 billion green bond after the United States pulled out of the pact. Chief Executive Tim Cook was one of several CEOs who directly appealed to President Donald Trump to keep the United States in the pact before he made his decision.

Apple said the data center would begin operations in the second quarter of 2019 in Aabenraa in southern Denmark near the German border.

It will power Apple's online services, including the iTunes Store, App Store, iMessage, Maps, and Siri for customers across Europe.

"We're thrilled to be expanding our data center operations in Denmark, and investing in new sources of clean power," Erik Stannow, Nordic manager for Apple, said in a statement emailed to Reuters.

"The planned facility in Aabenraa, like all of our data centers, will run on 100% renewable energy from day one, thanks to new clean energy sources we're adding," he said.

Apple's first data center in Denmark near the town of Viborg is due to begin operations later this year.

Apple said a planned data center in Athenry, Ireland, announced in 2015 had yet to begin construction.

Apple confirmed that the Irish data center is currently under judicial review.

Denmark, a leader in wind power, has abundant supplies

of wind energy as well biomass energy.

"The reliability of the Danish grid is one of the main reasons we will operate two sites in Denmark," Stannow said.

The small Nordic country hopes these investments will boost its IT sector.

"Denmark is becoming northern Europe's hub for data centers with a high prospective for growth for the tracking industries delivering solutions to the many data centers sprouting up all over the world," the foreign ministry said in a statement.

Source: http://fortune.com/2017/07/10/apple-data-center-denmark/

Making hydrogen fuel from humid air

One of the biggest hurdles to the widespread use of hydrogen fuel is making hydrogen efficiently and cleanly. Now researchers report in the journal *ACS Nano* a new way to do just that. They incorporated a photocatalyst in a moisture-absorbing, semiconducting paint that can produce hydrogen from water in the air when exposed to sunlight. The development could enable hydrogen fuel production in almost any location.

Traditionally, hydrogen destined for industrial use has come from fossil fuels. But this approach creates carbon byproducts and other pollutants. In search of a cleaner source, researchers have turned to water as a source of hydrogen. Current methods to split water focus on its liquid form and thus require liquid electrolytes, which lead to high cost, inefficiency and other technical challenges. These drawbacks could be overcome by using water in its gas phase, but few studies have explored this strategy. So Torben Daeneke, Kourosh Kalantar-zadeh and colleagues set out to fill this void.

Using a simple, scalable method, the researchers developed a photocatalyst to generate hydrogen from water vapor using a highly porous, sulfur-rich molybdenum sulfide. The compound belongs to a class of highly conductive materials previously recognized as efficient water-splitting catalysts in liquid. Testing showed that the sulfide strongly absorbed moisture from the air. Then, combining the sulfide with titanium dioxide nanoparticles, the researchers created an ink that can be coated onto surfaces, such as glass. Films printed with the ink produced hydrogen without electrolytes or external power sources at a relatively high rate. The moisture-absorbing photocatalytic paint can be applied to any surface such as building facades, introducing the novel capability of generating hydrogen fuel just about anywhere.

Source: https://www.sciencedaily.com/releases/2017/06/170614091830.htm

In-flight, on-demand hydrogen production could mean 'greener' aircraft

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 tech-

nology 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 researchers 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 on 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://www.sciencedaily.com/releases/2017/04/170424172210.htm

New ways to make clean hydrogen, rechargeable zinc batteries

A Stanford University research lab has developed new technologies to tackle two of the world's biggest energy challenges—clean fuel for transportation and grid-scale energy storage.

The researchers described their findings in two studies published this month in the journals *Science Advances* and *Nature Communications*.

Hydrogen fuel

Hydrogen fuel has long been touted as a clean alternative to gasoline. Automakers began offering hydrogen-powered cars to American consumers last year, but only a handful have sold, mainly because hydrogen refueling stations are few and far between.

"Millions of cars could be powered by clean hydrogen fuel if it were cheap and widely available," said Yi Cui, an associate professor of materials science and engineering at Stanford.

Unlike gasoline-powered vehicles, which emit carbon dioxide (CO_2,), hydrogen cars themselves are emissions free. Making hydrogen fuel, however, is not emission free: today, making most hydrogen fuel involves natural gas in a process that releases CO_2 into the atmosphere.

To address the problem, Cui and his colleagues have focused on photovoltaic water splitting. This emerging technology consists of a solar-powered electrode immersed in water. When sunlight hits the electrode, it generates an electric current that splits the water into its constituent

parts, hydrogen and oxygen.

Finding an affordable way to produce clean hydrogen from water has been a challenge. Conventional solar electrodes made of silicon quickly corrode when exposed to oxygen, a key byproduct of water splitting. Several research teams have reduced corrosion by coating the silicon with iridium and other precious metals.

Writing in the June 17 edition of *Science Advances*, Cui and his colleagues presented a new approach using bismuth vanadate, an inexpensive compound that absorbs sunlight and generates modest amounts of electricity.

"Bismuth vanadate has been widely regarded as a promising material for photoelectrochemical water splitting, in part because of its low cost and high stability against corrosion," said Cui, an associate professor of photon science at the SLAC National Accelerator Laboratory. "However, the performance of this material remains well below its theoretical solar-to-hydrogen conversion efficiency."

Bismuth vanadate absorbs light but is a poor conductor of electricity. To carry a current, a solar cell made of bismuth vanadate must be sliced very thin, 200 nanometers or less, making it virtually transparent. As a result, visible light that could be used to generate electricity simply passes through the cell.

To capture sunlight before it escapes, Cui's team turned to nanotechnology. The researchers created microscopic arrays containing thousands of silicon nanocones, each about 600 nanometers tall.

"Nanocone structures have shown a promising light-trapping capability over a broad range of wavelengths," Cui explained. "Each cone is optimally shaped to capture sunlight that would otherwise pass through the thin solar cell."

In the experiment, Cui and his colleagues deposited the nanocone arrays on a thin film of bismuth vanadate. Both layers were then placed on a solar cell made of perovskite, another promising photovoltaic material.

When submerged, the three-layer tandem device immediately began splitting water at a solar-to-hydrogen conversion efficiency of 6.2 percent, already matching the theoretical maximum rate for a bismuth vanadate cell.

"The tandem solar cell continued generating hydrogen for more than 10 hours, an indication of good stability," said Cui, a principal investigator at the Stanford Institute for Materials and Energy Sciences. "Although the efficiency we demonstrated was only 6.2 percent, our tandem device has room for significant improvement in the future."

Rechargeable zinc battery

In a second study published in the June 6 edition of *Nature Communications*, Cui and Shougo Higashi, a visiting scientist from Toyota Central R&D Labs Inc., proposed a new battery design that could help solve the problem of grid-scale energy storage.

"Solar and wind farms should be able to provide around-the-clock energy for the electric grid, even when there's no sunlight or wind," Cui said. "That will require inexpensive batteries and other low-cost technologies big enough to store surplus clean energy for use on demand."

In the study, Cui, Higashi and their co-workers designed a novel battery with electrodes made of zinc and nickel, inexpensive metals with the potential for grid-scale storage.

A variety of zinc-metal batteries are available commercially, but few are rechargeable, because of tiny fibers called dendrites that form on the zinc electrode during charging. These dendrites can grow until they finally reach the nickel electrode, causing the battery to short circuit and fail.

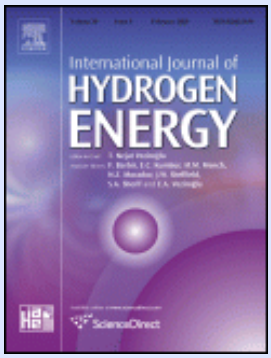
The research team solved the dendrite problem by simply redesigning the battery. Instead of having the zinc and nickel electrodes face one another, as in a conventional battery, the researchers separated them with a plastic insulator and wrapped a carbon insulator around the edges of the zinc electrode.

"With our design, zinc ions are reduced and deposited on the exposed back surface of the zinc electrode during charging," said Higashi, lead author of the study. "Therefore, even if zinc dendrites form, they will grow away from the nickel electrode and will not short the battery."

To demonstrate stability, the researchers successfully charged and discharged the battery more than 800 times without shorting. Our design is very simple and could be applied to a wide range of metal batteries," Cui said.

Source:
https://www.sciencedaily.com/releases/2016/06/160617160352.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.

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.

Most Downloaded IJHE Articles (May-July 2017)

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 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.
3. **Changing the fate of Fuel Cell Vehicles: Can lessons be learnt from Tesla Motors?**
   Hardman, S, Shiu, E, Steinberger-Wilckens, R. Int J Hydrogen Energy 2015;40 (4):1625–38.
4. **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):2039-2061.
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. **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.
7. **Review of the proton exchange membranes for fuel cell applications**
   Peighambardoust S.J., Rowshanzamir S., Amjadi M. Int J Hydrogen Energy 2017;35 (17): 9349:9384.

A comparative study of electrodes in the direct synthesis of CH4 from CO2 and H2O in molten salts

-Deqiang Ji, Yue Liu, Zhida Li, Dandan Yuan, Guanjian Yang, Mengpei Jiang, Yuhang Wang, Yanyan Yu, Hongjun Wu. Int J Hydrogen Energy 2017:42(29): 18156-18164.

Much research has been performed in recent decades on technologies aimed at curbing global warming. Widespread industrial reliance on fossil fuels has long been the primary culprit for the drastic increase in CO_2 in the Earth's atmosphere. This journal article examines electrode and electrolyte compositions for a proposed reaction between CO_2 and H_2O to form short chain hydrocarbons such as methane and ethane as well as pure hydrogen. Several molten salt electrolytes were investigated, which needed to be capable of dissolving O^{2-}, a byproduct of CO_2 decomposition. Another desirable aspect of the electrolyte would be that it had a relatively low melting point (~400^{o}C) in order to avoid unwanted thermal decomposition of carbonates, rather than the targeted electrochemical reduction. With these considerations, Li – Na – K – CO_3 of various mass ratios was the base for the different electrolytes while lithium hydroxide (LiOH) was used in co-electrolysis which facilitates the electrode reactions. The final electrolyte composition was $Li_{1.427}Na_{.359}K_{.214}CO_3$ - .15LiOH. Various metal combinations were used as the cathode and anode for the working reactor and gas composition output and efficiency were the metrics by which the performance was compared. The 30 cm^2 Ni wire anode – Fe wire cathode had the highest methane output percentage at 45.9%, with 53.1% hydrogen and .92% carbon monoxide at 86.6% efficiency. These results were acquired at a temperature of 550^{o}C at .25 A. These are promising results in conversion of CO_2 into production of methane and pure hydrogen.

http://www.sciencedirect.com/science/article/pii/S0360319917315604

-By Cyrus Daugherty

Hydrogen concentrator demonstrator module with 19.8% solar-to-hydrogen conversion efficiency according to the higher heating value

A. Fallisch, L. Schellhase, J. Fresko, M. Zedda, J. Ohlmann, M. Steiner, A. Bosch, L. Zielke, S. Thiele, F. Dimroth, T. Smolinka. Int J Hydrogen Energy 2017: In press.

The conversion of solar energy into hydrogen can be accomplished via several technologies. One of the promising technologies is the utilization of photovoltaic (PV) module along with an electrolyzer unit. Also, the solar cells can be utilized in direct contact with water (this concept is usually referred to as photo-electric cell or "artificial leaf"). The advantage of the "artificial leaf" is that no additional power electronics and electric cables and connections are needed.

In this work, a novel and patented concept of the Hydrogen Concentrator (HyCon), which combines III-V multi-junction solar cells with polymer electrolyte membrane electrolysis, has been developed. A unique weatherproof HyCon module with an area of 8 x 90.7 cm^2 was built and characterized in an outdoor measurement for over two months. During this measurement period, the module showed a stable operation regardless of the water volume flow. The module worked under natural convection without any circulation pumps at a suitable maximum temperature of 60-70 ^{o}C. The HyCon module consists of eight individual units (HyCon cells), each combining a photovoltaic and an electrolysis cell. Some of the HyCon cells reached a solar-to-hydrogen conversion efficiency of 20% according to the higher heating value at high current densities of 0.8 A/cm^2. On the module level, a maximum efficiency of 19.8% is reached. Based on the literature review conducted by the authors, this is the highest conversion efficiency so far achieved at such high current densities using a dual junction solar cell.

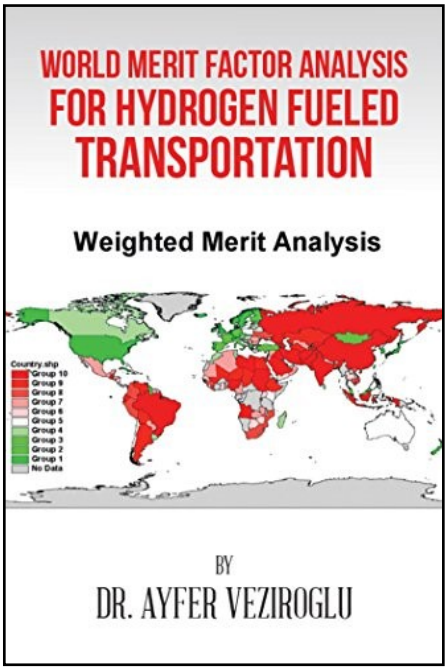
http://www.sciencedirect.com/science/article/pii/S0360319917328069

-By Yasser Ashraf Gandomi

From the Bookshelf

World Merit Factor Analysis for Hydrogen Fueled Transportation

By Dr. Ayfer Veziroglu



This book covers almost all the countries of the world in order to decide which countries would be able to convert to hydrogen-fueled transportation earlier and which countries would do it later.

We have decided that the following nine factors (which will be called "influence factors") will have more impact on a country's conversion to hydrogen-fueled transportation than other factors: size, population, income per capita, educational level, borders, petroleum dependence, vehicles per capita, and hydrogen-filling stations.

We have obtained the data for size (S), population (P), income per capita (I), and vehicles per thousand of population (V) for the year 2008. We have calculated educational expenditures as percentage of GDP for education level (E) for 2007.

After the basic merit factor analysis, we assumed that all the dimensionless influence factors have the same effect on the merit factors for deciding whether a country could move to the hydrogen-fueled transportation system faster than the other countries. In other words, we assumed that each dimensionless influence factor has a weight of one.

In the real world, some influence factors will have a greater effect than the others. Then we defined a new weighted merit factor. We have developed an analytical method in order to access the potential of countries for conversion to hydrogen-fueled transportation, which we have named "merit factor analysis." This has been based on the selection of influence factors, which influence the outcome, and on the decision of whether the effect of a given influence factor will support the desired outcome or will be an obstacle to the desired outcome. We have further refined our analytical system by the introduction of weighting factors that measure the impact of a given influence factor for the desired outcome or against the desired outcome. We have named the two versions of the analytical method "basic merit factor analysis" and "weighted merit factor analysis" respectively.

Of course, the analytical method that we have developed could be applied to other cases in order to compare the potential of a given entity for a desired outcome. For example, it could be applied for the profit potentials of commercial companies by selecting the appropriate influence factors and weighting factors.

https://www.amazon.com/Factor-Analysis-Hydrogen-Fueled-Transportation-ebook/dp/B01N9X4DCR/ref=sr_1_2?s=books&ie=UTF8&qid=1500925564&sr=1-2&keywords=Ayfer+Veziroglu

Hydrogen Student Design Contest

The Hydrogen Education Foundation's Hydrogen Student Design Contest
2017: Designing a Power-to-Gas System
www.HydrogenContest.org

2017 HEF Contest Challenge: Power-To-Gas

The Hydrogen Education Foundation has announced the topic of the next competition!

The 2017 Hydrogen Student Design Contest will challenge student teams from around the world to design a "Power-to-Gas System", a system that uses electricity to produce hydrogen for cross market uses, including energy storage, ancillary services, and transportation fuel. The teams will choose a site in their area, engage their local electric and gas utility, coordinate with regulatory bodies and safety experts, and create educational materials, including a short video.

The contest is supported by Title Sponsor Southern California Gas Company and Supporting Sponsors Air Liquide and Hydrogenics.

Register today!

Registration is open so register your team today. Registration ends **September 15, 2017**.

To learn more about registration and eligibility visit http://hydrogencontest.org/register.asp.

For more information about the contest visit http://www.hydrogencontest.org/.

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 and led by Dr. John Sheffield. Please email him at john.sheffield@dnvkema.com for more information.
- **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

SRI International

Overview:

Silicon Valley-based SRI International, a nonprofit research and development organization, performs sponsored R&D for governments, businesses, and foundations. SRI brings its innovations to the marketplace through technology licensing, new products, and spin-off ventures.

The SRI enables fuel cell commercialization by leveraging expertise in hydrogen safety, materials science, fuel cells, and technology scale-up. In particular, the SRI conducts the following areas of research regarding hydrogen energy:

- Hydrogen Production and Storage
- Hydrogen Safety
- Fuel cells

Hydrogen Production and Storage:

Emerging market needs for portable power and transportation applications are creating opportunities to develop novel hydrogen production and storage systems. SRI works with clients to address needs in the following areas:

- High-temperature membranes to produce hydrogen via water electrolysis.
- Chemical systems to produce hydrogen and oxygen through the reaction of aluminum and peroxides or other chemistries, including novel chemical hydrides.
- Green production processes for high-energy density hydrogen storage materials
- Nanostructured films with high surface areas to safely store hydrogen in systems that will meet Department of Energy (DOE) energy storage targets

SRI also has the expertise and capability to evaluate the performance, stability, and safety of hydrogen storage materials and devices.

Hydrogen Safety:

Increased use of hydrogen as an energy carrier has prompted the need to investigate the safety aspects associated with the use of hydrogen fuel cells and supporting infrastructure. SRI has partnered with Sandia National Laboratories to provide the data necessary to ensure that hydrogen can be used safely by the general public.

The goal of this research is to develop a defensible and traceable basis for creating new hydrogen codes and standards. To support Sandia's Hydrogen Safety, Codes, and Standards Program, SRI researchers perform medium- and large-scale experiments to acquire physical data on hydrogen dispersion, ignition, and combustion.

SRI has performed a wide range of experiments to investigate different aspects of hydrogen behavior. The focus of the experiments has ranged from acquiring fundamental data on hydrogen combustion and ignition phenomena to investigating unintended releases of hydrogen from fuel-cell vehicles in realistic operating environments.

SRI has performed several experiments to characterize hydrogen jet fires produced by leaks from high-pressure tanks; investigate spontaneous ignition of hydrogen caused by electrostatic discharge produced by entrained particulates; and characterize unintended hydrogen releases from fuel cell vehicles inside tunnels and warehouses. The data are used to validate computational models and perform quantitative risk assessments related to specific accident scenarios.

SRI has also conducted research to evaluate the effectiveness of risk mitigation strategies, such as the use of barrier walls of different configurations to protect people and property from hazards produced by hydrogen storage facilities.

Fuel Cells:

Fuel cells offer the promise of producing clean energy at high efficiency. SRI has been involved in the design, construction, and testing of fuel cells and semi-fuel cells, reformation systems, and components for more than 40 years. Recent work of SRI includes:

- Membranes for use in high temperature fuel cells and direct methanol fuel cells.
- Microbial fuel cells that run on wastewater. The cells operate with novel oxidizers and cell structures to enhance the power outputs.
- High-temperature fuel cells that can use carbon or hydrocarbons directly as fuel.

Fundamental research to explore the effect of impurities on solid oxide fuel cells.

Contact Info:

Barbara Heydorn
Director
Center of Excellence in Energy
SRI International
barbara.heydorn@sri.com
https://www.sri.com/

CALIFORNIA HYDROGEN BUSINESS COUNCIL

Hydrogen Means Business in California!

5th Annual

California HYDROGEN & FUEL CELL SUMMIT

September 25 - 27, 2017 | Cal/EPA | Sacramento, CA

Plus:

Fuel Cell Bus Workshop • Microgrid Tour

Program, Speakers, Registration, Attending Organizations and More at:

www.californiahydrogensummit.com

More events at www.californiahydrogen.org/events

SYMPOSIUM FC

Hydrogen Production and Storage

Endorsed by

The symposium will bring together world leading experts from Physics, Chemistry, Materials Science and Engineering to share up-to-date scientific and technical advances in the field, and to highlight outstanding problems and guidelines for future research. Fundamental aspects of catalysis, separation and purification processes; chemistry and physics of hydrogen bonding, adsorption and release mechanisms; materials synthesis, processing and characterisation; system implementation and performance evaluation including safety and economics issues will be featured.

SESSION TOPICS

FC-1 HYDROGEN PRODUCTION: *Thermochemical; Photoelectrochemical; Photobiological and photo-bio-mimetic; Biomass/waste reforming; Microbial Electrolysis Cells (MEC); Electrolysis from renewable energy; HT electrolysis (Hybrid cycles); Water-gas shift in advanced coal gasification; Hydrogen quality assessment;*

FC-2 HYDROGEN STORAGE: *Metal hydrides; Complex hydrides; Chemical hydrides; Organic hydrides; Physisorption of hydrogen on high surface area adsorbents e.g. carbon based material, metal-organic frameworks and nanostructures; CO2 reduction with hydrogen to synthetic hydrocarbons; Theoretical modelling; Storage testing, leak detection, safety, economic issues, etc.*

CIMTEC 2018

www.cimtec-congress.org

Upcoming Meetings & Activities

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/

California Hydrogen & Fuel Cell Summit
September 25-27, 2017
Sacramento, CA
http://www.californiahydrogensummit.com/

October 2017

232nd ECS Meeting
October 1-5, 2017
National Harbor, MD
http://www.electrochem.org/232

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/

January 2018

Hydrogen & Fuel Cells Energy Summit
January 24-25, 2018
Brussels, Belgium
http://www.wplgroup.com/aci/event/hydrogen-and-fuel-cells-energy-summit/

March 2018

European Hydrogen Energy Conference 2018
March 14-16, 2018
Costa del Sol, Spain
http://www.ehec.info/

3rd International Hydrogen Technologies Congress
March 15-18, 2018
Alanya, Turkey
http://www.ihtec2018.org/

April 2018

SAE World Congress Experience
April 10-12, 2018
Detroit, Michigan
http://wcx18.org/

May 2018

233 ECS Meeting
May 13-17, 2018
Seattle, WA
http://www.electrochem.org/233-planning-deadlines

June 2018

22nd WHEC
June 17-22, 2018
Rio de Janeiro, Brazil
http://www.whec2018.com/

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