international association for hydrogen energy
Clean and Abundant Energy for Sustainability

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Rick Perry to head U.S. Department of Energy

Former Texas Governor Rick Perry has been selected as Secretary of Energy by president Donald Trump's administration. Perry's history with energy as governor, his position on the U.S. Department of Energy (DOE) in his brief stint as a Republican presidential candidate in 2012, and his relationship with President Trump, in particular, are complicated, which makes the next four years of energy policy difficult to forecast.

The alignment of Perry's and Trump's ideologies on certain key issues, however, seem to be the reason Perry was tapped for the position. Perry oversaw huge developments in the energy sector as governor of Texas, which included vast expansion of wind energy capacity as well as aggressively incentivizing energy companies to move to Texas and create jobs. The dissolution of his bid for Republican candidacy in the 2012 presidential race, however, was ironically spurred by his inability, during a debate, to recall the name of one of the departments he wanted to dissolve. This department (along with the Departments of Commerce and Education) turned out to be the DOE.

Despite his early advocacy for elimination of the DOE, a brief look at Perry's record as governor of Texas can possibly provide insight in to what his tenure as head of Secretary of Energy might entail.

One aspect of Perry's legacy as governor is the massive expansion of the energy sector in Texas. By the end of Perry's 14-year stint as governor, Texas was ranked first in the nation in wind power with just shy of 19 GW of installed capacity. For reference, in 2001, when Perry became governor there was less than 200 MW of installed wind capacity. In 2015, at the end of Perry's gubernatorial term, Texas was also ranked tenth in the nation in terms of installed solar capacity, which amounted to 534 MW. Per the Solar Industries Association statistics, this was up from just 64 MW in 2012.

The spark that began this renewable energy expansion in Texas can at least partially be attributed to a bill that predated Perry's governorship. This piece of legislation, signed by Governor George W. Bush in 1999, restructured the Texas electricity industry and contained the Texas Renewable Portfolio Standard (RPS), which set targets for increased renewable energy capacity in Texas. These goals for renewable capacity were met and surpassed under Perry's governorship. Perry did not just expand the resource rich state in its renewable sector, he also oversaw large expansions in natural gas extraction and oil production. During his tenure, oil production increased by 260%, while natural gas increased by 50%. In Perry's farewell address to Texas legislature in January 2015, he stated, "Today, horizontal slant drilling is tapping oil and gas fields unreachable just a few years ago. This technology is testament to the power of the private sector to drive economic change. In Texas, we have chosen jobs. We have chosen energy security and we will one day end America's dependence on hostile sources of foreign energy."

As governor, Perry also made it clear that he is pro-coal. This is evident in his 2005 executive order to help prioritize and expedite coal plant permits; his record of advocacy for clean-coal in the form of a clean-coal technology

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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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council; and a bill for tax incentives for clean-coal plants.

The DOE has a fourfold mission in the form of 'energy,' 'science and innovation,' 'management and operational excellence,' and 'nuclear safety and security', however, its budget is not split evenly among these cornerstones. During the past three years, the majority of the DOE's budget has been dedicated to advancing nuclear energy and security. The DOE has even been called a misnomer because of this fact and has been otherwise referred to, informally, as the department of nukes.

Being a scientist is not a requirement for being the Secretary of Energy. For much of the energy department's existence, politicians with no formal scientific training have served as its head. It did, however, serve former Secretary of Energy Ernest Moniz well when called upon to broker a nuclear deal with Iran. Moniz, who holds a PhD in theoretical physics from Stanford, came to an agreement with Iranian diplomats regarding their nuclear program in 2015. On the other hand, managerial experience can also be a beneficial asset in cabinet positions. Optimistically, what Perry lacks in energy education (he holds a bachelor's degree in animal science from Texas A&M), he makes up for with experience in government.

This all comes in the wake of Perry's contentious relationship with both president Trump—Perry referred to Trump as a "cancer on conservatism"—as well as the DOE itself. Perry is surprisingly not the first person to hold the position of calling for the department's dissolution. Spencer Abraham, who served as former President George W. Bush's first Secretary of Energy, had similarly called for dismantling the DOE prior to his appointment to the post.

From several of Perry's comments made in speeches in 2011, when he was running for president, it can be gleaned that he was more focused on the Environmental Protection Agency and not the DOE. Speaking about dismantling the DOE at a speech in Hampton, New Hampshire, Perry stated, "Our energy industry has to be freed up from over-regulation." Nevertheless, in his opening remarks at his senate committee hearing on January 19, 2017, Perry claimed, "My statements made over five years ago about abolishing the DOE did not reflect my current thinking. In fact, after being briefed on some of the vital functions of the department of energy, I regret recommending its elimination." As previously mentioned, the DOE has less to do with environmental regulations than other functions such as managing the national labs, allocating and managing research, and increasing nuclear security.

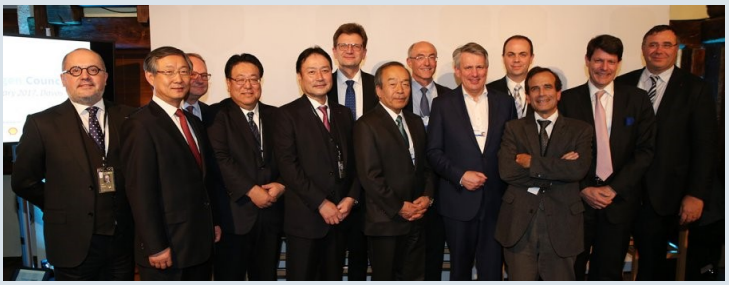
On the morning of Perry's senate hearing, news broke about some of the Trump transition team's proposed budget cuts. Among the cuts were a subset inside of the energy department. Nuclear physics and advanced scientific computing were to be rolled back to 2008 levels of funding, while the Offices of Electricity, Energy Efficiency and Renewable Energy, and Fossil Energy were all to be eliminated. Perry's answers to queries regarding this matter seemed to belie his commitment to the defense of the DOE's budget. Reflecting on Perry's hearing, two common phrases that Perry used seemed to pervade the proceedings which were: '*one size fits all* and '*all of the above*,' and these two phrases seemed to sum up how Perry negotiated the hearing. He made it clear that he does not support the proposition of the government favoring a specific sector of the energy industry or the idea of a one size fits all federally mandated energy policy, but he also wanted to be clear that diversification of energy sources is the real key to energy independence. Perry spoke very favorably about the national labs, and technological innovation and super-computing, but his budget commitment was less concrete.

While there was no discussion at his confirmation hearing about where hydrogen energy sits within this labyrinth of policy, funding, and bureaucracy. If the proposed budget cuts are indeed true, clean energy and renewable energy funding are not a priority of the Trump administration, and will likely face severe if not drastic cuts in the near future without strong support from Perry, U.S. Congress, industrial leaders, and advocates.

-Cyrus Daugherty

New "Hydrogen Council" launches in Davos

13 global industry leaders join together in promoting hydrogen to help meet climate goals



Thirteen leading energy, transport and industry companies have today launched a global initiative to voice a united vision and long-term ambition for hydrogen to foster the energy transition.

In the first global initiative of its kind, the 'Hydrogen Council' is determined to position hydrogen among the key solutions of the energy transition. Hydrogen is a versatile energy carrier with favorable characteristics since it does not release any CO_2 at the point of use as a clean fuel or energy source, and can play an important role in the transition to a clean, low-carbon, energy system. Hydrogen technologies and products have significantly progressed over past years and are now being introduced to the market. The Council will work with, and provide recommendations to, a number of key stakeholders such as policy makers, business and hydrogen players, international agencies and civil society to achieve these goals.

During the launch, members of the 'Hydrogen Council' confirmed their ambition to accelerate their significant investment in the development and commercialization of the hydrogen and fuel cell sectors. These investments currently amount to an estimated total value of 1.4 Bn/year[1]. This acceleration will be possible if the key stakeholders increase their backing of hydrogen as part of the future energy mix with appropriate policies and supporting schemes.

Meeting in Davos, Switzerland for the first time on Tuesday, the 'Hydrogen Council' is currently made up of 13 CEOs and Chairpersons from various industries and energy companies committed to helping achieve the ambitious goal of reaching the 2 degrees Celsius target as agreed in the 2015 Paris Agreement. The international companies currently involved are: Air Liquide, Alstom, Anglo American, BMW GROUP, Daimler, ENGIE, Honda, Hyundai Motor, Kawasaki, Royal Dutch Shell, The Linde Group, Total and Toyota. The Council is led by two Co-Chairs from different geographies and sectors, currently represented by Air Liquide and Toyota.

"The 2015 Paris Agreement to combat climate change is a significant step in the right direction but requires business action to be taken to make such a pledge a reality. The Hydrogen Council brings together some of the world's leading industrial, automotive and energy companies with a clear ambition to explain why hydrogen emerges among the key solutions for the energy transition, in the mobility as well as in the power, industrial and residential sectors, and therefore requires the development of new strategies at a scale to support this. But we cannot do it alone. We need governments to back hydrogen with actions of their own – for example through large-scale infrastructure investment schemes. Our call today to world leaders is to commit to hydrogen so that together we can meet our shared climate ambitions and give further traction to the emerging Hydrogen ecosystem." Benoît Potier, CEO, Air Liquide.

"The Hydrogen Council will exhibit responsible leadership in showcasing hydrogen technology and its benefits to the world. It will seek collaboration, cooperation and understanding from governments, industry and most importantly, the public. At Toyota, we have always tried to play a leading role in environmental and technological advances in the automotive industry, including through the introduction of fuel cell vehicles. Moreover, we know that in addition to transportation, hydrogen has the potential to support our transition to a low carbon society across multiple industries and the entire value chain. The Hydrogen Council aims to actively encourage this transition." Takeshi Uchiyamada, Chairman, Toyota.

A report entitled *How Hydrogen empowers the energy transition*[2]—commissioned by the Hydrogen Council—further details this future potential that hydrogen is ready to provide, and sets out the vision of the Council and the key actions it considers fundamental for policy makers to implement, to fully unlock and empower the contribution of hydrogen to the energy transition.

As global companies from major energy and industrial sectors, it is part of the corporate responsibility to provide solutions to manage the energy transition and move forward to a low-carbon, sustainable economy: joint action is required to tackle this formidable challenge. This is why we invite governments and key society stakeholders to also acknowledge the contribution of hydrogen to the energy transition and to work with us to create an effective implementation plan.

The members of the Hydrogen Council collectively represent total revenues of $1.07 trillion and 1.72 million employees around the world[3].

[1] How Hydrogen empowers the energy transition, Report, 2017, Hydrogen Council
[2] www.hydrogencouncil.com
[3] Company figures from financial years 2015 and 2016

Source: https://www.airliquide.com/media/new-hydrogen-council-launches-davos

Hydrogen fuel cell economy slowing, not stopping in Connecticut

Connecticut has emerged as a leading center for U.S. hydrogen and fuel cell development over the past several years. But the Connecticut hydrogen industry is about to become an unwilling test case for the ability of the national hydrogen sector to survive lean times.

Two key setbacks should serve as a warning sign for fans of the hydrogen economy — or they could demonstrate its resiliency, depending on perspective.

Goodbye, federal fuel cell tax credit

As reported by the Connecticut Mirror last month, one of the setbacks was national in scope.

That story started in 2015, when Congress passed a law that extended federal tax credits for major league wind and solar energy development.

Unfortunately for hydrogen economy fans, several minor league clean-power sectors were omitted from that legislation, including small-scale distributed wind, geothermal heat pumps, and combined heat and power, as well as fuel cells.

Apparently Republican leadership in Congress pledged to extend those credits at the earliest opportunity. However, a Dec. 31 deadline came and went without action after the Koch-funded group Americans for Prosperity launched a campaign against extending the credits.

As a result, projects in those sectors lost an investment tax credit of 30 percent as of 12:10 a.m. on Jan. 1.

When renewables eat each other

The other blow was specific to Connecticut. It came down last fall, when the Connecticut Department of Energy and Environmental Protection decided to skip over fuel cells for 25 state-awarded, clean-energy projects covering almost 800 megawatts in Connecticut, Massachusetts and Rhode Island.

By way of explanation, DEEP cited the low cost of competing forms of alternative energy, primarily solar.

Hydrogen and fuel cell advocates warn that the narrow focus on solar costs could come back to bite Connecticut ratepayers.

One factor that could boost costs is the need for additional energy storage, grid connections or backup power plants to supplement solar farms.

Another factor is the possibility that bidders on the contracts may have predicted lower costs that fail to materialize, due to rising demand for solar panels in the U.S. and globally.

Hydrogen economy forges on

Hydrogen stakeholders may yet be proven right about DEEP's decision. But as the Mirror reported, the fallout has already begun:

"Failure to win those contracts led FuelCell Energy to announce layoffs at its corporate offices in Danbury, its manufacturing site in Torrington, and several 'remote locations.' A total of 96 people were laid off, representing 17 percent of the company's work force," wrote the Mirror's Ana Radelat.

"Chip Bottone, president and CEO of FuelCell Energy said failure to extend the tax breaks contributed to the decision to shrink the workforce."

In the same interview, though, Bottone provided an important clue regarding a key factor that could help sustain the domestic hydrogen and fuel cell industry through lean times.

That would be the need for a robust domestic fuel cell industry in support of national security interests. The Department of Defense is a major consumer of fuel cell technology. NASA is another federal agency that relies heavily on hydrogen fuel and fuel cells.

Bottone pointed out that the U.S. has become a global fuel cell technology leader with an established domestic supply chain and strong demand for its products overseas.

In contrast, the U.S. solar cell manufacturing industry has seen its global market share fall off a cliff. Starting at a 1995 benchmark, the tailspin lasted until 2006 before leveling off far behind the current industry leader, China.

Connecticut has already established itself a one of top three states for the U.S. hydrogen and fuel cell economy (the other two are California and New York state), which could also help local companies lobby for a renewal of federal support.

The state's fuel cell industry is also credited with vaulting Connecticut into the Clean Tech Leadership Index Top Ten in 2014.

What about sustainable hydrogen?

Another factor that may sustain Connecticut's hydrogen economy is the interest of the Energy Department in sustainable hydrogen production.

The Connecticut company Precision Combustion is one example. Last June, the company won a competitive Energy Department small business grant to develop a solar-powered system for capturing carbon from industrial gases and converting it to other carbon-based products.

Renewable hydrogen—sourced from water using wind or solar in a power-to-gas system—would bump things up a notch up the sustainability ladder. If all goes well, power-to-gas facilities could begin sprouting in Connecticut.

Last year the Hartford Business Journal reviewed FuelCell Energy's proposal for the world's largest fuel cell "park" and noted the potential boost for wind and solar production in the state:

> "… the renewable energy industry will have the ability to make use of off-peak electricity to generate energy and then store it as hydrogen. That energy can be used to fuel zero-emission vehicles, produce thermal energy and electricity with fuel cell technology whenever needed, or be introduced into the natural gas pipeline. This power-to-gas application could potentially develop a new renewable gas credit market."

Unfortunately, the fuel cell park proposal was one of those skipped over by DEEP last fall.

However, FuelCell Energy is still pursuing the fuel cell project through other pathways and it has several additional proposals on DEEP's desk.

Source: http://www.triplepundit.com/2017/01/hydrogen-fuel-cell-economy-slowing-not-stopping-connecticut/

Consortium Simplefuel wins $1 million in U.S Department of Energy's H-prize

SimpleFuel receives award of H2 Refuel H-Prize Competition for small-scale hydrogen refueling system

The U.S. Department of Energy's (DOE) Fuel Cell Technologies Office (FCTO) and the Hydrogen Education Foundation (HEF) recently announced the competition finalist *SimpleFuel* as the winner of the $1 Million H2 Refuel H-Prize. This success can support economic growth, jobs, and domestic leadership in cutting edge energy technology.

The SimpleFuel™ team, a consortium made up of Ivys Energy Solutions, McPhy Energy North America and PDC Machines, designed their system to be a safe, small-scale hydrogen-refueling appliance capable of delivering up to 5 kg/day of hydrogen to vehicles at pressures up to 700 bar (10,000 psi). 5 kg is enough to fully fuel one fuel cell electric vehicle (FCEV) for 300-360 miles.

"In 2007 Congress established this competition, with bipartisan support, to inspire creative approaches and ad-

vances for hydrogen energy technologies," stated Jeff Serfass, President of the Hydrogen Education Foundation. "The development of the hydrogen infrastructure became the target of this competition, and I am pleased that DOE and HEF together have delivered on the objective for the H-Prize with SimpleFuel's grand achievement," Serfass concluded.

Phase 1 of the competition was launched in 2014, when America's engineers and entrepreneurs were invited to answer the call to design and build an affordable system for small-scale, non-commercial hydrogen fueling. After receiving and evaluating nine design submissions in 2015, one team—SimpleFuel—was selected by an independent panel of judges as the Finalist, to advance to Phase 2.

SimpleFuel constructed their system in 2016 in Warminster, Pennsylvania, followed by a 3-month data collection period, which ended in December 2016. During that time, an open house event was held, which was attend by DOE FCTO Director Sunita Satyapal, at which the team demonstrated their system by conducting a fueling of a Hyundai Tucson FCEV.

The National Renewable Energy Laboratory (NREL) analyzed the data collected during that testing period, and the cost information provided by the team was also independently reviewed. The H-Prize panel of judges deemed that the data collected showed that SimpleFuel's system met both the technical and cost criteria as outlined in the final competition guidelines, thereby unanimously declaring them the winner of the H2 Refuel H-Prize.

Hydrogen infrastructure remains a critical barrier to the widespread adoption of FCEVs. The future of FCEVs in a consumer environment is dependent upon a widely available network of fueling stations. At the current early stage of market introduction, there will be a need for small-scale refueling to serve communities and residences far from the commercial hydrogen fueling station network. The H2 Refuel competition was designed to help address this barrier through easily deployed small scale fueling systems for home and community use to bridge the gap while widespread infrastructure development takes place.

The Hydrogen Education Foundation administers the H2 Refuel H-Prize for the U.S. Department of Energy. More information on the H2 Refuel H-Prize are available at www.hydrogenprize.org or by phone at (202) 223-5547 x360.

Source: http://campaign.r20.constantcontact.com/render?m=1011200282442&ca=fc9165a7-d53b-427d-a56c-14ed05b87476

Funding for H2 solutions in manufacturing

The US Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE) is issuing Funding Opportunity Announcements (FOAs) to support early-stage, innovative technologies and solutions, including approaches to cost-effective hydrogen (H_2) use in manufacturing.

EERE's Advanced Manufacturing Office (AMO) works with universities, national laboratories, and for-profit and non-profit partners to identify and solve technology challenges in manufacturing.

H_2 is currently used in a range of manufacturing industries, notably the petroleum refining industry; and is also used in chemical production, metal refining, food processing and electronics manufacturing.

The focus of this topic is not necessarily to reduce the cost of H_2 generation, but rather to explore options for the potential use of H_2 feedstock.

These activities are directly relevant to, and will be coordinated with, EERE's Fuel Cell Technologies Office, which focuses on H_2 and fuel cell technology, including renewable, low-cost H_2 production.

Successful projects will reduce the technical uncertainty and develop new knowledge associated with potential breakthrough materials, processes and tools for US manufacturers that could improve their competitiveness and enhance their energy efficiency.

AMO anticipates making approximately 24 to 40 awards to fund projects for up to 36 months. Individual awards may vary from $250,000 to $2.5m.

Source: https://www.gasworld.com/funding-for-h2-solutions-in-manufacturing-/2012131.article

Toyota Chairman says fuel-cell cars need more time to catch on

Toyota Motor Corp. Chairman Takeshi Uchiyamada, known as the "father of the Prius" for his work on the world's best-selling hybrid car, said fuel-cell vehicles will take longer than gasoline-electric autos to become popular because of the need to build infrastructure.

"The hybrid sold much faster than we had anticipated," Uchiyamada, 70, told Bloomberg Television's Francine Lacqua at the World Economic Forum in Davos, Switzerland. "As for the FCV cars, we assume it won't be as fast as hybrid as the infrastructure needs to be prepared before it becomes major in the market."

Fuel-cell vehicles are a cornerstone of Toyota's plan to rid 90 percent of carbon dioxide emissions from its autos by 2050. To facilitate the infrastructure build-out, Toyota and four of its biggest car-making peers joined oil-and-gas giants including Royal Dutch Shell Plc and Total SA with plans to invest a combined €10 billion ($10.7 billion) in hydrogen-related products within five years.

Toyota has long contended it's more likely to convince consumers to use gasoline-electric hybrids and fuel-cell vehicles rather than battery-electric autos, which tend to have less driving range and take longer to recharge than filling up with gasoline or hydrogen. With annual sales of 3,000 fuel-cell vehicles currently, the manufacturer plans to increase the figure 10-fold by 2020, Uchiyamada said.

Fuel-cell vehicles may face more headwinds with President-elect Donald Trump threatening to reverse Barack Obama's policies on tackling climate change and pull the U.S. out of the 2015 Paris accord. Automakers are also pushing the Trump administration to allow them more latitude in meeting Obama's miles-per-gallon target of 50.8 by 2025. The standard was 35.3 mpg last year.

"Whether to aim for the hydrogen-based society is dependent on each countries and region," Uchiyamada said. "I don't think there will be much change in other regions other than the U.S."

Toyota plans to invest $10 billion in the U.S. over the next five years, maintaining its pace of spending during the last half decade, as Japan's largest automaker joined other manufacturers in unveiling spending plans in response to pressure from Trump to expand hiring in America.

Trump this month criticized Toyota's plans made 20 months earlier that it would build a Mexico factory to assemble Corolla compacts beginning from 2019, saying in a tweet the company should build the plant in the U.S. or pay a "big border tax." The Toyota City, Japan-based automaker already makes Corollas at a plant in Mississippi.

"We were a bit surprised that our name was mentioned by Mr. Trump," said Uchiyamada. "We have full confidence in our market in the U.S. If it means more growth for us we are willing to spend more in the U.S."

Source: https://www.bloomberg.com/news/articles/2017-01-19/toyota-chairman-says-fuel-cell-cars-need-longer-time-to-catch-on

Survey says most automotive executives believe fuel cells are the future

Based on a comprehensive new survey, it seems leading automotive executives cannot agree on whether electric vehicles or hydrogen fuel cell vehicles are the future.

In a report complied by research firm KPMG, which surveyed almost 1,000 senior executives from a number of automotive firms, 78 percent said they believe that fuel cells are the "real breakthrough" of zero-emissions driving. Additionally, 62 percent of respondents said that electric vehicles will fail due to infrastructure issues.

The study says that one of the key reasons why so many executives believe fuel cells to be the answer is "their strong attachment to the existing infrastructure and traditional vehicle applications."

For those that keep a close eye on the industry, you'll know that in recent years, many automakers have been exploring both electric and fuel cell vehicles, believing that one of the two will provide the answer for clean driving. Audi, for example, is developing both electric and hydrogen vehicles and Toyota, a firm believer in fuel cell technology, recently formed an electric car division.

Additionally, Hyundai said last year that it was only

developing plug-in hybrid vehicles as "an intermediate step before hydrogen fuel cell vehicles take hold in the coming decades."

Respondents to the survey asserted that the success of electric vehicles depends on coordinated actions for appropriate infrastructure for urban and long-distance uses.

Beyond the electric vs. hydrogen vehicle debate, the survey found that 76 percent of the executives that responded believe vehicles with internal combustion engines will still remain important for quite some time. Interestingly, 53 percent said that diesel engines are dead.

Source: http://www.carscoops.com/2017/01/survey-says-most-automotive-executives.html

Hyundai boosting Tucsan SUV fuel cell range to 348 miles

Hyundai is developing a new fuel cell for the Tucson SUV that will increase the current model's 248 mile range by 30 percent to 348 miles on a full tank of hydrogen.

In the latest play in the game of one-upmanship in the nascent fuel cell market, Hyundai's increased traveling distance exceeds the Toyota Mirai's 312 miles, but does not match the Honda Clarity's 366 miles.

California is the only state where the fuel cell Tucson is available, and with its limited number of hydrogen fueling stations—16 stations in Southern California, five in the Bay Area—"range anxiety" is not just about battery electric vehicles.

When it arrives in early 2018, the Tucson SUV fuel cell will have a lower sticker price of around $50,000 compared to the Clarity at $60,000 and the Mirai at $57,500.

Currently, the fuel cell Tucson is available to California consumers as a lease-only program with no lease-purchase at the end of term.

The lease requires a $3,000 down payment with a $500 per month payment for 36 months. As part of the lease, hydrogen fuel and maintenance are included, along with a permit to drive in High Occupancy Vehicle (HOV) lanes on the highway.

It is not known if Hyundai plans to continue with its lease-only strategy.

Additionally, *Motor Trend* reported that Hyundai is set to introduce a fuel cell-powered commercial bus in 2017, around the same time Toyota is expected to bring out its 77-seat fuel cell bus.

Source: http://www.hybridcars.com/hyundai-boosting-tucson-suv-fuel-cell-driving-range-to-348-miles/

BMW, Daimler, Honda and Hyundai join Toyota in betting on hydrogen fuel cells

Pretty soon Toyota, Honda and Hyundai might not be the only automakers offering hydrogen-powered cars.

BMW and Daimler will join the three fuel cell pioneers in aggressively pursuing fuel cell technology for transportation. The automakers, along with several major energy companies, have pledged a total investment of $10.7 billion into research and development of hydrogen-based products over the next five years.

Toyota will lead the 13-company group, which features multinational oil companies such as Royal Dutch Shell and France's Total S.A., assembled for the first time during the World Economic Forum in Davos, Switzerland this week. Taking on the collective title the "Hydrogen Council," the group is aiming to stop global warming from hitting 2 degrees Celsius, a standard set during the 2015 Climate Change Conference in Paris.

Toyota has pledged to cut carbon dioxide emissions from its vehicles by 90 percent by 2050 and hydrogen figures to play a major role in that effort. Toyota has been touting its hydrogen ambitions for several years, first showcasing the FCV Concept, the precursor to today's fuel cell-powered Mirai sedan, in 2013.

The Japanese automaker believes it will be easier to get consumers on board with fuel cell cars, which are refueled

in a similar fashion to gasoline-powered cars, than the plug-in battery vehicles being developed by its competitors.

Toyota has developed a plug-in hybrid system for its Prius Prime, but, considering it stuck with a traditional hybrid powertrain for the all-new Camry Hybrid, it doesn't seem like it plans on making the technology a key part of its lineup moving forward.

Hyundai and Honda also have fuel cell vehicles on the market, though like the Mirai, the Tucson Fuel Cell and the Clarity Fuel Cell are only available in California. The reason for this limited availability is the current dearth of hydrogen stations throughout the U.S., something that will likely be addressed by the Hydrogen Council's investments.

A Mirai can be purchased for $57,500 while the Tuscon and Clarity can only be leased.

Along with the five automakers, Shell and Total S.A., the Hydrogen Council is comprised of gas companies Air Liquide and Linde, mining company Anglo American, electric utility company Engie, rail company Alstom and heavy equipment manufacturer Kawasaki.

Source: http://www.nydailynews.com/autos/news/bmw-daimler-honda-hyundai-toyota-invest-hydrogen-article-1.2949540

Tata Motors reveals India's first hydrogen fuel cell bus

Tata Motors launched the future of mass public transportation at its Pune facility and took another step in the direction of green technology and mobility solutions. The company launched the Starbus Electric 9m, Starbus Electric 12m and the Starbus Hybrid 12m buses, which are designed, developed, powered by alternate fuels and made in India. The company says the Starbuses will be a good for smart cities. The company also showcased the country's first Fuel Cell bus (12m), LNG Powered bus (12m), and an 18m Articulated bus.

The Hydrogen Powered Starbus Fuel Cell bus is a zero-emission mass transport solution, for inter-city commute and has been developed in partnership with ISRO (Indian Space Research Organization). Combining hydrogen gas and oxygen, the fuel cell produces electricity to power the electric motor, with water and heat as a byproduct. This is the first time an Indian manufacturer has ventured in this direction. As far as Electric buses are concerned, Tata Motors finds a rival in the form of Ashok Leyland who recently revealed the Circuit series of all-electric buses, which was in fact India's first of this kind.

The company has already extensively tested the CNG hybrid buses across the country in cities like Mumbai, Ahmedabad and Surat and we first saw them in New Delhi during the 2010 Commonwealth games.

It was just last year that the company signed a contract for the single largest order for Hybrid Electric vehicle technology, with the Mumbai Metropolitan Region Development Authority (MMRDA), to supply 25 units of the Starbus Diesel Hybrid electric bus with Full Low floor configuration. These buses will be delivered in the first quarter of FY2017-18 and will connect Sion, Bandra & Kurla to Bandra Kurla Complex (BKC).

Ravindra Pisharody, Executive Director-Commercial Vehicles, Tata Motors said, "We have consistently been developing and manufacturing products that can contribute to CO_2 reductions across all road transport segments and with early investments in new technologies, we are geared up to further strengthen our market leadership. With our new range of Future ready buses, we will continue to play an active role in mass public transportation, with a commitment towards striking the right balance between sustainable growth and profitability."

Source: http://auto.ndtv.com/news/tata-motors-reveals-indias-first-hydrogen-fuel-cell-bus-1652559

All-new Hyundai fuel cell SUV confirmed for 2018

Hyundai has confirmed it will launch a new fuel cell vehicle for 2018 – and we are set to get our first sight of it at the Geneva Motor Show.

Executive vice president Euisun Chung announced the news at a press conference in Las Vegas where the company has been demonstrating the prowess of its autonomous Ioniq.

Mr. Chung confirmed the new model will be an SUV, and in contrast to the strategy the firm has followed with its current offering, the ix35, the next-generation fuel cell car will be built on an all-new platform and feature unique styling.

It is also set to be lighter than the current model, with a significantly longer range and a lower price.

Speaking exclusively to Auto Express, Tae Won Lim, senior vice president, Central Advanced Research and Engineering Institute, said: "Our target is to develop a cheaper, more durable, more reliable and more efficient system. It will be an all-new platform, special design and easy to assemble."

The current ix35 fuel cell vehicle weighs in at a chunky 1,830kg, while its £53,000 price tag has been a sticking point for all but the most fervent early adopters.

Explaining the thinking behind the new platform, Mr Lim continued: "We started our fuel cell development on our current platform but based on our experience, in order to have maximum benefit from fuel cell maybe we need a designated platform.

"We are doing our best efforts to reduce the material cost and that is the main target of our development."

Mr. Lim added that he was confident the company could achieve a much longer range than on the current car, with improvements of around 30 percent feasible.

He said: "I do not have the exact number yet but the current fuel cell does distances of about 300 miles. Our next version will be much longer than 300." Insiders have indicated to Auto Express that it could even reach 650km (403 miles).

And he added: "For longer driving distances you should use lighter materials or a smaller car. But with fuel cell we are free from distance anxiety. With a fuel cell system we can develop a bigger one [car]."

The model is likely to come with an array of hi-tech features, including, according to Mr. Chung, a new Driver Assistance system from the company. It will take the fight to Toyota's Mirai and Honda's Clarity fuel cell offerings.

And although the debate rages on as to whether fuel cell will ever be a viable eco solution in the long term with the rise of EVs, Mr. Lim said Hyundai was very firmly backing the tech.

He concluded: "For Hyundai, the fuel cell system is like a first child. It is very much a propriety technology and that is why we like to put our effort and love into fuel cell vehicles."

Source: http://www.autoexpress.co.uk/hyundai/98187/all-new-hyundai-fuel-cell-suv-confirmed-for-2018

China becomes 3rd country to test hydrogen-powered plane

China has become the third nation in the world to successfully test an aircraft using hydrogen fuel, the country's ministry of science and technology has announced.

During the test in Shenyang, Liaoning province, the plane, based on the RX1E electric aircraft, reached a height of 320 meters and emitted zero pollution, Science and Technology Daily, the official newspaper of the ministry, reported. It made China the third country to successfully test an aircraft powered by hydrogen fuel cells, following the US and Germany.

The aircraft's output performance, safety, reliability, and the environmental adaptability of the fuel cell system all met technical requirements during the flight, according to the ministry.

The plane is equipped with 20 kilowatts of hydrogen fuel cell power supply. It is powered by fuel cells and lithium batteries during its take-off and climb, and entirely by fuel cells during the cruise phase.

A charging time of 90 minutes enables the aircraft to fly for 45 to 60 minutes, the People's Daily reported in 2015. It was designed to be able to fly at a maximum altitude of 3,000 meters, according to the newspaper.

The push towards hydrogen fueled planes is largely aimed at cutting carbon emissions produced by aircraft. Airplanes dumped 700 million metric tons of carbon dioxide into the air in 2013, according to a 2015 report from National Geographic. That number is set to triple by 2050.

While the idea of hydrogen-fueled aircraft is not new, the notion has been shelved in the past due to its extremely high cost compared to traditional fuel, as well as the fact that hydrogen requires substantial amounts of energy to make.

Source: https://www.rt.com/news/373102-china-hydrogen-fuel-aircraft/

Hydrogen refueling stations for cars to reach 5,000 by 2032

This year, there will be 384 hydrogen refuelling stations worldwide

Refueling stations that would support a burgeoning hydrogen fuel-cell industry are on the rise and should reach nearly 5,000 by 2032, according to a new report.

The research report from Washington-based *Information Trends* indicates that hydrogen fuel station deployment in major markets is in full swing, bolstering prospects for large-scale consumer adoption fuel cell vehicles (FCVs).

In 2015, there were 115 hydrogen fueling stations worldwide, and 285 in 2016. This year, that number is expected to grow to 384. By 2022, there will be 1,306, and by 2032 there will be 4,808, according to *Information Trends*.

In the U.S., hydrogen refueling stations are expected to reach 78 this year. By 2022, there will be 197, and by 2032 there will be 1,208, according to the report.

Refueling stations are increasing in number as Audi and Mercedes-Benz are preparing to launch FCVs on the heels of rollouts of hydrogen-powered vehicles by Toyota, Honda and Hyundai.

In 2015, Toyota started selling its FCV Mirai, and Hyundai continued commercial sales of its fuel cell Tucson (in the U.S.) and ix35 (outside the U.S.). Honda unveiled its FCV Concept at several 2015 auto shows, and it began shipping its first vehicle that year.

Honda's third-generation FCV, the 2017 Honda Clarity Fuel Cell, began shipping last month at dealerships across southern California.

The Clarity Fuel Cell sedan can be leased and comes with $15,000 worth of free hydrogen fuel. The Clarity Fuel Cell has a 366-mile range and a fuel economy rating of 68 combined MPGe (miles per gallon of gasoline-equivalent).

In Europe, Denmark was the first country to deploy a nationwide hydrogen fueling infrastructure, but Germany is leading the deployment charge with 400 stations expected in the next six years, the report stated.

In the U.S., California is aggressively deploying hydrogen stations as part of its efforts to combat greenhouse gas emissions.

"Both Toyota and Honda, as well as Korea's Hyundai, have largely stayed away from electric vehicles but are embracing fuel-cell technology in a big way," said Naqi Jaffery, the lead author of *Information Trend*'s report, said in an email to *Computerworld*. "Both are providing funds for establishing hydrogen filling stations."

According to a U.S. Department of Energy Fuel Cell Technologies Market Report for 2015, the hydrogen fuel industry has reached several milestones over the past several years. Among them was gas company Linde, which in 2015 had more than 1 million hydrogen fuelings at BMW's plant in Spartanburg, South Carolina. BMW operates more than 350 fuel cell-powered forklifts to service the plant's production and logistics functions, making it the largest single-site fuel cell forklift fleet in the world.

While the costs of hydrogen stations are declining, their capacities are increasing, the Information Trends report stated. By 2032, hydrogen stations will have aggregate

capacity of 3 million kg/day. The competition for dominance in the fuel-cell vehicle market will be vigorous, triggering significant technological innovations and cost declines, it said.

"Hydrogen is the fuel of the future," Jaffery stated in a news release. "And, the proliferation of hydrogen stations represents the natural progression from fossil fuels to clean energy." The sums of money being poured in hydrogen station deployments is staggering, mostly raised through public-private partnerships."

Hydrogen fuel cells work by electrochemically combining hydrogen and oxygen to produce electricity, water and heat. Fuel cells continuously generate electricity as long as a source of fuel is supplied. Fuel cells do not burn fuel, making the process quiet, pollution-free, and as much as two to three times more efficient than combustion technologies. A fuel cell system can be a truly zero-emission source of electricity when hydrogen is produced from nonpolluting sources.

Last year, *Information Trends* said hydrogen FCVs will catch up to electric vehicle (EV) sales because of the advantage of shorter refuel times and greater drive distances.

The report stated that by 2020, sufficient hydrogen filling infrastructure will be in place in several regions of the world, giving a boost to the market for hydrogen fuel cell vehicles.

Worldwide, more than 20 million hydrogen fuel cell vehicles will be sold by 2032, and those sales will generate up to $1.2 trillion in revenue for the auto industry. By 2050, FCVs will be the "fastest growing segment of the auto market," according to Jaffery.

Source: http://www.computerworld.com/article/3159642/car-tech/hydrogen-refueling-stations-for-cars-to-reach-5000-by-2032.html

UK government commits more support to fuel cell vehicles

Arcola Energy, a developer of hydrogen fuel cells, and Haydale Composite Solutions, makers of gas storage tanks, have received the backing of the British government this week. The two companies will work together to develop a new drivetrain for commercial vans and trucks. The drivetrain will be based on hydrogen technology, which will ensure that the vans and trucks produce no harmful emissions while operating, similar to passenger vehicles equipped with fuel cells.

Funding aims to assist in the development of fuel cell vehicles for the commercial sector

The UK government has committed more than $600,000 to the endeavor, most of which is coming from the Department of Transport. The project is meant to help reduce the emissions that the transportation space is responsible for and assist in improving the air quality in towns and cities. This is part of an overarching initiative from the UK government, which involves funding several projects associated with the development of clean vehicles and the establishment of new infrastructure support systems.

Hydrogen fuel continues to gain traction in the transportation world

Hydrogen fuel is quickly becoming a very popular form of clean power in the transportation space. Most major automakers have either released fuel cell vehicles or plan to do so in the near future. In terms of commercial transportation, fuel cells are still relatively rare, but this is changing quickly due to the growing number of projects, like those in the United Kingdom, that are taking form. Despite these projects becoming more common, the adoption of fuel cell vehicles in the commercial transportation space is expected to continue lagging behind that being seen in other sectors. This is due to lacking infrastructure support.

Initial drivetrain will be a hybrid system

The commercial vans and trucks that will be developed by the partnership between Arcola Energy and Haydale Composite Solutions will initially make use of a hybrid drivetrain. The vehicles will be equipped with a fuel cell system, which will act as a range extender when necessary. In the future, fuel cell vehicles will likely play a major role in the commercial transportation space because of their efficiency and environmentally friendly nature.

Source: http://www.hydrogenfuelnews.com/uk-government-commits-more-support-to-fuel-cell-vehicles/8531062/

New system combines rainwater with renewable energy to produce hydrogen fuel

The United Kingdom's Clean Power Solutions has developed a new system that can reliably produce hydrogen fuel. The new system is designed to be used to generate fuel on site, which could help some organizations overcome challenges associated with operating a fleet of fuel cell vehicles. These vehicles are becoming increasingly popular, especially in the materials handling space. More companies throughout the world are investing in fuel cell vehicles as a way to become more environmentally friendly and comply with increasingly strict emissions regulations coming from governments.

New system can generate hydrogen reliably using rainwater and clean energy

The system designed by Clean Power Solutions will draw upon excess electricity generated by renewable energy solutions. This electricity will then be used to power the electrolysis process. Notably, rainwater will be used by the system, reducing its need to have access to an existing water supply. Clean Power Systems has developed the system to be modular so that it can better accommodate the demand for hydrogen fuel production. Currently, the system is already being put to use in the United Kingdom with plans to expand its use to the rest of Europe in the coming years.

Hydrogen fuel production remains a problematic issue facing fuel cells

Hydrogen fuel production has been one of the major challenges facing fuel cell vehicles, and fuel cells in general. Fuel cells have attracted a great deal of attention because of their efficiency and energy production capabilities. Currently hydrogen fuel production methods are energy intensive, however, and they are heavily reliant on fossil-fuels. This has made fuel cells relatively unpopular when compared to other forms of renewable energy, but they have established a strong presence in the clean transportation and materials handling spaces.

Renewable hydrogen production could make fuel cells more attractive

Using renewable energy and rainwater in the hydrogen fuel production process could encourage more companies to embrace fuel cells. The mobility of Clean Power Solutions' new hydrogen fuel production system will also help companies ensure that their fuel cell fleets have reliable access to the fuel they need to operate effectively. Clean Power Solutions is currently reaching out to other companies in order to determine interest in the new system.

Source: http://www.hydrogenfuelnews.com/new-system-combines-rainwater-with-renewable-energy-to-produce-hydrogen-fuel/8531103/

Ultra-cold storage—Liquid hydrogen may be fuel of the future

When NASA saved a shuttle-era storage facility at the agency's Kennedy Space Center in Florida from demolition five years ago, engineers already had future in mind for what to do with the building. Some three years later, NASA transformed the hangar and installed test equipment at an adjacent field for testing a new ground operations demo unit for liquid hydrogen. The testing has come to a successful conclusion after one and a half years.

The system is comprised of a 33,000 gallon liquid hydrogen storage tank recycled from the Titan Centaur program, with an internal cold heat exchanger supplied from a cryogenic refrigerator. The refrigerator, chiller and associated controls are housed in a metal storage container for insulation and to protect them from the corrosive sand and salt environment.

The system was designed, installed and tested by a team of civil servants and contractors from the center's Cryogenic Test Laboratory, with key support from engineers at NASA's Glenn Research Center in Cleveland and Stennis Space Center in Mississippi.

Testing was done in three phases over 18 months between April 2015 and September 2016. The system was put through its paces using an increasing amount of stored hydrogen - 30, 60 and 90 percent, respectively. The system was tested for three main objectives: zero boil-off, liquefaction and propellant densification.

According to Bill Notardonato, the demo unit's principal investigator in the Exploration Research and Technology Directorate at Kennedy, a zero boil-off capability is a prime candidate for use by the Ground Systems Development and Operations Program (GSDO) at the center, potentially saving NASA millions of dollars compared to pre-

vious operations.

Notardonato's team is consulting with GSDO on the design of the new pad B liquid hydrogen tank and future launch pad systems.

"For Space Launch System launches, GSDO will fill the rocket's core stage and interim cryogenic upper stage with hundreds of thousands of gallons of liquid hydrogen," said Shawn Quinn, GSDO assistant program manager. "An important feature of the new zero boil-off technology is the potential to reduce long-term energy costs and liquid hydrogen commodity costs."

Kennedy is preparing for the first integrated launch of NASA's Space Launch System and Orion spacecraft. Upgrades to Launch Pad 39B, where the rocket and Orion will launch on a test flight in late 2018, include a 1.4-million-gallon hydrogen tank. That's 50 percent larger than the current tank.

"The goal would be to integrate the unit's heat exchange system into the new tank, saving GSDO money by eliminating the loss of hydrogen," Notardonato said. "By accomplishing zero boil-off of liquid hydrogen, we could save one dollar in hydrogen for every 20 cents spent on electricity to keep it cooled."

The new unit contains a cooling system that removes heat and vents it into the atmosphere. What is left is supercooled hydrogen that is stored at minus 423 degrees Fahrenheit.

Liquefaction takes gaseous hydrogen and turns it into a liquid. Instead of the usual method of compression and expansion, the hydrogen is flowed into the tank and cooled down using helium refrigerant from a cryogenic refrigerator.

Notardonato said helium refrigerant is a good choice, because it is a common refrigerant that can meet the needs of an in-situ resource utilization process in deep space.

Propellant densification, or cooling a liquid below its normal boiling point to increase the storage density, was the most challenging objective. The new system performed flawlessly, transforming the liquid hydrogen into the world's largest volume of hydrogen slush at minus 435 degrees Fahrenheit.

Some commercial companies are using densified oxygen for their rockets, enabling cost-effective reusability of their core stages. Densifying oxygen is much easier than hydrogen, but the benefits of densified hydrogen could be far greater, according to Notardonato.

Notardonato said the next goal is to take the portable liquid hydrogen system to another center for densified hydrogen engine testing that could be used for a future commercial launch vehicle, helping to curb the cost of access to space. In parallel, the results are being shared with the GSDO Program and in-situ resource utilization mission planners to increase awareness of this new capability.

"It's an exciting new technology that will benefit NASA's Journey to Mars and has the potential to also benefit the nation's efforts to establish alternative energy sources," Quinn said.

Source:
http://www.spacedaily.com/reports/Ultra_Cold_Storage__Liquid_Hydrogen_may_be_Fuel_of_the_Future_999.html

Enhancing fuel cell performance with graphene

Scientists from the School of Chemical Engineering and Analytical Science, in the University of Manchester have come up with a way to utilize 2D materials in an actual operating direct methanol fuel cell. They have shown that the addition of single layer graphene by Chemical vapor deposition, on to the membrane area has significantly reduced the methanol crossover at the same time obtaining negligible resistance to protons thereby enhancing the cell performance by 50%.

Fuel cells count as interesting energy technology of the near future, as they pave the way for the production of sustainable energy using simple hydrocarbons as fuels. They work by a simple operational mechanism with the fuel oxidation on one side, and oxidant reduction on other side, which liberates electrons used for electrical energy generation. A wide variety of fuels, short chain alcohols have been used so far. Methanol remains a favorable candidate due to its high energy density, ease of handling and other operational characteristics.

Hence methanol fuel cells find their potential use in lap-

top chargers, military applications or other scenarios where the access to electricity is difficult. However the wider spectrum of commercial potential for methanol systems is greatly hindered by the methanol crossover occurring in the membrane area of fuel cells.

This passage of methanol from anode to the cathode through the membrane, creates short circuit and affects the fuel cell performance negatively. This is mitigated by using a barrier layer, in addition to the membrane used.

Andre Geim and his co-workers discovered the proton transfer through the single layer graphene and other 2D materials. Graphene is also known for its dense lattice packing structure, inhibiting the passage of methanol and other hydrocarbons based molecules across the membrane. However the actual application of these 2D materials, in fuel cell systems has not yet been realized.

Previous work in this field also tested different materials that yielded improved performance by reducing the methanol crossover, but these also significantly reduced proton transport, as opposed to this work in which transport remained unharmed. This would be of significant interest, as this would lead to usage of 2D materials in fuel cells.

Moreover, this gives the opportunity for membrane less fuel cell system operating with higher efficiency in the near future. This technology could further be extended to other fuel cells types namely hydrogen fuel cells. Hydrogen fuel cells, suffer from the usage of high cost humidifier, as these membranes need to be humidified for improved proton conductivity.

Whereas graphene showed improved proton conductivity with temperature, without the need for humidifier systems. The future prospect could be realized in such a way that the fuel cells will make a significant contribution to the future energy demand.

Source:
http://www.chemeurope.com/en/news/161395/enhancing-fuel-cell-performance-with-graphene.html

Safe and inexpensive hydrogen production as a future energy source

A research team led by Kiyotomi Kaneda and Takato Mitsudome at Osaka University have now developed a catalyst that realizes efficient environmentally friendly hydrogen production from organosilanes. The catalyst is composed of gold nanoparticles with a diameter of around 2 nm supported on hydroxyapatite. The catalyst was synthesized from chloroauric acid using glutathione as a capping agent to prevent nanoparticle aggregation, resulting in the formation of small size of gold nanoparticles. Glutathione-capped gold nanoparticles were then adsorbed on hydroxyapatite and glutathione was removed by subsequent calcination.

The team then added the nanoparticle catalyst to solutions of different organosilanes to measure its ability to induce hydrogen production. The nanoparticle catalyst displayed the highest turnover frequency and number attained to date for hydrogen production catalysts from organosilanes. For example, the nanoparticle catalyst converted 99% of dimethylphenylsilane to the corresponding silanol in just 9 minutes at room temperature, releasing an equimolar amount of hydrogen gas at the same time. Importantly, the catalyst was recyclable without loss of activity. On/off switching of hydrogen production was achieved using the nanoparticle catalyst because it could be easily separated from its organosilane substrate by filtration. The activity of the catalyst increased as the nanoparticle size decreased.

A prototype portable hydrogen fuel cell containing the nanoparticle catalyst and an organosilane substrate was fabricated. The fuel cell generated power in air at room temperature and could be switched on and off as desired. Images of the catalyst after use in the fuel cell resembled those of the unused catalyst, indicating that the hydroxyapatite-supported nanoparticle catalyst readily resisted aggregation.

Generation of hydrogen from inexpensive organosilane substrates under ambient conditions without additional energy input represents an exciting advance towards the goal of using hydrogen as a green energy source.

Source:
https://www.sciencedaily.com/releases/2016/12/161220094445.htm

University of Tennessee research reveals potential for 50-fold increase in catalyst mass activity

One of the stumbling blocks that has held back more widespread adoption of certain forms of green energy has been the high cost associated with first converting to them.

Research being conducted by a team of UT and US Department of Energy (DOE) national laboratories could soon change that. Their work has led to a new understanding of how and where electrochemical reactions occur, garnering them acclaim from the American Association for the Advancement of Sciences journal *Acclaim*.

That research—"Discovery of true electrochemical reactions for ultrahigh catalyst mass activity in water splitting"—allows the design of hydrogen-producing cells that increase the catalyst mass activity 50 times higher than before. This discovery is expected to lead to opportunities to maximize the use of catalysts and significantly reduce the cost of proton exchange membrane electrolyzer cells (PEMECs), which could contribute to an affordable supply of renewable hydrogen as we seek deeper decarbonization of the United States' energy supply.

"We discovered that placing the catalyst layer adjacent to good electrical conductors drastically increased the performance," said Feng-Yuan Zhang, an associate professor in UT's Mechanical, Aerospace, and Biomedical Engineering (MABE) Department and in NanoHELP. "In doing so, we can significantly reduce the cost of such devices."

An added benefit to the great increase in hydrogen production would be better adaptation and adoption of carbon-free forms of energy.

The big change in the new approach was a move from traditional electrolysis technology to what is known as proton exchange membrane electrolyzer cells (PEMECs). These cells have a higher response rate, a better efficiency, and are more compact than previous cells, among other advantages. The main purpose of PEMECs is to split water into its components—hydrogen and oxygen—before filtering and collecting the hydrogen. To improve the affordability and performance of PEMECs, it is important to understand the fundamental principles and operational dynamics of the electrochemical reactions occurring in PEMECs. However, these fast and microscale reactions are often masked from observation in locations behind other components.

"The challenge is that the conventional design of PEMECs makes it hard to observe the process," said Zhang. "With reactions taking place so rapidly at the center of PEMECs and at such a small scale, it makes it that much more difficult to study."

To overcome that, Zhang and the team developed novel materials and designed a transparent PEMEC with optical access to the ultrafast reaction sites, a critical step in understanding and perfecting the process.

"The work shows a potential pathway toward significantly reduced catalyst loading and reduced cost for electrolyzers, which has been a key impediment to their widespread implementation," said Matthew Mench, co-author and head of the department at UT.

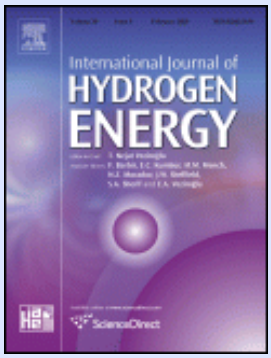
To confirm this finding, the researchers fabricated a novel PEMEC by sputter coating catalyst on the liquid/gas diffusion layer (LGDL), rather than spraying it in a uniform layer on the membrane. The measured PEMEC performance was similar to, though slightly lower than, that of the conventional catalyst layer. However, the new catalyst layer on the LGDL was only 1/1000th the thickness of the conventional layer, resulting in a 50-fold increase in catalyst mass activity compared with conventional catalyst-coated membranes.

"Our partners at the University of Tennessee had an idea about how to improve the performance PEMECs," said Green, now associate lab director for mechanical and thermal systems engineering at the National Renewable Energy Laboratory (NREL). "The collaboration made it possible to take it a step further, bringing together electrochemical research and advanced manufacturing expertise to improve the efficiency of producing and storing hydrogen."

Along with Zhang, Mench, and Green, fellow members of MABE Jingke Mo and Zhenye Kang took part in the project along with ORNL's Scott T. Retterer, David A. Cullen, and Todd J. Toops.

Source: http://mabe.utk.edu/ut-research-reveals-potential-for-50-fold-increase-in-catalyst-mass-activity/

International Journal of Hydrogen Energy Highlights



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

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   Gahleitner, G. Int J Hydrogen Energy 2012;38(5), 2039–61.

Techno-economic assessment of a plane based on a three reactor chemical looping reforming system

-Mohammed N. Khan and Tariq Shamim. Int J Hydrogen Energy 2016:41(48): 22677-22688

The feasibility of an innovative hydrogen reforming technique called chemical looping reforming (CLR) was analyzed both from a thermodynamic and economic perspective. CLR uses three different reactors to produce H_2 while capturing CO_2 in separate streams. Because CLR technology is relatively new, it has only been tested at a pilot plant level therefore, this study analyzed operational parameters and economic factors that can affect the cost of hydrogen when it is produced with this technique. The commercial viability of CLR strongly depends on the cost of H_2 production compared with other competing technologies such as steam reformation of natural gas, electrolysis, oil, etc. The results of this study can be used to find the optimum parameters, which will give the best performance of the plant based on the electrical and H_2 production efficiencies. From a thermodynamic perspective the effect of fuel flow rate (natural gas), steam flow rate, air flow rate and excess oxygen carrier percentage were varied and their effects on hydrogen efficiency, global efficiency and electrical efficiency were analyzed. Likewise, a parametric economic study was performed looking at the effects of capacity factor percentage, output electricity price, fuel price and iron oxide price on the cost of hydrogen. The costs are noted to be based on estimates in the United Arab Emirates where the study was performed. The results showed that the electrical efficiency depends on the amount of steam produced, which in turn depends on the reactor temperatures. The researchers looked at both CO_2 capture and non-capture technologies, which affect operating costs and overall efficiencies. The cost of H_2 in non-capture scenario is 1.404 $/kg, while with CO_2 capture, it is 1.679 $/kg. This price compares favorably with the price of 2.39 $/kg, which is the estimate for steam methane reforming.

http://www.sciencedirect.com/science/article/pii/S0360319916327306 *-By Cyrus Daugherty*

South African hydrogen infrastructure (HySA infrastructure) for fuel cells and energy storage: Overview of a projects portfolio

-Dmitri Bessarabov, Gerhardus Human, Andries J. Kruger, Steven Chiuta, Phillimon M. Modisha, Stephanus P. du Preez, Stephanus P. Oelofse, Immanuel Vincent, Jan Van Der Merwe, Henrietta W. Langmi, Jianwei Ren, Nicholas M. Musyoka . Int J Hydrogen Energy 2017. In press.

There exists a major challenge in Africa: 1.1 billion people live on the continent with 65% of the population having no access to electricity. It is predicted that by 2050 Africa's population would reach 1.9 billion and consequently, energy supply and access will continue to be major issues. South Africa is well endowed with Platinum Group Metals (PGM, such as Platinum, Palladium, etc.) and other mineral resources such as Titanium, Vanadium, Chromium, etc. Minerals and PGM beneficiation is currently a top priority for South African government as it is hoped to unlock foreign investments and to attract downstream value-adding manufacturers which in turn will create jobs.

The National Flagship Program, HySA (Hydrogen South Africa), is aimed at developing South African intellectual property, knowledge, human resources, products, components and processes to support the South African participation in the nascent, but rapidly developing international platforms in Hydrogen and Fuel Cell Technologies. HySA comprises of three R&D Centers of Competence: HySA Catalysis, HySA Systems and HySA Infrastructure. The Department of Science and Technology (DST) published the Ten-Year Innovation Plan for South Africa in 2007. According to this plan, one of the grand challenge outcomes for South Africa to have achieved by 2018 includes: Energy security—the race is on for safe, clean, affordable and reliable energy supply, and South Africa must meet its medium-term energy supply requirements while innovating for the long term in clean coal technologies, nuclear energy, renewable energy and the promise of the "Hydrogen Economy".

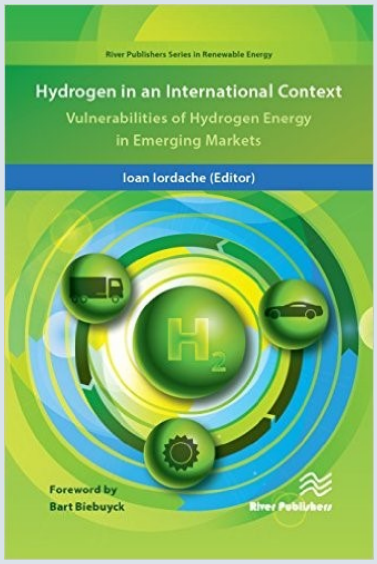
The paper provides brief introduction to the National South African Program, branded HySA as well as discussing potential business cases for deployment of hydrogen and fuel cell technology in South Africa. This paper also describes some key activities in the area of hydrogen production and storage within HySA Infrastructure Center of Competence in South Africa. The content of this paper is based on the presentation given during the recent WHEC 2016 Congress in Zaragoza, Spain. More specifically, the discussion of activities at HySA Infrastructure Center of Competence in the paper includes hydrogen production and storage.

http://www.sciencedirect.com/science/article/pii/S0360319917300034 *-By Yasser Ashraf Gandomi*

From the Bookshelf

Hydrogen in an International Context: Vulnerabilities of Hydrogen Energy in Emerging Markets

Editor: Ioan Iordache, Romanian Association for Hydrogen Energy, Romania



Hydrogen in an International Context: Vulnerabilities of Hydrogen Energy in Emerging Markets describes strategies and developments for hydrogen civilization efforts realized by various stakeholders such as authorities, institutes, research, industry, and individuals, in different countries and at different stages of the development cycle. Through their contributions, the authors in this book propose a new approach to relevant topics of interest, generically called the hydrogen economy and civilization.

Hydrogen vulnerabilities is a topic that includes new challenges that face the hydrogen energy market. Weaknesses for the hydrogen stakeholder are becoming more specific, and it is necessary to be current on these topics to understand the issues that Hydrogen energy faces. A prosperous implementation of hydrogen will require the assimilation of numerous, diverse and unfamiliar concepts into the public lexicon.

This book informs the reader about the status of hydrogen energy in the international market, and it includes a series of examples and case studies about hydrogen activities in various countries. Thus, due to the synergy of this collection of contexts for hydrogen civilization development, the reader should be able to reach a level of intuition enabling them to see the strengths and weaknesses of hydrogen.

http://www.riverpublishers.com/book_details.php?book_id=325

Become a Member of IAHE

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

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

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

Research Group Highlight

The Center for Energy Research

The Center for Energy Research (CER) was established at UC San Diego in 1972 to develop solutions for the growing challenges of energy supply and utilization in the society. The members of CER includes internationally recognized scientists, faculty from multiple UCSD departments, visiting scholars from all over the world, and students.

In this center, basic and applied research is conducted in fusion, solar energy, fuel cells, energy storage, and related disciplines. CER also sponsors energy-related lectures, symposiums, and academic conferences.

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

1. Renewable Energy

CER's focus on the renewable energy research includes:

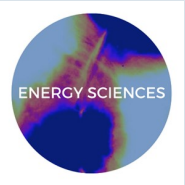
- Coimbra Energy Group
- Solar Resource Assessment and Forecasting Lab
- Urban Energy Efficiency Lab

2. Fuel Cells

CER's main focus is solid oxide fuel cells (SOFCs) with the focus on three main areas:

- Fundamental research on cell components and cell-stacks
- Experimental and theoretical studies to solve key performance and stability issues
- Development of innovative concepts to reduce cost, improve durability, and increase SOFC system efficiency.

3. Energy Sciences



CER' explores the different aspects of energy sciences via:

- High Energy Density Physics (HEDP) Laboratory
- Pulsed Power Plasmas
- Laser Matter Interactions

4. Energy Storage

CER's main objective for energy storage program includes:

- Accommodate Higher Levels of Renewable Generation
- Improve Operational Capability of Energy Storage
- Advance Energy Storage Technology
- Promote Commercial Development
- Optimize Resources, Microgrid Operations
- Grid Integration of Energy Storage

5. Fusion Energy

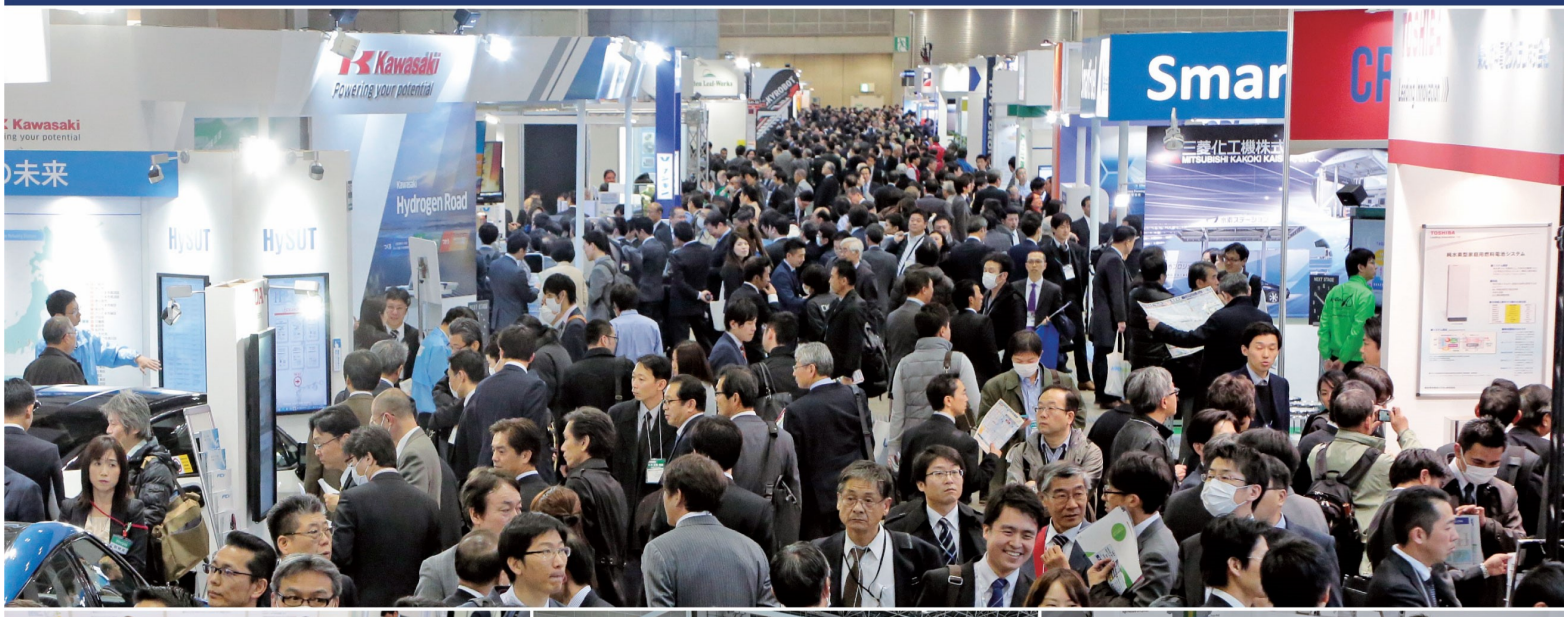
CER exploring the challenges and opportunities of fusion energy through the following projects:

- PISCES
- Confinement Systems
- ARIES
- Inertial Confinement Fusion (ICF)

Contact Info

9500 Gilman Drive #0417
La Jolla, California 92093-0417
P: (858) 534-6527
F: (858) 534-7716
Link: http://cer.ucsd.edu/about/index.html

Your Key Show in the Hydrogen & Fuel Cell Industry!



Held inside **World Smart Energy Week 2017**

13th Int'l Hydrogen & Fuel Cell Expo

FC EXPO 2017

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

Organised by: Reed Exhibitions Japan Ltd.

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

Exhibiting Information? >>> FC EXPO

WHTC 2017

THE 7TH WORLD HYDROGEN TECHNOLOGY CONVENTION
TOGETHER WITH CZECH HYDROGEN DAYS 2017
9–12 JULY 2017, PRAGUE, CZECH REPUBLIC

The 7th Hydrogen Technology Convention together with the Czech Hydrogen Days 2017 will be held on 9–12 July 2017 in Prague, Czech Republic.

The congress theme, "The Future Might Be Closer Than You Think", recognises that a clear trend is emerging towards the integration of renewable energy and hydrogen technology as a key enabling pathway towards 100 % renewable energy systems. An important part of the congress will be the exhibition of existing industrial solutions.

The organisers will gratefully accept any kind of support for the WHTC 2017 in Prague. Please see the partnership brochure to see the many possibilities on how to present your company at the event.

www.whtcprague2017.cz
www.whtcprague2017.cz/industry.htm

We look forward to seeing you in July 2017 in Prague!

Martin Fišer
UNITED HYDROGEN GROUP
Chief Representative for Europe
Czech Hydrogen Technology Platform
Chairman of The Board

Karel Bouzek
University of Chemistry
and Technology Prague
WHTC 2017 Scientific Committee Chairman

Chairpersons of WHTC 2017

Czech Hydrogen Technology Platform

Prague Congress Centre, 5. kvetna 65, 140 21 Prague 4, Czech Republic, www.kcp.cz

Conference Topics

Transportation Systems

New Trends

- Fuel cell & fuel cell stacks
- Fuel cell for powertrain
- Fuel cell as an auxiliary power supply

Deployment

- Road vehicles
- Refuelling infrastructure
- Non-road mobile vehicles
- Maritime, rail and aviation applications

Energy Systems

New Trends

- New materials and processes for hydrogen production
- Hydrogen energy conversion and utilization
- Materials and technologies for hydrogen storage

Deployment

- Hydrogen production from renewables, grid balancing
- Fuel cell systems for CHP and UPS
- Power to Gas
- Hydrogen storage, handling, and distribution

Cross-cutting issues

- Safety, education, and training
- Legislation, pre-normative research
- Experiences from complex demonstrations projects
- Hydrogen regions
- Financing of hydrogen technology

Czech Hydrogen Days 2017

- Situation in Central and Eastern Europe
- Situation in small countries
- Regional and Visegrad collaboration
- Tailored information for state and urban employees as well as for interested industrial partners

Registration fees

Registration fee	EARLY	LATE	ON-SITE
	until 12 April 2017	until 27 June 2017	as of 28 June 2017
IAHE, HYTEP Member *	560 EUR	710 EUR	810 EUR
Non-Member	680 EUR	830 EUR	930 EUR
Student **	330 EUR	480 EUR	580 EUR
Accompanying person	100 EUR	130 EUR	160 EUR

All fees are stated including the VAT. * To qualify for the respective fee, membership must be valid until the end of July 2017. ** The official proof of student status must be submitted online as a PDF attachment while registering.

WWW.WHTCPRAGUE2017.CZ

Upcoming Meetings & Activities

March 2017

FC EXPO 2017, 13th Int'l Hydrogen & Fuel Cell Expo
March 1-3, 2017
Tokyo, Japan
http://www.fcexpo.jp/en/

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

April 2017

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

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

18th International Conference on Emerging Nuclear Energy Systems
April 24-27, 2017
Hefei, Anhui, China
http://icenes2017.org

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

May 2017

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

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

June 2017

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

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

International Hydrail Conference 2017
June 27-28, 2017
Graz, Austria
http://hydrail.org/

HYPOTHESIS XII
June 28-30, 2017
Siracusa, Italy
http://www.hypothesis.ws/

July 2017

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

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

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

Get Connected—Internet Groups of Interest

LinkedIn Connections

Hydrogen Group

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

Global Hydrogen Ambassadors Network

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

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

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

Hydrogen Pathway

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

Renewable Energy Solutions

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

Global Renewable Energy Network

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

Fuel Cell & Hydrogen Network

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

Fuel Cells

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

Fuel Cell Energy

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

Facebook Connections

Horizon Fuel Cell Technologies

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

International Association for Hydrogen Energy

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

Blogs

Fuel Cell Nation

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

H2-International

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

Contacts and Information

Board of Directors

On the Web

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