MOBILITY INDUSTRY INSIDER

Q1 2020 | Pulse
Alternate Fuels

Succinct **PERIODIC SUMMARY OF DEVELOPMENTS** across trends, players activities, FutureBridge viewpoint, and what it means for industry participants

FutureBridge

WHAT'S INSIDE!

In Q1 2020 we saw more Supplier-Start up collaborations for fuel cell commercialization. Researchers are rigorously working to overcome the drawbacks of fuel cells. With the help of players such as Mazda, VW and Porche, Biofuels are catching pace in the market.

Q1 2020 Pulse also contains:

- Our take on the impact of COVID-19 on alternate fuels: With gasoline prices so low, the pressure is off to invest in alternative fuels
- Insights on research works in Fuel Cells and player activities
- Highlights from the development of our Startup Tracker

01 Emerging trends

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Fuel cell commercialization boosted by additional infusion of money by suppliers

CONTEXT

Suppliers are seeing the future potential for fuel cells in automotive applications. They are investing millions on startups who are developing fuel cells to get license and royalty across system in production. Bosch, one of the largest fuel cell suppliers has estimated that up to 20 percent of all-electric vehicles worldwide will be powered by fuel cells by 2030. The world's biggest automotive supplier by revenue is bullish on the potential of fuel cells for commercial vehicles.

The EU's fleet requirements for trucks call for a reduction of CO_2 emissions by 15% on average by 2025, and 30% by 2030. This will give a broad scope for the adoption of fuel-cell technology in the CV market. Suppliers such as Bosch and Cummins are working with fuel cell-based startups to support this trend.

Developments

- PowerCell has received an order of €1.05m for its S3 fuel cell stacks from Bosch. The stacks will be delivered to Bosch within the framework of joint development and licensing agreement between the two companies signed in April 2019.
- Cummins is continuing its investment in fuel cell technology by making an additional cash investment in Loop Energy. In exchange, Loop Energy was to supply Cummins with range extender systems for incorporation into demonstration trucks.
- Bosch has agreed to become a significant strategic investor in Ceres Power Holdings Plc. by increasing its current stake in Ceres to around 18% from 3.9%. Bosch is looking for the large opportunity of highly efficient solid oxide fuel cells in the future energy sector. The total investment by Bosch will be approximately €90 million (US$100 million).
- PowerCell has signed an exclusive distribution agreement for the Japanese market with Inabata & CO. Ltd. The new agreement gives the company an exclusive license to market and sells all PowerCell's products to all segments in the Japanese market, with the exception of the fuel cell stack and system based on the PowerCell S3 for the automotive segment.

PowerCell ➡ Shares have risen to **28%** >>

ITM Power ➡ Shares are up by more than **45%** >>

DEVELOPMENTS Emerging Trends

- By 2023, the European Commission shall evaluate the possibility of developing a common methodology for the assessment and reporting of the full life-cycle CO2 emissions of heavy-duty vehicles.
- Nissan partnered with Ceres Power to develop solid-oxide fuel cell technology for EV applications.

> "Commercializing technology is one of our strengths. We are now going to take on this task with determination and develop this market"
> *- Dr. Stefan Hartung, member of the Bosch board of management and chairman of the Mobility Solutions*

What should you investigate ?

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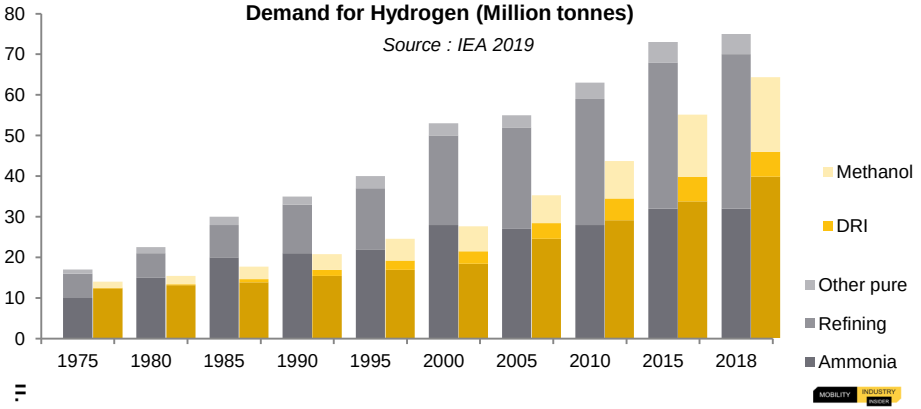
FutureBridge on fuel cell commercialization boosted by additional infusion of money by suppliers

- Suppliers are seeing potential profits in the area of billions of euros in the fuel cell technology business in the long term.
- Suppliers are looking for future aspects of fuel cells such as, Solid oxide fuel cells, which eliminates the limitations due to liquid electrolytes in PEM FCs. Bosch's investment (Increasing stake from 3.9 % to 18%) in Ceres Power shows the new trend in the fuel cell market. OEMs such as Nissan are expanding their fuel cell vehicle range with the support of startups
- Funds from a supplier will be used to further accelerate the startup's product development activities, project deployments, and growth plans.
- In commercial transport applications, fuel cell range-extended vehicles are preferred since there is no emission, no impact on vehicle payload weight or power demands or refueling time compared to battery-only systems. Startups who are working on this are getting more funding from suppliers and OEMs.

What should you investigate?

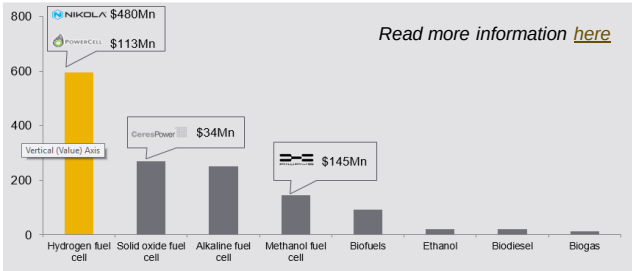
What are the challenges start-ups are facing to commercialize fuel cell technology?

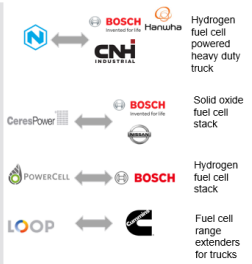
Why suppliers are focusing more on fuel cell range extenders?



Funding distribution & activities

Investors show interest in Hydrogen fuel cells





- Hydrogen fuel cell technology finding penetration in the commercial vehicle segment which is one of the main reasons for increased funding in startups which are working on fuel cells.
- Solid oxide fuel cells and Methanol fuel cell technology are emerging and can expect that it will gain more momentum in the future. Biofuels are also at the top of the investment priority list.

Read more information in Feb 2020 AF bulletin

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Q1’20 saw rigorous research in fuel cells owing to traction by the automotive sector

CONTEXT

Researchers are focusing on developing, integrating, and demonstrating hydrogen production and delivery, hydrogen storage, and fuel cell technologies for transportation, stationary, and portable applications.

Projects are ranging from fundamental research to overcome technical barriers, manufacturing process improvement to enable high-volume fuel cell production, systems analysis to identify the most promising commercialization pathways, and market transformation to support early market deployments.

Developments

- Ballard Power systems developed a Proton-Exchange-Membrane (PEM) fuel-cell technology for heavy and medium-duty industry applications that can travel up to 30 million kilometers (18.5 million miles) on roads.
- Isuzu and Honda have reached an agreement to conduct joint research on fuel cell-powered heavy-duty trucks.
- Researchers from Lawrence Berkeley National Laboratory (LBNL) and Nissan Research Center report on their investigation of the internal reforming of ethanol fuel on high-performance metal-supported solid-oxide fuel cells (MS-SOFCs) with infiltrated catalysts.
- US DOE awards Nel subsidiary funds for reversible fuel cell research. Proton Energy Systems Inc has been awarded $1.85 million by the US Department of Energy to develop a reversible fuel cell system capable of producing low-cost hydrogen, parent company Nel ASA

DEVELOPMENTS Emerging Trends

Researchers in Israel have designed a separate-cell photoelectrochemical (PEC) water-splitting system with decoupled hydrogen and oxygen cells for centralized hydrogen production

Researchers at the University of Ontario Institute of Technology are developing a new method to dissociate water vapor into hydrogen gas by microwave-generated plasma (plasmolysis).

What should you investigate ?

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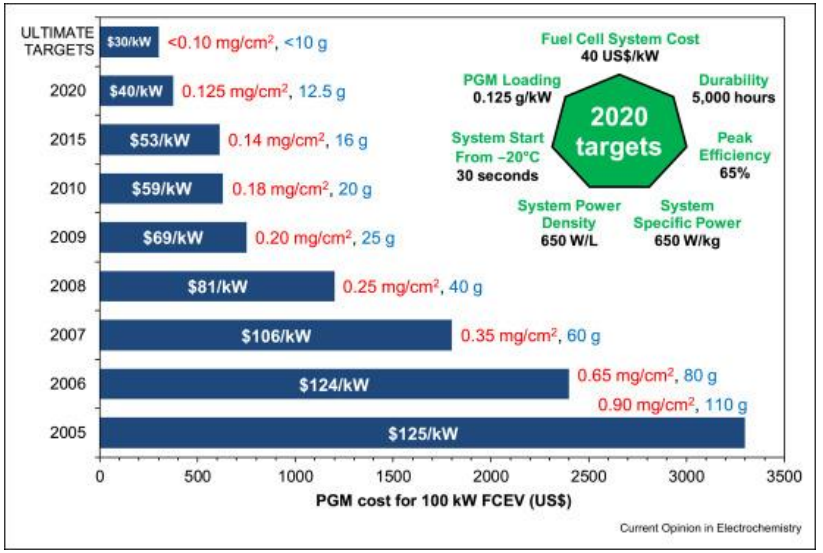
FutureBridge on rigorous research in fuel cells owing to traction by the automotive sector

- Automotive proton-exchange membrane fuel cells (PEMFCs) have finally reached a state of technological readiness where several major automotive companies are commercially leasing and selling fuel cell electric vehicles. Researches are going on the areas of improvement such as performance at high current density, durability, and cost.
- One of the biggest drawbacks is inefficiency. Currently, the catalysts used are expensive and do not work effectively. By increasing catalyst efficiency, the utility of fuel cells would expand.
- Researchers from the University of Aberdeen have discovered a new family of chemical compounds collectively known as a 'hexagonal perovskites'-could be the key to unlocking the potential of ceramic fuel cells. Scientists are claiming that the material exhibits high conductivity at lower temperatures. CFC is a fuel cell-based around a ceramic electrolyte material that exhibits high protonic conductivity at elevated temperatures.
- Toyota has developed a specially-designed fuel cell system using components of Mirai, for the world's first energy self-sufficient seagoing vessel powered by hydrogen – Energy Observer.
- Increasing catalyst activity has been considered as one of the major pillars in FC research. As the sluggish oxygen reduction reaction of the cathode dictates the overall performance of the cell, many efforts have been focused on investigating novel materials and structures regarding this perspective
- The application scope of fuel cells is expansive, including material handling, portable, stationary, power backup and transport. Fuel cells have myriad advantages over combustion-based devices, with over 60 percent efficiency in the conversion of the fuel's chemical energy to electrical energy.



Source >>

What should you investigate?

Why researchers are working to find new materials for fuel cell catalysts?

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Players clinging towards internal combustion engines powered by biofuels

CONTEXT

Governments around the world are thinking about banning gasoline and diesel cars in the decades to come.

But companies such as Mazda, VW, and Porsche still believe in IC engines and are backing a range of research projects that could help biofuels to survive in the future. They are expanding their IC engine vehicle range as well as research in synthetic biofuels endeavor with Universities.

There's a strange, magical appeal to alternative liquid fuels among those who want to preserve the status quo for internal combustion.

Developments

- Mazda continues to be involved in joint research projects and studies as part of an ongoing industry-academia-government collaboration to promote the wide-spread adoption of biofuels from microalgae growth. The company expects to continue using internal combustion engines in tandem with electric motors in around 95 percent of its cars in 2030. The company also expects liquid fuels to remain "dominant" in the automotive sector until "at least 2040.

- Volkswagen believes synthetic fuel created from biomass, or other sources, would keep combustion engines relevant. They are derived from natural materials and seem to be carbon-neutral, not emitting CO2 as well as harmful materials.

- Ford Europe approves the use biofuel Hydrotreated Vegetable Oil (HVO) as fuel in its Transit vans. The particular kind of biodiesel approved could reduce greenhouse gas emissions up to 90 per cent.

DEVELOPMENTS Emerging Trends

The US Department of Energy (DOE) announced up to more than $96 million in funding for bioenergy research and development. The main objectives of this project are to reduce the price of drop-in biofuels and scale-up risk of biofuel and bio product processes.

U.S. Agriculture Department will make available up to $100 million in grants to expand the infrastructure needed to sell more ethanol, biodiesel and other renewable fuels

What should you investigate ?

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FutureBridge on players clinging towards internal combustion, citing benefits of biofuels

- Mazda says that biofuels could make combustion-powered vehicles carbon-neutral. But like Porsche with synthetic fuels, Mazda believes its alt-fuel of choice, apparently microalgae biofuel needs more work to reduce cost. Mazda is collaborating on research in this endeavor with Hiroshima University and the Tokyo Institute of Technology. Audi has already revealed it is developing E-gasoline and e-diesel – a carbon-neutral synthetic diesel and both sulphur and benzene-free. BMW divulged that it remains committed to traditional petrol for another 30 years and carry on selling diesel for at least another two decades.
- Countries are implementing biofuel mandates even in the middle of the electrification boom. Malaysia expects to fully implement its B20 biodiesel program by mid-2021, rolling out the palm biofuel blend to 3,400 petrol stations nationwide. Brazil has increased the volume of biodiesel blended into diesel fuel around the country from 11% to 12%.

What should you investigate?

Which countries have implemented Biofuel mandates?

What are the key drivers that could help in the market penetration of Biofuels?

Expert statements on future scope of Internal combustion engine

"Expecting that internal combustion engines combined with some form of electrification will still account for some 95 percent of the vehicles it produces in 2030, and that liquid fuel will remain dominant in the automotive industry until at least 2040, Mazda considers a renewable liquid fuel essential to drastic CO2 reduction."

-Mazda spokesperson

We take our CO2 targets very seriously and want to be a role model on CO2, but that doesn't mean we will exclude the combustion engine.
- Matthias Rabe, VW's technical chief

We'll continue with petrol engines in the 911 and improve them step by step. We keep on investing in combustion engines. It's core to Porsche – especially the 911. We underlined the investment in future technology, but we have future investment in internal combustion also.
- Oliver Blume, CEO Porsche

02 Market trends: impact of COVID-19 on Alternate fuels

COVID-19 outbreak and negative impacts on Alternate fuels market

The fossil fuel market has succumbed due to COVID-19. A sharp decline in the oil market has been reported due to locked down announcements by governments all over the world to prevent the spread of the pandemic.

- Many U.S. ethanol plants have slashed production over March 2020 or idled entirely as the coronavirus outbreak cut into fuel consumption and cratered margins to refine the corn-based fuel.
- As governments urge people to stay indoors to curb the outbreak, fuel demand has tapered.

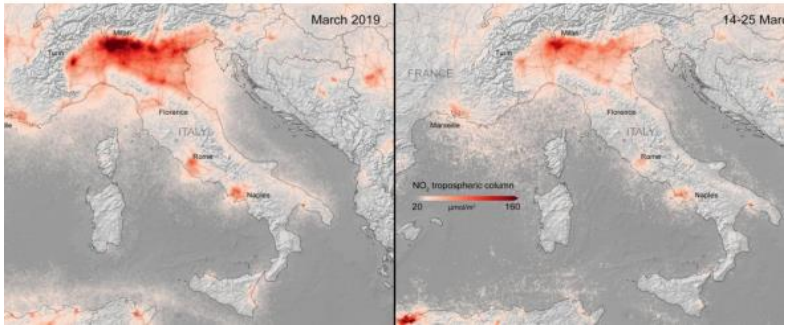
- COVID-19 is expected to wreak havoc on the biofuel sector and that is already depressing corn and other grain prices.
- U.S. gasoline includes about 10 percent ethanol. But the demand for gasoline is decreasing due to COVID-19 restrictions.

- Fuel cell stocks crashed, after an incredible run higher over the past six months, due to COVID-19 outbreak.
- Investors worried about Corona's outburst, thinking that the demand for fuel cells might decrease as the economy goes into recession.

COVID-19 positive impact on air pollution : opportunity for Alternate fuels

According to WHO, air pollution kills an estimated 7 million people around the world annually - significantly higher rates of death in people with COVID-19!

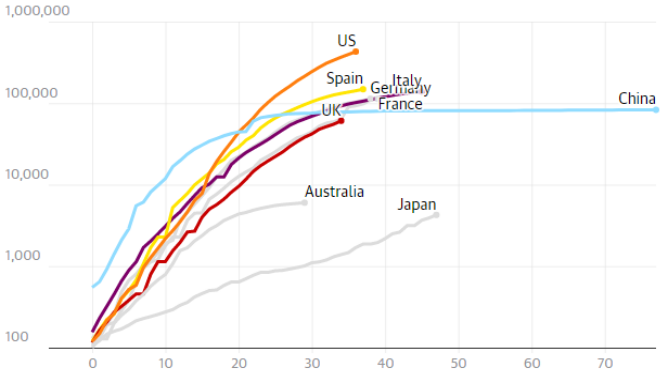
- Studies indicated a reduction of around **20-30 %** in surface **particulate matter** and **40%** in **NO2** over large parts of China.
- Cities in Italy such as Rome and Milan, the concentration of nitrogen dioxide (NO2), got reduced to **26** and **35%**



Images captured by European Space Agency (ESA) showed huge reductions in nitrogen dioxide concentrations over **Italy**

Source >>

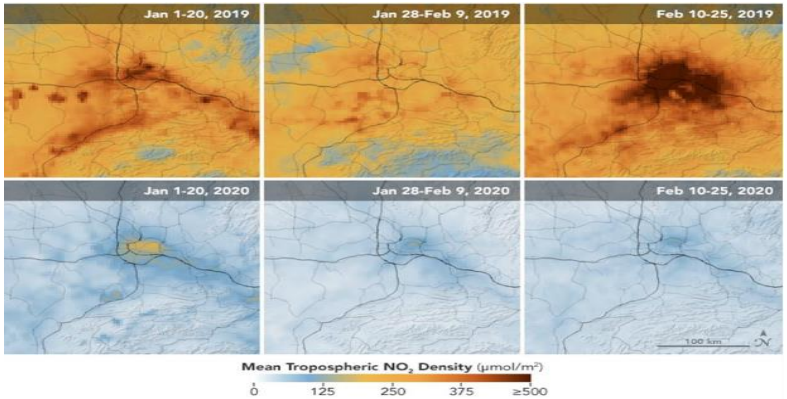
Confirmed cases of Covid-19 for selected countries



Source: Johns Hopkins CSSE Note: The CSSE states that its numbers rely upon publicly available data from multiple sources, which do not always agree

Source>>

Max no. of COVID-19 confirmed cases ~ low air pollution rates



Images captured by NASA showed huge reductions in nitrogen dioxide concentrations over **China**

Source >>

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COVID-19 positive impact on air pollution : opportunity for Alternate fuels

With gasoline prices so low, the pressure is off to invest in alternative fuels.

The main driver of climate change is fossil fuel combustion

After lockdown the air, pollution rate is going to rise again.

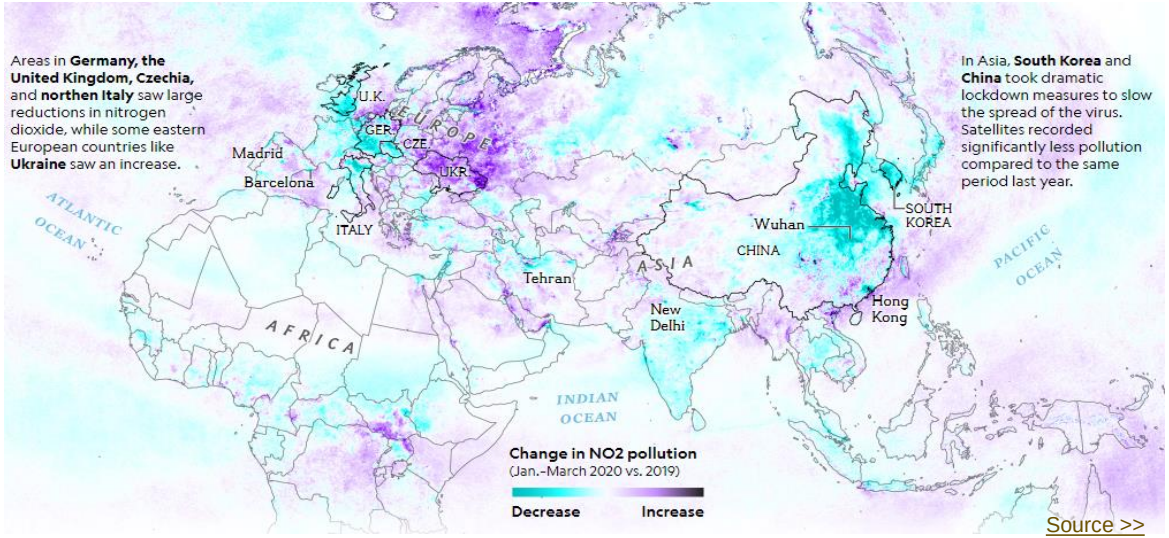
Alternate fuel vehicles plays a role in emission reduction.

AFV could reduce the mass emissions of volatile organic compounds (VOCs) and oxides of Nitrogen (NOx) and could decrease the atmospheric reactivity of the emissions (by using Methanol or Natural gas).

EVs can also reduce emission, but the electricity production is still depended majorly on fossil fuels, which indirectly increases emissions

Hydrogen fueled vehicles emit virtually no hydrocarbons, particulates, carbon dioxide, or carbon monoxide.

Heavy-duty vehicle use of hydrogen fuel cell or Methanol or Natural gas appears promising.



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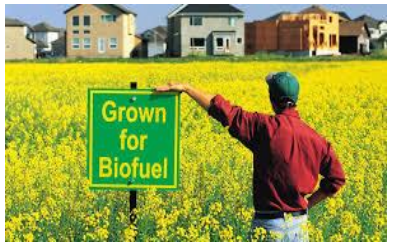
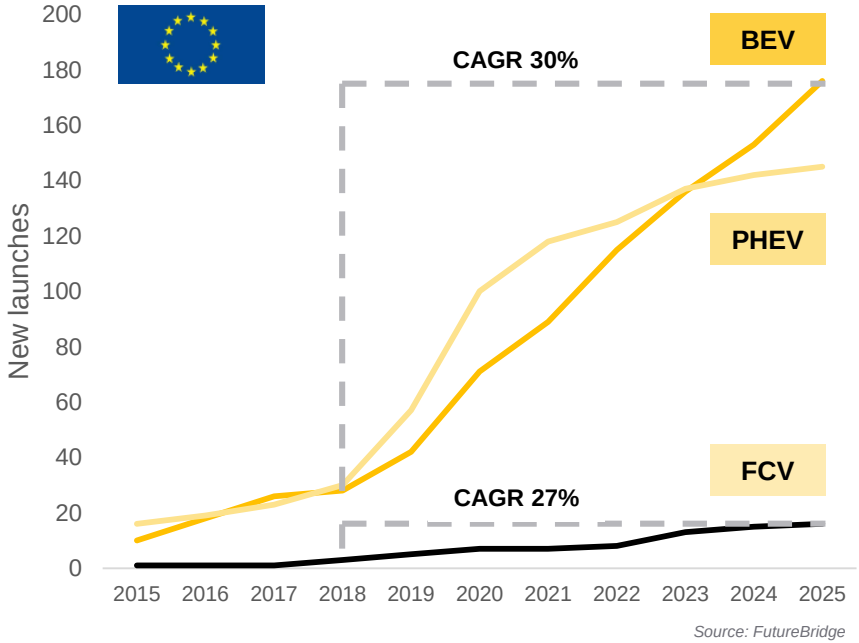


03 Regional adoption of fuel cells

Regional adoption of hydrogen fuel cell technology: Europe

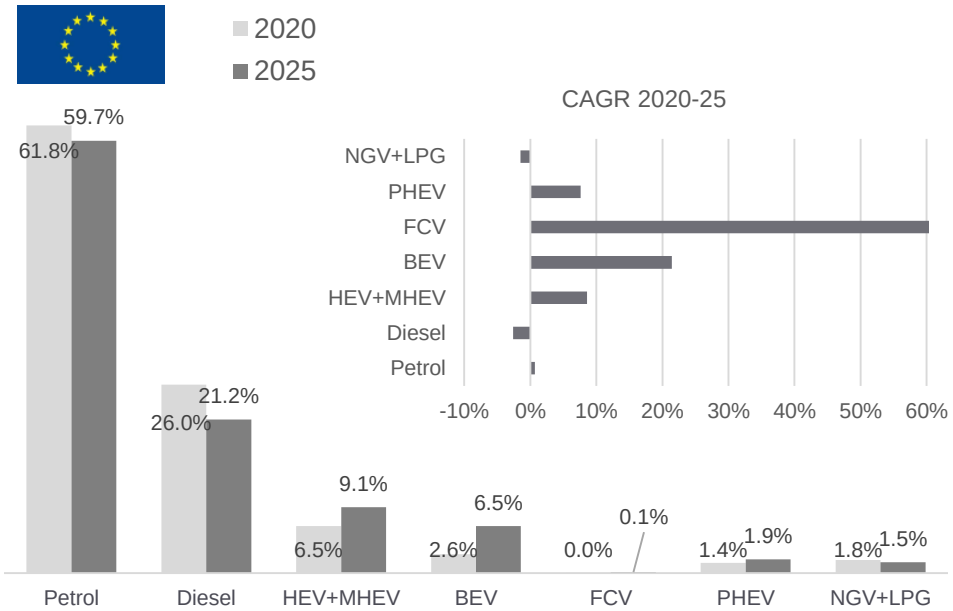
Carmakers respond to emission compliance with BEV, PHEV & FCEV offensive. Compliance with 2025/30 CO2 standards to push ECV penetration

Availability of BEV, PHEV and FCEV in Europe 2015-2025. FCV model offerings to grow with CAGR 27% between 2018-25



Source: FutureBridge

Powertrain mix forecast up to 2025. ICE will remain critical but not in its pure form. FCV sales to record CAGR 60.8% between 2020-25



Regional adoption of hydrogen fuel cell technology : Europe

European 'Clean Hydrogen Alliance': Building a European green industry

HYDROGEN TECHNOLOGIES AND SYSTEMS

- Potential to replace fossil-based energy with low-emission renewable hydrogen
- Could enable and optimize large-scale renewable electricity generation
- Could increase EU energy security and resilience

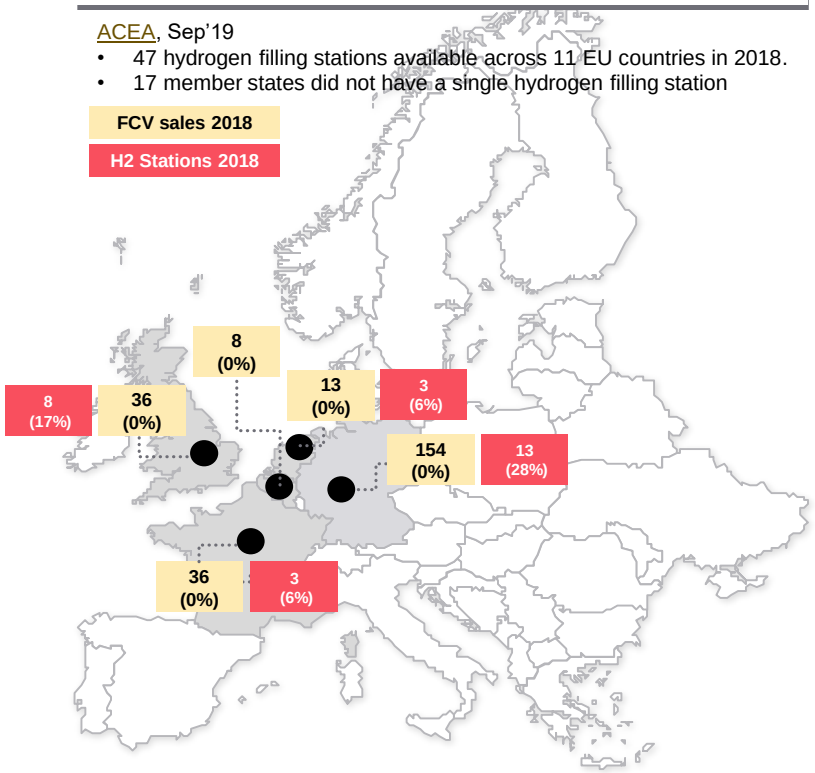
RECOMMENDATIONS:

- Develop a road map for a future European hydrogen economy.
- Build a supportive regulatory framework on renewable energy, develop common standards
- Support R&D investments and build an innovative industrial system through cross-border collaboration and partnerships in Horizon Europe
- Ensure safety and public acceptance through demonstrations and standardization

Fuel Cell new car sales & market share in 2018

ACEA, Sep'19

- 47 hydrogen filling stations available across 11 EU countries in 2018.
- 17 member states did not have a single hydrogen filling station



Regional adoption of hydrogen fuel cell technology : US

“Road Map to a US Hydrogen Economy”

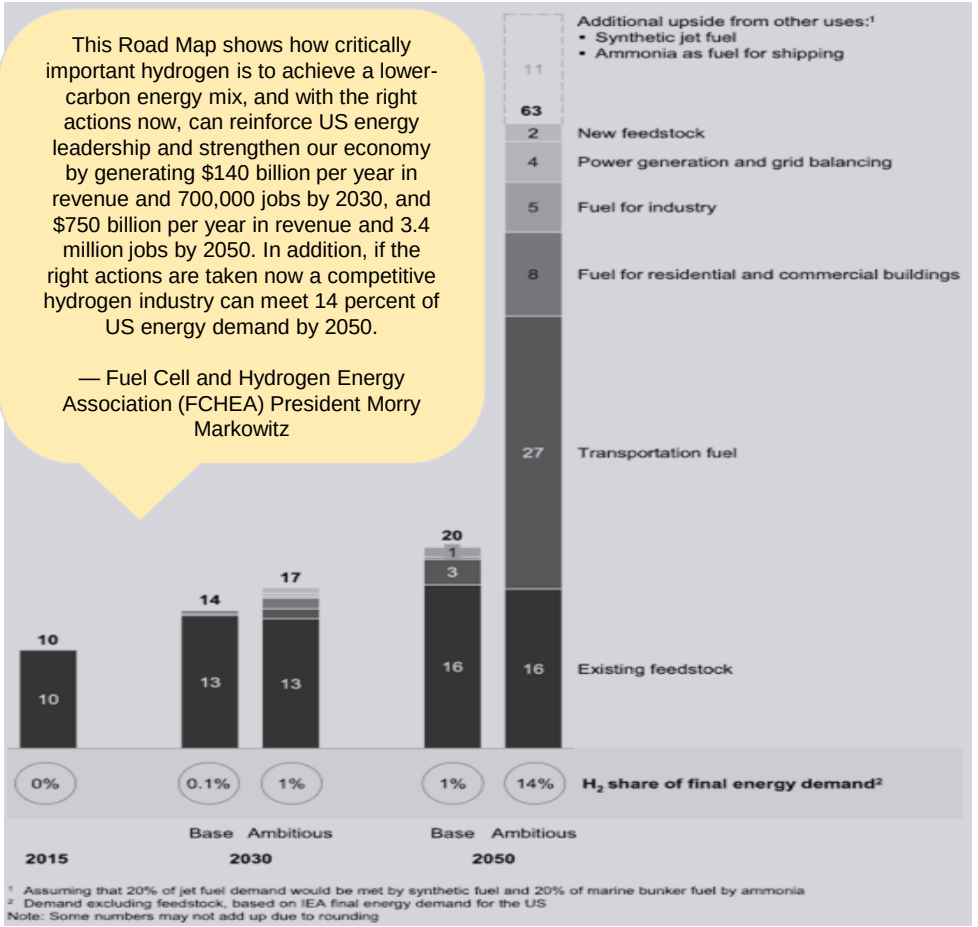
To realize the roadmap, nine actions need to happen:

- Set dependable, technology-neutral decarbonization goals.
- Create public incentives to bridge barriers to the initial market launch.
- Support infrastructure development.
- Expand the use of hydrogen across sectors and achieve economies of scale.
- Include hydrogen-based options in government procurement.
- Support research, development, demonstration, and deployment.
- Harmonize technical codes and safety standards.
- Support outreach and workforce development.
- Review energy sector regulations to ensure they account for hydrogen.

Hydrogen demand potential across sectors -2030 and 2050 vision

This Road Map shows how critically important hydrogen is to achieve a lower-carbon energy mix, and with the right actions now, can reinforce US energy leadership and strengthen our economy by generating $140 billion per year in revenue and 700,000 jobs by 2030, and $750 billion per year in revenue and 3.4 million jobs by 2050. In addition, if the right actions are taken now a competitive hydrogen industry can meet 14 percent of US energy demand by 2050.

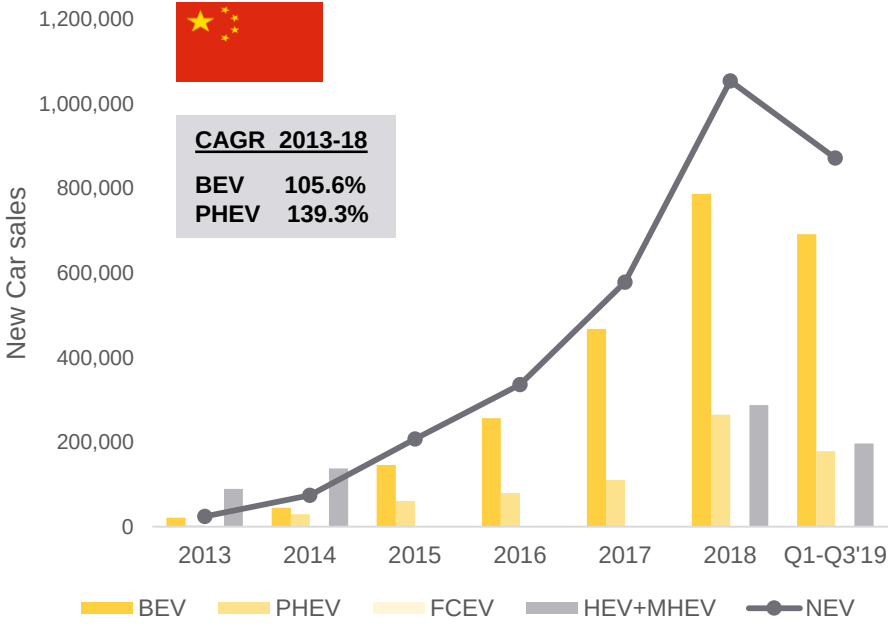
— Fuel Cell and Hydrogen Energy Association (FCHEA) President Morry Markowitz



New Energy Vehicle (NEV) status in China

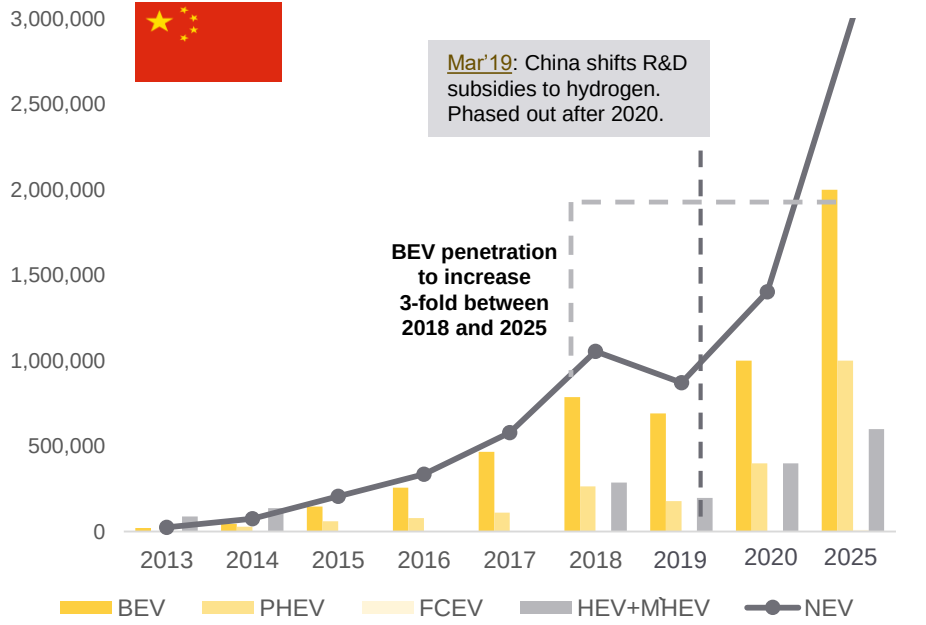
How will the shift in policy affect BEVs & FCVs?

1,251 FCV sales in Q1-Q3'19 from 1,527 in 2018, or 0.01% penetration in new car sales. Q1-Q3'19, NEV sales 872,000 or 5.7%



China NEV (BEV, PHEV, FCV) shares
Source: CAAM, FutureBridge analysis

We expect that FCV sales will triple between 2020 and 2025 with penetration accounting to 0.1% in the end of the forecast



Source: FutureBridge forecasting

4a Quarterly review of early-stage research in Fuel Cells

Emerging trends in the attributes of fuel cells for automotive

Researchers are focusing on reducing the fuel cell cost by enhancing the design or by introducing new materials as catalysts.

Materials to cut down Pt catalysts

- Georgia Tech / University of Oxford — Platinum-graphene fuel cell catalyst for superior stability over bulk Platinum >>
- University of Hyderabad / IISER Thiruvananthapuram / tifr — Selenium-graphene catalyst to replace Pt >>
- UBC The University of British Columbia — Iridium oxide catalysts for fuel cells >>
- universität wien / Aalto University School of Science and Technology — Graphene-nanoflake/CNT catalyst for fuel cells >>

New design to enhance efficiency

- University of Waterloo — Durable and potentially cheaper – fuel cell system >>
- Johns Hopkins University — Flexible and reactive nanomaterials for fuel cells >>
- Lancaster University — Kubas Manganese Hydride-1 (KMH-1) based molecular sieves for fuel cell system >>

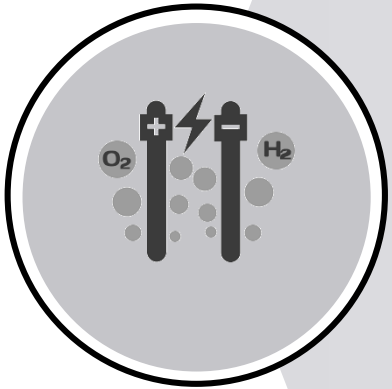
Researchers are finding ways to enhance efficiency of current fuel cells

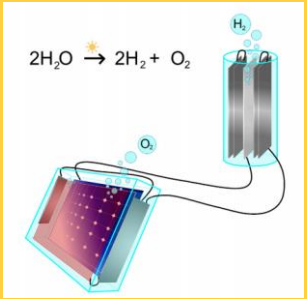
Research on Commercial vehicle applications

- SFU Simon Fraser University — Life cycle analysis of hydrogen fuel cell powered trucks >>
- Honda / Isuzu — Joint research on fuel cell powered heavy trucks >>
- Cummins — Research on hydrogen fuel cell heavy-duty truck >>

Hydrogen fuel acts as a solution for the range and payload issues of commercial vehicle sector.

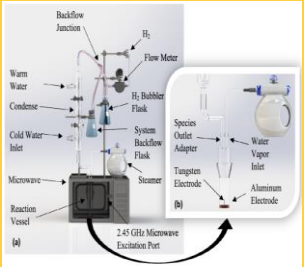
Research on Hydrogen production





Decoupled Photoelectrochemical Water Splitting System for Centralized Hydrogen Production

- Researchers at Israel Institute of Technology developed a separate-cell PEC system with decoupled hydrogen and oxygen cells was designed for centralized hydrogen production, using 100 cm2 hematite (a-Fe2O3) photoanodes and nickel hydroxide (Ni(OH)2)/oxyhydroxid (NiOOH) electrodes as redox mediators.
- The operating conditions of the system components and their configuration were optimized for daily cycles, and ten 8.3 h cycles were carried out under solar simulated illumination without additional bias at an average short-circuit current of 55.2 mA.



Hydrogen production by microwave based plasma dissociation of water

- Researchers from the university of Ontario have found a new method to dissociate water vapor into hydrogen gas by microwave generated plasma.
- The study investigates the energy and exergy efficiencies for applications involving the collection of hydrogen gas as an alternative fuel source.
- The plasma generated decomposes the steam molecules into hydrogen and oxygen radicals at the tip of the tungsten antenna. The produced gases, flow with steam into the condenser where water molecules are condensed and separated.

Research on fuel cell catalysts: to reduce the manufacturing cost of fuel cells

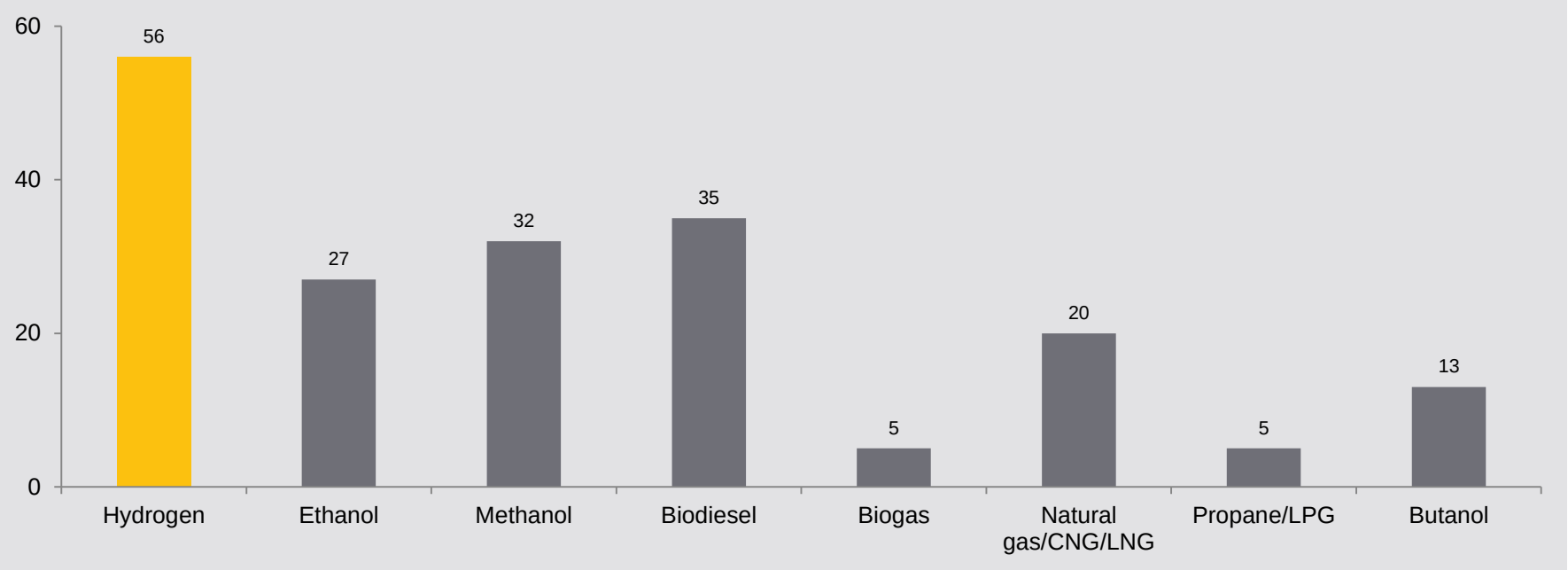
The catalysts used are expensive and do not work effectively enough. By increasing catalyst efficiency, the utility of fuel cells would expand.

- Researchers at Aalto University, University of Vienna, CNRS and Nikolaev Institute of Inorganic Chemistry developed a highly graphitized graphene Nano flake (GF)–carbon nanotube (CNT) hybrid catalyst doped simultaneously with single atoms of N, Co, and Mo

- Scientists from Los Alamos National Laboratory (LANL) and Washington State University (WSU), has developed a nickel-iron (NiFe)-based catalyst. ammonium-enriched anion exchange ionomer that improves the performance of an AEM electrolyzer to levels approaching that of state-of-the-art proton exchange membrane electrolyzers.

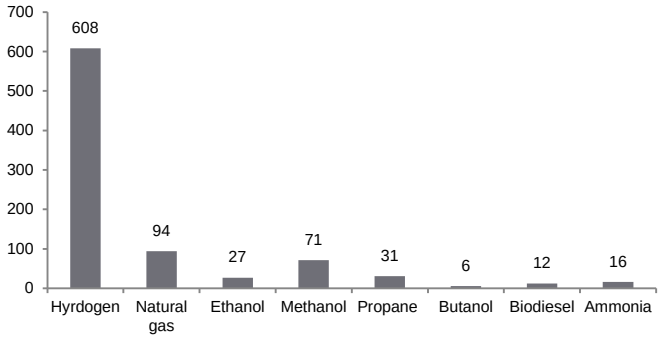
- Researchers from IIT Madras developed catalysts made of zirconium nitride nanoparticles that can replace Platinum in fuel cells. The catalyst is cheaper than Platinum and provides more stability.

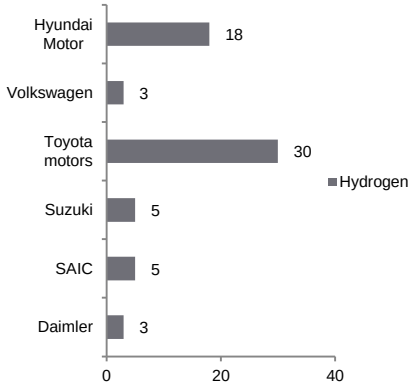
Research papers published in 2020 (over past three months)

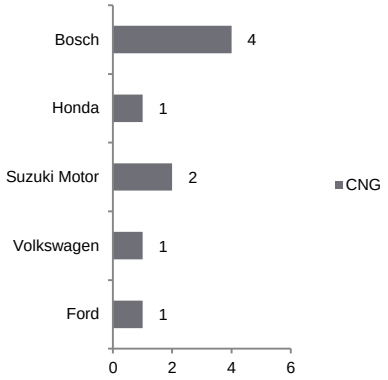


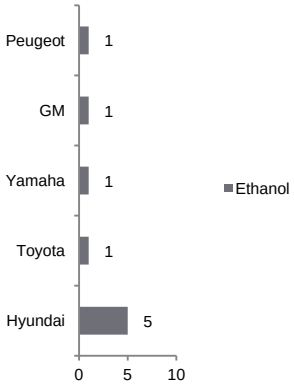
- **Hydrogen fuel cell** technologies have experienced cycles of excessive expectations followed by disillusion. Nonetheless, a growing body of evidence suggests these technologies form an attractive option for the deep decarbonization of global energy systems, and that recent improvements in their cost and performance point towards economic viability as well. More number of papers published in hydrogen showcases the growing interest towards fuel cell and hydrogen.
- **Biofuels** have been subject to much scrutiny over the past decade. Although much work has already been done on biofuel production, there are still disconnects between various aspects of the process. More research work is happening in areas such as Biodiesel, Ethanol and Biogas.

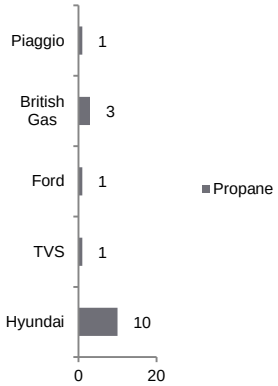
IP scenario for Alternative fuels – Past Six Months

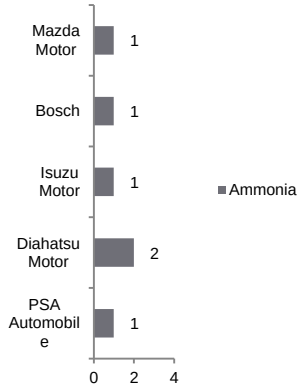












Assessment

- More patents are filed for Hydrogen fuel cells, followed by Natural gas, Methanol, Propane and Ethanol.
- Leaders in hydrogen fuel cell technology, Toyota and Hyundai filed more number of patents in Hydrogen.
- Suppliers such as Bosch is concentrating on Natural gas (CNG) and Ammonia as a replacement for fossil fuels instead of EVs. Their activities in patents showcase this fact.

Relevant Patents for Hydrogen Fuel Cell – Past Six Months

CN110254295A

Title:- Hydrogen leakage treatment system and method for hydrogen fuel cell automobile and automobile

Abstract:- The invention aims to provide a hydrogen leakage treatment system and method for a hydrogen fuel cell automobile and an automobile so as to solve the problem of potential safety hazards of hydrogen leakage in the hydrogen fuel cell automobile in the prior art. The hydrogen leakage treatment system for the hydrogen fuel cell automobile comprises a hydrogen bottle stored with hydrogen, a plurality of bottle valves connected to a bottle mouth of the hydrogen bottle, hydrogen pipes connected to the plurality of bottle valves in a one-to-one correspondence mode, a box body internally forming a sealing cavity and a hydrogen guide pipe, wherein the plurality of bottle valves are arranged in the sealing cavity, each hydrogen pipe penetrates through the wall of the box body and then is in communication with a corresponding load, one end of the hydrogen guide pipe penetrates through the wall of the box body and then is inserted into the sealing cavity, and the other end of the hydrogen guide pipe is in communication with air outside the vehicle body; and hydrogen leaked from at least one bottle valve enters the sealing cavity, and then is discharged into the air through the hydrogen guide pipe.

What patent speaks about:- The purpose of the present invention is to provide a hydrogen leakage treatment system and method for a hydrogen fuel cell vehicle and an automobile to solve the problem of hidden safety hazards of hydrogen leakage in the hydrogen fuel cell vehicle.

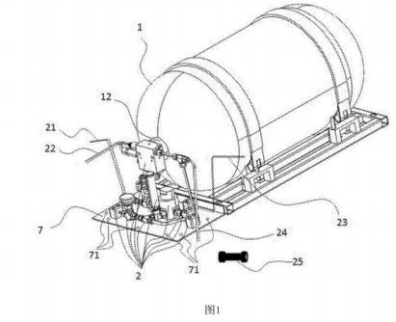


图1

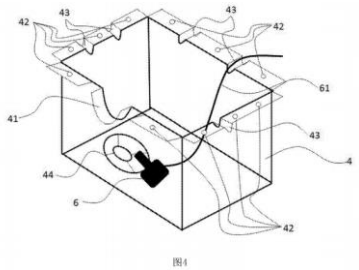


图4

CN209266501U

Title:- Novel cooling system of hydrogen energy automobile fuel cell stack

Abstract:- The utility model relates to a novel cooling system of a hydrogen energy automobile fuel cell stack. The system comprises a hydrogen fuel cell stack, a thermal management controller, a radiator, a water temperature sensor, a water pump, a temperature sensor, a first compressor, an evaporator, a second compressor, a condenser and an expansion valve, the radiator, the water temperature sensor and the water pump form a water-cooling circulation loop through a first pipeline; the evaporator, the second compressor, the condenser and the expansion valve form a refrigerant circulation loop through a third pipeline; low-temperature condensed liquid required by the evaporator is generated; the first compressor, the evaporator and the hydrogen fuel cell stack form an air cooling circulation loop through a second pipeline; the thermal management controller receives signals of the water temperature sensor and the temperature sensor and performs water cooling or air cooling treatment on the hydrogen fuel cell stack, and meanwhile, the heater arranged on the second pipeline can provide hot air for the hydrogen fuel cell stack when the temperature is too low, so that the hydrogen fuel cell stack is heated to a normal working temperature as soon as possible, the energy consumption is reduced, and the working efficiency is improved.

What patent speaks about:- The purpose of the present invention is to provide a cooling system of a novel hydrogen fuel cell fuel cell stack, which can quickly increase or decrease the temperature of the hydrogen fuel cell stack according to the needs of the hydrogen fuel cell stack.

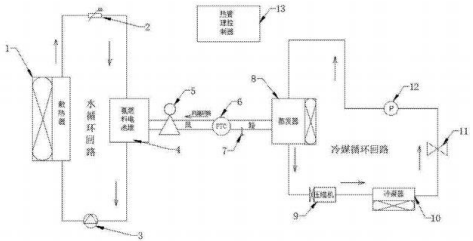


图1

4b Key activities of major players in Fuel Cells

Companies to watch

OEMs

- Toyota and Hyundai are world leaders of hydrogen fuel cell technology
- Renault added fuel cell light commercial vehicles to their range

Suppliers

- Bosch and Cummins are collaborating with OEMs for fuel cell technology
- Other suppliers like Ballard power systems, Plug Power are developing new fuel cell systems

Startups

- Fuel cell technology finding penetration in CV segment, where a greater range is required.
- Nikola Motors has secured $480 Mn investment

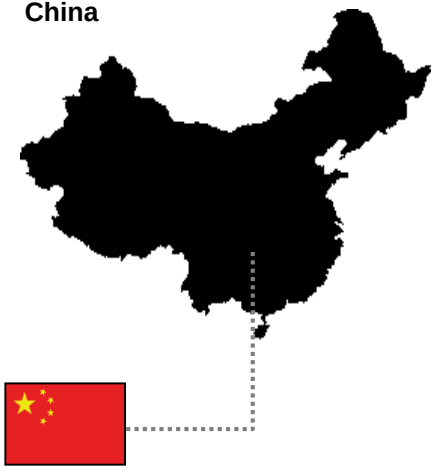
Players activities on major automotive markets : region wise

Europe

Activities:

- Daimler is planning to commercialize hydrogen fuel cell bus in next two to three years
- BMW is introducing the second-generation fuel cell technology developed together with Toyota in the BMW X6 and X7.
- Bosch in collaboration with PowerCell developing fuel cell systems for trucks and cars

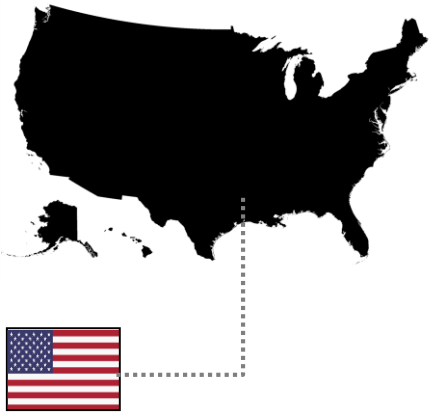
China



Activities:

- Toyota plans $1.2bn EV plant in China The plant is expected to produce 200,000 battery-only, plug-in hybrid and fuel-cell vehicles.
- Ballard Power Systems receives large order worth $19.2M to supply FCEV in China
- GM is planning to introduce at least 20 new electric and fuel-cell vehicle models in the U.S. and China by 2023.

US



Activities:

- Nikola is merging with VectoIQ, to become a public company
- Anglo American and Williams Advanced Engineering together developed World's largest electric vehicle powered by fuel cell
- Hyundai will provide the DOE with five NEXO FCEV to help fuel cell R&D. Canoo will provide engineering services to develop Hyundai FCEV vehicles

Future of fuel cell vehicles : Players are massively using fuel cells for CV applications

HYUNDAI H2 XCIENT Fuel Cell heavy duty truck

NIKOLA IVECO FPT Partnership for fuel cell truck

HYUNDAI HDC-6 NEPTUNE concept truck

Cummins Hydrogen fuel cell concept truck

PLUG POWER Class 6 trucks for logistics

BALLARD 8th generation fuel cell module for heavy duty sector

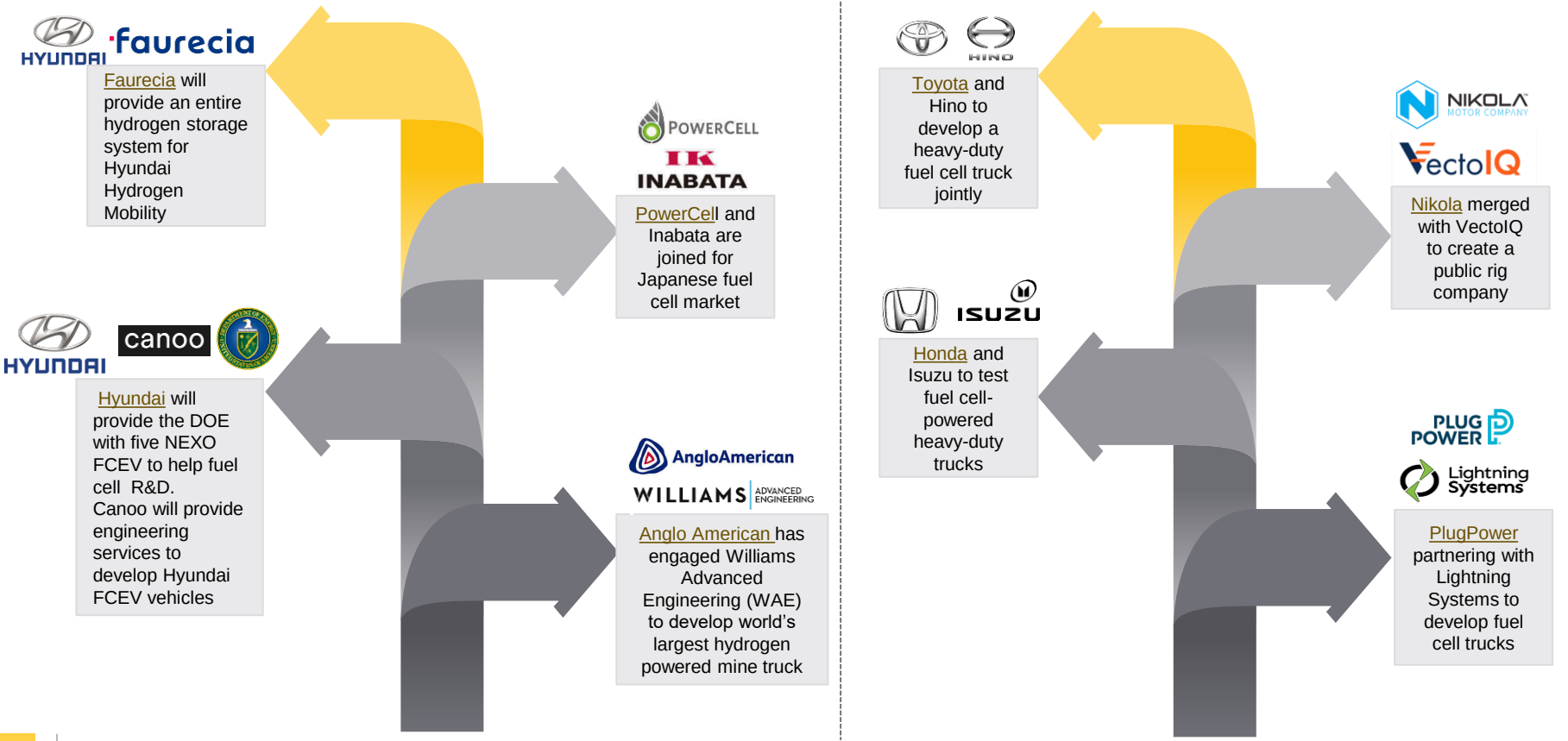
NIKOLA Fuel cell electric pick up

H2Rescue fuel cell truck

*image credits: OEMs , Supplier and Start-ups

Collaborations & Partnerships

For hydrogen-powered automobiles to have a presence on the roads by 2030, competing automotive giants, fuel cell manufacturers, and public and private sectors will need to create unprecedented partnerships.



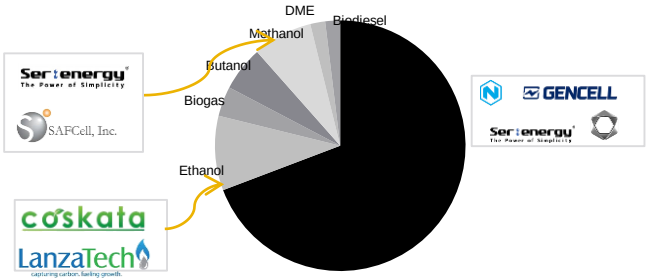
05 Startups Tracker highlights in Q1 2020

Startup Activities – 2020

63 startups are included in our Tracker as of Q1 2020

See our Startup tracker AF

Startups in AF by technology



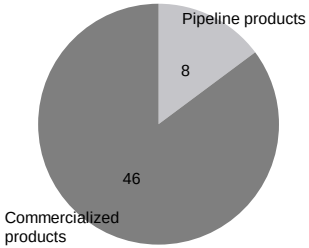
Some key startups active in H2 2019

Sertenergy® The Power of Simplicity → Methanol fuel cell technology

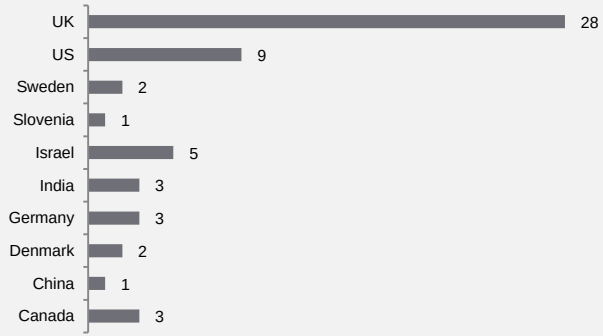
POWERCELL → Fuel cell stacks

AIWAYS → Methanol fuel cell supercars

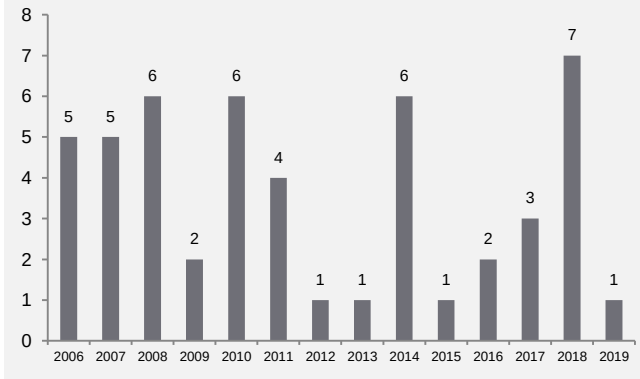
Startups by state of maturity of products



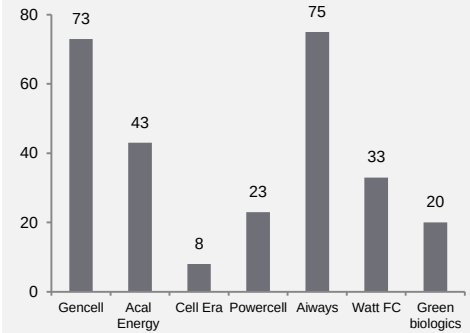
Startups by geography



Startup incorporation



Number of patents by startup

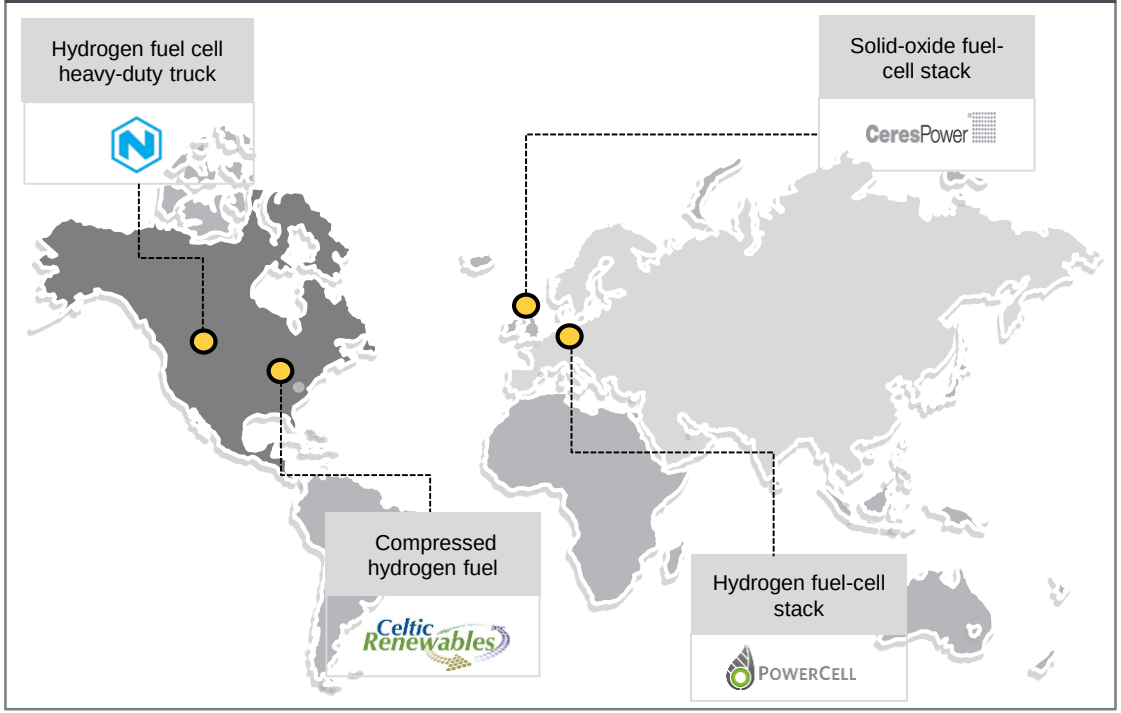


What are the hubs of startup innovation for AF

USA leads as an innovation hub, followed by the UK. Of the 63 startups, we monitor, more than 50% are working on fuel cells.

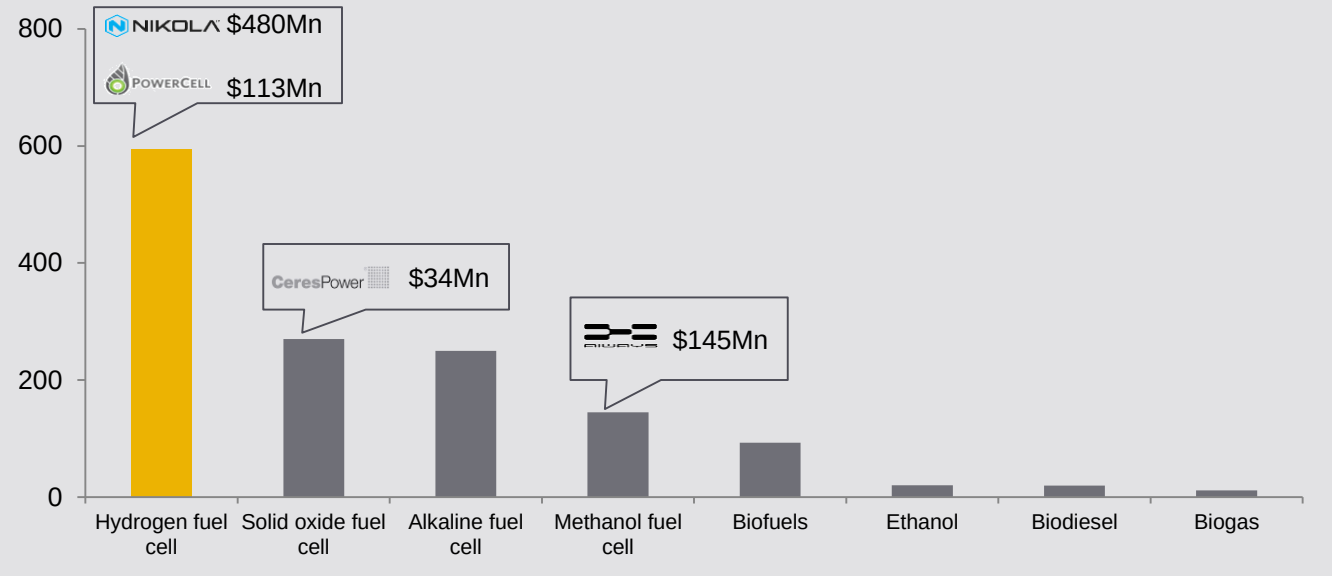
- Out of the **63** startups we have included in our Tracker, almost 50% focus on fuel cells technology more specifically hydrogen-based fuel cells.
- Nearly 50% of them are based in the **US** whereas 20% are based in **Europe** (UK, Germany, Denmark, Sweden etc.) and less than 10% in **Asia** (India and China).
- Major startups that have covered in Alternate are focusing on hydrogen fuel cell technology. Startups that are working on solid oxide FC systems and Methanol FC systems are securing more investments.
- Startups that are working on Biofuels such as Gevo, Celtic Renewables on-demand as the oil industry is collapsing due to COVID-19.

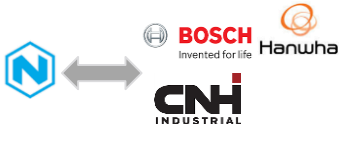
Key startups from major hubs in automotive Alternate Fuels



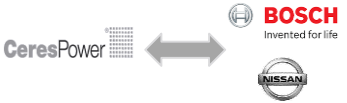
Funding distribution & activities

Investors show interest in Hydrogen fuel cells





Hydrogen fuel cell powered heavy duty truck



Solid oxide fuel cell stack

Hydrogen fuel cell stack

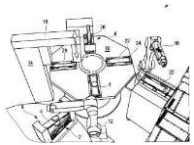
Fuel cell range extenders for trucks

- Hydrogen fuel cell technology finding penetration in the commercial vehicle segment which is one of the main reasons for increased funding in startups which are working on fuel cells.
- Solid oxide fuel cells and Methanol fuel cell technology are emerging and can expect that it will gain more momentum in the future. Biofuels are also at the top of the investment priority list.

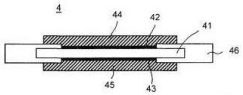
Startup highlight – PowerCell

PATENTS

Method for manufacturing a fuel cell stack
SE1850786A1
Patent discuss about a manufacturing method for fuel cell stack. The method comprises of assembling fuel cell parts such as bipolar plates, electrodes etc. to alignment stations



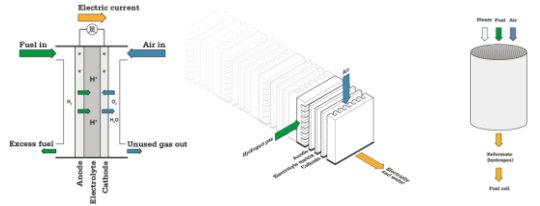
Fuel cell stack and bipolar plate assembly
EP3593395A1
Patent explains about the manufacturing of a bipolar plate assembly or a fuel cell stack. The object of the invention is to provide a bipolar plate assembly having an adjusted geometry so that the electrical hazards are eliminated.



Method for converting hydrocarbon fuel into hydrogen-rich gas
CN105293435A
Patent describing a method for converting hydrocarbon fuel into a hydrogen-rich gas which is applied to a fuel cell and/or exhaust treatment through autothermal reaction. In this method a reforming reactor is used in which a hydrocarbon fuel and an oxidant reacts to form hydrogen fuel.

TECHNOLOGY

Power Cell's fuel cell stacks are designed to work on reformate gas as well as pure hydrogen. Metal bipolar plates and state of the art membrane electrode assembly give a robust, low cost and high performance design. The fuel cells are based on PEM technology (Polymer electrolyte membrane). The technology's reliable and dynamic characteristics allows for full power output within seconds. Another feature is the capability for extensive starts and stops.



When in operation, the anode is fed with fuel in the form of hydrogen (H2), while the cathode is continuously fed with air (O2). The hydrogen molecules are oxidized at the anode, forming hydrogen ions and electrons. The electrons wander through the external electrical circuit, which connects the anode and cathode, to generate electricity. Meanwhile, the hydrogen ions are transported via the electrolyte to the cathode, where they combine with the oxygen molecules to form water and heat. The result is electricity, water and the heat generated by the reaction. Since the fuel cells are liquid cooled, the heat can e.g. be used to heat buildings.

ACTIVITIES

Competitors

BALLARD CeresPower ITM POWER

News

- Mar 30 , 2020 | PowerCell received order for PowerCell S3 from Bosch at a total value of $1.14 Mn >>
- Mar 10 , 2020 | PowerCell joins Swedish Electro mobility Center >>
- Feb 27, 2020 | PowerCell increased its sales for the full year 2019 with 10 percent >>
- Feb 17 , 2020 | PowerCell and Inabata & CO Ltd., sign exclusive distribution agreement for the Japanese market >>

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