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IEA H2 TODAY

Strategy Matters
IEA Hydrogen is at work on its next strategic plan, cognizant that the role of hydrogen in an integrated energy system is increasingly acknowledged by both governments and the marketplace. We are also pleased to report that institutionally, the IEA has a growing understanding of the cross-cutting role of hydrogen in the energy system.

IEA Hydrogen’s strategic landscape is expanding. New members, both from government and industry, are poised to join our Technology Collaboration Programme (TCP). As well, the United Nations Industrial Development Organization (UNIDO), which has 168 Member States, is actively re-engaging with IEA Hydrogen to pursue its interests in GHG emission reduction, waste-to-energy conversion in a circular economy-based energy system, and introduction of hydrogen in middle-income developing countries.

ExCo Meetings
The 77th IEA Hydrogen Executive Committee (ExCo) Meeting was held 13-15 December 2017 in Naples, Italy. The 78th IEA Hydrogen ExCo Meeting Part I, a dedicated strategic planning session, was held 29-30 May 2017 in London; Part II of the 78th ExCo Meeting is being held 20 June 2018 in Rio de Janeiro, Brazil, during the World Hydrogen Energy Conference (WHEC).

IEA Hydrogen Tasks
In our regular task renewal cycle, new and successor tasks are developed as current tasks close. For a complete report on the status of IEA Hydrogen tasks, see Task Ink. Two new analysis tasks have just been approved to enter the “Definition Phase.” The first task, whose definition will be led by the United Kingdom, has two topics: 1) market deployment of hydrogen technologies in the short term; and 2) pathways to scale from existing microscale activities to the large-scale economic use of hydrogen for energy in the longer term. The second task concerns Data and Modeling.

IEA Hydrogen is also excited to announce that Task 37 – Hydrogen Safety will soon launch the IEA Hydrogen Safety Journal.

IEA Hydrogen Promotion and Outreach
During the plenary session of the 13-15 December European Fuel Cell Conference (EFC) in Naples, Italy, General Manager de Valladares delivered a presentation entitled “IEA Hydrogen Vision and R,D&RD: Current perspectives, future prospects.” Chairman Lucchese attended the 13 June 2017 TCP task leader meeting of the IEA Combustion TCP where hydrogen applications and future cooperation were discussed.

On 10 September 2018, IEA Hydrogen will speak at an IEA Electrofuels Workshop in Brussels.

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Below, please see the IEA Hydrogen speaking and presentation schedule for the June WHEC 2018 in Rio de Janeiro. Included are the Hydrogen Council and IEA Hydrogen Round Table, as well as presentations by IEA Hydrogen Operating Agents and experts on their tasks and ExCo Members on topics of interest.

<table>
<thead>
<tr>
<th>DATE/TIME</th>
<th>WHEC PRESENTATION TITLE</th>
<th>IEA H2 REP/OA SPEAKER/AUTHOR</th>
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<tbody>
<tr>
<td>18 June 2:00-2:30</td>
<td><strong>Power-to-Hydrogen and Hydrogen-to-X</strong>: midterm appraisal of the IEA HIA Task 38 accomplishments</td>
<td>Chair P. Lucchese/ OA C. Mansilla</td>
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<tr>
<td>18 June 2:50-3:10</td>
<td>Fuel cell solutions for maritime applications: possibilities and challenges</td>
<td>OA S. Jafarzadeh/ OA I. Schjølberg</td>
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<tr>
<td>18 June 4:50-5:10</td>
<td>Economic Costs of Rapid Transitioning to Hydrogen Fuel Cell Light Vehicle Fleets in Japan and New Zealand</td>
<td>ExCo Rep J. Leaver/ Watanabe</td>
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<tr>
<td>18 June 5:10-5:30</td>
<td>Power-to-Hydrogen and Hydrogen Storage: High temperature metal hydrides for concentrated solar thermal energy storage</td>
<td>ExCo Rep C. Buckley</td>
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<tr>
<td>20 June 9:00 - 9:20</td>
<td>Japan’s current policy and activity toward hydrogen based society</td>
<td>Vice Chair Eiji Ohira</td>
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<tr>
<td>20 June 11:15-11:30</td>
<td>The Role of Hydrogen in International Energy Scenarios and Energy Policies</td>
<td>Chair P. Lucchese</td>
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<tr>
<td>20 June 11:30-12:30</td>
<td>Round Table: Hydrogen Council and IEA-Hydrogen – the Role of Hydrogen in Energy Policies</td>
<td>Chair P. Lucchese</td>
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<tr>
<td>21 June 9:00-9:20</td>
<td>The Next Phase of the National Innovation Program for Hydrogen and Fuel Cell Technologies in Germany</td>
<td>ExCo Rep K. Bonhoff</td>
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<tr>
<td>21 June 11:50- 12:10</td>
<td>Volumetric and gravimetric hydrogen storage capacity in metal-organic frameworks (IEA-HIA Task 32 “Hydrogen-based Energy Storage”)</td>
<td>OA M. Hirscher</td>
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**Trending Now**

The inaugural *Global Trends and Outlook for Hydrogen* report was published in December 2017. This special report identifies the environmental problems we face and examines why hydrogen offers an elegant solution to our current climate crucible. The report was prepared for professional audiences -- notably policy and decision makers -- with an interest in global energy innovation but no specific technical expertise in hydrogen. The report provides an overview of hydrogen uses, sources and production methods together with an introduction to fuel cell technology. It then systematically addresses hydrogen energy applications in many sectors, describing the technology and application status, and providing current examples that are “Trending now.” Included are:

- **Transport**: vehicle propulsion
  - Light duty passenger vehicles
* Buses
* Trains and light rail
* Ferries and smaller boats
* Airplanes and drones

- Power (and Heat)
- Cross-Cutting: Power to Hydrogen
- Industrial Applications

A discussion of Infrastructure - Hydrogen Refueling Stations (HRS) is also considered, as are Safety and International Codes and Standards. Leaders in government and industry are also identified.

The report takes another step toward building awareness, understanding and acceptance of hydrogen in an integrated energy system.

ALSO PUBLISHED

NOW, an IEA Hydrogen member and advisor to H₂ Mobility Germany, announces publication of a Comparative Analysis of Infrastructure: Hydrogen Fueling and Electric Charging of Vehicles, prepared by Jülich Research Centre. This scenario analysis shows that with 1 million H₂ vehicles (FCEVs) on the road, H₂ infrastructure is cheaper than a system of battery recharging points. The H₂ infrastructure advantage stems from dispensing of H₂ at centrally organized refueling stations (H₂ refueling stations). While both technologies are vital for successful decarbonisation of the transport sector, the build-up of H₂ infrastructure is more cost friendly over time than the battery infrastructure.

Outlines of a Hydrogen Roadmap, written by Marcel Weeda and Jorg Gigler of TKI New Gas, is now available in English. The Netherlands currently has over 100 hydrogen initiatives in various stages of development and this number is growing. To gain greater insight into the role that hydrogen may play for the energy transition and the steps that will have to be taken towards achieving this, the Ministry of Economic Affairs and Climate Policy has asked TKI New Gas (Top Sector Energy) to manage the drafting of a Hydrogen Roadmap. During its preparation, input from approximately 150 persons and organisations was gratefully used. For more information visit TKI New Gas.

Task 32 – Hydrogen Storage

Coming soon with Final Report for Task 32 – all publications will be included in this bibliography.

Task 36 – Life Cycle Sustainability Assessment


Task 38 – Power to Hydrogen/Hydrogen to Applications

**IEA H2 Members**

- Australia
- Belgium
- Commission of the EU
- China
- Denmark
- Finland
- France
- Germany
- Greece
- HySafe
- Israel
- Italy
- Japan
- Korea
- Lithuania
- The Netherlands
- New Zealand
- Norway
- Shell
- Southern Company
- Spain
- Sweden
- Switzerland
- United Kingdom
- United Nations Industrial Development Organization (UNIDO)

**HYDROGEN AND FUEL CELL MARKET SPACE**

Panasonic Corp. started selling its residential fuel-cell systems in the U.K. and Austria in 2017, seeking to solidify its lead in a product category that some see as a stepping stone to harnessing hydrogen as the fuel of the future. Sales through German partner Viessmann Group began in August 2017.

Plug Power Inc. has confirmed a new collaborative agreement with Walmart to facilitate further expansion of its ongoing relationship with Walmart Stores, Inc. **Plug Power expects to provide its GenKey hydrogen \( (H_2) \) filling station and fuel cell energy solutions to up to 30 Walmart sites in North America over the next three years.**

Toshiba Corporation has opened a new hydrogen \( (H_2) \) application centre at its Fuchu Complex in western Tokyo. The site is built around a newly designed H2OneTM \( H_2 \) power system that uses renewable energy to produce \( H_2 \) via electrolysis and supply it to fuel cell forklifts operating in the complex. The system is controlled by the Japanese company's \( H_2 \) energy management system H2EMSTM, which includes a new \( H_2 \) demand prediction function that forecasts supply requirements for each fuel cell vehicle.

7-Eleven Japan and Toyota inked an agreement in 2017 to work on developing hydrogen fuel cell trucks and power generators. Currently, 7-Eleven Japan is served by 5,800 delivery trucks, and about 15% of them are hybrids and other clean vehicles. The convenience store company's goal is for that percentage to go up to 20% by 2020, with help from automakers like Mitsubishi, Daimler, and Toyota.

CleverShuttle has launched a fleet of taxis powered by hydrogen in Hamburg Germany, in addition to the current fleets offering service in Berlin, Leipzig and Munich. **20 Toyota Mirais will be brought into service and they will be powered with environmentally-friendly \( H_2 \) from infrastructure partner H2 MOBILITY.**

A $1.45 million competitive Federal Transit Administration (FTA) grant has been awarded to the Champaign-Urbana Mass Transit District (MTD) AKA SARTA in Ohio, USA for the purchase of no-emission, hydrogen fuel cell electric buses and associated infrastructure. With the funds, SARTA is adding two more buses to its 11-bus fleet of electric buses powered by hydrogen fuel cells.

**Aberdeen, Europe's oil capital turns to clean, green hydrogen buses.** The £19 million ($24.98 million) project means that hydrogen buses are ferrying residents around Aberdeen as authorities look to reduce city center emissions and boost air quality.

**General Motors and the US Army** are exploring potential for hydrogen fuel cells in ground vehicles. **The ZH2 is based on a Chevrolet Colorado truck,** but the front and rear of the truck were changed to improve off-road mobility. The ZH2 has demonstrated it can travel 10-times farther and approach 10-times closer without audible or thermal detection compared with a conventional propulsion system.

**Toyota’s Project Portal hydrogen fuel-cell big rigs** started transporting cargo from the port of Los Angeles in Long Beach to rail yards and warehouses beginning October 23, 2017. Powering the short haul drayage trucks are two fuel stacks from Toyota's fuel-cell Mirai sedan and a 12kWh battery. The automaker says the big rig is capable of transporting 80,000 pounds and has a range of about 200 miles per fill-up. That's more than enough to move cargo around the Los Angeles area.
In November 2017, True Zero’s retail hydrogen sales achieved an enormous milestone as fuel cell electric vehicles in California surpassed 250,000 kilograms of clean hydrogen and 17 million miles from just 18 retail stations owned and operated by the company. The True Zero stations plus 13 others make up a total of 31 stations open across California, thanks to California Energy Commission (CEC) grant funding and a long-standing State commitment to zero emission vehicles.

Daimler and HPE want to power green data centers with hydrogen. Daimler, HPE, Power Innovations and the National Renewable Energy Laboratory are expanding fuel cell use to “micro-grids” inside server farms and data centers. Solar and wind power would provide the bulk of the energy, but fuel cells would fill in the gap when power demand is too high or an outage leaves no other choice.

China’s first hydrogen fuel cell industry park will be built in the economic and technological development zone of Wuhan, capital of central China’s Hubei Province. With an investment of 11.5 billion yuan (about 1.75 billion U.S. dollars) from a Shenzhen-based high tech company, the projected industry park will focus on research and production of hydrogen fuel cells.

Toyota has announced it is teaming up with FuelCell Energy (NASDAQ:FCEL) to build hydrogen fuel infrastructure at the Port of Long Beach in California to supply a growing hydrogen fleet. The companies will ultimately turn waste products like manure into clean hydrogen fuel and power for the electric grid. The plant will produce 1.2 tons of the fuel per day and 2.35 megawatts of electricity – extracted from methane, a byproduct of dairy cattle poop.

Jülich Research Center and H2Mobility published a comparative analysis of both electric and fuel cell vehicle infrastructure costs. Battery charging network is more cost intensive than hydrogen in the long term and H2 infrastructure works out cheaper once the one million vehicle threshold has been met.

Shanghai Automotive Group Co. (SAIC) and the Shanghai Chemical Industry Park signed a “Shanghai Chemical Industry Park And SAIC strategic cooperation framework agreement”. As part of the agreement, SAIC will deliver 100 fuel cell vans imminently with plans for another 300 fuel cell vans to be delivered by year end.

Japanese automaker Toyota has announced that it will be bringing its fuel cell vehicle, the Mirai, to Canada in 2018. The company made the announcement at the Montreal Auto Show, where Toyota noted that fleet sales will begin in Quebec.

The JIVE 2 fuel cell bus project was launched in January 2018. Coordinated by Element Energy, and supported by a €25m grant from the Fuel Cells and Hydrogen Joint Undertaking (FCH JU), the JIVE 2 project will deploy 152 fuel cell electric buses across 14 European cities throughout France, Germany, Iceland, Norway, Sweden, the Netherlands and the UK. This will expand the network of cities conducting fuel cell bus trials in Europe, demonstrating a growing appetite for the technology.

Toyota is boosting their efforts to develop fuel cell buses. They have launched a fuel cell bus series called Sora, with a focus on Japan. The Automaker plans to have more than 100 units operating for 2020 Tokyo Olympics.

Kenworth Trucking debuted its hydrogen fuel cell T680 Day cab at the 2018 Consumer Electronics Show (CES) in Las Vegas. The Kenworth T680 day cab is equipped with a hydrogen fuel cell, part of the Zero Emission Cargo Transport Demonstration project. The tractor uses lithium-ion batteries to power a dual-rotor electric motor, driving the rear tandem axle through a 4-speed automated transmission.
Hydrogen buses are coming to Denmark - Region Nordjylland and Aalborg Municipality just sent an order for three hydrogen buses in tender. The price is approximately six million kroner apiece. Both the EU and Growth Forum North Jutland will provide funding for the experiment.

The municipality of Mariestad in Sweden, energy company VänerEnergi and Nilsson Energy are working together to establish the world’s first solar-powered hydrogen (H\textsubscript{2}) refilling station. Nilsson Energy won the contract in November last year to build an independent off-grid H\textsubscript{2} production plant connected to the existing H\textsubscript{2} filing station. The contract also includes building a solar park, whose solar energy constitutes the fuel for the system.

ITM Power, together with Shell, are building a new hydrogen (H\textsubscript{2}) electrolysis plant – the largest of its kind in the world at Rhineland refinery, Germany. The PEM plant will have a peak capacity of 10 megawatts (MW). The European partner consortium of Shell, ITM Power, SINTEF, thinkstep and Element Energy has now secured €10m in funding from the European ‘Fuel Cell Hydrogen Joint Undertaking’.

Ballard Power Systems has announced the planned deployment of 500 licensed fuel cell electric commercial trucks – all using Ballard fuel cell stack technology – in Shanghai, China. Each of the 500 Dongfeng Special Vehicle trucks is licensed, plated and powered by a 30 kW fuel cell engine that was designed and integrated by Shanghai Reinventing Fire Technology Co. Ltd.

Hyundai reveals the Nexo - world-first driverless fuel cell vehicle with a target range of hydrogen of 500 miles on a single fill. The South Korean automaker has just achieved a world-first by driving a fleet of level 4 autonomous vehicles powered by hydrogen fuel cells completely autonomously on a 190-kilometre journey from Seoul to Pyeongchang.

Approximately 6500 Hydrogen Fuel cell vehicles have been sold by year end 2017. Over 50% of these vehicles were sold in California with Japan and Europe making up most of the rest of the market. Toyota has been most successful with over 75% of sales, more than double their previous year. Honda and Hyundai make up the remaining 25%.
**Task Ink**

**Collaborative R&D&D Theme**

Hydrogen Production, Integrated Hydrogen Systems, and Infrastructure Portfolios

**Current**

**Task 34 Biological Hydrogen for Energy and Environment**
Operating Agent: Alan Guwy and Jun Miyake

- The last Task 34 meeting was held at the 12th ABBS on 25-28 July 2017 in Khon Kaen, Thailand.
- A final “End of Task” Meeting will be held via teleconference to facilitate the writing of the final report.
- Experts have proposed a new successor task to Task 34 called “Biological Production and Conversion of Hydrogen for Energy and Chemicals.” This includes production of biological and bioelectrical hydrogen from biomass, platform chemicals from biomass, inter-conversion between hydrogen and platform chemicals, and integrated technologies for enhanced production and bio-refining.

**Task 39 Hydrogen In the Maritime**
Operating Agent: Ingrid Schjølberg and Sepideh Jafarzadeh

- INTA hosted the last Task 39 meeting, which was held 6-7 March 2018 in Madrid. TU Delft hosted the previous Task meeting on 26–27 September 2017 in Delft the Netherlands. The TU Delft meeting included 40 participants from 11 countries and 31 institutions.
- Some recent task accomplishments include the initiation and realization of Task 39, presenting the Task in different forums around the world (Tokyo, Spain, Portugal, and Brussels), and raising awareness about the Task and the important issues that it addresses.
- The next Task 39 meeting is planned for Autumn 2018, in Trieste (Hosted by University of Trieste).
- Two papers were submitted to the 22nd World Hydrogen Energy Conference (WHEC 2018). Collaboration between participants and attendance to present two white papers is planned.

**Closing**

**Task 33 Local Hydrogen Supply for Energy Applications**
Operating Agent: Dr. Øystein Ulleberg

- Final Report pending

**Task 35 Renewable Hydrogen Production (Super Task)**
Operating Agent: Dr. Eric Miller

- Final Report pending
Hydrogen Storage Portfolio

Current

Task 32 Hydrogen Based Energy Storage
Operating Agent: Dr. Michael Hirscher

• The last task meeting, a “Long Meeting,” was held 15-18 April 2018 in Venice, Italy. The previous meeting was held in Schloss Ringberg, Germany, 3-6 December 2017.
• A final “Short” Task 32 meeting will take place after MH2018 in Guangzhou, China, October 2018.
• Task accomplishments include a number of publications:
  * “Outlook and challenges for hydrogen storage in nanoporous materials” in Applied Physics A;
  * “Meta borohydrides and derivatives – synthesis, structure and properties” in Royal Society of Chemistry;
  * “The renaissance of hydrides as energy materials” and “Hydrogen carriers” in Nature Reviews Materials; and
  * “Complex metal hydrides for hydrogen, thermal and electrochemical energy storage” in Energies 2017.
• Task 32 Experts started defining a new task on “Energy Storage and Conversion Based on Hydrogen.” The proposed start is 1st January 2019 with a duration of 3 years.

Coming Soon

• A successor to Task 32 entitled “Energy storage and conversion based on hydrogen” will be considered at the upcoming 78th ExCo Meeting Part II in Brazil.

Analysis Theme

Current

Task 38 Power to Hydrogen; Hydrogen to “X”
Operating Agent: Dr. Christine Mansilla

• The last task meeting was hosted by Technova, in Tokyo, Japan on 26 February 2018.
• Next steps by subtask and Task Force:
  * ST2 Demonstrations: Next steps include continuation of data collection and analysis with focus on subsequent demonstrations in uncovered regions and for upscaling or commercial deployment of hydrogen systems, as well as identifying key roadmap components.
  * ST3 Literature: Deadline for ST3A first step reviews to be completed, and a selection of pertinent studies to be reviewed in more detail (containing reliable and pertinent data) in preparation for the next round to analyze data and establish a basis for ST5.
  * ST3B Legislation: Finish data collection and integrate HyLAW findings in order to begin analysis of legislative and regulatory aspects regarding hydrogen system deployment.
  * ST5 Case studies: Identify potential future case studies which have not been covered in the 4 established case studies, as well as increase participation and collaboration/support for established and potential case studies.
**TF Data Update:** More discussion must be had in order to understand how to share reliable and updated data between task forces and subtask groups. To be further developed in the near future.

**Future Steps:**
- Continuation of data collection and analysis to follow within the next few months.
- Preparation of hydrogen meeting and communications at the WHEC concerning Task 38 members and work.

**Closing**

**Task 36 Life Cycle Sustainability Assessment of Hydrogen Energy Systems**
Operating Agent: Javier Dufour

- The Final Task 36 experts meeting was held 11 December 2017 and the task has come to its end.
- Major accomplishments of the Task by subtask include:
  - Subtask A: Completed review of LCA studies and completed formulation and application of a harmonization protocol for life-cycle indicators of hydrogen (GWP, CEDnr, AP).
  - Subtask B: Review of LCC scientific literature in the field of hydrogen energy and distinction between conventional LCC and calculation of externalities. Influence on the optimized cost of hydrogen.
  - Subtask C: Review of SLCA/LCSA scientific literature in the field of hydrogen energy, analysis of the social acceptance of hydrogen (Int J Hydrogen Energy; 41: 5203-8), and robust LCSA framework including eco-efficiency assessment and the use of SLCA databases.

**Coming Soon**

**In Definition:** A new task on Data and Modeling (Task Organizer TBD).

**In Definition:** A new task on #1 market deployment of hydrogen technologies in the short term; #2 pathways to scale from existing microscale activities to the large-scale economic use of hydrogen for energy in the longer term (Task Organizer United Kingdom).

**Hydrogen Awareness, Understanding and Acceptance Theme**

**Current**

**Task 37 – Hydrogen Safety**
Operating Agent: Dr. Y. John Khalil

- IEA Hydrogen Safety Journal will launch soon.
- Next meeting will be held in the third quarter of 2018.
**Australia**

Dr. Craig Buckley of Curtin University led a successful application to the Australian Renewable Energy Agency (ARENA) International Engagement Program (IEP) on behalf of the Australian Association for Hydrogen Energy (AAHE). ARENA awarded AAHE $494,000 over the next five years.

Through the Australian Government Department of the Environment and Energy, Australia will lead the Hydrogen Innovation Challenge for Mission Innovation.

**Belgium**

Belgium is looking at a major energy paradigm shift. They are aiming to shut down their nuclear power plants, which now provide 50% of energy, by 2025. In lieu of nuclear power, their goal is to produce 40% of their power through renewable electricity by 2030. By 2035, Belgium plans to convert the natural gas grid to hydrogen, biogas, and syngas; new buildings will have no connection to Natural Gas grid by 2035. By 2050, no fossil fuels will be used to heat buildings. Belgium also has the following goals for electricity use and storage: 20% of new cars are to be zero-emission by 2025, and 50% of new cars are to be zero-emission by 2030. By 2020, 20 hydrogen stations are to be built.

Currently, Belgium only has 10 FCEV light duty vehicles on the road. However, they are participating in a number of projects focused on hydrogen and heavy duty applications. This includes the JU-FCH-project HighVLOcity which features five H₂ buses running in the Antwerp region; the Life & GrabHy (EU-Life, 3,5 M€) project, which features 2 garbage trucks; the H2SHare (Interreg –NWE, 3,6 M€) project, which features a 27 ton mobile hydrogen refiller truck; and the Waterstofregio 2.0 (Interreg Vlaanderen-Nederland) project, which features a 40 ton truck-trailer mobile hydrogen refiller. A dual fuel hydrogen/diesel engine powers the Hydroville in Antwerp. At Colruyt, 75 forklifts with indoor refilling have been deployed.

**China**

The National Energy Administration of China issued the Energy Technology Revolution Innovation Plan (2016-2030) at the end of 2016. The goal for hydrogen and fuel cells in this plan is to realize the popularization of hydrogen energy in China by 2050.

Currently there are a number of HRS under construction in Chinese provinces including LuAn, FoShan, ZhangJiaKou, NanHai, ChangZhou, and more. By 2020, they anticipate 5,000 FCEV and 100 HRS; by 2025 they anticipate 50,000 FCEV and 300 HRS; and by 2030, they anticipate 1 million FCEV and 1000 HRS. Subsidies for FCEVs (2016-2020) are RMB 200,000 for passenger vehicles, RMB 300,000 for light duty vehicles, and MB 500,000 for heavy vehicles.

China has also made a number of innovations in regards to H₂ and heavy duty applications. Their first hydrogen fuel cell train, designed by China Railway Rolling Stock Corporation, was recently developed and put into operation in Tangshan, China. In addition, they have made strides in aviation, including the following innovation breakthroughs: improved system integration, reliability assurance technology, and hydrogen security technology. In a big achievement, the first Chinese manned-aircraft powered by a fuel cell was successfully tested on 27 Dec 2017 in Dalian.

China is preparing for hydrogen to be used extensively during the 2022 Winter Olympics in Zhangjiakou. As part of their efforts, they will extend a “hydrogen highway” from Beijing to Zhangjiakou to ferry athletes and spectators to the games. Currently they have 100 Hydrogen buses in operation. The first automatic mass production line of H₂ Fuel Cell buses was launched in Aug 2017. They expect to produce 2,000 vehicles the first year as they scale up to 10,000 units per year.
Denmark: In Denmark, the Danish Minister of Energy opened a new methanisation plant where microorganisms convert CO$_2$ into methane. Hydrogen (from electrolysis) is mixed with CO$_2$ from the biogas and passed through a methanisation plant containing the archaea microorganisms. (The archaea organism originated in Icelandic volcanoes, where it converts hydrogen and CO$_2$ into methane.) The resulting biogas is supplied into the Copenhagen town gas network.

In other recent developments, Denmark established a new fund for fuel cell vehicles, which enables up to 40% funding of the vehicle cost in 2017 and 2018. They established a continuation of full tax exemption of the registration tax on fuel cell vehicles until 2021, while at the same time increasing tax on electric vehicles. Denmark is dedicated to increasing funding of energy R&D. As part of the “Mission Innovation” initiative, they’re obligated to double funding of energy R&D from 2015 to 2020. In 2018, the funding will be more than 500 million DKK.

Denmark also currently has a number of other Hydrogen oriented projects in the works. **HyScale’s** goal is to further reduce the size and increase of efficiency of hydrogen filling stations. **SPGC-Secure** power grid control is working on D&D of fuel cell based backup power systems for transformer systems. **BEEST (Boosting Economic Electricity Storage)** is focused on the development of scalable and efficient electrolysers.

Denmark currently has 10 Hydrogen refilling stations and 77 registered passenger cars. They also have a new fleet of ten fuel cell busses in Herning (home of NEL Denmark) based on EU funding.

**The European Commission (EC)** has a number of relevant directives that fall under the energy package “Clean Energy for all Europeans” [COM (2016) 860]. The three leading principles of this package are: put energy efficiency first; achieve global leadership in renewable energies; and provide a fair deal for customers.

The Clean mobility package [COM(2017) 283, COM(2017)675] creates new CO$_2$ targets for cars and vans for 2025 and 2030 to speed up the transition towards zero and low emission vehicles. It states that average CO$_2$ emissions are to be cut by 30% between 2021 and 2030. The revised Clean Vehicle Directive [2009/33/EU - COM(2017) 653] aims to promote clean mobility solutions in public procurement and foster demand and deployment of clean mobility solutions. As well, they have developed an action plan and investment solutions for the trans-European deployment of alternative fuels infrastructure [COM(2017)652].

The action plan on Alternative Fuels Infrastructure [2014/94/EU (AFID) COM(2017)652] plans to complement and better implement National Policy Frameworks aims to accelerate the deployment of AFI. “Europe on the Move”, the latest ramp-up of infrastructure in urban and suburban areas, has targeted 2025 as the deadline to install a backbone infrastructure in the TEN-T core networks.

Currently in the EC, there are 640 FCEV passenger vehicles (including range extenders) and 42 FCEB buses operational, with another 160 contracted. There are currently 130 HRS in operation, out of which the FCH JU publicly deploys 25. By 2025, The EC anticipates approximately 750 HRS. Germany (400), Italy (140) and the UK (65) have set the most ambitious HRS target numbers. Most countries have defined targets the maximum distance between HRS stations to below 300 km.

FCH2JU operations relevant to IEA Hydrogen include a 2017 call for proposals where 24 proposals were selected for funding for a total amount of approximately 114 million EUR ([http://www.fch.europa.eu/page/call-2017](http://www.fch.europa.eu/page/call-2017)). A similar 2018 Call for Proposals has closed in April 2018. The estimated budget will be 77 million EUR.
Currently the JRC (+FCH2JU) is involved in many IEA-HIA Tasks - 37 (Safety), 38 (P2H and H2X), and 39 (Maritime). They have planned the following events: a Plenary meeting of CEN-CENELEC Strategic Forum for Energy Management (SFEM) Working Group Hydrogen (April 2017); 5th International Workshop on Hydrogen Infrastructure and Transportation (EC, DoE, NEDO, NOW) in Berlin, May 2017; and the 7th International Conference on Hydrogen Safety, September 2017.

**France:** In June 2018, French Environment Minister Nicolas Hulot announced the intention to develop a national hydrogen plan for France.

**Germany:** Germany will co-lead the Hydrogen Innovation Challenge for Mission Innovation (MI) with Australia.

**HySafe:** The International Conference on Hydrogen Safety (ICHS), a unique event dedicated to Hydrogen Safety, took place in Hamburg, Germany 11-13 September 2017. Following ICHS, HySafe hosted the IEA Hydrogen Safety End of Term Workshop, also in Hamburg.

**Japan:** In Japan, at the first Ministerial Council on Renewable Energy, Hydrogen, and Related Issues (11th April 2017), Prime Minister Shinzo Abe stated: “Japan will be the first in the world to realize a hydrogen-based society. I request relevant ministers to formulate the basic strategy within this year.” In particular, he requested relevant ministers to accelerate the establishment of hydrogen refilling stations and streamline regulations, as well as formulating a unified scenario for building supply chains and introducing full-scale hydrogen power generation.

Other highlights include a new demonstration project to enhance H₂ demand. Power and heat supply systems using a hydrogen gas turbine went into service in January 2018. These are Power to Gas systems with 10MW electrolysis, intended to provide hydrogen to the Tokyo Olympic & Paralympic Games. To fund the project, a budget request was submitted by METI in JFY 2018 (Apr to Mar) requesting 30.2 billion yen (240 million EUR). (Subsidy:14.6 bil, RD&D: 15.6 bil)

Japan currently has 91 HRS in operation, with another 10 HRS under construction (completed in March 2018). As of 2017, Japan had 2,200 FCVs passenger cars and two 70MPa buses running in Tokyo and operated by the Tokyo government.

**Republic of Korea:** Korea has established incentives for newly implemented FCEVs. This includes a 50% reduction in the toll for expressways (starting September 2020) and the distribution of blue license plates for all EV and FCEVS for personal use. As well, they have established a new organization called H2 KOREA whose mandate is to develop load maps and support related industries.

Korea recently opened an FCEV parts testing center in Choongnam Province. Funding includes $63.6 M by 2021 invested in 18 R&D projects and $20.5 M by 2019 invested in nine different types of testing equipment. The first integrated fueling station opened in Ulsan in October 2017. This is the first national combination LPG and H2 refilling station in Korea, which will be used for next year's demonstration project of three Hyundai 3rd generation hydrogen buses operating in the metro area.

Currently, Korea has six open hydrogen-refilling stations and 17 either open or planned private research lab company refilling sites. They also boast five FCEV buses and 160 passenger cars. To promote the development of hydrogen industries, the “Hydrogen Electricity House” opened at Seoul in Aug 2017. It features the new Hyundai FCEV, which hit the market in February 2018 during the Pyeongchang winter Olympic Games.
The Netherlands: Outlines of a Hydrogen Roadmap, written by Marcel Weeda and Jorg Gigler of TKI New Gas, is now available in English. To gain greater insight into the role that hydrogen may play for the energy transition and the steps that will have to be taken towards achieving this, the Ministry of Economic Affairs and Climate Policy has asked TKI New Gas (Top Sector Energy) to manage the drafting of a Hydrogen Roadmap.

The Netherlands currently has over 100 hydrogen initiatives in various stages of development and this number is growing. Part Top Consortium Knowledge and Innovation on Gas (TKI Gas) have paired on the project and received a successful first tender of 0.75 M€ for projects and 0.1 M€ studies, just a portion of the 1.8 M€ budget for hydrogen innovation projects. In total, the 2017/2018 budget allocated 16.8 M€ for all fuels, a major part of which is focused on hydrogen projects.

Currently, the Netherlands has three HRS in use with another seven planned. There are 37 light passenger vehicles, 10 light commercial vehicles and one garbage truck on the roads. There are also five hydrogen buses in operation. FCH-JU JIVE II project has another 50 buses planned for 2019-2020.

New Zealand: New Zealand has made a number of changes to its energy strategy. They have made a commitment of 5 percent below 1990 energy levels by 2020. As well, they are targeting the Paris COP21 commitment of 30 per cent below 2005 levels by 2030 (or the equivalent to 11 percent below 1990). The government is striving to achieve 90% renewable electricity generation by 2025 and may add new targets. Potential measures include a target based on total primary energy or energy intensity.

R,D&I highlights include the UniQuad (a fuel cell farm bike), scheduled for completion in 2017. It has a Li-FePO4 12kWh battery; 3 kW PEM fuel cell; and 1 kg H2 fuel tank. In other news, HyLink is working on low cost, 2.5 kg/day H2 production and storage unit consisting of an alkaline electrolyzer, operating with 76% efficiency at 4 bar and HDPE storage (www.hylink.nz). Feasibility studies on export of renewable H2 from New Zealand are ongoing.

New Zealand Hydrogen Energy Consortium is exploring opportunities for hydrogen to meet industrial demand for clean, sustainable energy. Hiringa is aiming to build, own and operate hydrogen generation and distribution infrastructure in New Zealand, based close to existing capabilities of local oil and gas industries.

Norway: Norway has issued strong support to zero-emission transport, including both battery and Hydrogen. The Norwegian government has pledged 100 Million NOK (12 million USD) to develop hydrogen infrastructure. Private company ENOVA will support development of at least three more stations in 2018. Hydrogen vehicles enjoy strong tax incentives through 2025 (even better than EV incentives) and are exempt from local road tolls. In Oslo City (and in the surrounding Akershus county), there is a plan to make all taxis zero emission by 2022. In addition, there are several plans for H2-powered ferries to run on the west coast of Norway.

Norway started eight new centers on energy research (CEER) this year. This includes MOZEES: Mobility Zero Emission Energy Systems which has an annual budget 32 Mill. Kr. (4 Mill. USD), 50% of which comes from the Research Council. In addition, Norway started several new R&D projects within water electrolysis and Fuel cells, with several projects in development at NEL Hydrogen. (In addition to in country developments, NEL Hydrogen A/S is delivering 8 H2 filling stations to California, USA.) SINTEF will start a hydrogen safety project in 2018. The HYPER project at SINTEF, in collaboration with Japanese and European companies, will study H2 production from Wind and natural gas with liquefaction and transport in ships to Japan, Europe etc.
Currently Norway has five fuel cell buses and ~75 passenger cars. Their current H₂ infrastructure consists of one HRS @ 350 bar (for buses), 7 HRS @ 700 bar and plans for 20 more including two HRS in Bergen and one in Trondheim, which are under construction.

**NOW:** The Nationale Organisation Wasserstoff und Brennstoffzellentechnologie (NOW), an advisor to H₂ Mobility Germany, announced publication of a *Comparative Analysis of Infrastructure: Hydrogen Fueling and Electric Charging of Vehicles*, prepared by Jülich Research Centre. This scenario analysis shows that with one million H₂ vehicles (FCEVs) on the road, H₂ infrastructure is cheaper than a system of battery recharging points. The H₂ infrastructure advantage stems from dispensing of H₂ at centrally organized refueling stations (H₂ refueling stations). While both technologies are vital for successful decarbonisation of the transport sector, the build up of H₂ infrastructure is more cost friendly over time than the battery infrastructure.

**Sweden:** Currently, Sweden is taking part in the Nordic Hydrogen Corridor. This study is focused on enabling zero emission transport between the capitals of the Nordic countries. The study entails the pilot deployment for the introduction of eight new hydrogen-refilling stations (HRS), hydrogen production units and fuel cell electric vehicles (FCEV) along the TEN-T core network in Sweden. The study timeframe is 2017-2020. Partners include SWECO, Hydrogen Sweden, AGA, Hyundai and Toyota. Budget for the project is 187 MSEK, financed by partners and EU.

There are a number of other projects in the works, such as a large-scale bio-fuels project financed by Preem and Vattenfall. The aim of the project is to investigate the possibilities of using hydrogen in the production of large-scale biofuels for the Swedish market. Hydrogen will be used to convert renewable raw materials into biofuels to increase production. Project HYBRIT (Hydrogen Breakthrough Iron making Technology) aims to reduce carbon dioxide emissions from iron making by eliminating the need to use fossil fuels for iron ore reduction. The idea is to replace the blast furnaces with an alternative process, using hydrogen produced from “clean” electricity. By-product from iron making would be water and not carbon dioxide.

There are currently 28 FCEVs on the road and four early market stations open to the public, with plans for another 14 HRS by year 2020. Sweden also has a Hydrogen-powered medium-range forklift truck project underway. The aim is develop, demonstrate and test the forklift truck via cooperation between Kalmar and SSAB. The forklift is used in regular operations for internal transport and handling at SSAB. The forklift will be tested for 5-8 months, around the clock.

**Spain:** Hydrogen is included National Action Framework know as “Marco de Acción Nacional de Energías Alternativas en el Transporte a la Comisión Europea”. However, there is no budget allocated yet. Spain is actively involved in coordinating and collaborating with other EU Member States as regards alternatives fuels infrastructure and the Ministry of Energy push the actions to promote H₂ initiatives.

Currently there are six HRS open to private purposes and another 14 planned to be open to the public soon. As well, there are a number of Spanish entities involved with EU projects inducing: elyntegration, GERG, HYCARUS, Marcogaz, Hyacinth and rewind. National projects include Pilconeal, Renogas, Ships4blue, and Vuletah.

**UK:** The Department of Business, Energy and Industrial Strategy (BEIS) is investing £25m to provide the technical, performance, usability and safety evidence to de-risk the use of hydrogen for heat in buildings whilst working with others to prepare for a future occupied trial. “De-risking the distribution network” will provide quantified safety based evidence to confirm the GB gas distribution network can transport 100% hydrogen; as well as conducting ground and air concentration testing, background consequence testing, and operational testing. OFGEM (the gas market regulator) announced that Northern Gas Networks have secured £8.9m in funding to contribute to the effort to find out whether gas networks in Great Britain can safely transport gas that is 100% hydrogen.

As of the end of June 2017, there were 64 registered FCEVs from mainstream passenger car manufacturers on UK roads. These are comprised of 15 ix35 vehicles from Hyundai, 43 Toyota Mirais and six vehicles from Honda. Another
30 FCEVS (the Renault Kangoo) will soon be supplied to users under the OLEV fleet scheme but have been delayed due to issues with tank certification. In addition to these passenger vehicles, there are 20 FC buses (Van Hool and Wrightbus), -15 vans (KangooRE-EV), -15 dual-fuel combustion transit vans (ULEMCO), two dual fuel refuse trucks (Fife), and -ten micro-cars (Microband Riversimple).

Currently in the UK, there are 11 operational HRS > 80kg/day (of which 9 provide 700 bar) with five more expected to be deployed by mid-2018. In addition, two mobile refillers (OLEV) and two HRS in other locations (H2Me2) are already funded for installation in 2018. Three new bus refillers are planned for 2018 as well.

UNIDO: UNIDO’s mandate is Inclusive & Sustainable Industrial Development (ISID). Ongoing themes include creating shared prosperity, advancing economic competitiveness, and safeguarding the environment. They converge to achieve equitable & sustainable social, economic and environmental growth while mainstreaming involvement of and benefit to women and youth. UNIDO and hydrogen have been linked since the creation of UNIDO-ICHET (International Centre for Hydrogen Energy Technologies), which was open from 2005-2012 and funded by the Turkish government.

UNIDO’s inclusive industry mandate encompasses its Sustainable Energy Programme for Industry, the Sustainable Energy for All by 2030 initiative (SE4All), and UN Sustainable Development Goals (SDGs) 7, 9 and 13, as well as UNIDO’s key role in the UNFCCC Climate Change Centre & Technology Network (CTCN). UNIDO’s Department of energy has multiple programs organized around three strategic pillars: industrial energy efficiency, renewable energy, and climate policy and networks. There are also two cross-cutting programs: Sustainable Cities and Clean Tech Innovation. The UNIDO Energy portfolio includes 120 projects in 60 countries valued at 300 Million USD.

Other key programs and initiatives include: the Vienna Energy Forum (VEF); the Global Cleantech Innovation Program (CIP); the Global Network of Regional Sustainable Energy Centres (GN-SEC); and the UNFCCC Technology Mechanism Climate Technology Centre & Network. The latter, comprised of 158 country focal points and 400 implementing partners, has two prongs: mitigation and adaptation.

Mitigation is focused on reducing GHG emissions by thru agriculture; energy supply; forestry; industry; transport; and waste management. Adaptation focus is to strengthen climate resilience in agriculture and forestry; coastal zones; early warning & environment assessment; human health; infrastructure, transport and urban design; marine & fisheries; and water.

US: In the State of California, there are currently 31 retail and 3 (three) non-retail stations open, with another 13 in progress. In addition, funding for 65 stations has been acquired. In the Northeast US, there are 15 retail stations currently planned. Throughout the US, over 2,800 fuel cell cars have been leased or purchased. As well, the US boasts over 15,000 fuel cell forklifts purchased or ordered, (which accounts for ~6 million refillings). Fuel cell technology is moving into the delivery sector, with demo trucks delivering parcels in Sacramento, CA and Albany, NY.

The US government has made a number of new funding opportunities available in the H2 sector. Fuel Cell Technologies Office Annual FOA has announced over 30 awards (with a total of $15.8M in funding). Topics include PGM-free catalyst and electrode R&D, advanced water splitting materials, hydrogen storage materials discovery, and carbon fiber in pressure vessels. H2@Scale Cooperative Research and Development Agreement (CRADA) has distributed Up to $6M in funding with 22 selections from first round. Topics include modeling and analysis, materials compatibility, grid simulation, manufacturing R&D, co-products development, and performance verification.

As part of the IPHE International Safety and Reliability Data Sharing Initiative, the US has collaborated in the development of H2Tools.org, which tracks the global reach and development of H2 technologies. The site also includes a hydrogen equipment certification guide and permitting hydrogen fueling stations video.

Upcoming events include:

MESSAGE FROM THE CHAIR

One year into my term as Chairman, interest in hydrogen is intensifying in the business and public policy worlds, as well as within the IEA. One of the overarching IEA Hydrogen objectives for the period 2015-2020 is to broaden the perspective on the transformative role of hydrogen in an integrated future multi-sector energy system that mitigates climate change. We are pleased to report that there is increasing awareness of the benefits and vast potential of hydrogen on the global stage.

Strategy and analysis are two of the most important tools available to IEA Hydrogen to support our mission of accelerating hydrogen implementation and widespread utilization. We aim to make good use of both tools over the next two years of my chairmanship. We expect to have exciting news to share on both fronts in the very near future.

For moment, we can say that the core of IEA Hydrogen strategy—collaborative R,D&D—continues on its regular renewal cycle. Two successor tasks—in hydrogen storage & conversion based on hydrogen, and biological conversion of hydrogen for energy & chemicals—are now under consideration with more are to come. Two new analysis tasks are entering task definition, as well.

The remainder of the 2015-2020 cycle promises to be a period of optimism and progress for hydrogen.

Paul Lucchese
IEA Hydrogen Chairman
Cap Energies/CEA

The IEA H₂ NEWS is published twice a year by IEA Hydrogen, an IEA Technology Collaboration Programme. Our vision for a hydrogen future is based on a clean, sustainable energy supply that plays a key role in all sectors of the economy.