



# International Energy Agency (IEA) strategic initiatives and activities for hydrogen

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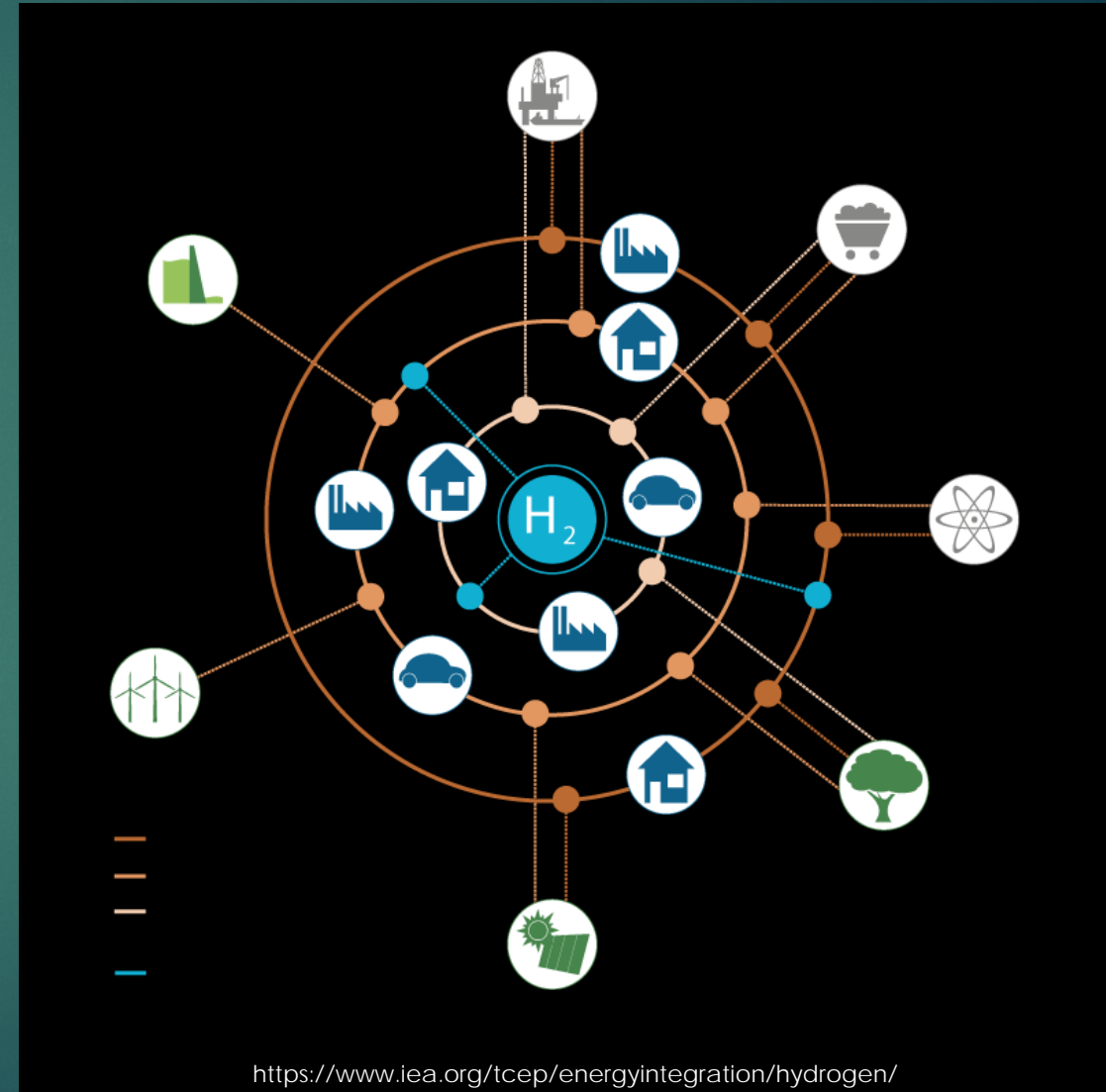
MBIE IEA-H2TCP REPRESENTATIVE FROM 2014 - ELECTED CO-VICE-CHAIR FROM 2017

# ACKNOWLEDGEMENTS

- ▶ Mark Pickup – Principal Policy Advisor MBIE
- ▶ Linda Wright – CEO, NZ Hydrogen Association
- ▶ Paul Lucchese – Chairman, IEA H<sub>2</sub>TCP
- ▶ Mary-Rose Valladares – General Manager, IEA H<sub>2</sub>TCP
- ▶ John B. Haldane – British geneticist who in 1923 envisioned a network of hydrogen-generating windmills powering Britain

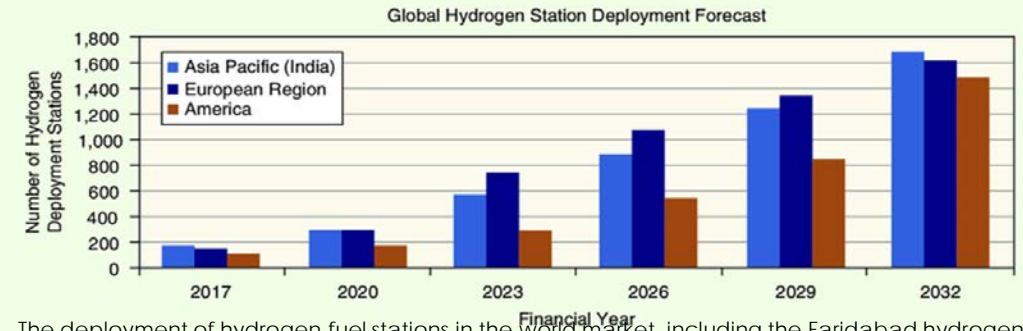
# Hydrogen Overview

- ▶ International Energy Agency estimates global hydrogen market is forecast to increase from US\$122 billion in 2018 to US\$155 billion in 2022.
- ▶ Current use of hydrogen is 55% ammonia synthesis, 25% in refineries, 10% for methanol production, and 10% other.

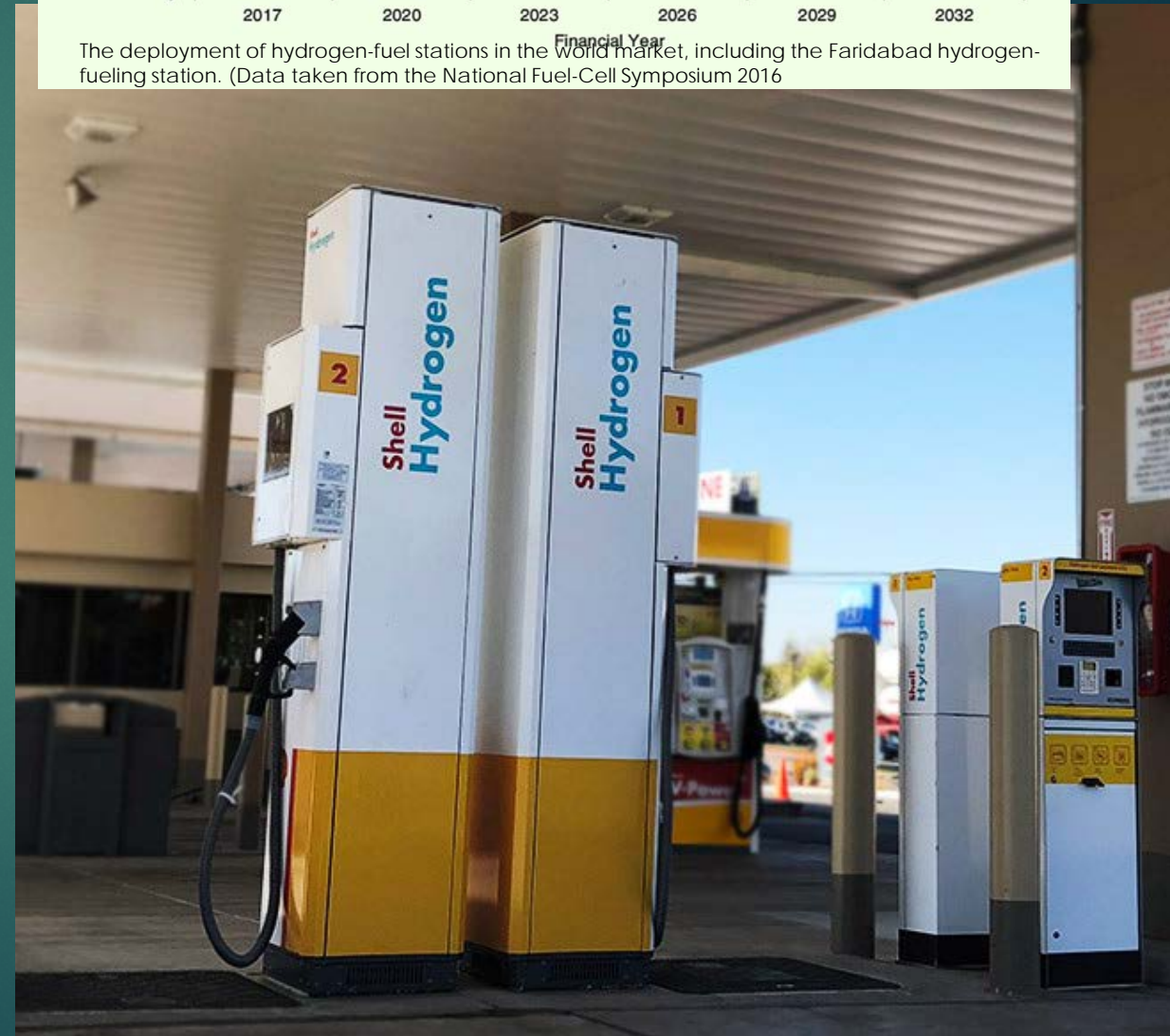


# Light Vehicle Activity

- ▶ Vehicles: 11,000 (53% USA, 38% Japan, 9% EU)(Mar 2019)
  - ▶ Hyundai Nexso, Toyota Mirai, Honda Clarity  
Cost: ~US\$70,000 (excl. tax credit), 500 km – 750 km range
  - ▶ Mercedes-Benz GLC F-Cell for lease.
  - ▶ Audi and Kia vehicles in 2020 (March 2019)
- ▶ Refuelling stations: 369 (41% Europe, 37% Asia, 21% N. America)(Feb 2019)
- ▶ HFCV adoption is 8-10 years behind EVs



The deployment of hydrogen-fuel stations in the World market, including the Faridabad hydrogen-fueling station. (Data taken from the National Fuel-Cell Symposium 2016)



# Buses

- ▶ JIVE (Joint Initiative for hydrogen Vehicles across Europe) will deploy nearly 300 FC buses in 22 cities across Europe by 2023 costing US\$720k each.
- ▶ 20 London double decker FC buses for 2020 at US\$700k each
- ▶ Tokyo plans to deploy 100 hydrogen FC buses for 2020 Olympics



<https://www.theguardian.com/uk-news/2019/may/10/london-to-have-world-first-hydrogen-powered-double-decker-buses>



<https://www.fuelcellbuses.eu/wiki/fuel-cell-electric-buses:fuel-cell-electric-buses/about-fuel-cell-electric-buses>

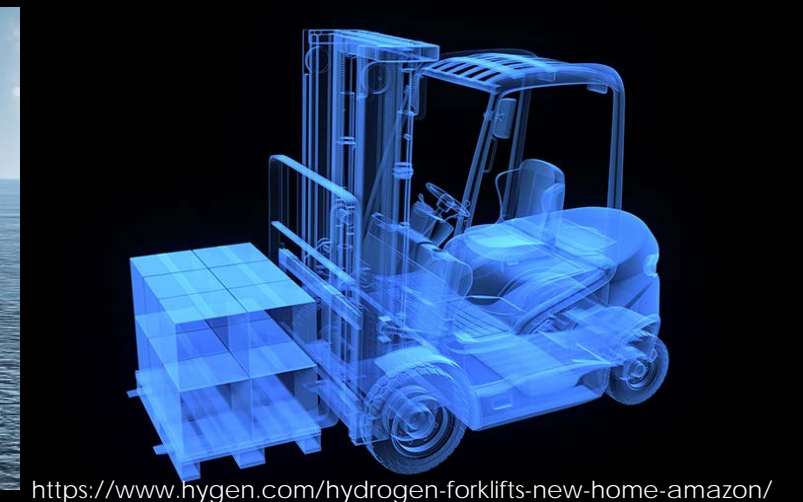
# Trucks

- ▶ Arizona based Nikola has pre-orders for 8,000 hydrogen FC trucks with a range 800 – 1200 km. c.f. Nikola battery powered trucks with battery sizes of 500 - 1,000 kWh and ranges of 320 - 640 km but reduced by 25% in extreme conditions.
- ▶ Hyundai has entered an agreement to supply 1,000 hydrogen FC trucks to Switzerland from 2019 – 2024.
- ▶ This year Toyota and Paccar unveiled the first of 10 hydrogen FC trucks for use in the Los Angeles area.



# Forklifts, Trains and Ferries

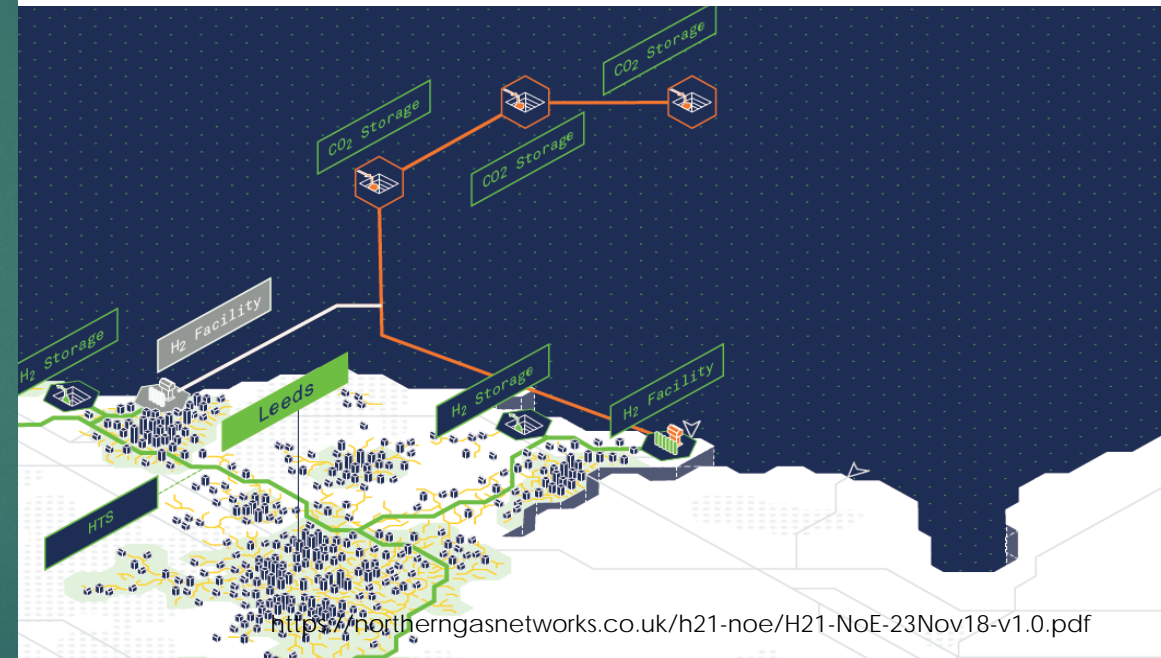
- ▶ Plug Power awarded two US\$600-million contracts in 2017 (qz.com) for forklifts for warehouses at Amazon and Walmart on the basis that they:
  - ▶ dont require frequent replacements during operations.
  - ▶ operate in freezing temperatures.
- ▶ Alstom operates 2 hydrogen FC trains on 100 km line in Germany.
- ▶ First commercial H<sub>2</sub> powered 20m catamaran is currently under testing in San Francisco funded by California Climate Investments program



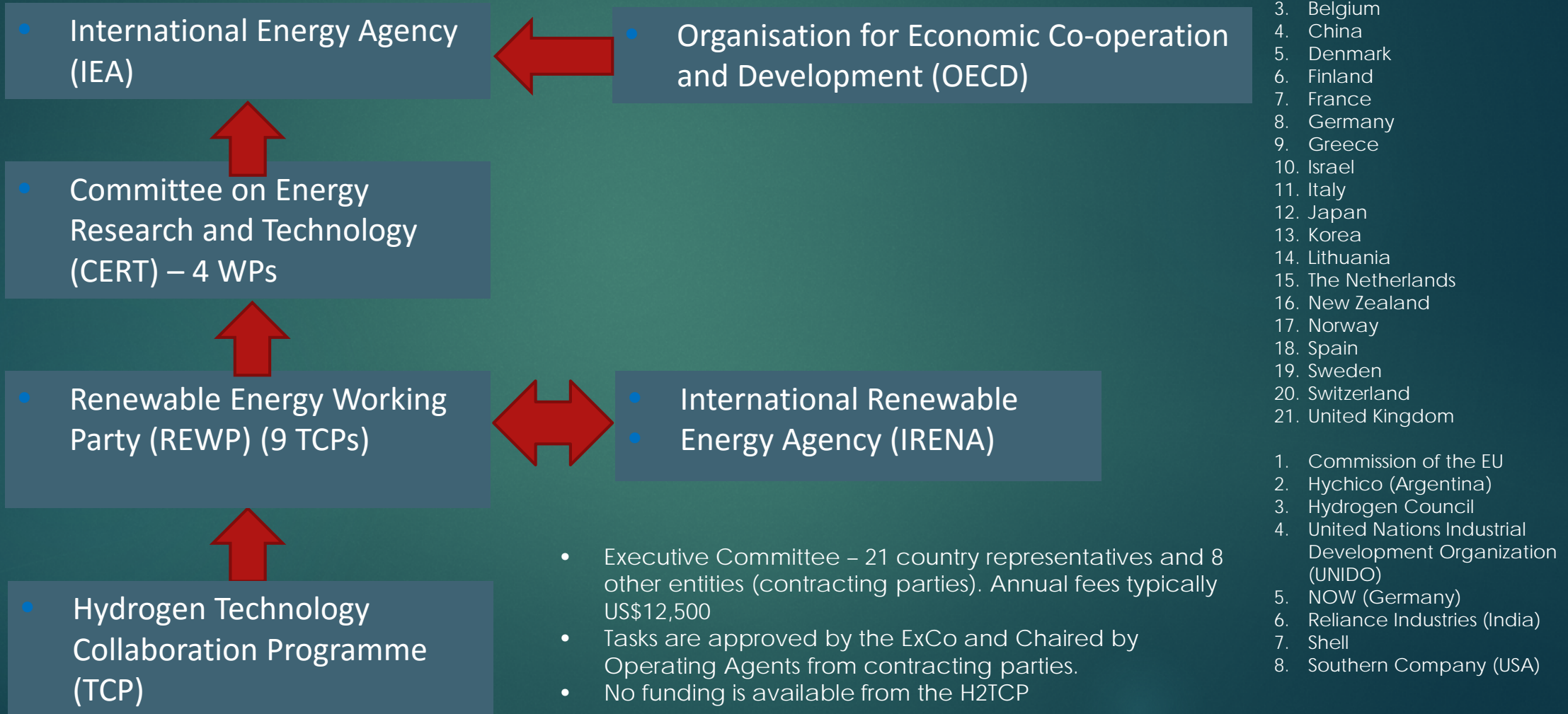
# Other

- ▶ H21 North England proposed project plans to convert 3.7 million homes from natural gas to zero emission H<sub>2</sub> by 2034 using CCS.
- ▶ Hydrogen Energy Supply Chain (HESC) project will export of 3 tonnes of hydrogen from 60 tonnes of brown coal with CCS from 2020 from Victoria to Japan.
- ▶ Recent renewables auctions in Chile and Morocco came in at US\$30/MW-h giving potential for hydrogen at US\$2/kg per kilo. ('The Economist' Nov 29th 2018)

SCOPE OF EMISSIONS	H21 NoE SYSTEM BASED ON 2018 UK MIX (G/KWH)	NATURAL GAS (G/KWH)	% REDUCTION IN EMISSIONS
Scope 1	14.40	183.6	92.2%
Scope 1+2	14.47 (14.4 + 0.073)	183.6	92.1%



# IEA Technology Collaboration Programmes



# IEA H<sub>2</sub>TCP -- Objectives

<http://ieahydrogen.org/>

- ▶ To provide a comprehensive understanding of the various technical and economic pathways for power-to-hydrogen applications in diverse situations
- ▶ To provide a comprehensive assessment of existing legal frameworks
- ▶ To provide business developers and policy makers with general guidelines and recommendations that enhance hydrogen system deployment in energy markets

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## IEA Hydrogen

... a global collaboration for research and innovation in Hydrogen technology

### WELCOME TO IEA HYDROGEN

With a 40 year operating history and significant accomplishments to its credit, the International Energy Agency (IEA) Hydrogen Technology Collaboration Program (TCP) is a unique leader in the management of coordinated hydrogen research, development and demonstration activities on a global basis.

Through the creation and conduct of nearly forty annexes or tasks, IEA Hydrogen has facilitated and managed a comprehensive range of Research, Development & Demonstration (R, D&D) and analysis programs among its Contracting Party (country and international organizations) and Sponsor (industry, PPP, non-profit) Members.

### CURRENT TASKS

Task 34 - Biological Hydrogen for Energy and Environment	2014-2017
Task 35 - Renewable Hydrogen Production	2014-2017
Task 37 - Hydrogen Safety	2015-2021
Task 38 - Power-To-Hydrogen and Hydrogen-To-X	2015-2019
Task 39 - Hydrogen in Marine Applications	2016-2019
Task 40 - Energy Storage and conversion based on hydrogen	2019-2021
Task 41 - Data and Modelling (Sub-Task C – Cooperation with ETSAP)	2019-2021

### IEA Hydrogen Safety Journal

[>> view/submit](#)

### LATEST NEWS

**The IEA Hydrogen Spring/Summer 2019 Newsletter is up now!** There have been a number of new developments since the last IEA H2 News. During the last quarter of 2018, IEA Hydrogen was proud to welcome four new members: one Contracting Party – Austria; and three Sponsor Members – the Hydrogen Council, Hychico, and Reliance Industries, Limited (RIL). In less than 10 months, IEA Hydrogen held four in-person ExCo Meetings in which strategic planning drove a significant part of the agenda for each meeting. IEA Hydrogen is now engaged in preparing a Request for Extension (RIE) to the IEA for the coming 2020-2025 period. To this end, a Strategic Plan for the new term and an End of Term Report for the current term (2015- 2020) are in development. The new IEA Hydrogen term will begin in March 2020. For more information about Member policies and activities, check out the [Member Update Table](#).

Experts from the IEA Hydrogen TCP, which has a global membership in hydrogen technology, recently gathered in Rotorua to discuss research and promotion of hydrogen as a fuel source for the future. Alongside the 80th ExCo meeting, a free public IEA Hydrogen Forum was held on Wednesday 20 February. Members and experts discussed hydrogen development along with the impact it could make in New Zealand, and on the global economy, with applications in transport, industry, and energy systems. View presentations from [Paul Lucchese](#), [Eiji Ohira](#), [Geert Tjarks](#), [Craig Buckley](#), [Jonathan Leaver](#), [Andrew Ciennett](#) and [Mary-Rose de Valladares](#).

The **Task 32 - H2 Based Energy Storage** End of Task Workshop held during the 16th International Symposium on Metal-Hydrogen Systems (MH 2018) on 1 November 2018 in Guangzhou, China featured some of the activities that contributed to making this task the world's largest and most important forum for hydrogen storage research. The following experts gave presentations that are available to view now: [Michael Hirscher](#), [Volodymyr Yartys](#), [Andreas Zuttel](#), [M. Latroche](#), [Teng He](#), [Craig Buckley](#) and [Martin Dornheim](#).

### CALENDAR

Jun 02	World Hydrogen Technologies Convention (WHTC) 2019
Jun 05	ETSAP TCP Workshop afternoon session on Hydrogen in energy models
Jun 24	Task 37 Meeting At the University of Oxford
Jun 30	Gordon Research Conference: Hydrogen-Metal Systems
Sep 26	Task 38 Plenary Meeting

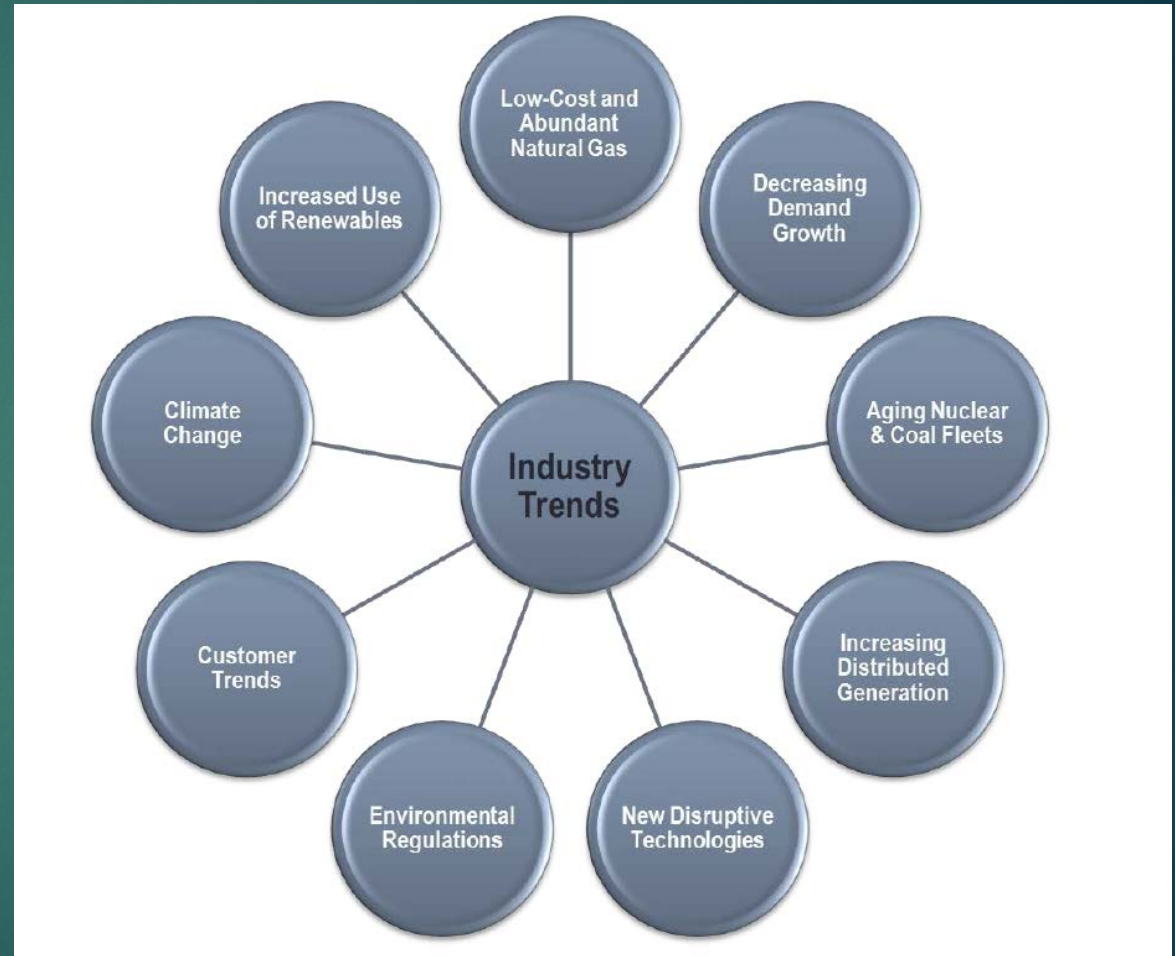
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# IEA H2TCP Strategy

<http://ieahydrogen.org/>

- ▶ To facilitate, coordinate, and maintain innovative RD&D activities through international cooperation and information exchange.
- ▶ Seven areas are targeted:
  - ▶ Technology
  - ▶ Energy Security
  - ▶ Environmental
  - ▶ Economic, Market
  - ▶ Deployment, and Outreach



# IEA H<sub>2</sub>TCP Strategic Activities

<http://ieahydrogen.org/>

## 2014 -2019 Tasks

- ▶ Task 34 - Biological Hydrogen for Energy and Environment 2014-2017
- ▶ Task 35 - Renewable Hydrogen Production 2014-17
- ▶ Task 36 - Life Cycle Sustainability Assessment 2016-18
- ▶ Task 37 - Hydrogen Safety 2015-2021
- ▶ Task 38 - Power-To-Hydrogen and Hydrogen-to-X 2015-19\*\*
- ▶ Task 39 - Hydrogen in Marine Applications 2016-19
- ▶ Task 40 - Energy Storage and conversion based on hydrogen 2019-2021
- ▶ Task 41 - Data and Modelling 2019-2021\*\*



## IEA HYDROGEN TASK 36

LIFE CYCLE SUSTAINABILITY ASSESSMENT  
OF HYDROGEN ENERGY SYSTEMS

### FINAL REPORT

for  
INTERNATIONAL ENERGY AGENCY (IEA) HYDROGEN  
TECHNOLOGY COLLABORATION PROGRAMME (TCP)

by: D. Iribarren, A. Valente, J. Dufour (Imdea Energy, Spain)  
with additional inputs from: P. Zapp (Forschungszentrum Jülich, Germany),  
K. Espegren (Ife, Norway), P. Masoni (Enea, Italy), and Y. Ishimoto (IAE, Japan)  
Systems Analysis Unit | Imdea Energy (Spain)



# Task 40 - Energy Storage and conversion based on hydrogen 2019-2021

## ► Working groups

1. Porous materials (coordination polymer framework compounds, MOFs, ZIFs, COFs, and carbon-based compounds)
2. Magnesium- and intermetallic alloys-based hydrides for energy storage
3. Complex hydrides (borohydrides, alanates, amides/imides-systems, magnesium-based compounds, reactive hydride composites)
4. Ammonia and reversible liquid hydrogen carriers
5. Catalysis
6. Electrochemical storage of energy (MH-batteries, ion-conduction)
7. Hydride-based thermal energy storage
8. Research and development for hydrogen storage and compression

- • Meetings every 6 – 9 months

# Task 38 Subtask

## Analysis of Demonstration Projects

PtH & grid services

HtX & storage services

techo-economical  
and/or regulatory  
objectives

global picture ?  
roadmap ?

	Results	% Av. data	% Results
Total number of demos	192	100%	100%
Nb of demos completed	97	73%	69%
Nb of ongoing demos	44	73%	31%
Nb of demos including grid services	41	84%	25%
Nb of Alkaline demos	87	86%	52%
Nb of PEM demos	73	86%	44%
Nb of SOEC demos	13	86%	8%
On-grid supply	42	76%	29%
Off-grid supply	76	76%	52%
On-grid + RES supply	27	76%	19%
Nb of demos with wind supply	43	63%	36%
Nb of demos with solar supply	48	60%	42%
Supply scheme: All-in	8	63%	7%
Supply scheme: Excess RES	65	63%	54%
Demos incl. Storage option	113	74%	79%
Shares of CHG storage	79	69%	60%
Shares of MH storage	10	69%	8%
Shares of CHG + MH storage	7	69%	5%
Shares of CNG/CH4 storage	6	69%	5%
Shares of Salt cavern storage	3	69%	2%
Baseload H2 production	16	31%	27%
Flexible H2 production	44	31%	73%
Demos with tech. Obj. only	90	81%	58%
Demos incl. Econ. Obj.	66	81%	42%
Operation validation obj	145	83%	91%
Efficiency obj	140	83%	88%
Upscaling obj	43	83%	27%
Pathway focus obj	97	83%	61%
Regulatory obj	17	83%	11%
Lobbying obj	7	83%	4%
H2 production cost obj	22	81%	14%
Nb of demos with upscaling plan	22	70%	16%
Nb of demos connected to other demos	53	78%	36%
Nb of demos connected to a roadmap	12	71%	9%

# Task Engagement

## ▶ Task 38 Power-To-Hydrogen and Hydrogen-To-X 2015-19

- ▶ Dolci, F., Thomas, D., Hilliard, S., Fu´nez Guerra, C., Hancke, R., Ito, H., Jegoux, M., Kreeft, G., **Leaver, J.**, Newborough, M., Proost, J., Robinius, M., Weidner, E., Mansilla, C., & Lucchese, P. (2019). Incentives and legal barriers comprehensive assessment of existing legal frameworks for power-to-hydrogen pathways: An international snapshot. *International Journal of Hydrogen Energy*, 1, 1-8. doi:10.1016/j.ijhydene.2019.03.045
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## ▶ Task 41 Data and Modelling (TIMES, UniSyD & others)

- ▶ Data collection of parameters describing the Hydrogen technologies, such as investment costs, efficiencies, lifetimes, learning curves etc.
- ▶ Develop knowledge of how to model Hydrogen in the value chain and improve current methods
- ▶ Collaboration with analysts in IEA HQ Analytics and the ETSAP community
- ▶ Applications and interactions for providing data for IEA, ETSAP and Hydrogen TCP tasks

# Task Engagement

- ▶ Calls to participate in new HTCP Tasks will be posted via the Hydrogen Association.
- ▶ Participants are typically research leaders whose interests align with those of the Task.
- ▶ Further information or assistance
  - ▶ Jonathan Leaver email: [jleaver@unitec.ac.nz](mailto:jleaver@unitec.ac.nz)
  - ▶ Mark Pickup email: [Mark.Pickup@mbie.govt.nz](mailto:Mark.Pickup@mbie.govt.nz)

# Links and references

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Thank you



BE(Hons)(Civil)(Auckland), PGDipEnergyTech(Geothermal)(Auckland), MS(Petroleum)(Stanford) PhD(Mechanical)(Auckland)

- ▶ Fellow of Engineering New Zealand
- ▶ MBIE IEA-H<sub>2</sub>TCP representative from 2014. Elected co-Vice-Chair from 2017.
- ▶ Plenary speaker at the U.S. National Hydrogen Association Conference 2010.
- ▶ Former Chief Petroleum and Geothermal Inspector (7 yrs), Ministry of Commerce
- ▶ Author in 35+ hydrogen related journal and conference papers from 2002 e.g.
  - ▶ Watabe, A., **Leaver, J.**, Ishida, H., & Shafiei, E. (2019). Impact of low emissions vehicles on reducing greenhouse gas emissions in Japan. *Int. J. Hydrogen Energy*, Volume 130, Pages 227-242. doi:10.1016/j.enpol.2019.03.057
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