



2021 ANNUAL REPORT

TASKS & MEMBER UPDATES

THE HYDROGEN TCP	2
CHAIR AND LEADERSHIP TEAM	2
TECHNICAL SECRETARIAT	2
EXECUTIVE COMMITTEE	3
CHAIR'S MESSAGE	5
MILESTONES IN 2021	6
CLOSING TASKS IN 2021	9
TASK 39 – HYDROGEN IN THE MARITIME	9
TASK 38 – POWER-TO-HYDROGEN AND HYDROGEN-TO-X	10
TASK 37 – HYDROGEN SAFETY	12
OPEN TASKS	14
TASK 41 – DATA AND MODELLING	14
TASK 40 – ENERGY STORAGE AND CONVERSION BASED ON HYDROGEN	17
MEMBER UPDATES	20
AUSTRIA	20
AUSTRALIA	22
BELGIUM	25
CANADA	27
CHINA	30
DENMARK	32
EUROPEAN COMMISSION	35
FRANCE	38
GERMANY	40
HYCHICO	43
HYDROGEN COUNCIL	45
ISRAEL	46
ITALY	49
JAPAN	52
NATIONAL ORGANISATION HYDROGEN AND FUEL CELL TECHNOLOGY (NOW GMBH)	54
THE NETHERLANDS	57
NEW ZEALAND	60
NTPC LIMITED	63
NORWAY	66
SPAIN	69
SWITZERLAND	72
UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION (UNIDO)	75
UNITED KINGDOM	79
UNITED STATES OF AMERICA	82

THE HYDROGEN TCP

The **Hydrogen Technology Collaboration Programme** (Hydrogen TCP) was established in **1977** under the [International Energy Agency](#)'s auspices to pursue **global collaborative hydrogen research and development** and information exchange among its member countries.



Through the creation and conduct of more than 40 research projects called **Tasks**, the Hydrogen TCP has facilitated and managed a comprehensive range of hydrogen R, D&D and analysis activities. The Hydrogen TCP was, prior to 2020, known as Hydrogen Implementing Agreement (HIA).

The Hydrogen TCP envisions a hydrogen future on a clean sustainable energy supply that plays a key role in all sectors of the global economy with a 40+ year operating history and significant accomplishments to its credit, the Hydrogen TCP is the premier global resource for technical expertise in hydrogen R, D&D.



PAUL LUCCHESE

CHAIR AND LEADERSHIP TEAM

The current Chair of the Hydrogen TCP is **Mr Paul Lucchese** (2017-2023), Head of the New Energy R&D program at [CEA](#). Mr Lucchese has been in the hydrogen and fuel cells field since 2001, actively involved in national (Vice-chair of the French Hydrogen Association), European (Chair of Hydrogen Europe Research for 8 years, member of the FCH JU Governing Board) and international (Chair of the Hydrogen TCP since 2017) organizations.

His background includes a Nuclear Engineering Degree at the École Centrale de Paris (1983) with a speciality in two-phase flow thermohydraulic, followed by a Master's in Applied Chemistry. Among the activities he currently carries out is the intervention in conferences and events, the review of reports, strategies and roadmaps, and the participation in diverse scientific committees.



EIJI OHIRA

MARCEL WEEDA

The Leadership Team is formed by the Chair and two Vice-Chairs: **Dr Marcel Weeda**, Senior Consultant for Energy Transition Studies at [TNO](#), the Netherlands; and **Dr Eiji Ohira**, Director General of the New Energy and Industrial Technology Development at [NEDO](#), Japan.

TECHNICAL SECRETARIAT

[ARIEMA Energía y Medioambiente S.L.](#) is the Technical Secretariat of the Hydrogen TCP since July 2020. ARIEMA is a Spanish company with more than 30 years of experience in the hydrogen sector, including the management of sectoral associations and platforms. It is also one of the

main Spanish companies that promote innovation projects, technology development, and public-private collaboration activities, having executed more than 100 R&D and innovation projects to date.



MARINA HOLGADO **ANDREA DEL CURA**






























The Technical Secretariat Coordinator is **Ms Marina Holgado**, Chemical Engineer and Energy Engineer with a Masters in Renewable Energies, Hydrogen Production and Fuel Cells. She is currently a Project Manager at ARIEMA.

The Technical Secretariat Assistant is **Ms Andrea del Cura**, Project Assistant at ARIEMA with a background in International Studies.

EXECUTIVE COMMITTEE

The Hydrogen TCP's Executive Committee (ExCo) is the main decision body. It is formed by representatives and alternates of the [Members](#). As of December 2021, the Hydrogen TCP is formed by 26 Contracting Parties (24 Member Countries + the European Commission + UNIDO) and 7 Sponsors (companies and other organizations).

During the year 2021, there have been four [ExCo Meetings](#), all of them online (85th – 88th ExCo Meetings) in April, June, September, and December.

	Australia		Hychico		Portugal
	Austria		Hydrogen Council		Reliance Industries Limited (RIL)
	Belgium		Israel		Shell Global Solutions International BV
	Canada		Italy		Southern Company
	China		Japan		Spain
	Denmark		Korea		Sweden
	European Commission		Lithuania		Switzerland
	Finland		New Zealand		The Netherlands
	France		NTPC		United Kingdom
	Germany		Norway		UNIDO
	Greece		NOW GmbH		United States of America



CHAIR'S MESSAGE

2020 set very high stakes in the field of hydrogen, so it does not come as a surprise that the year 2021 has followed the expanding trends of the sector. In what could be called “The Hydrogen Year”, many hydrogen-related initiatives, country roadmaps and strategies, as well as announcements of expected funds and resources have taken place.

Transition and progress have permeated the Hydrogen TCP as well. Our efforts have been focused on implementing our five-year Strategic Plan and ensuring that our values are present in all activities encompassed in the TCP's frame. 2021 has also been the first full year of *ARIEMA Energía y Medioambiente SL* as Technical Secretariat, a period in which modernization, adaptability, and divulgation have stood out.

I would like to take this opportunity to emphasize our role in accelerating the energy transition to hydrogen and accompanying the hydrogen momentum the world is going through. Our network of international experts has been committed to hydrogen research and hydrogen technologies development since 1977 and will continue doing so through Tasks and collaborative activities.

As one of the veteran organizations in the field, and as part of the International Energy Agency's Technology Collaboration Network, we work every day to create synergies among actors and avoid duplication of efforts. The *hydrogen fever* must not make us lose the focus on producing reliable, well-funded, accessible findings for the community. And that is exactly what our Tasks stand for.

During 2021, we have successfully reached the final steps of Task 38 on Power-to-Hydrogen and Hydrogen-to-X (launching the Recommendation Roadmap in June), Task 39 on Hydrogen in the Maritime (with its Final Workshop and Final Report in October) and Task 37 on Hydrogen Safety (to be succeeded by a new Task in Definition).

As some of our Tasks come to an end, many new ideas from our members arise during the Executive Committee Meetings. I am glad to announce that several Tasks in Definition are expected to kick off in the upcoming months. Noteworthy is the job Task Organizers and Managers are doing in the field of safety, renewable production of hydrogen, export value chains, offshore hydrogen production and many more essential topics.

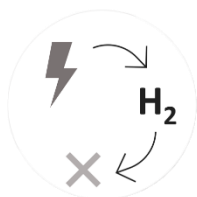
Once again, I would like to remark on the importance of global collaboration at all levels. It is a complex mission, but only if we work together, achievement of the ambitious net-zero goals is close to realistic.

The Hydrogen TCP will keep envisioning a future based on a clean sustainable energy supply that plays a key role in all sectors of the economy. Let's hope that 2022 will bring numerous triumphs and that the best is yet to come.

MILESTONES IN 2021

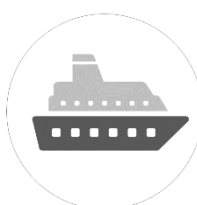
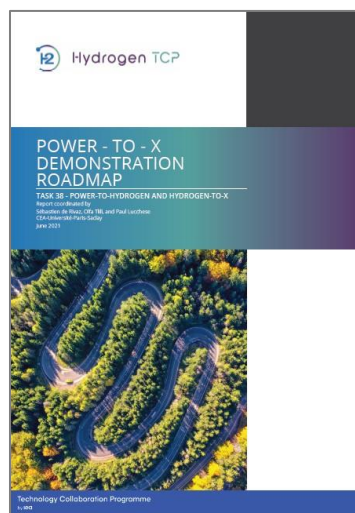
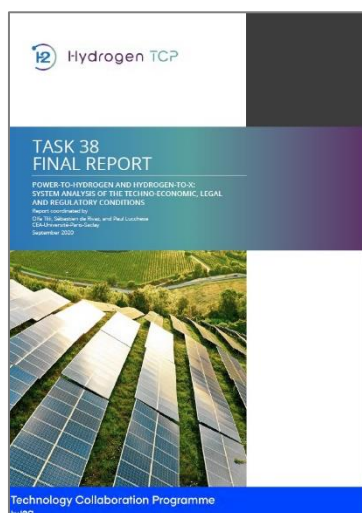
Summary of the main achievements and milestones of the year 2021, organized by categories.

TASKS



Task 38 ended in 2021, presenting its [Final Report](#) on July 1st, during the [Power-to-Hydrogen and Hydrogen-to-X Joint Workshop by the IEA and the Hydrogen TCP](#).

Task 38 has also produced a [Roadmap on Power-to-X Demonstration](#).



Task 39 has ended in the year 2021 as well, presenting its [Final Report](#) on Hydrogen in the Maritime in October at the [Task 39 Final Workshop](#).



Task 37 on Hydrogen Safety has been finalized but will be succeeded by the Task in Definition [Safety and RCS of Large-Scale Hydrogen Energy Applications](#).

The task in Definition on Underground Hydrogen Storage will kickoff early 2022, with over 50 interested parties and a proposed structure of 6 subtasks covering Hydrogen conversion and contamination, Storage integrity, Storage performance, Surface facilities, wells and materials, Economics and system integration and Planning, regulation, safety and societal embedding.

Other [Tasks in Definition](#) that are expected to start in the upcoming months are focused on Offshore Hydrogen Production, Hydrogen Export Value Chains and Hydrogen in the Mining, Mineral Processing, and Resource Sectors. All of them have had definition workshops throughout the year to define the preliminary structure, goals and expected development for future Tasks.

DOCUMENTS

Apart from producing its deliverables, experts from the Hydrogen TCP network have participated in the **review** of several papers and documents highly relevant for the hydrogen community such as the *Critical Minerals Report*, the *Global Hydrogen Review* and *The role of low-carbon fuels in clean energy transitions of the power sector* by the [IEA](#), *Task 41 Special Project "Renewable Gas – Hydrogen in the grid" Report* by the [Bioenergy TCP](#) and *MI Clean Hydrogen Discussion Paper* by [Mission Innovation](#).

MEMBERS



We have welcomed two new members this year!

USA has rejoined the Hydrogen TCP as a Contracting Party and the Indian company **NTPC** has joined as a Sponsor.



EVENTS

During 2021, the Hydrogen TCP has had **representation** in more than 15 events, it has actively [participated](#) in over 25 (such as the European Conference, the High-Level Conference on Hydrogen “Hydrogen in Society – Bridging the Gaps”, the Hydrogen Technology Expo Europe or Hydrogen Economy Europe); and has [organized](#) 2 public workshops (the joint workshop with the IEA on Power-to-Hydrogen and Hydrogen-to-X Joint Workshop and Task 39 on Hydrogen in the Maritime Final Workshop).



ERIK BUSCHE GIVING A KEYNOTE ON
BEHALF OF THE HYDROGEN TCP



MARINA HOLGADO AT THE HYDROGEN
TECHNOLOGY EXPO EUROPE'S BOOTH

COLLABORATION

Outside the IEA Network, the Hydrogen TCP collaborated in 2021 with the [International Atomic Energy Agency](#) and the [International Transport Forum](#).

T

A

S

K

S

CLOSING TASKS IN 2021

TASK 39 – HYDROGEN IN THE MARITIME

TASK MANAGER: Ingrid Schjøllberg - [NTNU](#) - Norway

TIMEFRAME: 2017 - 2021

SYNOPSIS

Task 39 purpose was to provide expertise on the use of hydrogen and fuel cells in the maritime industry, evaluate concepts, and initiate research and demonstration projects. The Task was finalized in mid-2021 and most of 2021 was dedicated to finalizing the Report.

The Task has built on a broad network of competence within hydrogen and the maritime sector, consisting of suppliers of hydrogen, end-users, regulators, research institutions, academia, funding parties and authorities. The range of participants has contributed to a diverse overview of the opportunities of hydrogen as a maritime fuel.

The main working methods have been joint workshops, presentations, and discussions on the topics of storage, production, supply, costs, design, energy management and system requirements.

The work focus has been to contribute to

- ◆ Technology overview which has included possibilities for the use of hydrogen in the maritime, challenges and opportunities
- ◆ Development of new concepts, technologies and components
- ◆ Safety and regulations in a global perspective and with a special focus on safety methods and risk management for on board solutions
- ◆ Develop an overview of an ongoing international demonstration project on the use of hydrogen in the maritime

MAIN TASK ACHIEVEMENTS AND RESULTS

The Final Report of the Task, which contains the key messages, is available [here](#).

KEY MESSAGES

- Hydrogen is a feasible solution for short term low emission and future zero-emission, both for short and deep sea.
- Port infrastructure is critical, with availability through local solutions supporting the electrification of ports.
- Current safety regulations do not prevent the use of hydrogen in the maritime setting.
- The barriers encompass issues of a technical nature along with regulatory, economic and transboundary and multi-layer governance differences.
- Demonstration projects are necessary for evidence-based learning.
- It will be crucial to reach economies of scale to allow for large scale adoption.
- Scaling up ship size, installed power, vessel range and freight capacity provide a logical route for rapid adoption of H₂ as a future fuel for ships.

TASK 38 – POWER-TO-HYDROGEN AND HYDROGEN-TO-X

TASK MANAGERS: Christine Mansilla, Olfa Tlili, and Paul Lucchese - [CEA](#) - France

TIMEFRAME: 2015 - 2021

SYNOPSIS

Task 38, entitled: “Power-to-Hydrogen and Hydrogen-to-X: System Analysis of the techno-economic, legal and regulatory conditions”, was approved by the Executive Committee to examine hydrogen as a key energy carrier for sustainable energy system.

The general objectives of the Task were to provide a comprehensive understanding of various technical and economic pathways for power-to-hydrogen applications in diverse settings, to provide a comprehensive assessment of existing legal frameworks for hydrogen systems, and to present business developers and policymakers with general guidelines and recommendations which enhance hydrogen system deployment in energy markets. The final objective was to develop hydrogen visibility as a key energy carrier for a sustainable and smart energy system, within a 2 or 3 horizon time frame.

SUBTASK/ TASKFORCE	NAME	LEADER
1	Management, strategy and communication	Paul Lucchese, Christine Mansilla and Olfa Tlili, CEA, France (support from Samantha Hilliard, Clean Horizon)
2	Mapping and review of existing demonstrations	Joris Proost, Université Catholique de Louvain, Belgium
3A	Review and analysis of the existing techno-economic studies on PtH HtX	Martin Robinius, Forschungszentrum Jülich, Germany
3B	Review of the existing legal context and policy measures	Francesco Dolci, JRC, European Commission
4	Systemic approach	Sheila Samsatli, University of Bath, United Kingdom
5	Case studies	Gema Alcalde and Carlos Fúnez Guerra, Centro Nacional del Hidrógeno, Spain
TASK FORCES		LEADER
Definitions		Rob Dickinson, Hydricity Systems, Australia
Data		Laurence Grand-Clément, PersEE, France
Electrolyzer data		Joris Proost, Université Catholique de Louvain, Belgium
Services to the grid		Rob Dickinson, Hydricity Systems, Australia Pierluigi Mancarella, University of Melbourne, Australia

MAIN TASK ACHIEVEMENTS AND RESULTS

Reports

- ◆ Task 38 Final Report, “Power-to-hydrogen and hydrogen-to-x: system analysis of the techno-economic, legal and regulatory conditions”, 2021
- ◆ Roadmap on Power-to-hydrogen and hydrogen-to-X demonstration projects, 2021
- ◆ Several Technology Briefs that can be found [here](#).

Workshops

- ◆ Workshop on hydrogen in energy models in Bath (ST4), 15/5/2017
- ◆ Workshop on Power-to-X demonstration projects in Asia, Tokyo, 27/2/2018
- ◆ Roundtable organization and participation at WHEC 2018: “The Role of Hydrogen in the Energy Policies”, WHEC 2018, Rio de Janeiro, 17-22/06/2018
- ◆ Workshop on demonstration Projects (ST2) in Aix-en-Provence, 20/11/2018
- ◆ Workshop on Hydrogen in the Mediterranean region (ST5) in Puertollano, 26/9/2019
- ◆ Task 38 experts have also participated in numerous conferences and events (WHEC, P2G, EEM, IAEE...)

Publications

Five papers have been published in international journals, mainly in the International Journal of Hydrogen Energy, and one paper is still under review. A wide range of topics has been addressed: regulatory framework, demonstration projects, power to X systems modelling, electrolyser costs, etc. A list is available below:

- J. Proost, 2019, IJHE, [Critical assessment of the production scale required for fossil parity of green electrolytic hydrogen](#)
- Z. Chehade, C. Mansilla, P. Lucchese, S. Hilliard, J. Proost. 2019, IJHE, [Review and analysis of demonstration projects on power-to-X pathways in the world](#)
- C. J. Quarton, O. Tlili, L. Welder, C. Mansilla, H. Blanco, H. Heinrichs, J. Leaver, N. J. Samsatli, P. Lucchese, M. Robinius and S. Samsatli. 2019, Sustainable Energy&Fuels, [The curious case of the conflicting roles of hydrogen in global energy scenarios](#)
- Dolci, D. Thomas, S. Hilliard, C. Fúnez Guerra, R. Hancke, H. Ito, M. Jegoux, G. Kreeft, J. Leaver, M. Newborough, J. Proost, M. Robinius, E. Weidner, C. Mansilla, P. Lucchese. 2019, IJHE, [Incentives and legal barriers for power-to-hydrogen pathways: An international snapshot](#)
- J. Proost, 2019, IJHE, [State-of-the-art CAPEX data for water electrolyzers, and their impact on renewable hydrogen price settings](#)

KEY MESSAGES

Main conclusions and recommendations for demonstration projects and beyond:

- 1) Adopt a selective approach and prioritization before launching a new demo project
- 2) Establish and organize a permanent knowledge and advisory platform on R&D and demos projects
- 3) Develop an updated guideline
- 4) Promote international collaboration and technology transfer through joint demo facilities platform

TASK 37 – HYDROGEN SAFETY

TASK MANAGERS: Y. (John) F. Khalil- [Collins Aerospace](#) - USA

TIMEFRAME: 2015 - 2021

SYNOPSIS

The overarching goal of this Hydrogen Safety Task is to support the acceleration of safe implementation of hydrogen-based technologies and their infrastructures through coordinated international collaborations and hydrogen safety knowledge dissemination.

Under Task 37, Dr Khalil managed a portfolio of research activities conducted by international hydrogen safety experts. Also, he organized five subtasks under Task 37 as shown in the table below. Each Subtask has assigned subtask Leader(s) and a team of internal hydrogen safety experts.

SUBTASK/ TASKFORCE	NAME	LEADER
A	QRA Tool Kit Integration (HyRam)	Prof. Katrina Groth -University of Maryland, USA
B	Accident Scenarios Development & Quantification	Prof. Knut Vagsather - University of South-Eastern (USN), Norway
C	Physical Effects / Phenomena	Prof. Vladimir Molkov - Ulster University N. Ireland, UK Prof. Jennifer Wen - Warwick University, UK
D	Human Reliability Analysis (HRA)	Prof. Frank Markert - Technical University of Denmark (DTU), Denmark
E	Materials Compatibility Issues	Prof. Tadahiro Shibutani - Yokohama National University (YNU) Yokohama, Japan Prof. Changjian Wang - Hefei University of Technology, China

MAIN TASK ACHIEVEMENTS AND RESULTS

One of the key activities of Task 37 was supporting the development and testing of the Hydrogen Risk Assessment Model (HyRam) toolkit which incorporates numerous hydrogen behaviour models into a user-friendly package designed to address key barriers to H₂ infrastructure deployment, including limited access to reliable data and lack of models describing hydrogen behaviour. Other activities of Task 37 included providing quantitative insights (both physics-based and probabilistic) to support the development of new as well as revised H₂ safety C&S (e.g., NFPA2 and ISO standards).

KEY MESSAGES

- Over the six-year duration of Task 37, Dr Khalil and his internal H₂ safety experts continued to provide risk quantitative insights (both physics-based and probabilistic) to support the development of new, as well as revised, hydrogen safety C&S (e.g., NFPA-2 and ISO standards).
- Dr Khalil emphasizes the importance of expanding the scope of hydrogen safety beyond the fuel-cell-powered light-duty vehicles (LDV) application and H₂ refuelling stations. In this regard, Dr Khalil recommends expanding the scope of H₂ safety to other applications such as maritime, commercial aviation (hybrid-electric & all-electric aircraft), power-to-gas (P2G), H₂ transport in long road tunnels and other confined-spaces such as garages.

FURTHER INFORMATION

- ◆ [Closed Tasks](#)

OPEN TASKS

TASK 41 – DATA AND MODELLING

TASK MANAGERS:

Until Feb 2022: Arne Lind, [IFE](#), Norway

From Feb 2022: Rob Dickinson, [Hydricity Systems](#), Australia

TIMEFRAME: 2019 – 2022

SYNOPSIS

Over the years leading up to about 2019, some members of the hydrogen research community developed increasing concerns about the limitations of current energy systems models and data currency. The primary concern was the ability of models to quantify hydrogen's opportunities in energy markets.

Given the role of the IEA in providing impartial advice to governments around the world, there was particular enthusiasm within both the IEA and in IEA Hydrogen to ensure that the IEA has access to the most up-to-date data and models.

PURPOSE, OBJECTIVES AND STRATEGY

SUBTASK	NAME	LEADER
A	Data consolidation of parameters describing hydrogen technologies	Laurence Grand-Clement (Persee, FR)
B	Develop knowledge of how to model Hydrogen in the value chain and improve current methods	Rob Dickinson (Hydricity Systems, AU)
C	Collaboration with analysts in IEA HQ Analytics and the IEA ETSAP community	Paul Dodds (University College London, UK)
D	Review reports from IEA	Arne Lind (Institute for Energy Technology, NO)

STATUS, RESULTS AND MAIN ACHIEVEMENTS IN 2021

The primary focus of **Subtask-A** has been on technology data categorised by Technology Readiness Level (TRL) and covering supply chains and utilisation. In 2021 we developed a data quality assessment process and an initial database structure. Testing and validation have begun in collaboration with members of Subtask-B based on a selected collection of energy model archetypes from that Subtask, as follows.

The primary deliverable of **Subtask-B** in 2021 was a long-format (10,000 words) review manuscript entitled “*A taxonomy of models for investigating hydrogen energy systems*” submitted to **Renewable & Sustainable Energy Reviews** (RSER) in January 2022. In this manuscript, we presented a hydrogen energy model taxonomy based on a review of 29 studies. We then defined nine specific archetypes that covered the entire range of these 29 studies by others. We used nine characteristics of models that are key to identifying hydrogen

opportunities in energy markets. A key result was that we identified common gaps in all nine archetypes.

For **Subtask-C**, we compared input model assumptions in 2019. We reviewed model outputs for consistency in September 2020 and hydrogen modelling in ETSAP at their meetings in September and December 2020. We deployed a new hydrogen energy module in the IEA's ETSAP-TIAM model in 2021, in collaboration with ETSAP developers. A joint IEA Hydrogen Task 41 – IEA ETSAP e-meeting was held in December 2020.

For **Subtask-D**, we reviewed two IEA reports: *The Role of Critical Minerals in Clean Energy Transitions: A World Energy Outlook Special Report* and *Global Hydrogen Review, An IEA Technology Report*. For the minerals report, we verified the author's assumptions regarding PEM, Alkaline, and SOEC electrolyzers, PEM fuel cells, and provided data on AEM electrolysis were available. For the second report, we contributed generic peer review services during its drafting process.

FORWARD-LOOKING

For **Subtask A**, further testing in 2022, and finalization of the database structure and its documentation is required. Filling of the “quality raw data” end in collaboration with Subtask B people will continue. Finally, in Subtask A, we will aim to ensure that a sustainable ongoing database management process is in place at the level of the IEA.

For **Subtask-B**, it has become clear that power-price-dynamics modelling is needed, of the potential of grid-connected powerfuel production to provide services to variable renewable electricity (VRE) generation and distribution systems as identified in Task 38. Such modelling is expected to provide the best value to IEA Hydrogen and the IEA in the time and remaining resources of Task 41.

For **Subtask-C**, we intend to identify best practices in energy system optimisation and submit journal manuscripts documenting this work.

KEY MESSAGES TO DATE

- Acquiring “quality / validated modelling data” is complex.
- Making data available to modellers is even more complex.
- Ensuring the ongoing validity of data and keeping it up to date will be challenging.
- Hydrogen energy modelling in ETSAP (TIMES) is just one of many “model archetypes”.
- The full potential of hydrogen's role in energy markets and inaction on climate change requires the deployment and use of a diverse collection of archetypes.
- A key aspect of assessing the potential for powerfuel integration into existing networks is price dynamics modelling.
- We will need to consider price dynamics modelling data (subtask A) as hierarchical. First: parameters of price dynamics models for given Region, then second, applying that model to power models for that Region (see Subtask B Taxonomy manuscript).

TASK PARTICIPANTS



CONTACT INFORMATION

- ◆ [Task 41: Data and Modelling](#)
- ◆ *From Feb 2022:* Dr Robert Dickinson
- ◆ robert.dickinson@hydricity.com.au
- ◆ m: +61 439 814 708

TASK 40 – ENERGY STORAGE AND CONVERSION BASED ON HYDROGEN

TASK MANAGER: Michael Hirscher - [Max-Planck-Institut für Intelligente Systeme](#) - Germany

TIMEFRAME: 2019 – 2021 (extended to 2024)

SYNOPSIS

Task 40 addresses “Energy storage and conversion based on hydrogen” by developing reversible or regenerative hydrogen storage materials. The goals and objectives in Task 40 are:

1. Develop reversible or regenerative hydrogen storage materials (solid or liquid) fulfilling the technical targets for mobile and stationary applications.
2. Develop the fundamental and engineering understanding of hydrogen storage materials and systems that have the capacity of fulfilling Target 1.
3. Develop materials and systems for energy storage and conversion based on hydrogen, including hydrogen storage for use in stationary, mobile and portable applications, electrochemical storage, and solar thermal heat storage.

WORKING GROUP	NAME	LEADER
1	Porous materials	Michael Hirscher
2	Magnesium- and intermetallic alloy-based hydrides	Luca Pasquini and Kouji Sakaki
3	Ammonia and liquid carriers	Ping Chen
4	Complex hydrides	Marcello Baricco
5	Catalysis	Claudia Weidenthaler
6	Electrochemical storage of energy	Michel Latroche
7	Hydride-based thermal energy storage	Craig Buckley
8	R&D for hydrogen storage and compression	Martin Dornheim

STATUS, RESULTS AND PROGRESS

2021 has been still dominated by the COVID-19 pandemic and Task 40 Experts could meet only virtually in several online meetings and additional working group meetings.

MAIN ACHIEVEMENT(S) IN 2021

Task 40 Experts have been working on 7 review papers summarizing the results of the different working groups achieved during the first 3 years. These reviews will be published in a special issue of *Progress in Energy*, IOP Publishing in 2022.

FORWARD-LOOKING

Task 40 Experts will continue to address both fundamental and applied research on hydrogen storage materials including electrochemical storage of energy utilizing hydride electrodes and ion conductors, concentrated solar thermal heat storage using hydrides, and the development of small-scale demonstration projects. Next meetings are planned in person:

- Task 40 Meeting in Louvain-la-Neuve, Belgium, 15th to 18th May 2022
- Task 40 Meeting in La Cristalera near Madrid, Spain, 18th to 21st September 2022.

KEY MESSAGES

Improving hydrogen storage measurement, plus two examples of how fundamental research in hydrides can be and is already implemented in battery technology:

- [Improving Reproducibility in Hydrogen Storage Material Research](#)
- [Today in the Lab - Tomorrow in Energy? Hydrogen meets batteries: hydrides for solid-state batteries](#)
- [Yesterday in the Lab - Now on the Road! Bipolar nickel-hydrogen battery for 2021 Toyota Aqua](#)

TASK PARTICIPANTS



CONTACT INFORMATION

- ◆ [Task 40: Energy Storage and Conversion Based on Hydrogen](#)
- ◆ Michael Hirscher, hirscher@is.mpg.de

M

E

M

B

E

R

S

MEMBER UPDATES

AUSTRIA

COUNTRY'S REPRESENTATION AT THE EXECUTIVE COMMITTEE OF THE HYDROGEN TCP

Theodor Zillner, Federal Ministry Republic of Austria, Climate Action, Environment, Mobility, Innovation and Technology



Alternate: Horst Steinmüller, WIVA P&G

HYDROGEN SECTOR OVERVIEW

Even the Hydrogen Strategy is not yet published, actions towards production, transport, storage and use of hydrogen and climate neutral gases have still priority towards a climate neutral Austria in 2040.

Is there a national hydrogen strategy?



It is expected in the near future

MILESTONES IN 2021

Many of the milestones listed in the Strategy will only become effective after the public announcement.

POLICY-RELATED MATTERS

Even the Hydrogen Strategy has not been published in 2021 the production and use of Hydrogen is part in the Austrian Recovery and Resilience Plan as well as in the Renewable Energy Expenditure Act.

R&D&D PROJECTS

In 2021 four new projects financed via the energy flagship region WIVA P&G have started. In addition, two mobility projects and one project dealing with the production of liquid fuel based on SOEC and Fischer-Tropsch technology have started. In the call for new projects within the energy flagship region WIVA P&G, 19 project ideas were submitted, of which eight full applications will be submitted in 2022. Their aim is to reduce so called white spots on the way to a carbon emission neutral Austria by 2040.

INFRASTRUCTURE

One new hydrogen filling station, one PEM electrolyser and one AEL electrolyser have started. The electrolyser capacity has now reached 12 MW. Furthermore, the work for underground storage of pure hydrogen has started.

KEY MESSAGES

- Austria, as partner of Mission Hydrogen will increase its effort to increase the production and use of hydrogen especially in Hydrogen Valleys. Up to four Hydrogen Valleys are planned for the next years.
- The industry sector as well as the heavy-duty transport sector will be the main focus for the use of hydrogen.

REFERENCES

- [WIVA](#)
- [Klima- und Energiefonds](#)

AUSTRALIA

COUNTRY'S REPRESENTATION AT THE EXECUTIVE COMMITTEE OF THE HYDROGEN TCP

John Curtin Distinguished Professor Craig Buckley, Curtin University

Alternate: Dr Andrew Dicks, Griffith University



HYDROGEN SECTOR OVERVIEW

Australia's National Hydrogen Strategy supports all production pathways and technologies that are capable of producing clean hydrogen, which is hydrogen produced using renewable energy or using fossil fuels with substantial carbon capture and storage (CCS). This allows Australia's emerging hydrogen industry to have the flexibility to pursue the pathways that best meet customer preferences as global markets emerge. Australia has all the ingredients required to be a major hydrogen producer and exporter. These include abundant and cheap renewable energy resources, geological storage resources and a proven track record as an energy exporter.

Is there a national hydrogen strategy?



[National Hydrogen Roadmap](#) – CSIRO. Released in 2018

[Australia's National Hydrogen Strategy](#) – 22 November, 2019

MILESTONES IN 2021

- In 2021 private sector investment in hydrogen-related technologies exceeded AUD 1.6 billion (80 projects – 20 announced in 2021) and government investment reached AUD\$2 billion
- The Australian Government has committed \$464 million towards 'Activating a Regional Hydrogen Industry: Clean Hydrogen Industrial Hubs' program to fund up to 7 hydrogen hubs. State and territory governments have backed this approach by providing funding to develop hydrogen hubs in their jurisdictions.
- In October 2021 Fortescue Future Industries (FFI) announced plans to build an electrolyser factory in Gladstone, Queensland with an initial capacity of 2 GW per annum. It is noted that in 2020 the World's global installed electrolyser capacity was 0.3 GW. FFI has a target of delivering 15 million tons of green hydrogen by 2030. In December 2021, FFI designed and built its own electrolyser.

POLICY-RELATED MATTERS

Although the Australian Government is clearly targeting hydrogen production from both fossil fuels with carbon capture and storage (CCS) and hydrogen produced from renewables (green hydrogen), some Australian industries such as the Fortescue Metals Group (FMG) are solely funding green hydrogen production projects. The Australian Government has committed \$565.8 million through the 2021–22 federal Budget to develop international partnerships on low emissions technology. The Special Adviser to the Australian Government on Low Emissions Technology, Dr Alan Finkel AO, is playing a key role in brokering these partnerships.

In 2021 the Australian Government announced 5 new international partnerships:

- Australia and Germany will work together under a new [Hydrogen Accord](#). The accord includes several new initiatives to accelerate the development of a hydrogen industry. Australia will contribute \$50 million and Germany €50 million
- Australia and Singapore will establish [a \\$30 million partnership](#) to accelerate deployment of low emissions fuels and technologies (like clean hydrogen) in maritime and port operations
- The Japan–Australia Partnership on Decarbonisation through Technology will increase our shared focus on [priority low emissions technologies](#), including clean fuel ammonia and clean hydrogen
- The Republic of Korea and Australia will work together to drive increased adoption of low and zero-emissions technologies
- Australia and the United Kingdom have agreed to collaborate on research and development across technologies crucial to decarbonising the global economy, including clean hydrogen.

R,D&D PROJECTS

- Future Energy Exports (FEnEx) Commonwealth Research Centre (CRC) awarded \$40 M Commonwealth funding over 10 years. Matched by \$38.7 M Industry funding.
- FEnEX has 4 Programs of which Program 2 is Hydrogen Export and Value Chains. Professor Craig Buckley is Program 2 Lead. R,D&D funding for 4 hydrogen-related projects awarded in 2021.
- ARENA funded \$1.427 billion over the next 10 years from Federal Government. \$70.2 M of this funding will be directed towards establishing a regional hydrogen export hub. \$74.5 M for a future fuels hub focussing on refuelling stations for hydrogen, electric or bio-fuelled vehicles
- In May 2021 ARENA announced \$103.3 M towards 3 commercial-scale renewable hydrogen projects – Part of its Renewable Hydrogen Deployment Funding Round. Recipients were Engie Renewables Australia (\$42.5 M towards a 10 MW electrolyser project in Karratha, WA), ATCO Australia (\$28.7 M towards a 10 MW electrolyser project in Warradarge, WA), AGIG (\$32.1 M towards a 10 MW electrolyser for gas blending in Wodonga, Victoria)
- The Australian Research Council has provided A\$33 M for hydrogen research

INFRASTRUCTURE

- Trafigura to build an AUD\$540 M hydrogen plant at its Australian lead smelter facility in Port Pirie, South Australia
- Australia's first public hydrogen refuelling station (HRS) opened in Canberra
- The World's first hydrogen energy supply chain (HESC) project located in the Latrobe Valley in Victoria commences operation
- 2.5 MW of electrolyser capacity installed

TRANSPORT SECTOR	BUSES	FCEVS PASSENGER	REGISTERED FCEVS
ON ROAD	0	65	38
PLANNED	10	> 60	> 60

HRS	EARLY MARKET STATION OPEN TO PUBLIC OR FLEET	PRIVATE RESEARCH LAB AND/OR COMPANY SITE	HRS SUBTOTALS BY HRS STATUS AND TYPE
OPEN	1	2	3
PLANNED	7	2	9

KEY MESSAGES

- The Australian government has set a goal for hydrogen production costs in Australia to fall below A\$2 per kilogram.
- Australia has the potential to become one of the largest global hydrogen suppliers by the beginning of the next decade

REFERENCES

- [State of Hydrogen 2021](#)
- [Fenex](#)
- [HESC](#)

CONTACT INFORMATION

Professor Craig Buckley

c.buckley@curtin.edu.au

BELGIUM

COUNTRY'S REPRESENTATION AT THE EXECUTIVE COMMITTEE OF THE HYDROGEN TCP

Joris Proost – Université catholique de Louvain (UCLouvain)

Adwin Martens – WaterstofNet (alternate)



HYDROGEN SECTOR OVERVIEW

Is there a national hydrogen strategy?



[Belgian \(federal\) Hydrogen Vision and Strategy: Green Hydrogen for a Clean Industry](#) launched in 29/10/2021

Apart from the national strategy, there is also the [Flemish \(regional\) Hydrogen Vision: European frontrunner via sustainable innovation](#) and the [H₂ \(regional\) Roadmap for Wallonia: the vision of the Industry](#).

MILESTONES IN 2021

- Unique hydrogen fuelling station in Antwerp, supplying road and marine applications [Explainer video - Hydrogen Refuelling Station - CMB.TECH - YouTube](#)
- Positive results of a study on the feasibility of hydrogen to Belgium [Study Hydrogen Import coalition confirms: Shipping wind and solar to Europe is feasible from 2030! \(waterstofnet.eu\)](#)
- First 40 ton truck-trailer demonstrated in Belgium [Colruyt Group is the first in Europe to test a 44-tonne hydrogen truck](#)
- Approvement of the HAYRPORT project: an infrastructure project that will produce hydrogen to power various vehicles located on the Liège Airport site. [Validation of HAYRPORT project in Liège Airport](#).
- [Approvement of 4 green H₂ production pilot sites dedicated to decarbonising heavy transports.](#)

POLICY-RELATED MATTERS

The Flemish government earmarked 125 million euros for hydrogen projects: 106 million euros has been assigned to 5 projects hydrogen connected to the ports. Flemish minister Crevits signed a memorandum of understanding with Tasmania for supplying hydrogen technology and importing green hydrogen.

Wallonia Government earmarked 47 million euros for hydrogen projects in 2021 and will provide an actualized H₂ strategy in 2022.

Belgian Minister Vanderstraeten signed MOU with Oman, Chile and Namibië on importing green hydrogen.

CANADA

COUNTRY'S REPRESENTATION AT THE EXECUTIVE COMMITTEE OF THE HYDROGEN TCP

Stephanie Tracy – Natural Resources Canada, Government of Canada

Oshada Mendis – Natural Resources Canada, Government of Canada



HYDROGEN SECTOR OVERVIEW

Hydrogen is recognized as playing a vital role in meeting Canada's targets for reduction of greenhouse gas emissions by 2050, and beyond. As one of the top 10 producers of hydrogen in the world, Canada is poised to bring low-cost, low-emissions hydrogen to the global market. Recognizing the relative strengths of different regions, Canada will take a multi-faceted approach to hydrogen production, likely including hydroelectric and nuclear generation using off-peak electricity for electrolysis, and steam methane reforming combined with carbon capture, utilization and storage.

Is there a national hydrogen strategy?



[Hydrogen Strategy for Canada](#)

December 2020

MILESTONES IN 2021

- The Government of Canada launched the [Hydrogen Strategy Implementation Strategic Steering Committee](#) also supporting Canada's strengthened climate plan, which included a federal investment of \$1.5B in a Low-carbon and Zero-Emissions '[Clean Fuels Fund](#)'.
- The Government of Alberta released its [hydrogen roadmap](#) aiming to be a major supplier of clean hydrogen, heavily leveraging existing natural gas reserves combined with carbon capture, utilization and storage technology, as well as other low-carbon hydrogen production pathways.
- The Government of British Columbia released its [hydrogen strategy](#), including 63 actions for government, industry and innovators to undertake during the short term (2020-25), medium-term (2025-30) and long term (2030 and beyond). The strategy's immediate priorities include scaling up production of renewable hydrogen, establishing regional hydrogen hubs and deploying medium- and heavy-duty fuel-cell vehicles.
- Edmonton (Alberta) [Hydrogen Hub](#) launched with \$2M in funding. With support from the Transition Accelerator, a charity focused on the move to net-zero emissions, planning is underway for more than 25 potential projects related to the supply, delivery and use of low-carbon hydrogen. More 'hub' investments are being explored across Canada.

POLICY-RELATED MATTERS

Canada and Germany signed a [memorandum of understanding](#) to collaborate on clean hydrogen including the potential to cooperate on projects for its production, use and trade. A [memorandum of understanding](#) was also signed with the Netherlands to share knowledge in fields such as standards, trade rules, policies, technologies, certification and investments to support the development of clean hydrogen. In mid-2021, Canada's Senate approved [Bill C-12](#), requiring by law that the Government of Canada set national targets for greenhouse gas reduction to enable net-zero emissions by 2050. And as mentioned above, a strategic steering committee was launched for the effective implementation of Canada's hydrogen strategy. It oversees 16 working groups across the entire hydrogen value chain that bring together industry and government to define workable pathways to success and clear the barriers to get there.

R&D&D PROJECTS

Through the Program for Energy Research and Development (PERD), approximately CAD 2.1M was awarded in the 2021-22 fiscal year for seed projects to advance the landscape for hydrogen codes and standards in Canada. As of early 2022, proposals were submitted for allocation of another CAD 3.5M per year for the next four years in topics such as hydrogen embrittlement of pipelines and well integrity considerations for in-situ hydrogen production and/or underground storage of hydrogen in geological formations. Additionally, work in the Advanced Clean Energy Program will accelerate the development of fossil-free hydrogen by electrolysis and integration of fuel cells into surface transportation and aviation.

INFRASTRUCTURE

- Heavy-duty freight transportation is one of the largest contributors to greenhouse gas emissions in Canada. The Alberta Zero Emissions Truck Electrification Collaboration (AZETEC) aims to change that through its demonstration project to operate two long-range hydrogen fuel cell trucks between the cities of Calgary and Edmonton, Alberta, including installation of a [refueling station](#).
- Suncor Energy and ATCO Ltd. announced plans to partner in the [development of a clean hydrogen project](#) in Alberta that would produce more than 300,000 tonnes per year of clean hydrogen, and cut carbon emissions in Alberta by more than 2M tonnes per year; the biggest project in Canada to date.
- [Enbridge Gas began delivering natural gas, with up to 2% blended hydrogen](#), to approximately 3600 residents of the city of Markham, Ontario in a pilot program developed with support from Cummins Inc. through construction and operation of a Power-to-Gas plant in 2018.
- Governments of Canada and Alberta signed a deal to support a [\\$1.3B carbon neutral hydrogen plant in Edmonton developed by Air Products Canada](#). The plant would produce 1,500 tonnes of hydrogen from natural gas per day and capture 3M tonnes of CO₂ per year. Air Products Canada operates three hydrogen facilities in Alberta and one in Ontario.
- Huron Clean Energy and Carbon Engineering have plans to [use Direct Air Capture of CO₂ to produce hydrogen via electrolysis](#) (powered by hydroelectricity) and combine the H₂ with CO₂ to produce hydrocarbons that can be used in place of traditional fossil fuels, with a production capacity of 100M litres per year. The fuel would be near carbon neutral when burned, resulting in 90% fewer emissions vs. traditional fossil fuels.

KEY MESSAGES

The next four years will see an unprecedented increase in hydrogen R&D&D, driven by the federal government's hydrogen strategy, in cooperation with many provincial governments, to develop hydrogen as a low-carbon energy carrier.

CHINA

COUNTRY'S REPRESENTATION AT THE EXECUTIVE COMMITTEE OF THE HYDROGEN TCP

Ping Chen – Dalian Institute of Chemical Physics.

Alternate: Teng He

Lijun Jiang – General Research Institute for Nonferrous Metals.

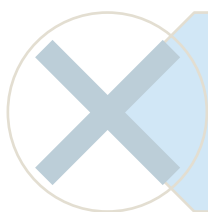
Alternate: Shumao Wang



HYDROGEN SECTOR OVERVIEW

Increasing the use of hydrogen — a gaseous element in great abundance — could help support the government's goals of dramatically reducing China's emissions of carbon dioxide, one of the main greenhouse gases driving climate change. Expanding production of hydrogen and developing refuelling infrastructure may help increase the number of new-energy vehicles on the road and help China hit peak carbon emissions before 2030 and reach carbon neutrality by 2060. China's 14th Five Year Plan labels hydrogen a "frontier" area that the country pledges to advance.

Is there a national hydrogen strategy?



Not yet. China's 14th Five Year Plan labels hydrogen a "frontier" area that the country pledges to advance. Even though a national strategy for hydrogen development has yet to be developed, 16 provinces and cities have launched their own five-year plans that specifically feature hydrogen.

MILESTONES IN 2021

Olympics demonstrate hydrogen applications([Olympics demonstrate hydrogen applications - Chinadaily.com.cn](https://chinadaily.com.cn/olympics-demonstrate-hydrogen-applications/))

The use of fleets of hydrogen-fueled vehicles during the 2022 Beijing Winter Olympics is demonstrating the wider application of the green energy source and will help in the acceleration of its development.

More than 1,000 hydrogen fuel cell vehicles are being used for the 2022 Beijing Winter Games, according to hydrogen energy company Beijing SinoHytec. In September 2021, four hydrogen refuelling stations built by Sinopec to serve the Winter Games were opened.

POLICY-RELATED MATTERS

The central government of China released the outline for the upcoming 14th Five Year Plan (2021-2025) (14th FYP). Hydrogen appears in the top national economy FYP for the first time. The Chinese government has confirmed its support for developing hydrogen and energy storage sectors as part of the "new strategic industries".([China - hydrogen roadmap: 4 things to know - Hydrogen Central \(hydrogen-central.com\)](https://hydrogen-central.com/china-hydrogen-roadmap-4-things-to-know/))

A national hydrogen industry plan is still lacking. Notably, provincial governments are pushing forward the hydrogen agenda even harder, as various regional development plans for 2021-2025 suggest. ([China's Hydrogen Market in 14th Five-Year Plan: Provincial Strategy Breakdown - Energy Iceberg](#))

R&D&D PROJECTS

The most important project should be the demonstration of hydrogen application in the Beijing Winter Olympics, which was mentioned in the first part

INFRASTRUCTURE

In 2021, 101 hydrogen refuelling stations were built. In the same year, the production and sales of hydrogen fuel cell vehicles were 1777 and 1586, respectively.

PROJECTS

Ministry of Science and Technology of China launched “Hydrogen Technology Projects ” in 2021 with 795 million Yuan, including 18 subprojects that cover hydrogen production storage and utilization in fundamental research, key technologies, and demonstrations.

DENMARK

COUNTRY'S REPRESENTATION AT THE EXECUTIVE COMMITTEE OF THE HYDROGEN TCP

Asger Myken – Danish Gas Technology Centre

on behalf of the Danish Energy Agency



HYDROGEN SECTOR OVERVIEW

The interest in hydrogen is rapidly growing in Denmark. The country aims to be among the front runners in the world within the production of green hydrogen, to reduce its carbon-emission footprint and mitigate climate change. To foster this development, the Danish government has set up several financial schemes to support projects within Power-to-X and green gas production. The Danish hydrogen sector as of today has a consumption of about 18,000 tons of hydrogen a year, of which approximately 98 % are consumed by the two Danish refineries. Hydrogen today originates mainly from natural gas. It is intended to cover the current and additional future hydrogen consumption with green hydrogen produced in Denmark. Furthermore, the country aims to become an export nation of green hydrogen and its derivatives to other hydrogen consuming neighbouring countries like Germany. This is made possible by the utilisation of solar and especially wind power onshore and offshore. The offshore production of hydrogen is expected to be boosted by the possibility of hydrogen production on the planned energy island in the North Sea. The Danish hydrogen industry employs today around 680 specialists, and there is further potential for employment, especially in rural areas.

Is there a national hydrogen strategy?



There is no specific Danish hydrogen strategy/roadmap. A [Power-to-X](#) and [Green gas strategy](#) was published in December 2021

MILESTONES IN 2021

- At the end of the year, the Danish government published two important strategies for the country's hydrogen development: "Green gas strategy" and the "[Power-to-X strategy](#)"
- As of today, +20 hydrogen projects are announced in Denmark, which will comprise approximately 7 GW electrolysis capacity in 2030
- The Danish state-owned gas distribution and transmission companies, Evida and Energinet, are now authorised to transport other gasses than natural gas, including hydrogen
- About 850 million DKK (114 million EUR) are set aside to support two Danish IPCEI projects: Green Fuels for Denmark, HySynergy 2.0

POLICY-RELATED MATTERS

The Danish Ministry of Climate, Energy and Utilities on behalf of the Danish government published the strategies for *Green gas* and *Power-to-X*. These publications are the result of the government's "Climate agreement" from 2020.

In the hydrogen context, the green gas strategy aims to pave the way for the transportation of hydrogen in the Danish gas system. Through this, the gas system becomes an active asset in the green transition and would support the system integration of Power-to-X facilities in the country.

The Power-to-X strategy on the other hand sets four milestones for technological development:

- 1) Power-to-X shall actively support the fulfilment of the Danish climate goals
- 2) Changing the regulatory environment and enhancing the infrastructure so that Power-to-X over the short term can reach market conditions
- 3) Interaction of Power-to-X and the entire energy system is intended to be safeguarded
- 4) Ensuring that Denmark can export Power-to-X products and technologies.

R&D&D PROJECTS

Within the Energy Technology Development and Demonstration Programme (EUDP), the following projects are of interest:

EUDP round I 2021:

- Renewable Dynamic Distributed Ammonia Plant (REDDAP)- production of renewable ammonia – 10 MW electrolysis
- DynAmmonia – development of PtX technology for dynamic ammonia production from renewable energy – SOEC stacks of 5 kW, later upscaling to 1 MW

EUDP round II 2021:

- Green Lab DK – Test Centre for Hydrogen Technology: material tests, hydrogen quality analysis, metrology, efficiency tests and leakage
- Boosting Economic Electrolyzer Stack Technology 2: Improvement of electrolysis efficiency
- SafePtX – sensors as a security component in the PtX industry
- CCCH₂ – Combined Carbon Capture and Green Hydrogen Production.

A new project with 100 MW electrolysis capacity under the "GreenLab Skive" umbrella is applying for a Grant Agreement within the EU Green Deal 2.2 Funding Call.

INFRASTRUCTURE

Everfuel launched a plan for the Danish hydrogen fuel network. The company's plan is the construction of add up to 19 strategically positioned fueling sites in Denmark by the end of 2023. By now, Denmark has five hydrogen fueling stations: Korsør, Aarhus, Kolding, Copenhagen and Esbjerg.

Energinet Gas TSO and Gasunie Deutschland published a pre-feasibility study on hydrogen infrastructure, where the gas transmission companies investigated a 350 – 450 km pipeline from

Esbjerg or Holstebro (Denmark) to Hamburg (Germany). The aim is the creation of a market dialogue for the export of green hydrogen produced in Denmark for the German industry.

Energinet, Danish gas TSO, is an active part of the European Hydrogen Backbone plan, that grows to a 40,000 km pipeline network now covering 21 countries.

Evida, Danish gas DSO, is part of the European project, Ready4H2, that investigates the feasibility of converting the existing distribution networks of several European countries to the transportation of hydrogen.

KEY MESSAGES

- The Danish hydrogen sector is expected to rapidly grow within the next years, especially within Power-to-X
- Due to its wind potential, the country is expected to become a major producer of hydrogen via green electricity. Denmark is establishing [the world's first energy islands](#), marking the beginning of a new era for large-scale offshore wind power.
- Export of green hydrogen and its product derivatives, as well as technology, are expected to become important sectors in Denmark
- The transportation sector could become a consumer of hydrogen in Denmark, only a few new industrial hydrogen consumers are expected

REFERENCES

- Green Gas and Power-to-X strategies in [English](#) and [Danish](#)
- [4 milliarder til grøn gas](#) (in Danish)
- [Hydrogen in Numbers 2021](#), Hydrogen Denmark (in Danish)

EUROPEAN COMMISSION

COUNTRY'S REPRESENTATION AT THE EXECUTIVE COMMITTEE OF THE HYDROGEN TCP

Beatriz Acosta Iborra – European Commission Joint Research Centre

Luca Polizzi - European Commission, DG Research & Innovation



HYDROGEN SECTOR OVERVIEW

The [European Green Deal](#) outlines the main policy initiatives for reaching net-zero global warming emissions by 2050. With the [2030 Climate Target Plan](#), the Commission proposes to raise the EU's ambition on reducing greenhouse gas emissions to at least 55% below 1990 levels by 2030. The [hydrogen strategy for a climate-neutral Europe](#) sets out a vision of how the EU can turn clean hydrogen into a viable solution to decarbonise different sectors over time, installing at least 6 GW of renewable hydrogen electrolyzers in the EU by 2024 and 40 GW of renewable hydrogen electrolyzers by 2030.

Is there a specific hydrogen strategy?



[Hydrogen Strategy for a Climate Neutral Europe](#),
adopted on 8 July 2020

MILESTONES IN 2021

- The “fit for 55” [Climate and Energy Package](#): The European Commission adopted on 14th July a new package to align the energy and climate regulatory framework with the higher level of ambition to reduce greenhouse gas emissions. Hydrogen features prominently in several of the proposed legislation.
- The [Hydrogen and Gas Markets Decarbonisation Package](#), adopted on 15th December contains a set of legislative proposals facilitating the uptake in Europe of renewable and low carbon gases, including hydrogen.
- The [Clean Hydrogen JU](#) was established on 30 November 2021. The EU will support the Partnership with 1 billion euro for the period 2021-2027, complemented by at least an equivalent amount of private investment (from the private members of the partnership), raising the total funding to above 2 billion euro.

POLICY-RELATED MATTERS

The “fit for 55” package contains a set the legislative tools to deliver on the targets agreed in the [European Climate Law](#) and fundamentally transform the EU economy and society for a fair, green and prosperous future. Hydrogen use, playing a key role in the [EU Green Deal](#), is enhanced with these legislative initiatives:

- Proposal for a revision of the Renewable Energy Directive (RED II)
- Revised Alternative Fuels Infrastructure Regulation (AFIR)
- EU Emission Trading Scheme

- Set of policy measures on transport: TEN-T regulation, FuelEU Maritime and ReFuelEU Aviation
- Set of policy measures on taxation and trade: revision of the Energy Taxation Directive and a new Carbon Border Adjustment mechanism.

Those initiatives were complemented with the [hydrogen and decarbonised gas markets package](#) including proposals for a recast:

- Regulation on the [internal markets for renewable and natural gases and hydrogen](#)
- Directive on [common rules for the internal markets in renewable and natural gases and hydrogen](#).

These Commission proposals create the conditions for a shift from fossil natural gas to renewable and low-carbon gases. One of the main aims is to establish a hydrogen market, create the right environment for investment, and enable the development of dedicated infrastructure, including trade with third countries. The market rules will be applied in two phases, before and after 2030, and cover access to hydrogen infrastructures, separation of hydrogen production and transport activities, and tariff setting. A new governance structure, the European Network of Network Operators for Hydrogen (ENNOH), is created to promote a European hydrogen infrastructure and elaborate on specific technical rules.

The [European Clean Hydrogen Alliance](#) is part of EU efforts to ensure industrial leadership and accelerate the decarbonisation of industry in line with its climate change objectives. It supports the large-scale deployment of clean hydrogen technologies by 2030 by bringing together renewable and low-carbon hydrogen production, demand in industry, mobility and other sectors, and hydrogen transmission and distribution. It has now more than 1500 members. The Commission collected back in May 2021 more than 1000 projects from alliance members. The alliance prepared a [pipeline of investment projects](#) to deploy hydrogen technologies, which were presented at the European Hydrogen Forum in November 2021.

R&D&D PROJECTS

Since its set up in 2008, Fuel Cells and Hydrogen Joint Undertaking (FCH JU) has funded 285 research and demonstration [projects](#), with an overall budget of over 1 billion euros. FCH JU ceased operations on 29 November 2021.

The [Clean Hydrogen Partnership](#) is the successor of the FCH JU, to take over its legacy portfolio and to continue developing the European value chain for safe and clean hydrogen technologies. It will focus on advancing technologies for green hydrogen production, distribution and storage and on supplying sectors that are hard to decarbonize, such as heavy industries and heavy-duty transport applications.

The European partnerships [Clean Aviation](#) and [Europe's Rail](#) also relevant to hydrogen were established as well in 2021.

[Horizon Europe](#) is Europe's key funding Programme for research and innovation. It has a budget of 95.5 billion euros. It tackles climate change, helps to achieve the UN's Sustainable Development Goals and boosts the EU's competitiveness and growth. Under the call [Clean and](#)

[competitive solutions for all transport modes](#) opened in December 2021, several topics are pertinent for hydrogen.

INFRASTRUCTURE

FCH JU funds demonstration of FCEV light-duty vehicles, busses and heavy-duty vehicles and the related hydrogen-refuelling infrastructure:

- 1390 FCEVs have been contracted through FCH JU, out of which 895 are currently deployed and 495 planned or in the development phase (mainly via [H2ME](#), [H2ME2](#) projects and [ZEFER](#) project);
- 119 FC buses have been deployed to date through FCH JU and 247 are planned or in the development phase. A total of 315 buses have been deployed or planned to be deployed through the [JIVE](#) and [JIVE 2](#) projects (including all buses currently under development);
- FC trucks contracted through FCH JU: 15 garbage trucks via [REVIVE](#) and 16 trucks via [H2Haul](#);
- 176 HRS are deployed in Europe, out of which 72 are deployed via FCH JU (mainly via [H2ME](#) and [H2ME2](#) projects). A chart displaying key data on the number and type of hydrogen refuelling stations deployed in Europe, including location and capacity can be found [here](#).

FCH JU also funds projects deploying stationary fuel cells, micro CHP units and electrolyzers:

- Around 4267 planned stationary fuel cells for residential use of which are 2829 deployed; 74 fuel cells for distributed residential use planned of which 36 deployed; 2 large fuel cells for industrial use deployed (one in China) and another one planned;
- 4357 μ CHPs contracted via FCH JU, out of which 2880 already deployed (mainly via [PACE](#) and [EneField](#) projects – around 95% of total FCH JU μ CHPs);
- 16.8 MW of electrolyzers deployed in Europe through FCH JU (of which 13 discontinued) and another 53.8 MW planned.

KEY MESSAGES

- Hydrogen plays a central role in achieving the main objective of the European Green Deal and is one of the key sectors contributing to the [recovery plan](#) for Europe. Fifteen EU Member States have already committed 9.3 billion euro to hydrogen uptake as part of their Covid-19 recovery plans.
- The Commission's [hydrogen and decarbonised gas market package](#) sets rules for the design of the hydrogen market to give certainty to investors and ensure scaling-up of projects while fostering integrated energy system planning and promoting consumer engagement.

REFERENCES

- [Energy system integration: hydrogen](#)
- [Supporting clean hydrogen](#)
- [European Clean Hydrogen Alliance](#)
- [Energy research and innovation](#)
- [European Partnership for Hydrogen Technologies](#)

FRANCE

COUNTRY'S REPRESENTATION AT THE EXECUTIVE COMMITTEE OF THE HYDROGEN TCP

Paul Lucchese & Pierre Serre-Combe (alternate) – CEA (Atomic and Alternative Energies Commission)



HYDROGEN SECTOR OVERVIEW

To face the challenges of ecological transition and climate emergency, the French State plans to develop low-carbon and renewable hydrogen and their industrial, energy and mobility uses.

The national hydrogen strategic plan was published jointly on 9 September 2020 by the Minister of Ecological Transition and the Minister of Economy and supervised by a National Hydrogen Council (Conseil National de l'hydrogène) which was set up on 11 January 2021.

Baked by 7.2 then 10 billion euros of public money over 10 years, this strategy addresses 3 priorities:

- decarbonize industry by building a competitive electrolytic hydrogen production sector in France,
- develop transportation (work vehicles, heavy vehicles and very frequently- used vehicle fleets, powered by renewable or low-carbon hydrogen,
- support research, innovation and skills development with a view to promoting future applications.

MILESTONES IN 2021

- 11th of January, a National Hydrogen Council is set up
- 17th of February, publication of an ordinance on hydrogen
- April 2021, 7 HydrogenTerritory projects are funding
- 28th of may, kickoff meeting with industrial sectors for adjusting a regulatory package on H2
- 16th of November, Frenc President annouces €1.9bn more to support Hydrogen deployment

POLICY-RELATED MATTERS

The legal framework in France is being consolidated to structure hydrogen market and to build confidence to investors and stakeholders (+30% new players vs 2020).

The French authorities published an ordinance on hydrogen dated 17 February 2021. One of its purposes is to introduce into the French Energy Code, categories of Hydrogen (renewable, low-carbon or carbonaceous). Depending on the energy used to create hydrogen, only renewable or low-carbon hydrogen (determined from CO2 eq emission threshold) will benefit from a support mechanism.

Other purposes are to guarantee access to natural gas transmission and distribution facilities to give conditions for underground storage, to buid a framework for guaranteeing and tracking the origin of hydrogen. France is also supporting an important project of common European interest (IPCEI) for hydrogen with a financial allocation of €1.5bn. For this budget, France has considered

15 industrials project addressing industrialisation and gigafactories of electrolyzers and components for transportation sector (fuel cells, tanks...)

R&D&D PROJECTS

More than 50 R&D projects have been notified in 2021. Those include in particular:

- Real experimentations of hydrogen fire and explosion in a tunnel within the European project HyTunnel.
- Evaluation of the possible cogeneration configurations between the Rankine cycle of the nuclear reactor and the electrolyser.
- 7 research programmes focusing on SOEC, Proton Ceramic Membrane Electrolyser, PEMFC Material, Durability PEMFC System, Direct Multi-Fuel Cell, Solid Storage – Hydrides, HP Storage and Logistic

INFRASTRUCTURE

The infrastructure running in France are listed by [VI'GHY](#), the French hydrogen observatory managed by FRANCE HYDROGEN:

In 2021 we enumerate:

- 5 MW of electrolyser producing 45000 T Low Carbon H₂ (5%)
- ~380 FCEVs:
- 22 FC Bus : 22
- 325 Forklifts: 325
- 57 Hydrogen Refueling System
- 14 Hub for Hydrogen



KEY MESSAGES

- Since the beginning of 2021, about 300 M€ of public funds have been committed which correspond to €1bn public/private investment.
- Seven major geographical clusters are identified and will enable cost reductions through the pooling of production serving similar sectors in a specific geographical area.
- New Industrial Partnership and Investment is going on with creation of 2 Joint Venture (GENVIA for High Temperature Electrolyser, HYVIA for duty vehicle) and a McPhy (Electrolyzer and HRS maker) investment of 30-40 M€ for Gigafactory in Belfort-France (1GW/y)

REFERENCES

- [France Hydrogène](#)
- [Liten CEA Tech](#)
- [Fédération de Recherche "hydrogène" du CNRS](#)

GERMANY

COUNTRY'S REPRESENTATION AT THE EXECUTIVE COMMITTEE OF THE HYDROGEN TCP

Dr. Erik Busche – Forschungszentrum Jülich GmbH

Prof. Dr Christopher Hebling - Fraunhofer Institute for Solar Energy Systems ISE



HYDROGEN SECTOR OVERVIEW

Is there a national hydrogen strategy?



The [National Hydrogen Strategy](#) (NWS) of the German Government was released in 2020.

It considers H₂ technology as a core element of the energy transition and aims at policy creation for market ramp-up, on R&D to increase efficiency, export of innovative technology and on an international partnership to shape and secure national H₂ supply. It focuses on “green” hydrogen from renewable resources. The strategy is divided into phase 1 for market launch until 2023 and phase 2 for building international partnerships until 2030 and is supported by an additional budget of 7 bn. € for phase 1 and 2 bn. € for phase 2. In September 2021, the Federal Government published the [first progress report](#) on the implementation of the NWS.

MILESTONES IN 2021

The following milestones are examples of the progress in the field of hydrogen in 2021:

- June 2021: The [H2Global](#) foundation was established. Through the H2Global concept, green hydrogen production sites and export H₂ to Germany (and Europe) are to be supported by compensating the difference between hydrogen supply cost and the highest bidding price at the demand side. H2Global is currently in the launch phase.
- July 2021: Europe's largest PEM green hydrogen electrolyser (10 MW) started operation at Shell's Rhineland Refinery in Wesseling as part of the [REFHYNE](#) project.
- July 2021: The [Trailblazer project](#) is the first to receive funding from the stimulus package under the National Hydrogen Strategy. An electrolyser (20 MW) for the production of green hydrogen will be connected up to an existing hydrogen pipeline and will supply key-enabling industries with renewable hydrogen.
- September 2021: The [funding guideline for international Hydrogen projects](#) along the value chain is published.

POLICY-RELATED MATTERS

A [National Hydrogen Council](#) (NWR) was appointed by the Federal Government and acts as an independent, bipartisan advisory board to advise the State Secretary's Committee for Hydrogen in further development and implementation of the National Hydrogen Strategy. Since its appointment, the NWR already issued several position papers and commissioned the creation

of a comparative meta-study on the potential future demand for hydrogen and synthesis products within the EU and Germany.

In April 2021 the Federal Constitution Court judged against the Federal Climate Change Act. The national climate targets and the annual emission amounts allowed until 2030 have been rated incompatible with fundamental rights insofar as they lack sufficient specifications of further emission reduction from 2031 onwards. Subsequently, the national climate targets have been tightened.

At the end of 2021, a new federal government has been elected which shifted the responsibility for climate policy from the environment to the energy ministry so that energy and climate are concentrated in a single responsibility.

An important step for economic competitiveness has been the exemption of the production of green hydrogen from the levy for renewable energy. The amendment of the energy industry act (EnWG) provides the first foundation for a hydrogen network infrastructure. Further adjustments will be required.

R&D&D PROJECTS

R&D&D is funded on a national level by the 7th Energy Research Program in the area of basic and applied research. In addition to this and as No. 25 of the action plan of the NWS the research initiative “Hydrogentechnologies 2030” was started with three flagship collaboration projects. Additional funding is provided by the governments of the Federal States. The NIP program supports R&D and market activation with a focus on mobility applications [5]. It was established in 2007 and is in its second phase (2016-2026).

SPECIFICS

TERM	FUNDING LEVEL	PRIORITIES	HIGHLIGHTS
7 th Energy Research Program	151 m€/a (new projects approved in 2020)	Sector coupling, PtX, fuel cells	3 new living lab projects for green hydrogen production, underground storage and industrial usage were started (H2-Wyhlen, Energiepark BL, H2-Stahl)
Hydrogen Flagship Projects	700 m€	Electrolyser series production Offshore H ₂ -production H ₂ Transport	H ₂ Giga, H ₂ Mare, TransHyDe 200 partners
NIP II	606 m€ (2016-2021/September)	Mobility applications Regional innovation	HyLand program for regional Hydrogen concepts

OTHER APPLICATIONS

In September 2021 the future locations for the **Hydrogen Innovation and Technology Centre (ITZ)** focusing on mobility applications were announced to be Chemnitz, Duisburg, Pfeffenhausen und Norddeutschland, which will receive 290 m€ support from the federal government.

INFRASTRUCTURE

Germany engages in a funding program on the EU level (Important Project of Common European Interest, IPCEI) which supports large R&D projects and projects of first industrial applications in 22 member states with a focus on investment. In Germany, 62 applicants with a total project budget of 33bn€ and a planned electrolysis capacity of 2GW will be supported with 8bn€. The projects are grouped in multiple waves which will sequentially get started with the first projects to be expected in 2022. Important topics are industrial applications and traffic.

On a national level, the NIP II program organized by NOW continues to support the supply of hydrogen vehicles and infrastructure.

Current implementation status (end of 2021) across different support mechanisms:

Application	Capacity
FC Trucks	20
FC Bus	54
FC Forklifts	117
FC Cars	1347
Refuelling Stations	91
Electrolyser	58 MW
Stationary FC	18251

An overview of existing power-to-gas sites including electrolyzers can be found [here](#).

REFERENCES

- [The National Hydrogen Strategy](#)
- [National Hydrogen Council](#)
- [7th Energy Research Programme of the Federal Government](#)
- [NOW GmbH](#)
- [Willkommen bei den Wasserstoff-Leitprojekten](#)

HYCHICO

REPRESENTATION

Sergio Raballo – CEO (Sergio.Raballo@grupocapsa.com.ar)

Ariel Pérez – Energy Manager (rperez@grupocapsa.com.ar)



INTRODUCTION

Hychico is a private company established in 2006. We are firmly convinced that green hydrogen will play a significant role in the future as an energy carrier. Following this vision, our actions have been focused on the production of hydrogen from wind energy in Patagonia.

The main activities of Hychico are power generation from renewable sources and the production of hydrogen and oxygen by means of water electrolysis.

HYDROGEN

The Hydrogen Pilot Plant has been in operation since January 2009 and Diadema Wind Park I was the first in Argentina to supply energy to the Wholesale Electric Market as of December 2011. The area where the projects were developed was selected considering the experience of Hychico's Holding Group in the field of energy resource exploration and exploitation and the fact that it already has operations in Patagonia.

Being one of the first companies in the region to install and operate electrolyzers, we have also experienced injection of hydrogen into depleted gas reservoirs, co-fired hydrogen in gas engines and sold to third parties high purity oxygen as a co-product of the electrolysis.

MILESTONES IN 2021

- Completion of the pre-feasibility Study “International Supply Chains of Renewable Energy Using Hydrogen: Argentina The Netherlands”
- Participation in national consortium “[H2Ar - Consortium for the Development of the Hydrogen Economy](#)” (2021-2022)
- The national “Economic and Social Council” (CES), depending on the Ministry of Economy invited Hychico to participate, as part of private-sector representation, in the development of the “[National 2030 Hydrogen Strategy](#)”.

PROJECTS

With more than 10 years of experience producing hydrogen and oxygen by means of water electricity, Hychico has performed several projects with very high-performance levels such as more than 85.000 operational hours of a Genset fueled by mixtures of natural gas-hydrogen, underground H₂ storage in depleted gas reservoirs and bio-methanation processes among others.

The Hydrogen Plant operates two electrolyzers with a total flow rate of 120 Nm³/h of Hydrogen and 60 Nm³/h of Oxygen. The High Purity Hydrogen (99.998 %) is mixed with natural gas from

the oil field and used as fuel in a 1.4 MW Genset, with an internal combustion engine specially adapted to operate with rich or poor Gas - Hydrogen mixtures.

It is worth mentioning that mixtures with high hydrogen content (42%), were reached successfully, achieving good Genset performances and greenhouse emission gases reduction.

Through strategic agreements, Hychico is gaining experience to extend the output range of electrolyzers and their capacity to control power depending on wind availability. An ongoing project is currently running and its scope includes a Wind Turbine - Electrolyser connection.

Storing large quantities of hydrogen is one of the critical aspects of integrating hydrogen into the energy matrix and developing a hydrogen economy. Given the proximity of the hydrogen plant to some depleted oil and gas reservoirs, the possibility of underground hydrogen storage in one of them is currently under consideration as a pilot project. Moreover, we continue with the pilot project to produce methane from hydrogen and carbon dioxide by underground controlled methanogenesis. The efforts include the site's biological characterization, identification and optimization of both operational (injection rate, H₂, CO₂ mix composition, residence times, etc.) and reservoir parameters (temperature, physical and chemical properties of the formation water, etc.).

In the context of the transition to an energy system with net-zero CO₂, the Patagonia region in Chile and Argentina has large wind resources without any large demand centres and, in a similar situation, the north of both countries closed to the Andes Mountains has one of the highest solar radiation in the world. For this reason, nowadays we expanded our vision to “green” hydrogen production in South America with the objective to leverage the outstanding solar radiation and wind resources of Chile and Argentina.

FORWARD-LOOKING

- Analyze capital investment required to maintain our electrolysis plant performance.
- Study possible green hydrogen production projects for exportation from South America to Europe.
- Review renewable energy intermittency impacts on electrolyzers and ammonia process plant fed by green hydrogen, and study possible storage solutions such as underground storage.
- Participate in the local and international hydrogen value chain development.

REFERENCES

- [Hychico](#)
- [Capex](#)

HYDROGEN COUNCIL

REPRESENTATION

Andrei Tchouvelev

Daria Nochevnik

Hydrogen
Council

INTRODUCTION

Hydrogen Council is a global coalition of CEOs united by a common vision and ambition: for hydrogen to enable the clean energy transition.

HYDROGEN

The Hydrogen Council currently represents over 130 industrial leaders globally.

MILESTONES IN 2021

The work of the Hydrogen Council is now structured around the following internal programs:

- ◆ Safety/ Regulatory Program
- ◆ Hydrogen Sustainability Program
- ◆ Policy and Advocacy Program
- ◆ Finance and Bankability Program
- ◆ Industry Evolution Program

PROJECTS

- [Hydrogen for Net Zero](#)
- [Policy Toolbox for Renewable and Low Carbon Hydrogen](#)
- [Roadmap towards zero-emissions vehicles: BEVs and FCEVs](#)

FORWARD-LOOKING

Our priority work items include the launch of the study *A roadmap towards robust certification systems for hydrogen* - IEA invited to become a Knowledge Partner and to join the project Advisory Board. In parallel, the Hydrogen Council is preparing a proposal for a Task on Hydrogen Certification under the IEA TCP.

REFERENCES

- [Hydrogen Council](#)

ISRAEL

COUNTRY'S REPRESENTATION AT THE EXECUTIVE COMMITTEE OF THE HYDROGEN TCP

Dr Gideon Friedmann – Chief Scientist (Acting). The Ministry Of Energy

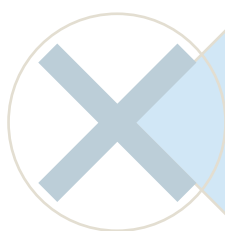


HYDROGEN SECTOR OVERVIEW

A number of activities are in the works:

- First two hydrogen refuelling stations are being built, with the first one expected to operate in late 2022. Several heavy vehicles will be imported to run with fuel from this station. In the beginning, it will use grey hydrogen, changing to blue hydrogen sometime between 2023-2024.
- Hydrogen standard for transportation is being adopted.
- Hydrogen refuelling station standard is being adopted.
- Hydrogen use in current NG network is being examined.
- Hydrogen valley ideas are in first stages of forming.

Is there a national hydrogen strategy?



Expected later in 2022

MILESTONES IN 2021

- New standards for hydrogen refuelling stations and hydrogen fuel for transportation are being adopted.
- The first Hydrogen fueling station was approved to be constructed.
- Funds were given to the first 10 Hydrogen trucks and buses.
- Gencell – a Fuel Cell company – is being traded at the Tel Aviv stock exchange after raising about \$60 Million in a successful IPO at the end of 2020 (additional funding raised in Jan 2022)
- H2Pro – a green Hydrogen generation company - raised \$22 Million in a private offering in which Breakthrough Energy Ventures participated (additional funding raised in Jan 2022)

POLICY-RELATED MATTERS

None.

In December 2021 the SII (The standards institute of Israel) adopted two international ISO standards.

- Gaseous hydrogen – Fueling stations: Fuel quality control (SI 19880 Part 8) [GASEOUS HYDROGEN - FUELLING STATIONS: FUEL QUALITY CONTROL](#)
- Hydrogen fuel quality – Product specification (SI 14687) [HYDROGEN FUEL QUALITY - PRODUCT SPECIFICATION](#)

Additional standards are expected to be adopted and published during 2022.

R&D&D PROJECTS

The Chief Scientist Office (CSO) at the Ministry of Energy supports R&D through three national programs and two international programs:

- Direct support for academic research - support is 100% for research projects.
- Support for startup companies - support is 62.5% for projects with technology innovation.
- Support for Pilot and Demonstration projects - support is 50% for commercial deployment of novel technologies.
- The Bird Energy fund is a Binational Industrial Research and Development (BIRD) Foundation that support joint US-Israel projects in the energy field.
- The US-Israel energy center of excellence is a Bi-National 5-year program to support research in 4 core areas: Energy Storage, Cyber Security for infrastructure, Water and Energy, Natural Gas. It is operated by the BIRD Foundation.

In 2021 the Office of the Chief Scientist invested over 35 million USD in energy-related R&D projects and 5 Million USD.

List of Hydrogen related projects that were approved or started in 2021:

Program	Project	Company
Pilot & Demonstration	Intercity Hydrogen bus	Auto Chen
Pilot & Demonstration	Mobile hydrogen fueling station	Oficiency
Pilot & Demonstration	Hydrogen bus & truck	BAZAN Group
Pilot & Demonstration	Hydrogen truck	Colmobil
Pilot & Demonstration	Hydrogen forklift	BAZAN Group
Pilot & Demonstration	Hydrogen truck	Sonol
Pilot & Demonstration	Hydrogen truck	BAZAN Group
Pilot & Demonstration	Green Hydrogen generation & storage	Doral & H2pro
Pilot & Demonstration	Green Hydrogen generation & storage	PEI
Academia	Hydrogen conversion to energy	Technion Israel Institute of Technology
Academia	Green Hydrogen generation	Several
Academia	NG Pyrolysis to Hydrogen	TAU university
Academia	Fuel Cell improvements	Several

INFRASTRUCTURE

- In 2022 the first hydrogen refueling station will be operational in Israel
- The first Green hydrogen plant by H2PRO is expected to begin construction in March 2022

KEY MESSAGES

- First transportation pilots will be realized in 2022, with significant expansion in 2023
- First green hydrogen projects are expected to start late in 2022 or early 2023
- Israel with its innovative eco-system will try to be a significant player in bringing new technologies to the Hydrogen economy.

REFERENCES

- [The Standards Institution of Israel](#)

ITALY

COUNTRY'S REPRESENTATION AT THE EXECUTIVE COMMITTEE OF THE HYDROGEN TCP

Representative:

Dr Alberto Giaconia, PhD

ENEA - Casaccia Research Center, Rome, Italy

Department of Energy Technologies and Renewable Sources (TERIN)

Via Anguillarese 301 - 00123 Rome (Italy)

Email: alberto.giaconia@enea.it



Alternate:

Dr Massimiliano Della Pietra, PhD

ENEA - Casaccia Research Center, Rome, Italy

Department of Energy Technologies and Renewable Sources (TERIN)

Via Anguillarese 301 - 00123 Rome (Italy)

Email: massimiliano.dellapietra@enea.it

HYDROGEN SECTOR OVERVIEW

Hydrogen consumption in Italy is almost entirely limited to industrial uses in refinery and chemical processes (e.g. ammonia) and is predominantly grey hydrogen. Currently, hydrogen consumption in Italy is approximately 16 TWh, equal to 1% of overall national energy consumption (1,436 TWh) corresponding to about 480,000 t/year, of which about 8,500 t/year are marketed in cylinders and special pipes. In order to boost the development of the renewable hydrogen market, in November 2020 the Italian Ministry for the Economic Development (MISE) published the "Guidelines for the National Strategy on Hydrogen" and opened a consultation to identify industrial sectors that will most benefit from H₂ technologies. Subsequently, with the aim of further improving the ambitious targets set in the Italian NECP (National Energy and Climate Plan), in February 2021 the Italian Recovery and Resilience Plan (RRP) has been approved. The RRP foresees almost 60 billion euros of investments dedicated to the ecological transition of which 4 billion euros will be explicitly dedicated to the deployment of hydrogen technologies.

Is there a national hydrogen strategy?



Not yet, it is a work in progress:

[Guidelines for the National Strategy on Hydrogen](#) launched in 2020

[Recovery and Resilience Plan](#) published in 2021

POLICY-RELATED MATTERS & MILESTONES IN 2021

- February 2021: RRP approved, [foreseeing 3,64bn€ investment in the field of hydrogen](#)
- May 2021: kick-off of the project [ENEA Casaccia hydrogen demo valley](#)
- Summer 2021: Italian industry's participation in the first two IPCEI hydrogen waves

- February 2022: Change of the “*Regulation on the chemical and physical characteristics and presence of other components in the fuel gas.*” Allowing up to 2% in volume of hydrogen to be introduced in the natural gas grid
- Receive RED II, simplification for connection of electrolyzers and incentives for hydrogen foreseen

R&D&D PROJECTS

Italy is one of the leading EU countries in terms of the number and funding of H₂ & FC R&D projects, with over 160 projects and 120 beneficiaries in 321 participations financed by the FCH 2 JU in the period 2008-2020 mobilizing over 107 M€ funding. National programs are currently funding 5 projects worth 8.5 M€. There are also several R&D initiatives taking place in universities. Moreover, Italy and EU member states aim at cooperating to scale up H₂ technologies and develop infrastructures in the framework of the IPCEI (Important Project of Common European interest) on Hydrogen. In this framework, Italy participated actively, during summer 2021, in the final definition of the chapeau document of the IPCEI hydrogen waves “technology” and (hard-to-abate) “industry”.

Fund for Research on the electrical system (2019-2021)	
TERM	2019-2021
FUNDING	Italian Ministry for the Economic Development (MISE)
PRIORITIES	Hydrogen R&D activities on Power-to-Gas technology
MORE INFORMATION	Mainly focused on P2G technologies to store excess RES power.
Hydrogen Demo Valley	
TERM	2019-2022
FUNDING	Italian Ministry for the Economic Development (MISE)
PRIORITIES	Demonstration of the first Italian hydrogen valley
MORE INFORMATION	<p>The project is part of the Mission Innovation initiative and refers to Challenge IC#8 "Renewable and Clean Hydrogen". Through collaboration and coordination at an international level, aims at contributing to the development of a global hydrogen market through the active involvement of public and private stakeholders operating in the hydrogen value chain, in order to overcome technological, regulatory and normative barriers.</p> <p>The project deals with the technological demonstration in an integrated and operational environment (TRL 8) of technological and system solutions: different technologies will be studied, implemented and demonstrated for the production of hydrogen from Renewable Energy Sources (RES), its transport and distribution as pure H₂ or blended with natural gas, in the pipeline, up to the use of H₂ in different sectors such as energy, industry, sustainable mobility and production synthetic commodities (gas/liquids).</p>

Funded through the first Mission Innovation Hydrogen Challenge.

- Many other projects have been announced, most of them are in the development and authorization phase and some of them have already been selected for funding under different programs.
- H2iseo for the conversion of diesel trains in Valcamonica, named in the PNRR and selected by the Innovation Fund for funding.
- Project AGNES, port of Ravenna for the production of hydrogen on shore (100MW) and off shore (5MW)
- The Hydrogen Valley in Puglia proposes the construction of three green hydrogen production plants in Brindisi, Taranto and Cerignola for a total capacity of 220 MW, powered by photovoltaic production for a total power of 380 MW.
- Innovation Hub for Hydrogen in Carlentini, Sicily

INFRASTRUCTURE

Currently, 4 HRS are built in Italy. One public HRS in Bolzano for cars and busses were, at the end of 2021, 12 H₂ buses are operating plus tens of FC cars (Hyundai ix35 and Nexo) added to the park in 2020; 3 private HRS for buses (Milano, Sanremo, Capo d'Orlando) and one private HRS (JRC Center in Varese). Some HRS have been built but are not operational yet (Milano, San Donato, and Mestre), 5 HRS will be provided through the LIFE Alps Project along A22 highway in North Italy, one HRS in the Industrial area of Terni (using surplus H₂ from Chlor-alkali process). The establishment of trains and heavy trucks is planned too. Several expressions of interest have been submitted by industrial players for First Industrial Deployment projects in the H₂ value chain, including electrolyzers Gigafactories, blending with natural gas and the introduction of hydrogen lines in steel factories for the production of "green steel". Italian gas Transmission System Operator, SNAM, is continuing its activities on the injection of 5 to 10% hydrogen in the natural gas grid.

KEY MESSAGES

- 2bilions euro to be invested in hydrogen technologies for the hard-to-abate sector
- Build around 40 refuelling stations, giving priority to strategic areas for heavy road haulage
- Investments for green hydrogen production technologies in the pipeline (RRP)Hydrogen Valleys supported by RRP

REFERENCES

- [Recovery and Resilience Plan](#)
- [Enea Hydrogen Valley](#)

JAPAN

COUNTRY'S REPRESENTATION AT THE EXECUTIVE COMMITTEE OF THE HYDROGEN TCP

Eiji Ohira – New Energy and Industrial Technology Development Organization (NEDO)



HYDROGEN SECTOR OVERVIEW

Japan released the Basic Hydrogen Strategy in December 2017. The Strategy shows future visions that Japan should achieve with an eye on 2050 and also serves as an action plan to accomplish the visions by 2030. The strategy sets a goal that Japan should reduce hydrogen costs to the same level as conventional energy and to achieve the goal, provides integrated policies across ministries ranging from hydrogen production to utilization under the common goals.

Japan's Cabinet approved the Sixth Strategic Energy Plan in October 2021. The Sixth Strategic Energy Plan has been formulated by showing the approach to energy policy toward achieving carbon neutrality by 2050 and the GHG emission reduction target in 2030. In this plan, hydrogen is positioned as a new resource looking ahead to the carbon-neutral and hydrogen power generation was included in the 2030 energy mix for the first time.

		(FY2019 ⇒ previous energy mix)	Energy mix in FY2030 (ambitious outlook)	
Energy efficiency improvement		(16.55 million kl ⇒ 50.30 million kl)	62 million kl	
Final energy consumption (without energy conservation)		(350 million kl ⇒ 377 million kl)	350 million kl	
Power generation mix Electricity generated: 1,065 TWh ⇒ Approx. 934 TWh	Renewable energy	(18% ⇒ 22-24%)	36-38%	※If progress is made in utilization and implementation of R&D of renewable energy currently underway, 38% or higher will be aimed at. (details of renewable) solar 14~16% wind 5% geothermal 1% hydropower 11% biomass 5%
	Hydrogen/Ammonia	(0% ⇒ 0%)	1%	
	Nuclear	(6% ⇒ 20-22%)	20-22%	
	LNG	(37% ⇒ 27%)	20%	
	Coal	(32% ⇒ 26%)	19%	
	Oil, etc.	(7% ⇒ 3%)	2%	
(+ non-energy related gases/sinks)			46%	
GHG reduction rate		(14% ⇒ 26%)	Continuing strenuous efforts in its challenge to meet the lofty goal of cutting its emission by 50%	

FIG 1. JAPAN'S ENERGY MIX IN 2030

The plan also mentioned hydrogen target:

	Current	2030	2050
Cost (JPY/Nm3)	100	30	20
Supply Amount (Million tons/year)	2	3	20

Is there a national hydrogen strategy?



[Basic Hydrogen Strategy](#)

launched in December 2017

MILESTONES IN 2021

Items	Japan's Target (2030)	Current status (as of Sept 2021)
Residential Fuel Cell	5.3 million	> 410,000
Mobility		
Passenger Vehicles	800,000	> 6,500
Fuel Cell Buses	1,200	> 100
Hydrogen Refueling Station	900	> 160 (public stations)

POLICY-RELATED MATTERS

Ministry of Economy, Trade and Industry established the “Hydrogen and Fuel Cell Strategic Council” with participation from related industries, academia, local government and other stakeholders in December 2013. The hydrogen strategy in Japan has been discussed by this Council.

R&D&D PROJECTS

NEDO is a central player in Japan's national research and development project on hydrogen. NEDO is working on many technological development themes, from the production of hydrogen to its utilization. Through this effort, the world's first liquefied hydrogen tanker was developed in 2021. The navigation test of this tanker between Japan and Australia was completed in February 2022.

NEDO Fuel Cell and Hydrogen R&D program	
TERM	April 2018 – March 2023 (NEDO's Fourth Five-Year Plan)
FUNDING	US\$ 210 million (in JFY 2021)
PRIORITIES	<ul style="list-style-type: none"> -Fuel Cells (PEFC, SOFC) -HRS (streamlining regulation, low-cost equipment, developing new regulation, code and standard) -Hydrogen Gas Turbine, Hydrogen Engine, Hydrogen Boiler -Hydrogen Supply Chain (Liquefied Hydrogen, OCH) -Hydrogen Production (Electrolysis, Thermal decomposition) -Power to Gas

Furthermore, in 2021, NEDO started a new project for the social implementation of the hydrogen supply chain and hydrogen power generation. NEDO will scale up the technologies it has developed so far to a practical scale and realize an international hydrogen supply chain by 2030. It is planned to invest 300 billion yen in this project in 10 years.

NATIONAL ORGANISATION HYDROGEN AND FUEL CELL TECHNOLOGY (NOW GMBH)

REPRESENTATION

Franz Lehner – Head of Division International Cooperation

Luisa Boll – Programme Manager International Partnerships



INTRODUCTION

The National Organisation Hydrogen and Fuel Cell Technology (NOW GmbH) is a public programme management organisation of the German Federal Government. It is responsible for the coordination and management of different government programmes, including the National Innovation Programme Hydrogen and Fuel Cell Technology (NIP). NOW GmbH supports research, development, and demonstration activities along with procurement initiatives for the purpose of market activation. NOW GmbH is tasked with initiating and evaluating projects and, where possible, interlinking them to create synergies.

NOW GmbH aims to raise overall awareness of hydrogen, fuel cells and e-mobility through public communication activities and through supporting the knowledge transfer at the interface of policy, industry and research. Part of NOW's mission is also to enhance international collaboration, for example through working towards common standards and regulations.

NOW GmbH is responsible for the coordination and management of the National Innovation Programme Hydrogen and Fuel Cell Technology (NIP), the Local Electric Mobility funding programme and the National Centre for Charging Infrastructure. On behalf of the BMDV, NOW GmbH also supports the development of the Federal Government's Mobility and Fuel Strategy and coordinates funding projects within it. NOW is also responsible for hydrogen-related activities under the Export Initiative Environmental Technologies of the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV).

HYDROGEN

In 2016, the second phase of the National Innovation Programme Hydrogen and Fuel Cell Technology (NIP II) was launched. While the first phase (NIP I) from 2008 to 2016 was focused on reaching market readiness for hydrogen and fuel cell technologies, the second phase (NIP II) focuses on market activation. The NIP is coordinated and implemented by NOW GmbH. In 2020, Germany launched its [National Hydrogen Strategy](#).

MILESTONES IN 2021

- As part of the **HyLand** programme, 30 new municipalities and regions [were awarded the status of HyStarter or HyExperts](#);
- Locations for the **site of a Hydrogen Technology and Innovation Centre (ITZ)** for mobility applications were [selected and announced](#);
- Mission Innovation launched its Clean Hydrogen Mission.

PROJECTS

HyLand - Hydrogen Regions in Germany

HyLand is a competition launched in 2019 by the Federal Ministry of Digital and Transport (BMDV), which is already in its second round. HyLand motivates actors in all regions of Germany to initiate, plan and implement hydrogen-related concepts. The aim of the competition is to identify and promote the most innovative and promising regional concepts.

With the HyLand concept, German municipalities are accompanied on their way to the hydrogen economy as HyStarters, HyExperts or HyPerformers, depending on their level of knowledge. As part of HyLand, which started in 2019, from over 200 concept submissions from all over Germany 25 regions are being supported with ca. 67 Mio. €.

Within the framework of HyLand II, 30 further municipalities and regions [were awarded the status of HyStarter or HyExperts](#) in September 2021. The 15 new HyStarters receive support for the development of a regionally tailored hydrogen concept and the formation of a network for local hydrogen actors for one year. NOW GmbH received 65 expressions of interest for HyStarters in the phase from March to May 2021. A total of 51 applicants applied for a place among the HyExperts, of which the 15 selected ones are supported with funding of up to 400,000 euros each for consulting, planning and services to develop a feasible overall concept for a regional hydrogen economy.

As part of the HyLand network, the regions are supported and accompanied by the corresponding funding instruments and networks in the creation of regionally integrated concepts for the introduction of hydrogen and fuel cell technology.

Competition for the Site of a Hydrogen Technology and Innovation Centre (ITZ) for Mobility Applications

A competition coordinated by NOW GmbH aimed to find locations for a hydrogen technology and innovation centre that focuses on the value chain of hydrogen and fuel cell technology for mobility applications. The ITZ will offer small and medium-sized enterprises and start-ups in particular the development environment they need to position themselves on the international market.

Competition entries could be submitted until January 2021. [In September 2021, the BMDV chose](#) Chemnitz, Duisburg, Pforzheim and a network of three cities in northern Germany: The Hydrogen and Mobility Innovation Center (HIC) in Chemnitz, the Hydrogen Technology Application Centre (WTAC) in Pforzheim and a network of three cities in northern Germany. In the future, they will operate under the names Innovation and Technology Centre (ITZ) Chemnitz, ITZ Pforzheim and ITZ Duisburg.

In addition, Bremen/Bremerhaven, Hamburg and Stade will together form the ITZ North and focus primarily on hydrogen applications in shipping and aviation.

FORWARD-LOOKING

- The coalition treaty of the new government pledges to make Germany a lead market for hydrogen technology by 2030. To that end, the national hydrogen strategy shall be continued in 2022 and be updated in an ambitious manner to enable a swift market ramp-up.
- Launch of the Hydrogen Valley Working Group together with the European Commission as part of the Clean Hydrogen Mission is planned for 2022; the goal of the Mission is to deliver 100 Hydrogen Valleys by 2030.
- NOW GmbH's call for public refueling stations for commercial vehicles ran until the end of January 2022 and is currently being assessed (as of February 2022). Another call is planned for the middle of 2022.

KEY MESSAGES

- As part of the **National Innovation Programme Hydrogen and Fuel Cell Technology**, one of the focus areas has been the further development of the **HyLand programme** which supports regional buildup of hydrogen activities.
- The locations of the German **Hydrogen Technology and Innovation Centres were selected**.
- In 2022, NOW GmbH is expanding its activities around the funding of **hydrogen refueling stations**.
- The incoming **German coalition government** pledged to double the **2030 electrolyser** deployment target from 5 to 10 gigawatt. It also stated in its [2021 coalition treaty](#) (translation from German by NOW GmbH):
 - “The hydrogen strategy will be continued in 2022. (...) For a rapid market ramp-up and until a low-cost supply of green hydrogen is available, we are relying on a technology-agnostic design of hydrogen regulation”.
 - “In the interest of a rapid market ramp-up, we promote future-proof technologies, even if the availability of green hydrogen is not yet sufficiently secured. We do not want to limit the use of hydrogen to specific fields of application”.
 - “We want to drive forward the development of an effective hydrogen economy as quickly as possible and achieve an electrolysis capacity of around 10 gigawatts in 2030. We will ensure this, among other things, through European and international energy partnerships”.

REFERENCES

- [NOW GmbH](#)
- [German National Hydrogen Strategy](#)
- [BMVI](#)
- [H2.Live](#)
- [Clean Energy Partnership](#)
- [Clean Power Net](#)

THE NETHERLANDS

COUNTRY'S REPRESENTATION AT THE EXECUTIVE COMMITTEE OF THE HYDROGEN TCP

Carla Robledo – Ministry of Economic Affairs and Climate Policy (EZK)

Simone te Buck – Netherlands Enterprise Agency (RVO)



HYDROGEN SECTOR OVERVIEW

The Dutch approach to developing the important role of hydrogen in a sustainable energy system is driven by ambitious climate policies and commitments and taking into account the scope of the entire value chain. Rather than viewing hydrogen production and various applications as separate issues, the Netherlands has adopted an integrated approach to establish a clean hydrogen market. Hundreds of pilot projects are underway in which companies and research organisations are building a complete hydrogen ecosystem, not only focusing on technology but also on creating demand, business models and on tackling regulatory and safety issues. This is often done in public-private partnerships and in a very pragmatic way with an open approach to innovation. The newly instated National Hydrogen Program (“Nationaal Waterstof Programma” or NWP) in January 2022 is a clear example of a public-private partnership that contributes to achieving the large ambitions. The NWP will support the application of hydrogen in various sectors and help to achieve the goals in the field of hydrogen by facilitating and accelerating initiatives, as well as enabling the collaboration between various stakeholders and monitoring the progress.

The Netherlands is backing up its strong hydrogen ambitions stated back in 2019 in the National Climate Agreement and reinforced in 2020 with its Hydrogen Strategy, with supportive legislation and funding (approx. 1 bln euro appointed for hydrogen during Budget Day in September 2021 and a large Climate Fund of 35 mln euro appointed by the new Cabinet beginning of 2022, of which 15 mln euros will be for low-carbon gaseous energy carriers, including hydrogen).

Is there a national hydrogen strategy?



[Government Strategy on Hydrogen | Publication | Government.nl](#) March 2020

MILESTONES IN 2021

- December 2021 – [Letter](#) to the Parliament over the organization and development of a hydrogen market
- November 2021 – [Green Transport Delta](#) project for hydrogen motors, fuel cells and tank infrastructure was awarded 47 mln euro
- September 2021 - [Joint position paper](#) of the Pentilateral Energy Forum on the regulatory framework for hydrogen published

- September 2021 - +1 billion EUR for Hydrogen announced during Budget Day: €750 mln for the hydrogen backbone, €250 mln for upscaling electrolysis, €35 mln for IPCEI and more.
- August 2021 – 4 projects were pre-notified for the technology wave of the [Important Projects of Common European Interest \(IPCEI\)](#) and 9 electrolysis projects for the industry wave. The electrolysis projects account together up to 1300 MW and the estimated subsidiary costs are approx. €2,2 billion.
- July 2021 - [National plan for a Hydrogen Programme](#) delivered to the former State Secretary Dilan Yeşilgöz-Zegerius
- July 2021 - [Hyway27](#) study of a national hydrogen backbone finalized and offered to the parliament. [Letter](#) presented to the Parliament in July 2021.
- April 2021 – [European subsidy](#) for Hydrogen trains in Province of Groningen (€5,8 mln from CEF)
- April 2021 – [National Growth Funds](#) allocated to hydrogen (73 mln EUR directly, 265 mln EUR extra reserved, a total of €338 mln). [GroenvermogenNL | Homepage](#)
- March 2021 – [Green Deal “H2 Districts”](#) for hydrogen in the built environment
- March 2021 – [International Hydrogen Guide](#) presented

POLICY-RELATED MATTERS

The year 2021 was marked by strong political commitment for hydrogen providing funding for infrastructure projects. The new government's coalition agreement presented in December 2021 reinforced the commitment to achieve a clean energy system where hydrogen plays a fundamental role, by providing a €35 billion Climate Fond, where at least €15 bln will be destined for sustainable gasses, such as hydrogen.

International collaboration has been key in 2021 on a both bilateral and multilateral level. The Netherlands is developing an import strategy for which it has established bilateral joint statements in 2021 with [Chile](#), [Uruguay](#), [Namibia](#) and [Canada](#). The Netherlands is also participating in the international discussions on trade, certification, upscaling, market development and more via de multilateral forums, such as IPHE, IRENA, IEA H2 TCP, Clean Energy Ministerial and the Hydrogen Ministerial.

R&D&D PROJECTS

A summary of current hydrogen projects in The Netherlands can be found [here](#). Here below a list of some relevant hydrogen R&D&D projects that have taken place in 2021:

- [Flex H2](#) - demonstrate of offshore wind to green hydrogen production (€4 mln subsidy), December 2021
- [Symbatt](#) – a project that will implement and test the battolyser concept which integrates generation, marketing and interim storage and conversion to hydrogen in one chain (€3,2 mln subsidies), December 2021
- [First dutch home heated by hydrogen](#) connected to a local, underground hydrogen network – November 2021
- Successful start demo project with hydrogen storage in salt caverns-[Hystock](#), Sept 2021
- [PoSHYdon](#): first offshore H₂ production pilot begins. Received funding of €3,6 mln from DEI+, July 2021
- Opening of one of the largest [hydrogen filling stations in Europe opened in Groningen with 20 new hydrogen busses](#), June 2021
- [First hydrogen tractor](#) in Stadsboerderij Almere, NL (H2Trac Arnhem), June 2021

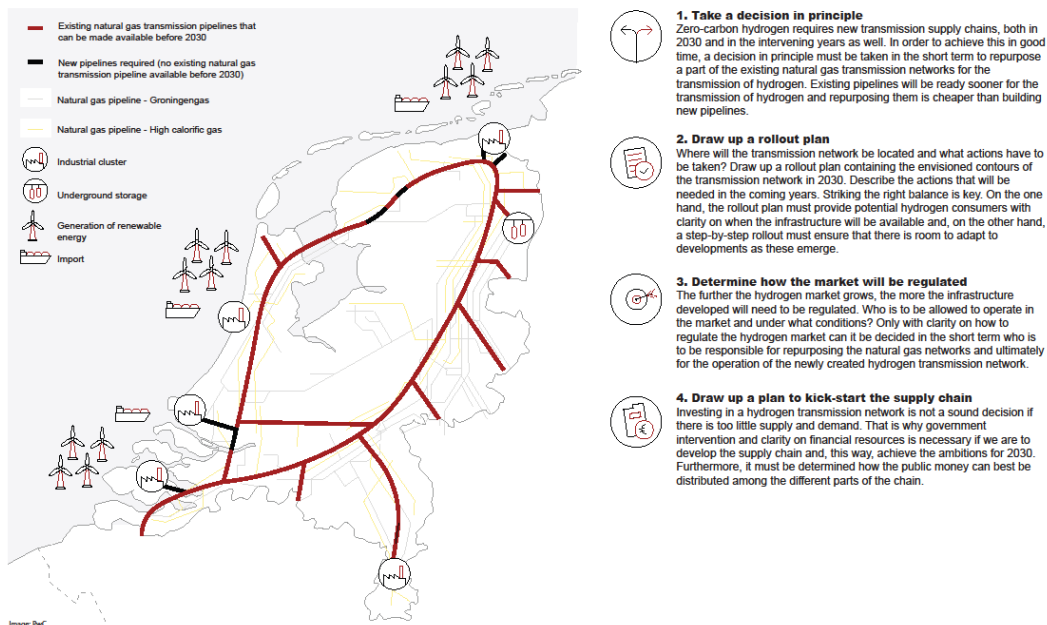
- [Hydrogen demo house](#) opened “Hydrogen Experience Center” from grid operator Alliander as training location May 2021
- TU Delft Solar Team developed the [first flying hydrogen boat](#) in the world, the “Hydro Motion”, May 2021
- Two [garbage trucks on hydrogen](#) in Helmond, NL operational since May 2021
- [Hyscaling](#)- establishing a Dutch electrolyser industry (€3,8 mln subsidy)

INFRASTRUCTURE

The [Hyway27](#) study concluded that it is safe and cost-effective to reuse existing gas pipelines for hydrogen (4 times less expensive than newly built infrastructure) and establish the hydrogen backbone. 1200 km of hydrogen pipelines with underground hydrogen storage are projected in 2027.

HyWay 27: Realisation of a national hydrogen network

The Ministry of Economic Affairs and Climate Policy, together with Gasunie and TenneT carried out the HyWay 27 study. The study concluded that the current natural gas transmission network provides a cost-efficient basis for safe hydrogen transmission. The national hydrogen infrastructure, including connections to storage facilities, is needed to realise the Netherlands' hydrogen ambitions by 2030. This report makes the following recommendations.



KEY MESSAGES

- A lot of plans were presented in the last years about hydrogen projects and specially electrolyser and large import projects. It is expected that a large number of these will come to FID in 2022/2023 and realization can soon begin.

REFERENCES

- [Nationaal Waterstof Programma](#)
- [Waterstof | RVO.nl | Rijksdienst](#)
- [TKI Nieuw Gas | Topsector Energie](#)

NEW ZEALAND

COUNTRY'S REPRESENTATION AT THE EXECUTIVE COMMITTEE OF THE HYDROGEN TCP

Representative: Dr Jim Hinkley – Victoria University of Wellington

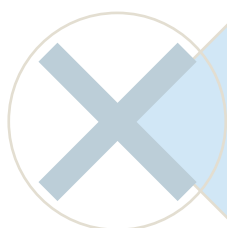
Alternate: Professor Alan Brent



HYDROGEN SECTOR OVERVIEW

The New Zealand Government has recognised that hydrogen can provide significant opportunities for the country with the potential to address sectors that are difficult to decarbonize, to manufacture green commodities and as a potential energy export vector for the country's considerable untapped renewable energy resources. There are a number of projects underway around the country to develop and demonstrate the necessary technologies and further assess the value proposition of various options. The R&D community is engaging with international partners to address a number of the technology gaps in for example steelmaking, electrolysis and ammonia synthesis.

Is there a national hydrogen strategy?



A white vision paper was published in 2019, followed by supply and demand modelling in 2020.

Work on the roadmap is expected to start in 2022.

MILESTONES IN 2021

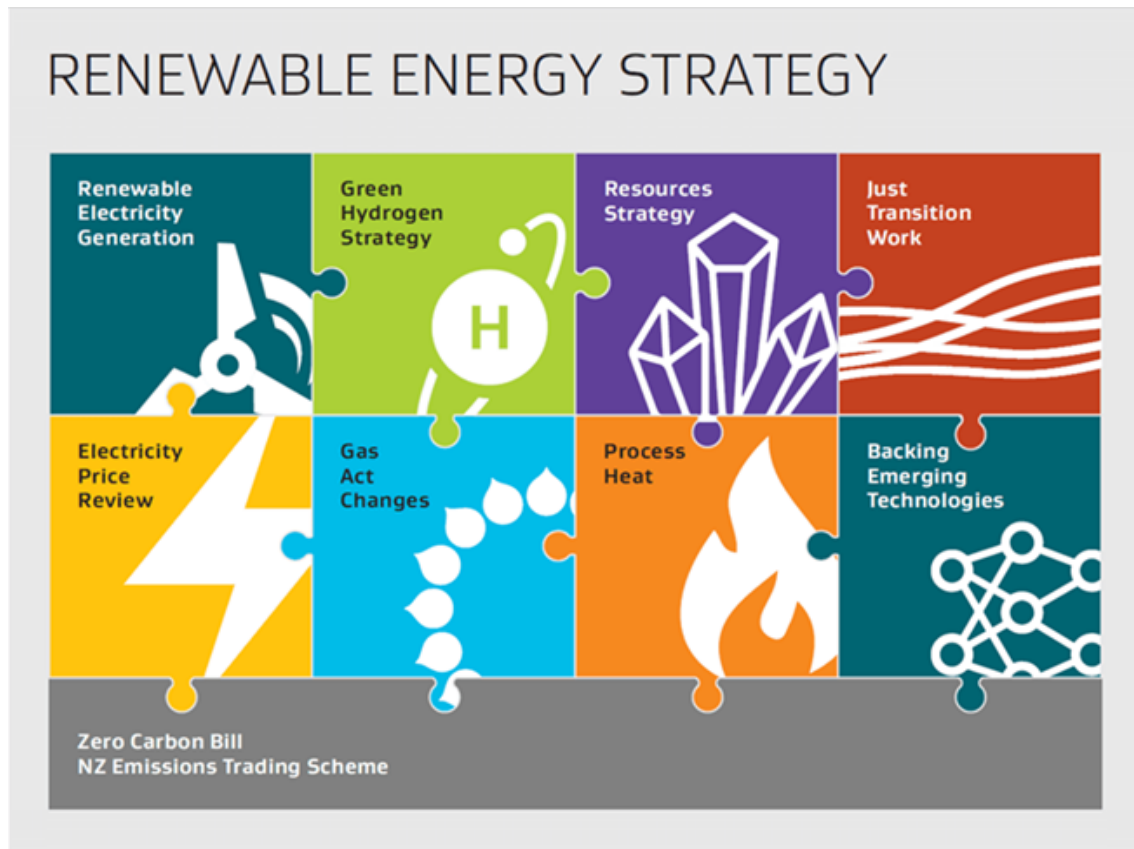
A few of the key milestones in the field of hydrogen that have taken place during the year 2021:

- Ports of Auckland installing a 1 MW electrolyser as part of their ambition to be a zero-emission port by 2050; they already have a refueling station already powering [New Zealand's first hydrogen fuel cell bus](#)
- Tuaropaki Trust and Obiyashi Corporation of Japan [starting producing New Zealand's first green hydrogen](#) from a 1.5 MW electrolyser running on geothermal electricity
- Hiringa Energy has been [granted resource consent](#) for construction of 4 wind turbines as part of a NZ\$70 million project to supply green hydrogen to an existing urea manufacturing plant that currently uses natural gas for ammonia synthesis
- Hiringa Energy also [secured funding from the NZ government](#) to establish a hydrogen refueling network for heavy duty vehicles
- Hyundai New Zealand [launched their XCIENT Fuel Cell Truck](#) in December

POLICY-RELATED MATTERS

The New Zealand Government has bold ambitions for decarbonizing the economy and has a target of 100% renewable electricity generation by 2050. Green hydrogen is part of the energy strategy currently being prepared to meet the Zero Carbon Bill (see figure below). NZ has been aware of the hydrogen opportunity for some years and was the first country globally to sign a memorandum of co-operation with Japan to work on hydrogen together. While a formal

hydrogen strategy is still in development, significant groundwork has been laid with a white paper vision document released in 2019 and supply and demand modelling released in 2020.



R&D&D PROJECTS

Hiringa Energy

- \$70m project in partnership with Ballance Agri-Nutrients to provide baseload power and green hydrogen from wind farm to urea plant
- Partnered with Universal Hydrogen to introduce [zero-emission regional aviation](#) via fleet conversions

Ports of Auckland

- Zero-emissions port by 2040. Trial of hydrogen container cranes when available
- Refueling station for other users (bus and light vehicles)

Auckland transport have started using 1 of 2 hydrogen buses

- Manufactured in NZ by GBV, waiting on a second ex UK

Obayashi Corporation and Tuaropaki Trust

- Demonstration of geothermal power to H₂ via 1.5 MW electrolysis plant – commissioned

Victoria University (& Robinson Research Institute)

- Hydrogen reduction of NZ ironsand (\$6.5m)
- Analysis of levelized cost of green hydrogen production for very heavy vehicles in NZ

Institute of Geological & Nuclear Sciences Limited (GNS)

- Next-generation electrocatalytic systems for energy production and storage (\$8.5m)

University of Otago

- Electro- and photocatalytic water splitting (\$1m)

- Collaboration between Prof. Brooker and Dr Paul Jerabek of the Helmholtz Zentrum (Hereon) research institute to establish New Zealand/German research cooperation under the Asia-Pacific Research Area (APRA) programme of the Federal Ministry of Education and Research (BMBF). 15 PhD student scholarships announced.

McDiarmid Institute (multi-institution collaboration hub)

- Range of projects including low-temperature ammonia synthesis, porous organic frameworks

Green Hydrogen Catalyst Funding call closed June 4

- 4 projects of up to \$2m each working with German partner organisations (parallel BMBF call)

INFRASTRUCTURE

List remarkable infrastructure-related facts of 2021 and accumulated data / planned for the upcoming months.

Hiringa Energy

- Roll out of hydrogen refuelling network from 2022, targeting heavy-duty freight
- First 4 stations can service >90% of heavy transport tkm
- RH drive trucks sourced from the US based Hyzon motors and Hyundai

First Gas Hydrogen Pipeline Trial Feasibility Study

- First Gas = distribution network owner in North Island (no reticulation in S. Island)
- Assessed logistics of hydrogen gas transport using the existing natural gas pipeline
- Goal is to supply [zero carbon gas by 2050](#)
- Biomethane injection, green gas certification, hydrogen injection trials

KEY MESSAGES

- New Zealand government and industry are embracing the opportunity that hydrogen presents through a variety of demonstration projects across the value chain
- 2022 will see a number of projects introduce various technologies at scale to the market: there will be three electrolyzers of 1.5 MW or more in operation and the initial deployments of green chemistry and various fuel cell vehicles from cars and buses to heavy vehicles

REFERENCES

- [NZ Government \(MBIE\)](#)
- [NZ Hydrogen Council](#)
- [Hiringa Energy](#)

NTPC LIMITED

REPRESENTATION

Mr. Mohit Bhargava, Executive Director (Renewable Energy)

Alternate: Mr. DMR Panda, General Manager (Hydrogen Energy)



INTRODUCTION

NTPC is India's largest energy conglomerate with roots planted way back in 1975 to accelerate power development in India. Since then it has established itself as the dominant power major with presence in the entire value chain of the power generation business. From fossil fuels it has forayed into generating electricity via hydro, nuclear and renewable energy sources. This foray will play a major role in lowering its carbon footprint by reducing greenhouse gas emissions.

To strengthen its core business, the corporation has diversified into the fields of consultancy, power trading, training of power professionals, rural electrification, ash utilisation and coal mining as well.

Vision: To be the world's leading power company

Mission: To provide reliable power and related solutions in an economical, efficient and environmentally friendly manner, driven by innovation and agility.

NTPC's Core Values



HYDROGEN

NTPC's Green Hydrogen Mission: To supply reliable and cost effective Green Hydrogen and be an integrated energy major in the Green Hydrogen value chain across transport, industry and power sectors.

MILESTONES IN 2021

- MoU signed with Union Territory of Ladakh (India) for development of Green Hydrogen Technologies.
- Tendering process of Green Hydrogen Fuelling station completed, project to be awarded shortly.
- 240 kW electrolyser/50kW Fuel Cell based Green Hydrogen Microgrid at NTPC Simhadri. Contract awarded on 14.12.2021 and work started.

- Green Methanol Project awarded and work started (2 TPD Green H₂, 10 TPD of Green Methanol, 20TPD CO₂ capture)

PROJECTS

(A) Green Hydrogen Mobility Projects

(i) Green Hydrogen Mobility (Leh)

- Dedicated (1.70 MW) Solar Plant for Green H₂ Station contract award – final stage
- Hydrogen Fuelling Station contract award – final stage of awarding
- Hydrogen Buses (5 Nos. for Delhi) – Tendered (Bid Opening date: 21.02.22)

(ii) Green Hydrogen Mobility (Delhi)

- Dedicated (3 MW) Solar Plant planned
- Hydrogen Fuelling Station planned at Badarpur
- Hydrogen Buses Tendered (Bid Opening date: 21.02.22)

(iii) Green Hydrogen Blending

- Green H₂ Blending (starting with 5% by Vol.) with PNG (Natural Gas) at NTPC Kawas township (Tendered, Bid Opening Date: 28.02.22)

(B) Green Hydrogen based Energy Storage

- Pilot Project-1: 240 kW electrolyser/50kW Fuel Cell-based Green Hydrogen Microgrid at NTPC Simhadri. Contract awarded on 14.12.2021 and work started.

(C) Green Methanol Project

NTPC Vindhyachal (MP)

- Contains 3 Blocks (i) 20 TPD CO₂ Capture plant (ii) 2 TPD H₂ generation plant & (iii) 10 TPD Methanol Plant
 - CO₂ Capture plant from flue gas awarded on 12.02.21, Work in progress. Expected completion by March 2022.
 - 2 TPD PEM based H₂ generation plant awarded and work is in progress. Expected completion by October 2022.
 - 10 TPD Methanol plant is awarded. Expected completion by March 2022.
- The 2 TPD H₂ PEM Electrolyser shall be the largest PEM electrolyser to be commissioned in India

(D) R&DD Projects:

i. Strategy for R&DD Projects

- In areas where NTPC can compete with the present global technology status
- Development of Infrastructure and pilot to integrate technology being developed.
- To generate data for reference, scaleup, benchmarking, SOPs, safety and policy formulation.

ii. Hydrogen production from Biomass/MSW/RDF:

- To produce H₂/chemical/liquid fuel by gasification of biomass/MSW
- Status:
 - Phase-I: Site work for gasification of MSW to produce syngas/electricity under progress, Planned for commissioning by Mar 22
 - Phase II: Integration of further purification, shift reaction and gas separation is planned and is under process design.

iii. **NETRA (NTPC R&D) Green Hydrogen grid:**

- Set up of 25 kW green power from hydrogen PEM Electrolyser, 200 bar Storage and Fuel cell system. The objective are:
 - Comparison of Battery storage (1MWh) and Hydrogen Storage system (25 kWe)
 - Infrastructure for integrating following Hydrogen technologies under development
 - Developing direct DC-DC Coupling of Solar PV and PEM Electrolyser
- Contract awarded in Dec 2021

iv. **Development of Sea Water Electrolyser for hard/sea water electrolysis**

- To enable electrolysis using hard/water as pure/DM water availability can be an issue
- Phase-I: Development of low cost, durable, chlorine and clogging resistance catalyst/electrodes/membranes
- Phase-II: Fabrication of scaled-up prototype, IPR and licensing clauses
- Status: Three sets of electrodes developed. Under long term stability testing and process of a patent. Fabrication of prototype by Mar 22.

v. **Development of High-Temperature Steam Electrolyser system (HTSE)**

- To decrease electricity required for water electrolysis as conventional ones consumed @55 kWh/kg of Hydrogen. HTSE has the potential to reduce electricity by 25-30%
- NTPC developed a system around R&D stack (from technology provider) for using plant steam and electricity for producing H₂
- Contract awarded on 09.12.2021

vi. **Development of static Hydrogen Storage**

- To reduce issues related to mechanical compression (O&M/leakage/high power)
- Metal Hydride based compression system for H₂ from 30 to 300 bar in 3 stages
- Status: Under progress, planned to demonstrate by Mar'22.

FORWARD-LOOKING

i. **Hydrogen Production by water splitting using direct solar energy (Blue sky Project)**

To reduce addition step from the process of converting solar to electricity to hydrogen

- Phase-I: Development of catalyst and electrodes for split water using sunlight (Photon)
- Phase II: Development of Reactor
 - Status:
 - Catalyst, electrodes and lab-scale reactor developed.
 - Scale-up and engineering of a reactor shall be carried out depending on the result of lab-scale studies

ii. **Tender for selection of technology partner for 1000 MW electrolyzer supply for two years**

- 400 MW PEM electrolyzer
- 600 MW of other technology (Alkaline, SOEC, AEM etc)

KEY MESSAGES

- NTPC intends to become the leader in Green Hydrogen supply and also have a significant presence in its end-use.
- NTPC would play a major role in developing Hydrogen Economy in India and assist the country in becoming one of the largest exporters of Green Hydrogen and its derivatives

REFERENCES

- [NTPC](#)

NORWAY

COUNTRY'S REPRESENTATION AT THE EXECUTIVE COMMITTEE OF THE HYDROGEN TCP

Øystein Ulleberg – Institute for Energy Technology
Åse Slagtern – Research Council of Norway (alternate)



HYDROGEN SECTOR OVERVIEW

In 2021 there was a significant increase in funding of industrial and market-oriented hydrogen projects in Norway. A total of 1.5 billion NOK (ca. 150 MEUR) in public funding for hydrogen projects was awarded in 2021 (twice the amount in 2020). Most of the funding was provided to producers and end-users in industry (70%) and maritime transport (23%), many of which are in the Western part of Norway (Vestland and Rogaland).

Norway has clear strategy and action plan to demonstrate full-scale industrial hydrogen projects over the coming years. In 2021 about 50% (75 MEUR) of the funding was earmarked IPCEI Hydrogen projects. The strong focus on the establishment of new industry-driven hydrogen projects is supported by funding for research and technology development, where about 13% (20 MEUR) went to R&D and 30% (47 MEUR) went to demonstrations and experimental developments.

Is there a national hydrogen strategy?



Chapter 6.3 in White Paper on
“Energy for Work – Long-term Value Creation from Norwegian
Energy Resources”
[Meld.St.36 \(2020-2021\)](#)

MILESTONES IN 2021

Several major milestones were achieved in Norway in the field of hydrogen in 2021. A national hydrogen road map and funding for some large hydrogen projects were announced:

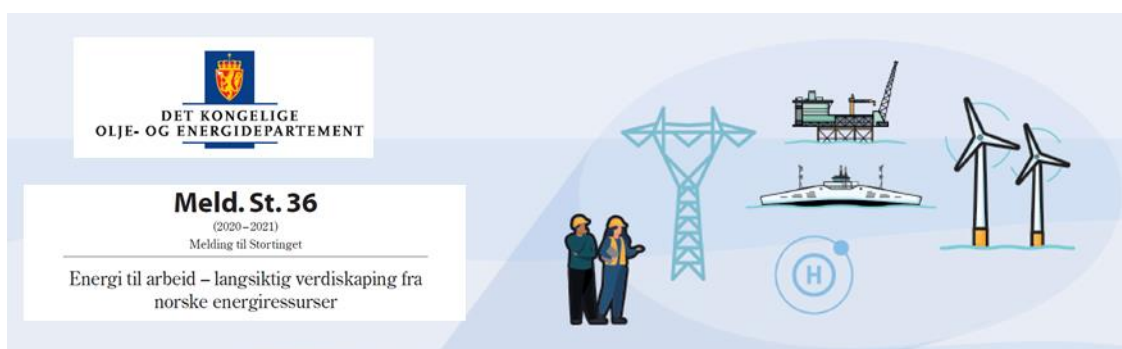
- **11 June** – Norwegian hydrogen road map issued in a white paper from the government to the parliament ([Government.no](#)).
- **3 December** – The Norwegian Public Roads Administration announced a new 15-year contract for the operation of the two new hydrogen ferries between the Lofoten Islands and Bodø from 2025-2040 ([vegvesen.no](#)).
- **17 December** – More than 1 billion NOK (100 MEUR) awarded to three large industrial hydrogen projects headed by the companies Yara, Tizir, and Horison Energi, where two of the projects are nominated as Norwegian contributions to IPCEI Hydrogen ([Enova](#)).

POLICY-RELATED MATTERS

The Norwegian government launched a national hydrogen strategy in June 2020. This was followed up with a hydrogen roadmap described in a white paper issued to the Norwegian Parliament on 11 June 2021. The white paper states the need for research, development, demonstration, and market introduction required to develop cost-efficient methods and value chains relevant for the production, transport, storage, and use of clean hydrogen and that activities in these areas are to be supported by the following four national funding agencies:

Research Council of Norway, Innovation Norway, Enova and Gassnova. In addition, a gradual increase in the CO₂ tax and possible requirements for use of hydrogen in public procurements will be used to stimulate the development of a hydrogen market. Hydrogen has a high priority, as indicated by the front page of the white paper from 2021 (figure below).

Norway has a large offshore oil and gas industry (7th largest exporter of natural gas in the world) Public-private efforts are in place to demonstrate industrial-scale carbon capture and storage (CCS) systems that will enable the production of blue hydrogen. The power production in Norway is mainly hydroelectric and the plan is to supplement this with large amounts of offshore wind. Hence, both blue and green hydrogen technology and system developments are supported. There is also a strong industrial interest to produce blue and green ammonia (NH₃) for use in existing industrial applications and future maritime applications.



FRONT PAGE OF WHITE PAPER OF 2020-2021 INCLUDING THE NORWEGIAN HYDROGEN ROADMAP

R&D&D PROJECTS

R&D&D projects in Norway cover blue and green hydrogen production and value chains for industrial and maritime applications, including research on hydrogen purification, water electrolysis, liquid hydrogen storage and transport, subsea hydrogen storage and pipelines, hydrogen safety. Examples of R&D projects established in 2021 (from [RCN Project Bank](#)):

- HYDROGEN: Climate and environmental impacts of hydrogen emissions (2021-2024)
- Hydrogen Pathways 2050 - Transition of the Norwegian society and value creation from export (2021-2025)
- SH2IPS – Safe Hydrogen Implementation: Pre-normative research for Ships (2021-2026)
- Safe Hydrogen Fuel Handling and Use for Efficient Implementation (2021-2025)
- Device – Developing value chains for CO₂-storage and blue H₂ in Europe (2021-2025)
- Hydrogen Large Scale Ship Transport (2021-2023)
- LH₂ Pioneer – Ultra-insulated seaborne containment system for global LH₂ ship transport (2021-2024)
- HYSTACK – Low cost, high-efficiency PEM electrolyser stack (2021-2023)
- Electrolyser 2030 - Cell and stack designs (2021-2025)
- HOPE – Hydrogen fuel cells solutions in shipping in relation to other low carbon options - a Nordic perspective (2021-2023)
- Novel oxygen carriers in sustainable hydrogen production (2021-2025)
- H2CarbonCat Zero-emission Hydrogen propulsion carbon fibre catamaran (2021-2023)
- Revolutionizing Green Hydrogen Production with Next Generation PEM Water Electrolyser Electrodes (2021-2025)
- INTERPORT – Integrated energy systems in ports (2021-2025)

- Highly efficient combined production of green hydrogen and chemicals (2022-2025)

INFRASTRUCTURE

There is today only a small and limited hydrogen infrastructure in place in Norway; only 3-4 hydrogen refueling stations were in operation in 2021. However, there are several large hydrogen projects underway and the Norwegian government has made an action plan to establish the following by 2025:

- 5 hydrogen hubs for maritime transport
- 2 industrial projects with hydrogen production
- 5-10 pilot projects for development and demonstration of new hydrogen technologies and solutions

In the maritime sector, there are several hydrogen projects that have come far in the development of new hydrogen infrastructure. Examples of two promising maritime hydrogen projects (*AURORA* and *HySHIP*) in the Western part of Norway is provided below.

LH₂-production and supply

- **AURORA**, PILOT-E project and IPCEI-candidate
- Project lead: BKK
- Renewable energy-based water electrolysis
- LH₂-production at Mongstad, 6 tonnes per day
- Delivery of LH₂ to maritime applications from 2024



Hydrogen Fuel Cell Coastal Cargo Vessel

- **HySHIP**, EU-project with ENOVA-funding
- Project lead: Wilhelmsen
- Remove traffic from the road, 25 000 trucks trips/year
- Fixed coastal sailing route in South-Western Norway
- Freight of goods and LH₂-storage modules
- Fuel cell and hydrogen driven ship



KEY MESSAGES

- Norway has committed to becoming a low-emission society by 2050 and hydrogen is considered to be a vital energy carrier to achieve this goal
- Norway has established a national hydrogen strategy, a roadmap, and an action plan for the establishment of new infrastructure and technology developments for blue and green hydrogen value chains
- The public funding level for research, demonstration, and market introduction has increased significantly in 2021 and key energy companies and industries in Norway have committed to several large hydrogen projects.

REFERENCES

- [Norwegian Government – Hydrogen roadmap](#)
- [Enova – Hydrogen projects](#)
- [Research Council of Norway – Hydrogen projects](#)
- [MoZEES - National Research Center Zero Emission Transport](#)
- [Norwegian Hydrogen Association](#)
- [Ocean Hyway Cluster – Hydrogen for Maritime](#)
- [Hydrogen Cluster – Cross-Sectoral Value Chain](#)

SPAIN

COUNTRY'S REPRESENTATION AT THE EXECUTIVE COMMITTEE OF THE HYDROGEN TCP

M Pilar Argumosa – INTA (National Institute of Aerospace Technology)



HYDROGEN SECTOR OVERVIEW

The hydrogen sector in Spain is on the rise at the moment as time and money are being invested in the development of this technology. Both private and public companies are betting on hydrogen by creating strategic alliances, funding new projects and finalizing previous ones.

Is there a national hydrogen strategy?



[The Spanish Hydrogen Strategy](#)

[\(Hoja de ruta del Hidrógeno\)](#)

Launched in October, 2020

MILESTONES IN 2021

H ₂ refueling stations	New H ₂ refueling stations open to the public: Pamier (Huesca), Madrid, Barcelona
	Pamiers H2 Refueling station ; Madrid H2 Refueling station ; Barcelona H2 refueling station
New hydrogen buses	Madrid hydrogen bus is operating since February 2021. Zaragoza inaugurated its first hydrogen bus in October. Its route consists of going from the city center to the airport. Barcelona also received its first H ₂ bus to be used as a city buses fleet in December.
	Zaragoza H2 bus ; Barcelona H2 bus ; Madrid H2 bus
GREEN H ₂ plant	The first hydrogen plant from renewable energy is ready to kick off in Mallorca (Power to Green Hydrogen Mallorca). It will produce 300t of H ₂ /year from renewable energy.
	Green Hydrogen plant

POLICY-RELATED MATTERS

The national strategy on Hydrogen is not only reflected in the National Hydrogen Roadmap launch in 2020, there are other strategic and legislative documents that take into account the role of green hydrogen as a key energy vector for achieving climate neutrality in 2050. These include the National Integrated Energy and Climate Plan ("PNIEC") 2021-2030, the Draft Law on

Climate Change and Energy Transition⁵, the Long-Term Decarbonisation Strategy 2050, the Fair Transition Strategy⁷ and the Energy Storage Strategy.

But all of them relies on Spain's potential to position itself as a technological leader in the production and use of green hydrogen, given the advantageous climate and large areas available for the installation of renewable energy projects (solar or wind).

The first step to accomplish this target is the launch of the Strategic Project for the Recovery and Economic Transformation (PERTE) of Renewable Energies, Renewable Hydrogen and Storage. This PERTE will mobilize resources worth 16.37 billion euros, of which 6.92 billion euros will come from the Recovery, Transformation and Resilience Plan and more than 9.45 billion euros from the private sector, with the aim of modernizing the national production model around the energy transition. The first two calls of this project are related to renewable hydrogen projects allocating funding of 400 million €.

R&D&D PROJECTS

Several hydrogen projects are already running in Spain covering renewable hydrogen production, distribution and the use of hydrogen in the road and maritime transport, cogeneration or UAVs.

Furthermore, new initiatives are arising signed agreement between industries, regional administration, research centers, associations and end-users to promote new investments for the deployment of hydrogen hubs and regional valleys for green production, as well as technological developments and infrastructure networks.





Some examples are:

- ◆ Collaboration agreement between Air Liquide and REdexis to deploy H₂ refuelling station in Spain for heavy duty vehicles. [More info](#)
- ◆ Tax-As-Service. Madrid Region, Toyota, Madrileña Red de Gas, Price Waterhouse, Grupo Ruiz are promoting the introduction of a Cab fleet of 1000 FCV in Madrid. [More info](#)
- ◆ HyDeal España. Joint venture to produce Green Hydrogen in Asturias. [More info](#)
- ◆ Basque H₂ hub. Bizkaia region and Petronor will develop a public-private demonstration center of hydrogen for aviation and heavy-duty transport in the new Energy Intelligence Center. [More info](#)
- ◆ H2inPORT in Seville or Solar hydrogen hub in Huelva to promote green hydrogen plants based on big Spanish industries investments (Iberdrola, Fertiveria, Endesa, Naturgy,...) [More info](#)
- ◆ Aviation Green Hydrogen alliance to align the aviation sector final users (Airports, air lines and OEM) with the hydrogen value chain.
- ◆ Shyne. Spanish Hydrogen Network. Multi-sectoral consortium aimed at promoting renewable hydrogen. Set up by 33 entities, it will build an ecosystem that connects major regional initiatives related to hydrogen already underway such as the Basque Hydrogen Corridor (BH2C), the Hydrogen Valley of Catalonia, and the Hydrogen Valley of the Region of Murcia. [More info](#)



[CLICK HERE TO CHECK R&D&D SPANISH PROJECTS](#)

INFRASTRUCTURE

	HRS 	BUSES 	REGISTERED FCEVS 	TRAINS 
OPEN/ ON ROAD	9*	3	15	-
PLANNED (by 2025)	38	150-200	5.000-7.000	2
PROJECTED	2	7	-	1

* In Spain there are 10 HRS in operation but only 3 are public: 2 lab site HRS (Puertollano and Walqa in Huesca), 4 private HRS (Albacete, Huesca and 2 in Sevilla) and 3 recently open to the public stations (Huesca, Madrid and Barcelona). New ones are projected as one in Zaragoza and one in Mallorca



HYDROGEN BUS AND REFUELLING STATION IN MADRID

(source: [ABC](#))

SWITZERLAND

COUNTRY'S REPRESENTATION AT THE EXECUTIVE COMMITTEE OF THE HYDROGEN TCP

Stefan Oberholzer – Swiss Federal Office of Energy SFOE



HYDROGEN SECTOR OVERVIEW

Besides efficiency measures, the Swiss energy strategy is strongly focused on electrification in various sectors. There are areas, for example in heavy traffic, where it makes sense to use hydrogen as an energy carrier to reduce greenhouse gas emissions. Thanks to a [strong private sector initiative](#), Switzerland is today a global pioneer in the use of "green" hydrogen for heavy goods vehicles. A non-negligible factor is an incentive that is currently associated with the exemption from the performance-based heavy vehicle fee (LSVA) for electrically powered trucks.

Moreover, the use of renewable hydrogen can also contribute to the reduction of greenhouse gas emissions in the industrial sector, and hydrogen is likely to play a major role in the transport and trade of renewable energies globally and in Switzerland. According to the [Swiss Energy Perspectives 2050+](#) published in 2020, domestic production of (green) hydrogen for use in heavy transport is expected to reach about 2 TWh/year by 2050, which would be produced by electrolysis using electricity from run-of-river hydroelectricity. In addition, it remains to be seen to what extent electricity from other renewable sources (PV) could also be used in Switzerland for domestic hydrogen production in the future.



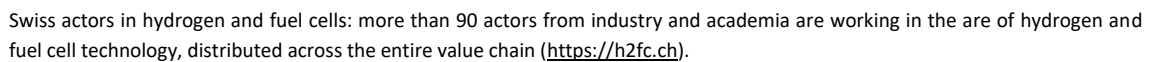
In Switzerland, a roll-out of fuel cell trucks is currently taking place on a private initiative and a nationwide network of hydrogen filling stations is being built together with production capacities for green hydrogen (source: [Hydrospider](#)).

So far, Swiss energy policy has focused on intelligent framework conditions rather than industrial policy measures. The energy and climate targets should be approached in a technology-open manner. The Swiss Federal Office of Energy, however, is currently analysing the specific potential of hydrogen for achieving the energy and climate targets and strengthening Switzerland's security of supply in more detail.

Under development

- Hydrogen refuelling stations (HRS) in operation end of 2021: 10 (1.2 per Mio capita)
- Refuelling of hydrogen (green hydrogen) per HRS and year: 31 tons
- FC trucks in operation end of 2021: 46
- Electrolysis (green hydrogen for transport): 2 MW (in planning 20 MW for end of 2022)
- Swiss-German Hydrogen forum by NOW and SFOE

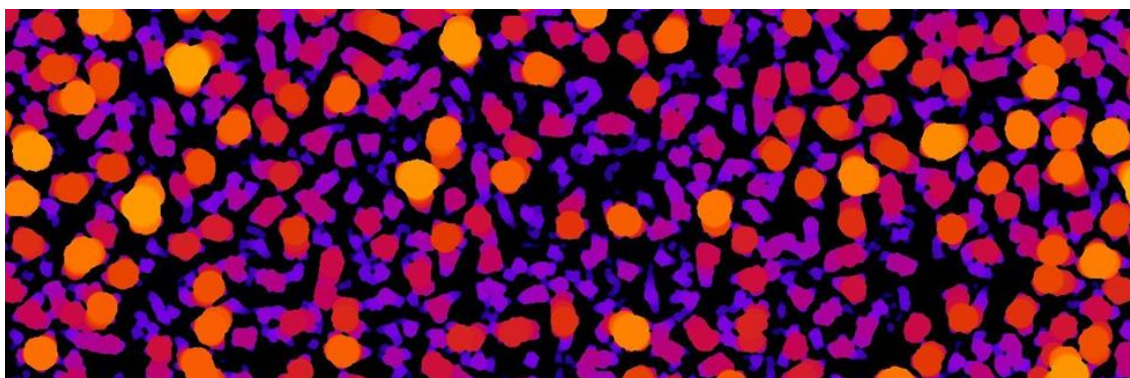
In Switzerland, approximately 28 million Euros of public funding is used for Research Technology & Development (RTD) in the field of hydrogen and fuel cell technology (figures for 2020), 22% thereof for pilot and demonstration. A large part of these funds is deployed competitively through various funding sources, with projects in the European context accounting for a large share. 71 projects are currently (23.02.2022) ongoing in various areas: Solar Hydrogen (12.5 %), PEM-electrolysis (6.4 %), Alkaline electrolysis (2.4 %), High-temp. electrolysis (2.4 %), Hydrogen storage (7.7 %), Other Hydrogen (18.4 %), PEFC (23.2 %), SOFC (19.7 %), Other Fuel Cell (7.2 %). For an overview, see [Hydrogen and Fuel Cells in Switzerland](#).



The Hydrogen RTD Programme of the Swiss Federal Office of Energy (SFOE) involves a broad range of stake-holders (see map of actors) and is part of long-standing coordinative activities by the SFOE to support research and development of energy technologies in Switzerland. SFOE funds are deployed in a subsidiary manner to fill gaps in Switzerland's funding landscape. Grants are given to private entities, the domain of the Swiss Federal Institutes of Technology (ETH), universities of applied sciences and universities.

R&D&D-Highlight

The efficiency of PEM electrolyzers is a key property and its improvement is based on material development. Thereby, the interface structure between the anodic porous transport layer (PTL) and the catalyst layer (CL) is a crucial factor limiting the efficiency of the cell. Researchers at the Paul Scherrer Institute have produced and characterised a series of materials with different microporous layers (MPL) with advanced interfacial properties. These new transport layer materials offer superior electrochemical performance compared to conventional single-layer structures, with up to three times higher catalyst layer utilisation and a decrease in the (anodic) mass transport overpotential by ≈ 100 mV at 2 A/cm^2 . The introduction of such high-performance porous transport layer structures has the potential to lead to lower operating and capital costs for polymer electrolyte water electrolyzers. (T. Schuler et al., [Hierarchically structured porous transport layers for polymer electrolyte water electrolysis](#). Advanced Energy Materials, 2020.



Cross section through porous transport layer of polymer electrolyte water electrolysis cell. Black Ti-body; coloured: pores, color coded according to pore size (purple 20 μm to yellow 60 μm). (source: [PSI Electrochemistry Laboratory](#)).

REFERENCES

- [Hydrogen and Fuel Cells in Switzerland](#)
- [Swiss Federal Office of Energy](#)
- [H2 Mobilität Schweiz](#)
- [H2 Produzenten](#)
- [Hydropole](#)
- [IPHE Switzerland](#)

CONTACT INFORMATION

Dr. Stefan Oberholzer

Swiss Federal Office of Energy

stefan.oberholzer@bfe.admin.ch

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION (UNIDO)

REPRESENTATION

Naoki Torii, Industrial Development Expert, Department of Energy, UNIDO



INTRODUCTION

UNIDO is the specialized agency of the United Nations that promotes industrial development for poverty reduction, inclusive globalization and environmental sustainability. The mission of the United Nations Industrial Development Organization (UNIDO), as described in the Lima Declaration adopted at the 15th session of the UNIDO General Conference in 2013, as well as the Abu Dhabi Declaration adopted at the 18th session of the UNIDO General Conference in 2019, is to promote and accelerate inclusive and sustainable industrial development (ISID) in the Member States.

HYDROGEN

While the industry is among the largest sources of GHG emissions, it is also a leading provider of climate technology solutions and inclusive and green jobs. UNIDO is at the forefront of efforts to build a more resilient, greener and circular economy for sustainable growth and prosperity. It does this by assisting Governments, institutions and the industry to adopt innovative industrial technologies and sustainable energy solutions that reduce the environmental impact of industrialization while creating economic and social benefits.

In line with its mandate to promote Inclusive and Sustainable Industrial Development (ISID) and its ongoing work on SDG 9, as well as the global trend towards achieving net-zero emissions in line with the objective of the Paris Agreement, UNIDO seeks to enhance its actions towards decarbonizing the economy while creating shared prosperity. In this context, hydrogen is, among others, seen as a key driver for the pathway especially in “hard to abate” industrial sectors. UNIDO is working on enhancing its actions towards promoting hydrogen production, application and utilization within developing and transitioning economies.

UNIDO has vast experience in working with industries and promoting renewable energy for productive use at the global level. The organization has also worked on several projects and initiatives for the promotion and industrial application of hydrogen.

UNIDO cooperated with the Turkish Ministry of Energy and Natural Resources to establish and host the International Centre for Hydrogen Energy Technologies (ICHET) based in Istanbul. The objective of ICHET was to promote tangible applications of hydrogen energy technologies in developing countries.

Furthermore, UNIDO is entrusted with the promotion of global cooperation and dialogue on hydrogen in industry and with the shaping of UNIDO’s engagement in the global hydrogen debate. To support this work, a UNIDO Interdivisional Hydrogen Working Group was established that provides technical guidance on hydrogen application in the industry.

MILESTONES IN 2021

UNIDO GLOBAL PROGRAMME FOR GREEN HYDROGEN IN INDUSTRY

UNIDO launched its '**Global Programme for Green Hydrogen (GH₂) in Industry**' in July 2021 with the support of governments from Austria, China, Germany and Italy. The Global Programme aims to stimulate the accelerated uptake and deployment of GH₂ in industries of developing countries and transition economies. The Global Programme foresees two main pillars of work: 01) the establishment of a Global Partnership for Hydrogen in Industry, and 02) the Technical Cooperation (TC) Programme. Both pillars are interlinked and supported by the International Hydrogen Energy Centre in Beijing.

The **Global Partnership** constitutes a platform for the UNIDO Member States, industry, private sector, investors, research and academic institutions. The Partnership engages in key activities including policy dialogue, awareness-raising, knowledge sharing, technical standards and certifications development. The Partnership addresses four essential areas of work:

- 1) Fostering policy dialogue amongst partners on GH₂. By aligning climate and industrial development targets of countries, the Partnership aims to scale-up production and application of GH₂ in industry.
- 2) Facilitating joint project development and pooling of expertise to assist countries and regions in building up and mobilizing investments for GH₂ projects, industrial clusters and value chains.
- 3) Creating knowledge products (e.g., guidelines, training manuals, best practices) on innovative GH₂ technologies and uses in hard-to-abate sectors and sector coupling, technical and safety standards, business models and enabling policies.
- 4) Organizing global awareness-raising and capacity building for different stakeholders to address social, economic and climate impacts of GH₂ in industry.

Within the framework of UNIDO's Global Programme, the Partnership supports the **TC Programme**. The TC Programme cooperates with governments in developing countries and transition economies to design country-specific GH₂ projects in industry. As a key element, UNIDO developed a 3-stage GH₂ industrial cluster model to accelerate the application of locally produced GH₂ in industrial zones, clusters and parks. Its objective is to assist in the early-stage development and deployment of GH₂ and catalyze investments, partnerships for the accelerated uptake of GH₂.

The cluster model aims to serve as a roadmap for countries to decarbonize industries and thereby achieve their climate and industrial development goals. Furthermore, one of its objectives is to create job opportunities and generate innovation and social and economic gains for the respective region/country. Additionally, this model foresees assistance in working on policy frameworks and incentives to create a conducive environment for applying GH₂.

An overview of activities have been carried out for both outcomes of the Global Programme:

- UNIDO has made its submission to the GH₂ Compact Catalogue, which is a coalition led by the Governments of Denmark, Chile and Germany in collaboration with IRENA and the World Economic Forum. The compact catalogue is part of the global effort required to unite and connect actions and commitments from global stakeholders on SDG-7 during the High-level Dialogue on Energy at the United Nations General Assembly.

- UNIDO organized the Expert Group Meeting (EGM) on 'Models for the uptake of GH₂ in industries of developing and in-transition countries: examining industrial clusters, parks and hydrogen valleys'. It was organized virtually on 20-21 October with 74 attendees from 23 countries. During the EGM, leading experts from hydrogen clusters and valleys shared experiences in designing and managing different models of industrial clusters, parks and hydrogen valleys for GH₂ application.
- A COP26 high-level panel discussion was organized on 10 November, for 'GH₂ application driving the growth of renewable energy and advancing inclusive energy transition'. In partnership with the Austrian Federal Ministry of Climate Action, UNIDO brought together partners from developing countries and transition economies to bring greater visibility into GH₂ initiatives that are planned and undertaken for advancing its uptake.

SUPPORTING THE ESTABLISHMENT AND DEVELOPMENT OF THE INTERNATIONAL HYDROGEN ENERGY CENTRE

The International Hydrogen Energy Center (IHEC) in China was launched in July 2021 with the support of UNIDO and The People's Republic of China. The inauguration ceremony of IHEC's new office building was organized in November 2021 in Beijing.

The IHEC aims to achieve technological breakthroughs, demonstrate the scaling-up applications of hydrogen energy technology and industrial innovation system, play a strategic role in helping develop the global hydrogen energy industry for achieving clean and renewable energy goals in line with United Nations Sustainable Development Goals 7, 9, and 13.

The IHEC will undertake partnership and technical cooperation activities while disseminating its best practices and knowledge through UNIDO's extensive network of international and national offices, centres and projects, south-south, triangular and regional cooperation, and support capacity building towards enhancing green hydrogen economies.

The IHEC plans to build three key industrial demonstration parks and develop a series of technical guidelines in the first phase to support the national hydrogen economy and international hydrogen cooperation till the year 2026.

- A demonstration of operating hydrogen fuel cell logistics vehicle and the world's largest hydrogen refuelling station will be built in Daxing, Beijing.
- Relying on the 2022 Winter Olympic Games, the world's largest hydrogen commercial vehicle operating demonstration park will be carried out in Zhangjiakou, Hebei Province.
- The world's largest hydrogen metallurgical chemical demonstration will be constructed in Baotou, Inner Mongolia.
- Development of series standards and certifications and technical guidelines based on the demands and experiences gained from the industrial demonstration parks and projects.

In November 2021, UNIDO and IHEC jointly organized Experts Group Meeting to support the capacity building. IHEC organized International Hydrogen Energy Industrial Development Forum and bilateral meetings with diplomats, business teams, and company representatives from Australia, Japan and UK led by their embassies in Beijing.

SPECIFICS

Supporting the establishment and development of the International Hydrogen Energy Centre	
Term	2021 - 2026
Funding	Government of China
Government Co-ordinating agency	China International Center for Economic and Technical Exchanges (CICETE), Ministry of Commerce (MOFCOM) of the Government of China
Counterpart	Beijing Municipal Bureau of Economy and Information Technology (BEIT) Beijing Tsinghua Industrial Development Research Institute (TIDRI) Beijing Yitong Hydrogen Energy and Fuel Cell Technology Innovation Research Institute
More information can be found here .	

REFERENCES

- [UNIDO](#)

UNITED KINGDOM

COUNTRY'S REPRESENTATION AT THE EXECUTIVE COMMITTEE OF THE HYDROGEN TCP

David Mason, Department for Business, Energy and Industrial Strategy, [BEIS](#)

Prof Paul Dodds, [UCL](#)



HYDROGEN SECTOR OVERVIEW

Low carbon hydrogen will be critical for meeting the UK's legally binding commitment to achieve net-zero by 2050, and Carbon Budget Six in the mid-2030s on the way to this. Hydrogen can support the deep decarbonisation of the UK economy, particularly in 'hard to electrify' UK industrial sectors, and can provide greener, flexible energy across power, heat and transport. Moreover, the UK's geography, geology, infrastructure and expertise make it particularly suited to rapidly developing a low carbon hydrogen economy, with the potential to become a global leader on hydrogen and secure economic opportunities across the UK.

Is there a national hydrogen strategy?



[UK hydrogen strategy](#)

17 August 2021

MILESTONES IN 2021

- Publication of the [UK Hydrogen Strategy](#) on 17 August 2021, outlining a comprehensive roadmap for the development of the wider UK hydrogen economy over the 2020s.
- Consultations of the following policy developments were published on 17 August 2021:
 - [Design of a business model for low carbon hydrogen](#)
 - [Designing the Net Zero Hydrogen Fund \(NZHF\)](#)
 - [Designing a UK Low Carbon Hydrogen Standard.](#)
- Two UK CCUS clusters taken forward which include the large scale production of low carbon hydrogen: [HyNet North West](#) and the [East Coast Cluster](#). The [Scottish Cluster](#) has been announced as a reserve cluster.
- The [Glasgow Hydrogen Breakthrough](#), launched by world leaders and private sector representatives at COP26 and signed by 33 countries, aims to have affordable renewable and low carbon hydrogen globally available by 2030.
- The launch of the UK's [Net Zero Strategy](#) in October 2021 included the announcement of the Industrial Decarbonisation and Hydrogen Revenue Support scheme, which will support both electrolytic and CCUS-enabled low carbon hydrogen production.
- The UK co-launched the [Mission Innovation Clean Hydrogen Mission](#) in June 2021, co-leading it alongside the European Commission, Australia, Chile and the United States.
- The UK became a full member of the [Clean Energy Ministerial Hydrogen Initiative](#).
- The UK signed a [partnership](#) with the Breakthrough Energy Catalyst including additional funding for the development of UK based hydrogen projects.
- [Hy4Heat](#) delivered the UK [hydrogen demonstration house](#) which opened on 15 June 2021 and there was a first holistic [safety report acceptance](#) of the use of hydrogen gas in certain types of domestic properties and buildings.

- The [H100 Fife project](#) is developing a world-first hydrogen network in Buckhaven and Methil that will bring renewable hydrogen into homes in 2023.
- Our world-leading Hydrogen Transport Hub in Tees Valley allocated £2.5m of funding for real-world user based [trials of transport applications](#) using clean, green hydrogen.

POLICY-RELATED MATTERS

- In addition to the publication of the [UK Hydrogen Strategy](#), the UK Government has been gathering evidence to better support low carbon hydrogen production. The support consulted on includes: [development of the NZHF](#) to support new hydrogen production projects; [development of a Hydrogen Business Model](#) to stimulate private investment in low carbon hydrogen projects; and [development of a Low Carbon Hydrogen Standard](#) to ensure that support for the production and use of low carbon hydrogen is consistent with the UK's path to net zero.
- Further to the Hydrogen Strategy, the UK's [Net Zero Strategy](#) published in October 2021 set out a comprehensive set of measures to support and capitalize on the UK's transition to net-zero by 2050, including our hydrogen ambitions.
- The UK Government launched Calls for Evidence on [decarbonisation readiness](#) for new power generation, including the use of hydrogen, in July 2021 and on [hydrogen-ready industrial boilers](#) in December 2021.
- The Scottish Government published a [draft hydrogen action plan](#) in November 2021 for a consultation to encourage the growth of the emerging hydrogen sector in Scotland.
- The Welsh Government also published their [Hydrogen in Wales report](#) in January 2021 for consultation, setting out pathways for developing the Welsh hydrogen sector.

R&D&D PROJECTS

The UK runs a number of innovation projects supporting developments in the production and use of hydrogen in industrial, commercial and domestic settings:

- The UK is supporting hydrogen use as part of the transformation to low carbon solutions including through programmes such as the £60m [Low Carbon Hydrogen Supply 2 competition](#), £55m [Industrial Fuel Switching 2 competition](#) and £40m [Red Diesel Replacement competition](#). The closure reports from earlier phases of the [Industrial Fuel Switching](#) and [Hydrogen Supply](#) competitions were published.
- Phase 2 of the £315m [Industrial Energy Transformation Fund](#) was launched in 2021, increasing readiness for the hydrogen economy by supporting companies to invest in fuel switching technologies, increasing the demand for hydrogen in industry and helping to build the commercial case for low carbon hydrogen projects.
- The [Industrial Decarbonisation Challenge](#) run by UK Research and Innovation provides up to £170m, matched by £261m from industry, to accelerate the development and deployment of technologies such as CCS and hydrogen fuel switching.
- The £68m [Longer Duration Energy Storage Demonstration competition](#), aims to accelerate commercialisation of innovative longer duration energy storage projects at different technology readiness levels, with hydrogen included in the scope.
- [20MW electrolyser](#) to be sited at Whitelee Wind Farm near Glasgow.
- The £25m [Hy4Heat](#) programme is establishing if it is technically possible, safe and convenient to replace natural gas with hydrogen in residential and commercial buildings and gas appliances.
- The UK Government has pledged £525m over 5 years from 2019 to fund zero-emission buses. The £270m [Zero Emission Bus Regional Areas scheme](#) is due to announce more successful bidders in Spring 2022, having announced initial winners in October 2021.

- The UK has invested £3m in 2021/2 to support the early development of the [Tees Valley Hydrogen Transport Hub](#). The funding has been used for pilots which aim to seed hydrogen demand in the area and catalyse the collaborations between industry, academia, and the local authorities that will be the foundation of its future success as a living lab. The 7 pilots include trials of hydrogen-fuelled vans and HGVs and vans.
- The government have invested £20m in 2021 in the [Zero Emission Road Freight Trials programme](#) to support industry to conduct feasibility studies into developing cost-effective, zero-emission HGVs and their associated infrastructure in the UK. The [Net Zero Strategy](#) announced that we will be building on the success of this work and expand the programme to trial three zero-emission HGV technologies at scale on UK roads: hydrogen fuel cell, catenary electric and battery electric HGVs.

INFRASTRUCTURE

- The [HyNet and East Coast Clusters were announced](#) as successful following [Phase 1 of the Carbon Capture Usage and Storage Sequencing Process](#) in October 2021. Projects within the clusters will have the opportunity to be considered to receive any necessary support including access to the [£1bn CCS Infrastructure Fund](#), and business models for transport and storage, power, industrial carbon capture and low carbon hydrogen.
- BP has announced plans to [build a new large-scale electrolytic hydrogen plant](#) in Teeside with a capacity of 60MWe by 2025 and 500MWe by 2030. This is in addition to [BP's planned 1GW blue hydrogen facility](#) on Teeside.
- Protium has announced plans to build [40MW of electrolytic production](#) at Wilton Universal Group's site on Teesside, including storage.
- In June 2021, the Mayor of London inaugurated a [Hydrogen Refuelling Station](#) in West London, alongside 20 new fuel cell buses, funded by the Department for Transport (DfT).
- From December 2021, Birmingham City Council's [20 fuel cell double-deckers](#) also started to roll out in service. These were also funded by the DfT.

KEY MESSAGES

- The UK Hydrogen Strategy reaffirms the Government's aim, working with industry, to have 5GW of low carbon hydrogen production capacity in the UK by 2030 – hydrogen that will be used across the economy, helping to decarbonise vital industrial sectors and provide flexible energy across power, heat and transport.
- Low carbon hydrogen provides opportunities for UK companies and workers across the UK's industrial heartlands – with government analysis suggesting the sector could be worth £900 million and support 9,000 jobs – unlocking over £4 billion in private investment – by 2030.
- The UK's world-leading supply chains, expertise, innovation and technology position the UK, with the right investment, for global leadership in the hydrogen economy. Following the Strategy's publication, the Government is working with investors and other stakeholders to understand and unlock the full spectrum of opportunities across the hydrogen landscape. The UK Government wants to see a lasting and sustainable clean energy sector that can exploit global clean growth opportunities such as those associated with low carbon hydrogen.

REFERENCES

- [UK Government](#)
- [UK Research and Innovation](#)

UNITED STATES OF AMERICA

COUNTRY'S REPRESENTATION AT THE EXECUTIVE COMMITTEE OF THE HYDROGEN TCP

U.S. Department of Energy (DOE)

Office of Energy Efficiency and Renewable Energy

(Hydrogen and Fuel Cell Technologies Office) and Office of Fossil Energy

and Carbon Management



HYDROGEN SECTOR OVERVIEW

Hydrogen is a versatile fuel that offers a path to sustainable long-term economic growth and a path to fighting the global climate crisis. It can add value to multiple sectors in the economy and support America's ongoing manufacturing renaissance and serve as a sustainable energy source across a variety of end uses. The U.S. DOE Program is committed to continued research, development, demonstration and deployment (RDD&D) in working towards the Administration's goals of 100% carbon-pollution-free electric sector by 2035 and a net-zero emissions economy by 2050. In working towards these goals, Secretary of Energy Jennifer Granholm launched the first of the Energy Earthshots – The Hydrogen Energy Earthshot – on June 7, 2021, working towards \$1 for 1kg of clean hydrogen in 1 decade. The Hydrogen Shot goals support the broader H2@Scale mission to enable the low-cost, efficient and safe production, storage and delivery of clean hydrogen for utilization across sectors at relevant scales for achieving major economic and environmental benefits. Clean hydrogen is specifically expected to play a key role in difficult-to-decarbonization sectors such as heavy-duty transportation, as well as chemical and industrial manufacturing.

Is there a national hydrogen strategy?



[Department of Energy Hydrogen Program Plan \(2020\)](#)

National Clean Hydrogen Strategy Roadmap and Hydrogen Shot Strategy Document, both expected mid-2022

MILESTONES IN 2021

- ◆ June 7: U.S. Energy Secretary Jennifer Granholm announced the DOE Energy Earthshots Initiative, beginning with the first Earthshot – Hydrogen Shot – seeking to reduce the cost of clean hydrogen by 80% to \$1 per kilogram in one decade. This was announced during the [Annual Merit Review and Peer Evaluation Meeting \(AMR\)](#), which had nearly 2,000 attendees.
- ◆ August 31-September 1: DOE hosted the virtual [Hydrogen Shot Summit](#), convening more than 3,200 stakeholders to initiate dialogue around concrete actions and innovation needed to achieve the Hydrogen Shot goal.
- ◆ DOE launched the [Hydrogen Shot Fellowship](#) to recruit diverse talent who can contribute to making Hydrogen Shot a reality. Hydrogen Shot Fellows will engage in Hydrogen Shot related work including hydrogen production, storage, infrastructure, utilization research, development and demonstration activities.

POLICY-RELATED MATTERS

- January 20: The Biden-Harris Administration took office and set specific priorities around tackling the climate crisis, reducing carbon emissions, investing in clean energy technologies, ensuring environmental justice and lifting up disadvantaged communities. Examples of new programs and goals around these topics include:
 - Achieving [100% clean electricity grid by 2035 and net-zero emissions by 2050](#)
 - Creating a government-wide [Justice40 Initiative](#) with the goal of delivering 40 % of the overall benefits of relevant federal investments to disadvantaged communities
- On November 5, 2021, the U.S. House of Representatives [passed](#) the Bipartisan Infrastructure Bill (BIB) which was signed into law on November 15, 2021. Includes funding for the U.S. Department of Energy (DOE) to deliver reliable, clean and affordable energy to communities across the U.S., covering \$9.5 billion for clean hydrogen, with \$8 billion for at least four regional clean hydrogen hubs, \$1 billion for electrolysis RD&D, and \$500 million for clean hydrogen manufacturing and recycling RD&D.

R&D&D PROJECTS

- The DOE has a broad portfolio of RD&D as described in the [U.S. Department of Energy Hydrogen Program Plan](#). Some key initiatives in this portfolio include:
 - [H2NEW](#) – a consortium of nine DOE national laboratories focused on making large-scale electrolyzers
 - [M2FCT](#) – a DOE-funded consortium of five primary national labs focused on overcoming challenges in PEMFCs for heavy-duty application
 - [HyBlend](#) – an initiative to address technical barriers to blending hydrogen in natural gas pipelines
 - Other consortiums include [HydroGen](#), [ElectroCat](#), [HyMARC](#), and [H-Mat](#).
- October 6: DOE [announced](#) approximately \$8 million in funding for nine cooperative projects that will complement existing H2@Scale efforts and support DOE's Hydrogen Shot goals. The selected projects will leverage the Advanced Research on Integrated Energy Systems (ARIES) platform to enable the integration of hydrogen technologies in future energy systems, including energy storage and a specific focus on safety and risk mitigation.
- October 7: DOE [announced](#) \$20 million in funding for a project that will support the DOE's H2@Scale vision for clean hydrogen across multiple sectors and help meet the Department's Hydrogen Shot goal of \$1 per 1 kilogram in 1 decade. The project will demonstrate technology that can produce clean hydrogen energy from nuclear power.
- May 12: DOE announced the selection of eight [projects](#) totalling \$6.4 million in funding and focused on fundamental and applied research to enable the use of hydrogen as a gas turbine fuel.
- January 15: DOE [announced](#) \$160 million in funding to help recalibrate the Nation's fossil fuel and power infrastructure for decarbonized energy and commodity production. The funding is aimed to develop technologies for the production, transport, storage, and utilization of fossil-based hydrogen, with progress towards net-zero carbon emissions. The first round of 12 [projects](#) totaling \$16.5 million in funding was awarded on July 7. Additional awards will be made in 2022 and 2023.

INFRASTRUCTURE

- The current infrastructure in the U.S related to hydrogen production and utilization is summarized in Figure 1 below. As some examples, the U.S. has deployed over 550 MW of backup power, over 50,000 hydrogen-powered forklifts, more than 172 MW produced by PEM Electrolyzers, over 60 fuel cell buses, more than 45, hydrogen retail stations, and greater than 12,000 fuel cell cars.

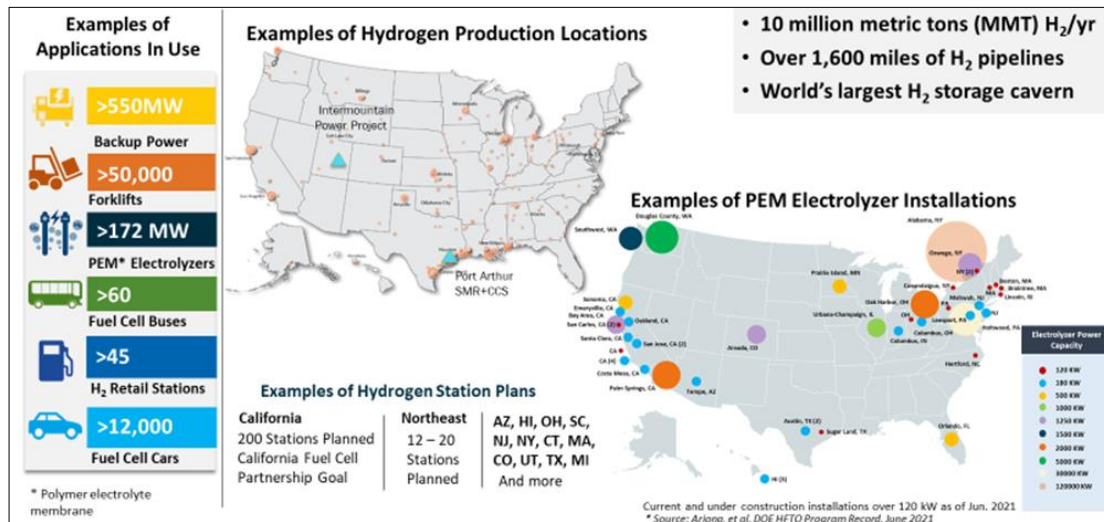


FIGURE 1. OVERVIEW OF U.S. HYDROGEN INFRASTRUCTURE

KEY MESSAGES

- Clean Hydrogen is a crucial part of the U.S. National strategy in addressing clean energy needs and the climate crisis, particularly important in difficult to decarbonize sectors
- Tackling the climate crisis with the help of large-scale clean hydrogen deployment is an all hands on deck mission that requires involvement from multiple offices in the Office of Energy Efficiency and Renewable Energy as outlined in the [U.S. Department of Energy Hydrogen Program Plan](#)

REFERENCES

- [Hydrogen and Fuel Cell Technologies Office | Department of Energy](#)
- [Office of Fossil Energy and Carbon Management | Department of Energy](#)
- [Fuel Cell & Hydrogen Energy Association \(fchea.org\)](#)

