Introduction to the Hydrogen TCP

Hydrogen TCP

In a nuthsell

ADNOC
HYCHICO
eni
एनटीपीसी NTPC
Southern Company
Hydrogen Council
Reliance Industries Limited
NOW Nationale Organisation Wasserstoff- und Brennstoffzellentechnologie

35

Members

24 Member Countries
9 Sponsors
European Commission + UNIDO

40+

Tasks

4 Ongoing
39 Finished
≅ **8** in definition

250+

Experts involved

In collaborative research on hydrogen and hydrogen technologies

What is the Hydrogen TCP?

- The Hydrogen Technology Collaboration Programme was established in 1977 to pursue international collaborative research in the hydrogen field under the auspices of the International Energy Agency
- It carries out R,D&D activities through projects focused on specific topics called Tasks
- Its Executive Committee is formed by representatives and alternates of its 24 Member Countries, the European Commission, UNIDO and 6 Sponsors

How does it work?

- Members pay an annual fee contribution of 11 350 €*. These common funds are used for maintenance and strategic activities

  Countries with GDP < 300 billion USD and GDP per capita< 20,000 USD can request a 50% reduced rate

- Tasks are managed with in-kind contributions from participants
- Overall objectives can be found on the Strategic Plan, updated every 5 years
- Updates and findings are brought together at the ExCo Meetings (about 3 per year)

Strategic Plan 2020 - 2025

A future where **hydrogen plays a key, cross-cutting role** for the world economy in a sustainable, global, integrated & flexible energy system.

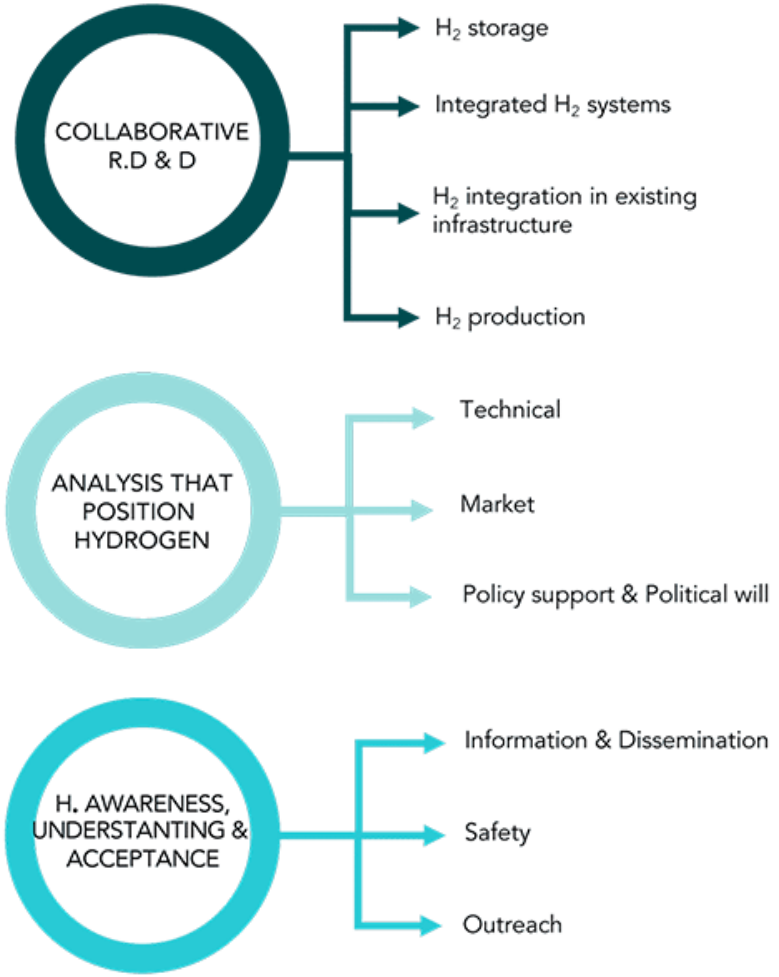
Facilitate, coordinate and maintain innovative RD&D activities as a **hub for international cooperation and Knowledge exchange.**

VISION

MISSION

STRATEGY

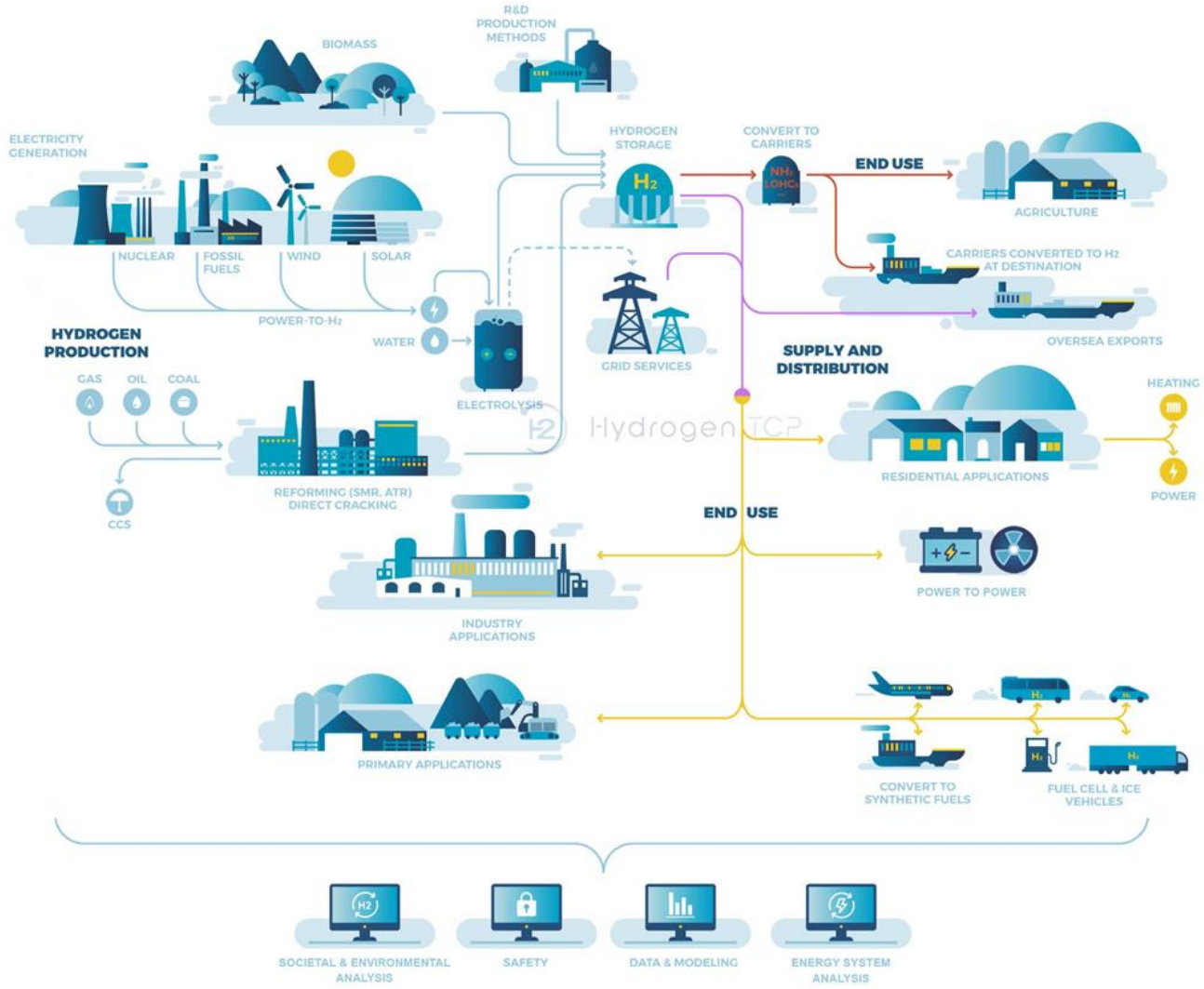
Accelerate the implementation and widespread efficient use of hydrogen to minimize global warming, optimize environmental protection, improve energy security and contribute to sustainable economic development - and preserving the hydrogen TCP as **a leading global source for hydrogen expertise**.



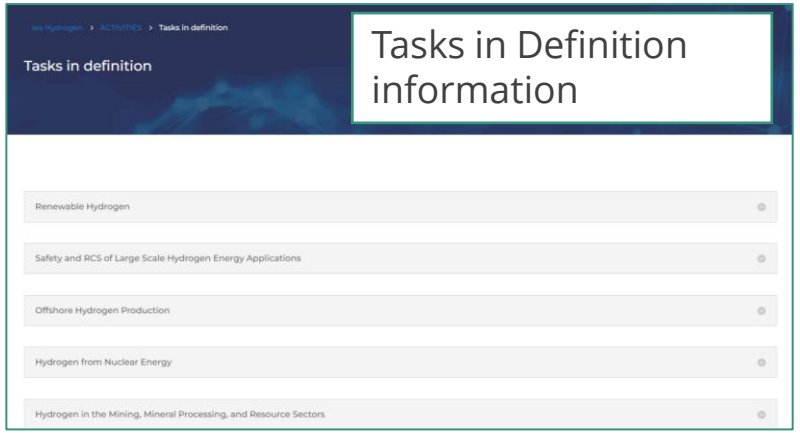
Activities

- Events (organization + participation)
  - Workshops, conferences, plenary sessions, and webinars
- Meetings (at ExCo and Task level)
- Document review for other organizations (IEA, other TCPs, international groups…)
- Dissemination through website and social media
  - Blog
  - Twitter
  - LinkedIn
- Planned strategic activities: hydrogen production projects Database, Technology Observatory…

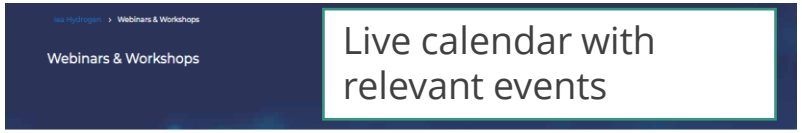
Hydrogen TCP website



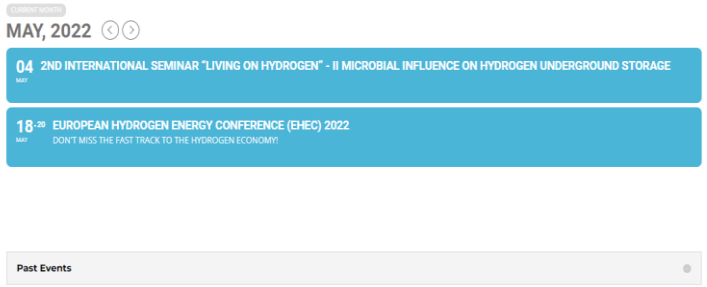
Hydrogen TCP website



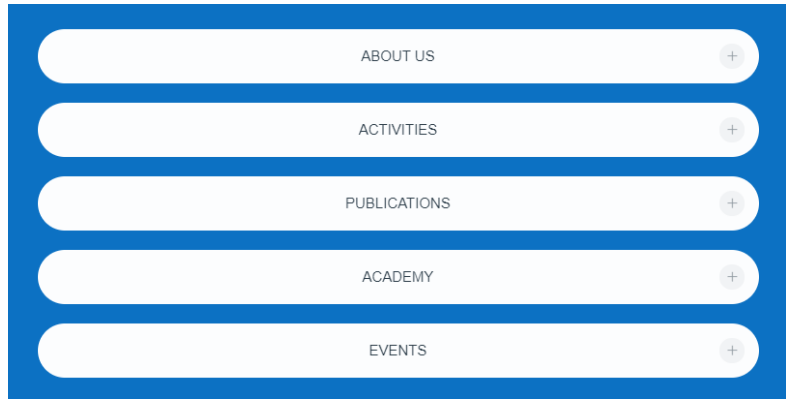
Tasks in Definition information



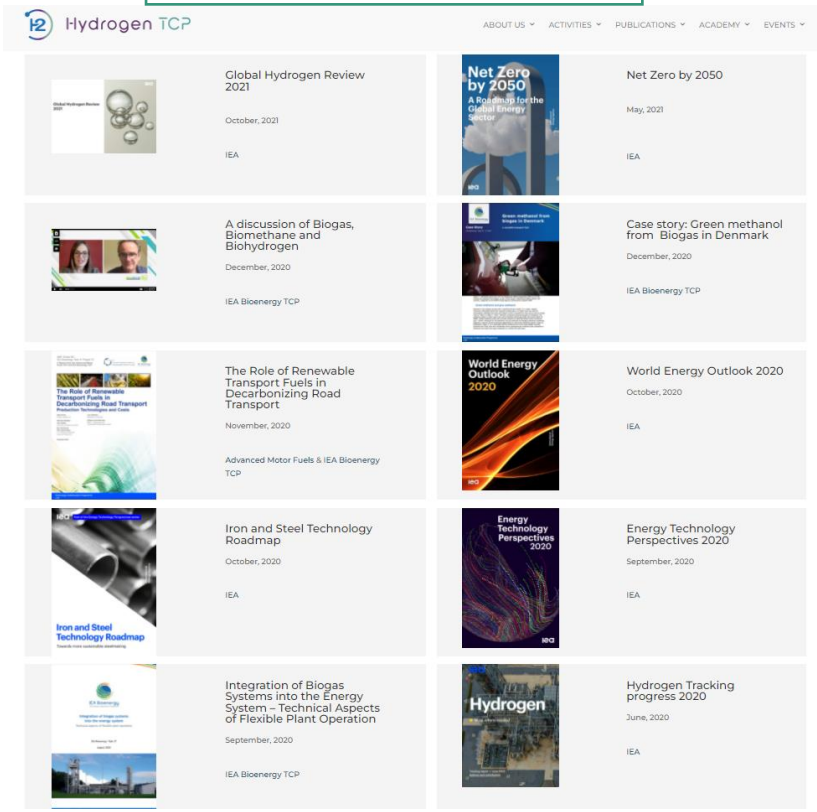
Live calendar with relevant events



www.ieahydrogen.org



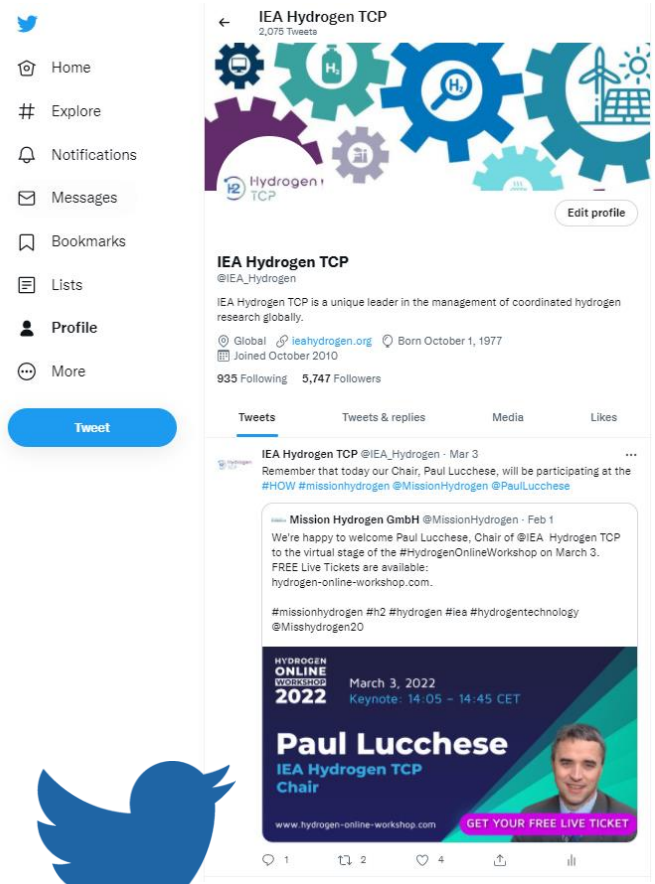
Relevant hydrogen-related documents repository



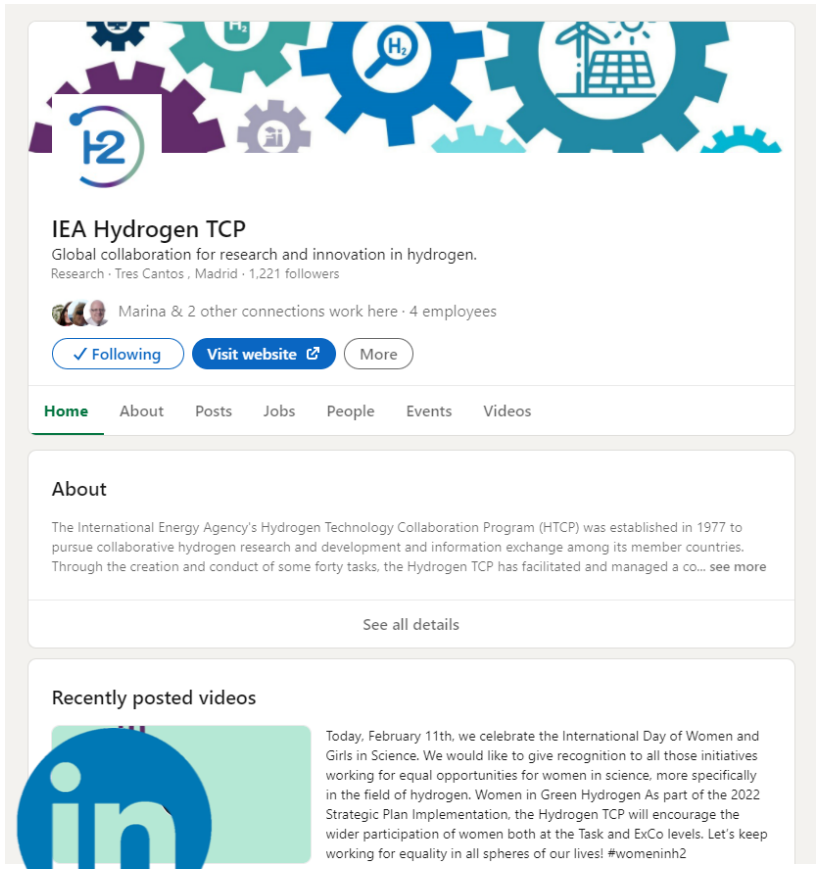
and much more!

Hydrogen TCP

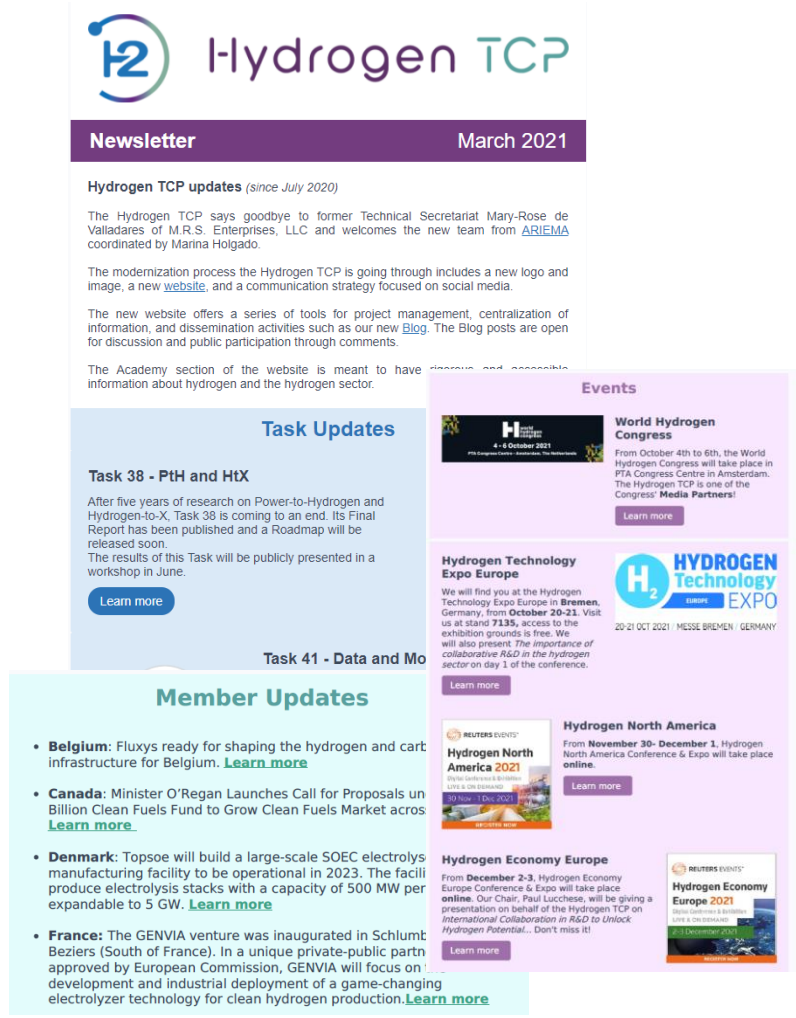
Other dissemination



@IEA_Hydrogen



IEA Hydrogen TCP



Newsletter (biannual)

Members

Representatives and alternates at the Hydrogen TCP Executive Committee (ExCo) level

Hydrogen TCP

Members' Responsibilities

- Maintain management oversight of the Hydrogen TCP to ensure the overall quality and effectiveness of the various elements of the program
- Ensure effective participation by their national/entity experts in the Hydrogen TCP Tasks and other activities
- Act as a link between their national strategies (or entities strategic and the Hydrogen TCP Strategic Plan

Why should you become a Contracting Party?

- ✓ **Collaborate** with other members on cutting-edge hydrogen R,D&D
- ✓ **Access** an archive of over 40 years of research
- ✓ **Increase** and share your hydrogen expertise
- ✓ **Connect** with scientists, and national leaders committed to reliable, sustainable, and clean energy
- ✓ **Open doors** to all national companies, entities, and individuals to participate in Tasks

How to become a member

1. When a new Member shows interest in joining, we invite them to present their interest formally in our next Executive Committee Meeting, we allocate a slot of 10-15 min presentation + 10 min Q&A to discuss on current status on hydrogen, main priorities and areas of interest

2. A written procedure is launched to invite this new member to join the ExCo

3. If no opposition is received, the TCP Chair sends a letter to the entity/country formally inviting it to join the TCP

4. The potential new member sends back a letter of acceptance with copy to the IEA Secretariat

5. On receipt of the acceptance letter, the IEA Legal Office sends a TCP Signature Page to be signed and dated

The Technical Secretariat will issue the invoice with the proportional contribution to the Common Funds based on the month the new member joins (standard contribution fee 11 350€/year)

Specific information on procedures can be found on our website and the **Procedures Manual** are available here.

Tasks

Main Hydrogen TCP activities

What is a Task?

- Collaborative research **project** among parties related to hydrogen
- Usually **3-year** duration
- Led by one or more **Task Manager**(s)
- Each one has a different scope, framework and is structured in **Subtasks**
- Any member can propose a **Task**
- Participation in is indicated by submittal of a **Letter of Participation**
- Task's **Work Plan** includes scope, goals, milestones, participation requirements, structure, deliverables…
- When approved by the Executive Committee, the Task is assigned the next consecutive number and becomes part of the Hydrogen Implementing Agreement (HIA) as an **Annex**

Types of Tasks

Closed

Tasks that already finished. List and related reports can be found here.

Open

Tasks that are currently active. Information about them and related documents can be found here.

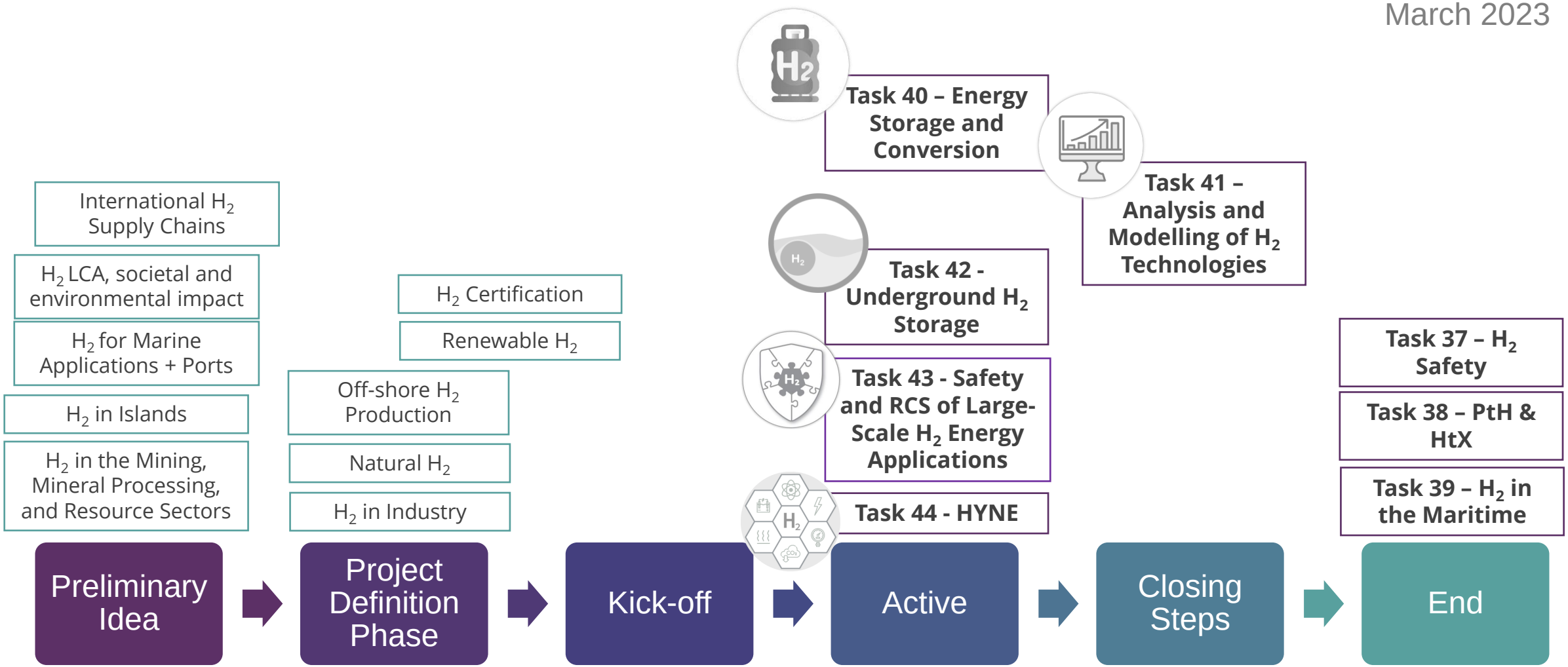
In definition

Potential Tasks in the process of defining scope and terms of their work. Information and requirements to join can be found here.

Task portfolio status

Hydrogen TCP

March 2023



Task 40

Energy storage and conversion based on hydrogen

Main goals

I. Develop reversible or regenerative H_2 storage materials (solid or liquid) fulfilling the technical targets for mobile and stationary applications

II. Develop fundamental and engineering of H_2 storage materials and systems that fulfil Target I

III. Develop materials and systems including H_2 storage for use in stationary, mobile and portable applications, electrochemical storage, and solar thermal heat storage.

Research areas

- Porous materials as cryo-adsorbents for hydrogen (coordination polymer framework compounds, MOFs, ZIFs, COFs, and carbon-based compounds)
- Magnesium- and intermetallic alloy-based hydrides for energy storage
- Complex hydrides (borohydrides, alanates, amides/imides-systems, magnesium-based compounds, reactive hydride composites)
- Ammonia and reversible liquid hydrogen carriers
- Catalysis
- Electrochemical storage of energy (MH-batteries, ion-conduction)
- Hydride-based thermal energy storage
- Research and development for hydrogen storage and compression

Task 40

Energy storage and conversion based on hydrogen

Deliverables

7 recently published papers

Metallic and complex hydride-based electrochemical storage of energy

Magnesium- and intermetallic alloys-based hydrides for energy storage: modelling, synthesis and properties

Hydrogen storage in complex hydrides: past activities and new trends

Fundamentals of hydrogen storage in nanoporous materials

Hydrogen storage in liquid hydrogen carriers: recent activities and new trends

Hydride-based thermal energy storage

Research and development of hydrogen carrier-based solutions for hydrogen compression and storage

Meetings and activities

2 in-person meetings in 2022

15-18 May, Louvaine-la-Neuve, Belgium

18-21 Sept Madrid, Spain

Next in-person meeting planned

9-12 May 2023, Nottingham, UK

Hydrogen TCP

Task 41

Analysis and Modelling of Hydrogen Technologies

Main goals

I. Develop an updated and updatable long-lasting database on hydrogen technologies.

II. Develop an improved appreciation of hydrogen energy modelling.

III. Support decision-making.

IV. Closer collaboration between the Hydrogen TCP and the ETSAP analysis community.

Task structure

Data consolidation of parameters describing H_2 technologies: during and since the definition of this Task, the growth of the H_2 industry accelerated exponentially. To keep up with the frenetic pace of industry growth, the originally envisioned database would have had to evolve too quickly to be established and maintained as a mere TCP Task. In the meantime, IEA launched its Global Hydrogen Review series, which reports annually on H_2 technology.

Develop knowledge of how to model hydrogen in the value chain and improve current methods: as reported in RSER (Blanco et al. 2022), we classified H_2 models based on 29 studies. 9 model archetypes were identified, each with associated challenges. The Task considered potential solutions to those challenges and suggested future work. There is a need for international collaboration among countries with a high proportion of VRE. Engagement with commercially successful leading modelling firms is paramount.

Collaboration with analysts in IEA HQ Analytics and the ETSAP community: final report for this sub-task is available here. Suggested future work includes modelling the impact of inherited CO_2 emissions along the paths from production to end products.

Review reports from IEA

Task 41

Analysis and Modelling of Hydrogen Technologies

Deliverables

- **June 2022:** Herib Blanco, Jonathan Leaver, Paul E. Dodds, Robert Dickinson, Diego García-Gusano, Diego Iribarren, Arne Lind, Changlong Wang, Janis Danebergs, Martin Baumann, "*A taxonomy of models for investigating hydrogen energy systems*", **Renewable and Sustainable Energy Reviews**, 167 (2022) 112698 https://doi.org/10.1016/j.rser.2022.112698
- **August 2022:** Lead authors: Paul Dodds, Daniel Scamman, Kari Espegren; with Markus Blesl, Jan Duerinck, Patrícia Fortes, Hiroshi Hamasaki, Antti Lehttila, Shivika Mittal, Kannan Ramachandran), Eva Rosenberg, "*Final Report for the Project: Modelling of hydrogen*", https://iea-etsap.org/index.php/etsap-projects

Key messages

- ✓ Modelling H_2 is complex because no single archetype covers all the features and applications of H_2.
- ✓ Soft-linking or modelling suites can overcome this challenge.
- ✓ The Task developed a comprehensive reference energy system (RES) for hydrogen in ETSAP models.
- ✓ Best-practice guidelines for representing H_2 in energy system models, focusing on TIMES, were developed.
- ✓ In general, H_2 modelling applications are new relative to legacy applications. Some developers are progressing well, including TIMES / ETSAP and Energy Exemplar's PLEXOS.
- ✓ No existing models adequately deal with electricity markets in regions with very high VRE proportions. Hence further work in this area is highly recommended.
- ✓ Extending this work to model the flow of inherited CO_2-e emissions would lead to a productive collaboration with certification scheme development.

Task 42

Underground Hydrogen Storage

Main goals

I. Solve R& D challenges which establish the technical, economic, and societal viability of underground hydrogen storage
II. Prepare for responsible demonstration and upscaling.
III. Covering porous reservoirs, salt caverns, and lined-rock caverns.

While salt caverns are already being deployed for static storage of H_2, there is a need to test the technical feasibility of fast-cyclic and high-performance injection, production, and optimal management of dense clusters of them. The technical viability of UHS in porous reservoirs is relatively less established, and still under more fundamental scientific and technological investigations.

Task structure

H_2 Conversion & Contamination: how H_2 interacts with the rock matrix, fluids and micro-organisms. Microbial and geochemical processes may lead to H_2 conversion and impact the safety, efficiency, quality and recoverability of UHS.
Storage Integrity: will determine the safety and efficiency of the storage projects (e.g., recoverability) and impacts on nearby subsurface activities and resources. Subsurface processes and properties determine integrity, sealing capacity, and geomechanical behaviour to (fast) cyclic H_2 injection and production.

Storage performance: determining and improving the performance of storage operations as well as the criteria and methods to select, rank and validate potential storage sites.
Surface facilities & wells: safety and performance of a storage site strongly depend on a proper well design and materials that withstand the impacts of H_2. Engineering and safe design of top-side facilities and wells.
Economics & system integration: evaluate and determine drivers, boundary conditions, pathways for system integration and general economic parameters for demonstration and development of UHS.
Planning, regulation, safety & society: compile and share recommendations, guidelines, best practices and decision support info with policymakers, regulators, operators, NGOs…. Address public participation and educational events.

Task 42

Underground Hydrogen Storage

Activities in 2022

- TRL Assessment Report for IEA, July
- 3 events co-organized: first UHS Summer School (11-14 July, with TU Delft), in-person Task Workshop (17-18 Nov, with Clean Hydrogen Partnership), and UHS Workshop Perth (2 Dec, WITH Curtin Univ)
- Presented at 4 events: UHS Workshop/Webinar (10 Feb, US DOE), Living on H_2 (4 May, Norce), EHEC2022 (20 May, AeH2), GeoHydrogen (23 Nov, BGR)
- 12 online Task meetings/workshops
- First Task Report: Technology Monitor for UHS (*expected to be out in March 2023*), with recommended actions for industry, research organizations and other stakeholders for a safe and responsible demonstration and implementation of UHS.

Key messages

- ✓ **Increase technological confidence in UHS based on lab and pilot tests**: there is insufficient information and experience from real subsurface H_2 injection and extraction activities to reliably predict and monitor the H_2 behaviour and impacts in porous reservoirs.
- ✓ **Develop a market for UHS:** there is often a lack of reliable information on cost aspects, revenues and the long-term economic viability to justify the high investments associated with the development of UHS projects.
- ✓ **Risk assessment and uncertainty reduction:** there is a lack of basic information and models to support an integrated assessment and quantification of risks.
- ✓ **Increase Societal Embeddedness Factors**: support governments, stakeholders and public in defining the framework and criteria for establishing a social license to operate.

Task 43

Hydrogen Safety and RCS of large-scale hydrogen energy applications

Main goals

I. Large-scale compressed and liquid H_2 energy systems and applications.
II. Horizontal safety & regulatory attributes of large-scale H_2 energy systems and applications.
III. Developing uniform methodologies via case studies, available PNR, results' synthesis and analysis.
IV. Practical recommendations and solutions for industry and standardization and regulatory bodies:
    a. Inform relevant international and national RCS development activities.
    b. Help the H_2 industry with market deployment and establishment of best practices.
V. Development of joint products, peer-reviewed publications, educational and training materials, conference papers, white papers, reports, new work item proposals for standard development, etc.

Task structure

Subtask A: social comprehensive risk.

Subtask B: safety culture & Management system.

Subtask C: to harmonize consequence models, harm criteria, assumptions, and QRA database.

Subtask D: various standard requirements posing harmonization challenges for hazardous areas classification.

Subtask E: data for future analysis for industry recommendations to improve hydrogen system safety.

Subtask F: Inform RCS; ISO, IEC, CEN/ CLC, Global SDOs, global government bodies, IMO, ICAO, Rail. Inform industry; Hydrogen council, EIGA/CGA, Ammonia/LOHC stakeholders, others.

Hydrogen TCP

HYCHICO Hydrogen Council

Task 43

Hydrogen Safety and RCS of large-scale hydrogen energy applications

Activities

- 1st in-person meeting in Buxton, UK, HSE, October 17-21, 2022.
- **Next in-person meeting:** February 27 – March 3, 2023 at NREL, USA
- Develop joint papers for peer-reviewed journals (like IJHE) and relevant conferences (like ICHS)
- Develop recommendations to RCS, ISO, IEC, CEN / CLC, Global SDOs, Global government bodies, IMO, ICAO, Rail
- Develop recommendations to Industry: Hydrogen Council, EIGA / CGA, Ammonia / LOHC stakeholders, and others.

Key messages

- ✓ The first IEA Hydrogen TCP Task on Hydrogen Safety was launched in Oct 2004. The focus being on enriching the knowledge and closing gaps on H_2 properties and risk analysis.
- ✓ There has been a significant change of pace of RES-based clean energy technologies that have significant H_2 content changes the narrative around safety. Global regulatory bodies have set aggressive targets to reduce pollution and carbon footprint to protect international environment.
- ✓ Common topics to be addressed as hydrogen energy applications deploy at large-scale include compressed and liquid H_2 systems, safety culture and management system, uniform methodologies for safety distances and hazardous areas classification, large scale electrolysis and confined environment.

Task 44

Energy storage and conversión based on hydrogen

Main goals

This Task aims to identify and provide analysis on the development of Hydrogen production from Nuclear Energy. This Task will serve as a platform and framework for sharing and contributing information one the different possibilities of Hydrogen production from Nuclear Energy by:
- Identifying the on-going and planned activities in this subject
- Providing a holistic analysis of the situation, context and constraints to identify all conditions to fulfill for this technology to be deployed.

Task structure

Subtask 1: State of the art / Data and Knowledge Acquisition
Subtask 2: Process of hydrogen production systems from nuclear energy
Subtask 3 : Hydrogen production for high value products and services
Subtask 4: Business case model analysis & scenarios
Subtask 5: Recommendations, stakeholder engagement, communication & dissemination
Subtask 6: Task management and coordination

Tasks' Participants Responsibilities

- Each Task will specify its requirements to join, scope of work and activities to be carried out on its Work Plan

- In general terms:
  - Attend to Task Meetings
  - Provide knowledge and research capacity
  - Keep national/company Executive Committee (ExCo) representative informed
  - Comply to the specific requirements detailed in the Participation Letter

- Participation is in-kind and it is estimated to be ≈ 0,1 person/annum

- For information on how to join a Task, visit the Procedures Manual available here

Why should you join a Task?

- ✓ **Join** a network of international experts
- ✓ **Participate** on cutting-edge hydrogen R,D&D
- ✓ **Visit** facilities and laboratories from other Task participants
- ✓ **Set the ground** for joint demonstration projects
- ✓ **Contribute** to defining the state-of-the-art for hydrogen technologies

Collaboration

Joint activities with entities within the IEA Network and external

Collaboration within the IEA Network

Some examples of our collaboration within the IEA Network

Hydrogen TCP ieaghg IEA-AMF

Building blocks for e-fuel production Workshop

PROVISIONAL AGENDA

13:00 - 15:00 CET | MONDAY 27TH MARCH 2023 | ONLINE (TEAMS)

This workshop will provide some insights into the avalability of e-fuel building blocks
Organised by IEA AMF (Task 64), IEAGHG, and IEA Hydrogen TCP

13:00 CHECK-IN AND WELCOME

Zoe Stadler, Task Manager for Task 64 on E-fuels and end use perspectives, IEA AMF TCP

Abdul'Aziz Aliyu, Technology Analyst HICC, IEAGHG

Marina Holgado, Technical Secretariat Coordinator, IEA Hydrogen TCP

13:10 HYDROGEN PRODUCTION, STORAGE AND TRANSPORT FOR E-FUEL PRODUCTION

Dr. Marcel Weeda, Hydrogen TCP Vicechair, The Netherlands

Senior consultant at TN, program manager H2 at the TKI New Gas, member of Dutch National H2 Program's sounding board, and part of IPHE's H2 production analysis Taskforce.

13:25 COST OF CO2 + TECHNICAL SPECIFICATIONS AND COST FOR ITS TRANSPORT

TBD

More Workshops being planned:

- H2 + CCUS with IEAGHG
- Electrolysis with Advanced Fuel Cells TCP
- Hydrogen combustion in ICEs and turbines with Advanced Combustion TCP

13:40 POWER-TO-METHANE PLANT IN AUSTRIA

Dr. Emanuele Moioli, R&D engineer, Hitachi-Zosen Inova, Switzerland

Chemical engineer with years of experience in the research and development of energy storage and power-to-gas.

13:55 E-FUEL PROJECT DEVELOPMENT – ACCELERATING THE TRANSITION TO RENEWABLE AVIATION

Karl Hauptmeier, Managing Director, Norsk e-Fuel, Norway

MSc. in Energy and Process Engineering. Previously he was Senior Product Manager of Sunfire, worked with the International Energy Agency and for McKinsey & Company.

14:10 MODERATED DISCUSSION ON REMARKS

14:50 CONSOLIDATION OF THE KEY MESSAGES, SUMMARY AND CLOSING REMARKS

Technology Collaboration Programme
by iea

Peer reviewers for IEA strategic reports on hydrogen:

Hydrogen TCP

TRL Assessment on H_2 technologies

STRATEGIC ACTIVITY

Background

IEA is updating its Clean Energy Technology Guide (CETG). TRL Assessment is critical, IEA wants to contrast estimated TRL values, description of technologies and current projects, with experts worldwide to be able to achieve the most accurate result. They have asked the Hydrogen TCP for advice/help regarding their **TRL assessment activities in new emerging H_2 technologies**. Hydrogen TCP has proposed to **transform this IEA-TCP's collaboration into a strategic activity.**

Objectives (general)

- ✓ Strengthen our collaboration with IEA
- ✓ Strengthen our collaboration with synergic TCPs
- ✓ Position the Hydrogen TCP as a reference for technical knowledge

Analysis

Hydrogen TCP Technical Secretariat has analyzed IEA's CETG hydrogen-related technologies (94): **30 TRL GROUPS have been identified**.

TRL Assessment 1st Phase

40+ technologies assessed

30+ experts mobilized

Next steps

Collaboration

IEA International Energy Agency

ieaghg

IEA Bioenergy Technology Collaboration Programme

COMBUSTION TCP

Hydrogen TCP

Tasks in definition

Open Tasks

TRL Assessment on H_2 technologies
STRATEGIC ACTIVITY

Our Goal…

- ✓ Produce **Hydrogen TCP-centered initiatives/outputs**
- ✓ Strategic activity, **constant and updatable**
- ✓ Several tasks are involved, and produce relevant inputs for the TRL Assessment strategic activity
- ✓ Own database for hydrogen technologies which feeds IEAs CTEG publication periodically
- ✓ New Tasks are launched within the TRL Assessment framework

Main conclusions:

- We should develop this activity to the maximum quality and coverage of technologies possible, focusing not only on providing the required info by the IEA but also on creating TCP's products (Technology Briefs).
- The Work would be done in three main phases:
  Phase 0: identifying missing technologies and completing the list, identifying experts (from TCP network and external collaborators), defining the methodology (Q1 2023)
  Phase 1: gathering info and providing results to the IEA (Q2 2023)
  Phase 2: creating TCP results, Technology Briefs (from Q3 2023 onwards)

Collaboration with other organizations

Some examples of our collaboration with other organizations

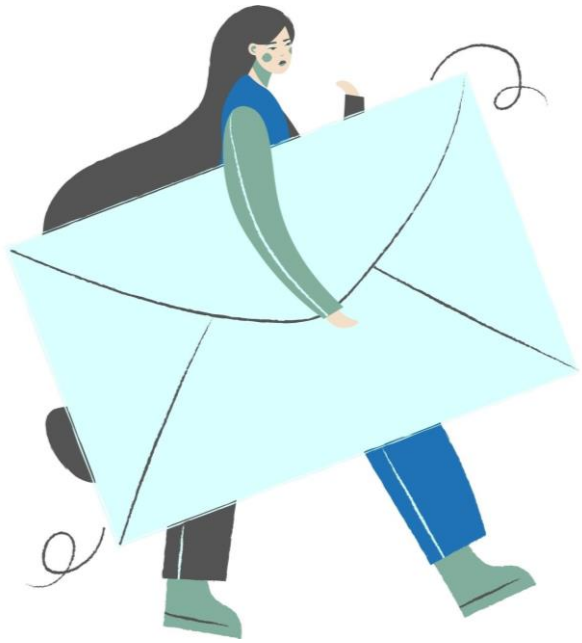
Hydrogen TCP Awards of Excellence
STRATEGIC ACTIVITY

- ✓ To recognize excellence in international collaboration in research, development, and application of H_2 technologies.
- ✓ To leverage innovation in H_2 technologies and applications.
- ✓ To promote and increase the outreach for winning and finalist projects.
- ✓ Public/private energy companies, start-ups, universities, and research institutions can participate

2022 Topic: "Integrating electrolysis with wind, solar and/or nuclear energy"
Winner: project nuGen™ Zero Emissions Haulage Solution

This project not only succeeded in integrating electrolysis with solar energy but also in demonstrating full integration of the hydrogen value chain from production to final use.
Set at Anglo American Mogalakwena Platinum mine in South Africa, it is a fully integrated, end-to-end green hydrogen system, consisting of hydrogen production (demonstrating solar PV plant (340kW) and 3.5MW electrolyser), refuelling station and haulage system (2MW hybrid fuel cell-battery truck).
Natascha Viljoen, CEO of Anglo American Platinum and Jan Klawitter, Head of International Policy for Anglo American received the Award. Engie and Bright Minds partnered in this project.
"This project is a symbol of what is possible when we work together collaboratively. One truck will take the equivalent emissions to 1000 cars on the road. Anglo American has currently 400 trucks in use and the ambition to retrofit them to use hydrogen" – Natascha Viljoen, CEO of Anglo American Platinum.

Thank You!



For more information, contact the Technical Secretariat:

Marina Holgado, ARIEMA

Marina.Holgado@ieahydrogen.org