Final report

1. Project details

Project title	IEA Hydrogen TCP 2019-2020
File no.	64018-0075
Name of the funding scheme	EUDP (marts 2018)
Project managing company / institution	DGC
CVR number (central business register)	12105045
Project partners	DGC
Submission date	25 March 2021

2. Summary

IEA Hydrogen TCP

The aim of the project is to participate in the Hydrogen TCP, to stimulate hydrogen R&D activities in Denmark and to co-ordinate Danish and international scientific work on hydrogen and related subjects. At the end of 2020 IEA Hydrogen TCP had 31 members from countries, international organisations, and industrial sponsors. The increase in memberships is expected to continue in 2021.

DGC's tasks and work in the IEA Hydrogen TCP includes:

- Participation in IEA Hydrogen TCP Executive Committee
- Facilitate Danish participation from Industry and Academia in IEA Hydrogen tasks (Working groups)
- Communication and outreach on IEA Hydrogen activities and task results via web, papers, workshops, and conferences

Furthermore, to coordinate the Danish Hydrogen TCP participation with the Danish Energy Agency, who is the formal Danish representative in the Hydrogen TCP.

2019-2020: Main activities and results

Hydrogen and Power to Gas has been at the very top of Energy agenda during the last 2 years and both IEA and other international organisations, nations and leading energy companies have pointed out Hydrogen as a key component in the CO_2 neutral energy system.

IEA Hydrogen TCP has during this period collaborated intense with IEA analyst's on hydrogen and validation of IEA publications (The future of hydrogen, 2019; Energy outlook, 2020), been in the International Hydrogen Coordination Group (Irina, IEA, Hydrogen Council, IPHE, CEM, Hydrogen TCP, Advanced Fuel Cell TCP) and supported the IEA program: Today in the Lab – Tomorrow in Energy.

The Hydrogen TCP has during the last 2 years been through a major modernisation to serve as the perfect tool for international collaboration in boosting hydrogen technologies globally. This modernisation is based on the three pillars: new strategic work plan with ambitious goals, a new leadership team and a new technical secretariat.

During 2019-2020 three tasks are finalized, two new tasks are approved, and one is extended. Several tasks are in the definition phase or in preparation. Most tasks have Danish participation.

Dansk sammenfatning

IEA Hydrogen TCP

Målet med projektet er at deltage i Hydrogen TCP, stimulere brint FUD-aktiviteter i Danmark og koordinere dansk og internationalt videnskabeligt arbejde om brintrelaterede emner. Ved udgangen af 2020 havde IEA Hydrogen TCP 31 medlemmer fra lande, internationale organisationer og industrielle sponsorer. Yderlige medlemskaber forventes i 2021.

DGC's opgaver og arbejde i IEA Hydrogen TCP inkluderer:

- Deltagelse i IEA Hydrogen TCP Executive Committee
- Fremme dansk deltagelse fra Industri og universiteter i IEA-brintopgaver (arbejdsgrupper)
- Kommunikation om resultater og aktiviteter i IEA Hydrogen TCP

Desuden at koordinere den danske TCP-deltagelse med Energistyrelsen, som er den formelle danske repræsentant i Hydrogen TCP.

2019-2020: Aktiviteter og resultater

Brint og Power-to-Gas har været øverst på energidagsordenen i de sidste 2 år, og både IEA og andre internationale organisationer, nationer og førende energiselskaber har udpeget brint som en nøglekomponent i det CO2-neutrale energisystem.

IEA Hydrogen TCP har i denne periode samarbejdet intenst med IEA-analytikere om brint og validering af IEA-publikationer (The future of hydrogen, 2019; Energy outlook, 2020), deltaget i International Hydrogen Coordination Group (Irina, IEA, Hydrogen Council, IPHE, CEM, Hydrogen TCP, Advanced Fuel Cell TCP) og bidraget til IEA-programmet: Today in the Lab - Tomorrow in Energy.

Hydrogen TCP har gennem de sidste 2 år været igennem en større modernisering for at være forberedt til de mange opgaver og det voksende internationale samarbejde om at styrke brintteknologier globalt. Denne modernisering er baseret på tre søjler: Ny strategisk arbejdsplan med ambitiøse mål, et nyt lederteam og et nyt teknisk sekretariat.

I løbet af 2019-2020 er tre tasks (samarbejdsprojekter) afsluttet, to nye tasks er igangsat og en er udvidet og forlænget. Flere nye tasks er i definitionsfasen eller under forberedelse.

Der er forsat god dansk deltagelse i taskarbejdet.

3. Project objectives

The main objectives (for DGC) have been an active Danish participation in the relevant HIA tasks, contact to the IEA Hydrogen Secretariat and information Dissemination and outreach.

Most of the DGC resources have been spend on:

- Regular contact to the TCP secretariat
- Preparation in Executive Committee meetings
- Ensure progress in the task work.
- Recruitment of new Danish task members (new tasks and ongoing tasks)
- Represent TCP at relevant workshops and conferences.
- Hydrogen TCP involvement in the IEA activities relevant for Hydrogen
- Create a new and up-dated IEA Hydrogen TCP Strategic plan 2020-25
- DGC newsletters on IEA Hydrogen and project reports to the Danish Energy Agency and the Danish Gas Companies

DGC has during the last 2 years – as past chairman for the Hydrogen TCP – been serious involved in the major modernisation of the TCP: Member of the leadership group, who made the call for tender for a new TCP secretariat and later in the selection process. Member for Task for web site modernisation and member of task for implementation of the new strategic plan 2020-25.

The work on hydrogen energy technology has been developed by the following ongoing Hydrogen TCP tasks during 2019 – 2020:

- Task 37 – Hydrogen Safety (successor to Task 31)
- Task 38 – Power-to-Hydrogen and Hydrogen-to-X (finalized end of 2020)
- Task 39 – Hydrogen in Marine Transport
- Task 40 – Energy Storage and Conversion (successor to Task 32)
- Task 41 – Analysis & Modeling (In collaboration with IEA Analytics and the IEA ETSAP community)

Furthermore, the following new tasks are in the definition phase:

- Hydrogen Production in Wind Farms
- Renewable Hydrogen Production
- Underground Hydrogen Storage
- Hydrogen Applications in the Mining, Resources and Mineral Processing Sectors
- Hydrogen Export Value Chains
- Hydrogen from Nuclear Energy

There is Danish participation in all ongoing tasks.

4. Project implementation

WP1: ExCo. Main activities

- Preparation of End and Term Report and Strategic Plan 2020-2025, Discussions with IEA / CERT
- ExCo meeting Roterua, February 2019 (2 days)
- ExCo web meeting, December 2019 (2 days)
- ExCo meeting Paris, February 2020 (2 days)
- ExCo web meeting, October 2020 (3 days)
- ExCo web meeting, December 2020 (3 days)
- TCP Modernization Plan
- Planning of ExCo meeting in Copenhagen spring 2020 (the meeting was postponed due to COVID19)
- Tender and evaluation of tenders for a new secretariat, March-May 2020 (committee with current and former ExCo chairmen, including Jan K Jensen)
- Election of chairman and vice-chairmen
- New TCP web site (and logo), November 2020

Cooperation. Internal IEA meetings

- IEA Hydrogen Workshop (February 2019) (Chair and GM
- TCP Universal Meeting June 2019 (Chair and GM)
- 4 REWP Meetings
- 2 CERT Meetings
- In early 2019, the Chairman was seconded part-time to the IEA for several months to advise on preparation of the IEA Hydrogen Report

Cooperation. External meetings

- WHTC in Japan: Previewing the Strategic Plan June 2019 (delivered by VC Ohira)
- Atlantic Council - 13th Gas & Oil TCP Meeting - presentation (GM)
- Workshop on H2 with CCS - November 2019 (Organizer; 3 presentations by Chair, GM
- Webinar Security and Sustainability webinar at George Washington University, GM
- AREDAY presentation (GM) - August 2019 - “The Hydrogen Space”
- Planet Philadelphia - radio interview (GM)
- Hydrogen and Nuclear (Chair)
- Viennese Chamber of Commerce (January 2020)
- Frequent meetings in the Hydrogen Coordination Group during 2020

WP2: Task work

- Final reporting task 32 “Materials for hydrogen-based energy storage”
- Completion of Task 38 “Power to X - X to applications”, including several workshops during the projekt
- Completion of Task 39. Maritime – closing seminar has been postponed to 2021 due to COVID-19.
- Task 41 Analysis & Modeling (Approved). Purpose: to improve the data base of hydrogen technologies. The project will also contribute to the review of the IEA's analyzes and technology logistics. Task 41 collaborates with ETSAP TCP.
- New task: Renewable hydrogen production (water and biomass). Task Definition Conference has been postponed due to COVID-19)
- New task proposal: Hydrogen Export Supply Chains: Task Definition Workshop early 2021
- New task proposal: Hydrogen Applications in Mining. First Task Definition Workshop in 2020
- New task proposal: Hydrogen Underground Storage. Task Definition Workshop early 2021

WP3: Communication. Primarily via:

- https://www.ieahydrogen.org/ (Hydrogen TCP website)
- https://www.dgc.dk/ (DGC website)

Development of the project

The project's three WPs are all ongoing activities, which is why there are no delays in relation to the WP work.

The COVID-19 situation has postponed the planned ExCo meeting in Copenhagen in the spring of 2020. Likewise, two End-of-task workshops are postponed due to COVID-19 situation.

Project results

Results during the period 2019-2020:

Results of the ExCo collaboration (WP1)

- Strategic Plan 2020-2025: https://www.ieahydrogen.org/vision-and-targets-2/
- Strengthened cooperation with IEA / CERT
- New Secretariat: http://www.ariema.com/en/hydrogen
- New presidency
- Growth in IEA Hydrogen members. As 2020 closed, there were 31 IEA Hydrogen TCP Members. Canada, a founding member of the IEA Hydrogen Implementing Agreement, re-joined the TCP in 2019 as a Contracting Party. Portugal has joined the TCP and USA is in process and expected to re-join the TCP early 2021.
  Singapore and Thailand participated as observers in the 80th ExCo Meeting February 2019 in Rotorua and South Africa participated as an observer in the 82nd ExCo Meeting February 2020 in Paris,

Results of the task collaboration (WP2)

- Task 32: The final report on hydrogen storage
  The final report covers the development of hydrogen storage in materials, including electrochemical and thermal storage systems in the last 6 years. A status is given for different storage methods as well as the current development status and future prospects.
  The second part of the final report contains a two-page status for each of the approx. 30 sub-projects included in task 32.
  A special task results report: "Materials for hydrogen-based energy storage - past, recent progress and future outlook" is published in a special issue of the Journal of Alloys and Compounds.
  There is DK participation in task 32.

- Task 36 Life Cycle Sustainability Assessment of Hydrogen Energy Systems: Technology Brief: http://ieahydrogen.org/pdfs/Task-36-Brief.aspx

- Task 38 Power to X - X to applications. The final report is published at the TCP website end of 2020 and a number of results have been published in international journals:
  Review and analysis of demonstration projects on power-to-X pathways in the world, International Journal of Hydrogen Energy
  Incentives and legal barriers for power-to-hydrogen pathways: An international snapshot, International Journal of Hydrogen Energy
  There is DK participation in task 38.

Results regarding. communication, includes:

- Annual Reports
- Task Reports
- Newsletters and Press Releases

All publications can be downloaded at: https://www.ieahydrogen.org/publications/

A new TCP initiative is **The Hydrogen Safety Journal** is published by the Hydrogen TCP and it covers the latest developments in this specialized field. Under the leadership of Dr. Y. (John) Khalil, Editor-in-Chief, this peer-reviewed Hydrogen Safety Journal seeks submissions on topics of interest to hydrogen safety.

Frank Markert, Associate professor at the Technical University of Denmark, is member of the Hydrogen Safety Journal Editorial Board.

5. Utilisation of project results

The Danish energy systems are facing large changes and challengers during the conversion from fossil fuels to an energy system based on renewable energy.

The Danish participation I IEA Hydrogen TCP offers a great opportunity for being at the forefront at the hydrogen energy research, which may be an advance, because hydrogen is one of tools for the implementation of the national energy policy.

Danish companies and researchers participate in the execution of the IEA Hydrogen Tasks, which offers an excellent opportunity for international collaboration, creation of project consortia's and exchange of scientific results.

Main Danish interests are: Conversion of electricity to hydrogen (electrolysis, Power to Gas issues, energy storage, Integration of energy systems); roll out of hydrogen infra-structure; hydrogen re-fuelling stations and hydrogen vehicles and hydrogen regulatory conditions (legal and safety).

6. Project conclusion and perspective

During the last 2 years there has been an increasing global interest for hydrogen as an enabler for a carbon free energy system – and an increasing interest and number of members in the IEA Hydrogen TCP.

Hydrogen is being internationally recognized as one of the main pillars for a future clean energy system, as it will play a key role in meeting long-term climate change mitigation and renewable energy goals set by countries all over the world. As an energy vector capable of storing large quantities of energy for long periods it is the perfect match for intermittent renewable power.

Its wide range of applications makes hydrogen the solution to efficiently decarbonize not only the electricity production but also energy-intensive sectors such as transport, industry, and buildings, being the perfect tool for sectors coupling, as it enables flexible dispatching of energy across sectors.

The expert task participation, indicating the importers of the Hydrogen TCP work and the great opportunity offered for international collaboration on the challengers on the future energy systems. More than 200 hydrogen experts participate in the HIA tasks making the IEA Hydrogen TCP to a unique platform for hydrogen knowledge. This has been discovered by the IEA HQ in Paris and a close corporation between the IEA and the Hydrogen TCP has been ongoing during the last two years.

During the last 2 years Danish experts form i-NANO, DTU, Ballard-Europe, Energinet and DGC has been active in the Tasks of the Hydrogen TCP.

The Hydrogen core business on Hydrogen production, Hydrogen storage, Hydrogen infrastructure systems and hydrogen safety are all issues of great importance for the future energy systems, why they also are the main issues in the actual Strategic Plan (2020-2025).

The Strategic plan 2020-2025 also includes a topic on Hydrogen end use and a more commercial orientation of the task word can be observed. PtX technology, Hydrogen safety issues and standardisation, Large scale storage of hydrogen, Distribution of hydrogen in natural gas networks and industrial use of Hydrogen in industry are all examples of break through of hydrogen technologies, which will also be subjects for task collaborations in the Hydrogen TCP.

7. Appendices

Strategic Plan 2020-2025: https://www.ieahydrogen.org/vision-and-targets-2/

END-OF-TERM REPORT 2015-2020: https://www.ieahydrogen.org/vision-and-targets-2/

Today in the Lab - Tomorrow in Energy (DK/TCP input (HyBalance project), July 2020: https://www.iea.org/articles/carbon-free-hydrogen-from-low-cost-wind-power-stored-for-use-on-demand

IEA Hydrogen End of task reports: https://www.ieahydrogen.org/tasks-reports/

- Task 38: IEA Power-to-Hydrogen and Hydrogen-to-X: System Analysis of the techno-economic, legal, and regulatory conditions
- Task 36: Renewable hydrogen production
- Task 35: Life cycle sustainability assessment of hydrogen energy systems

Annual reports: https://www.ieahydrogen.org/annual-reports/

- Annual report 2018
- Annual report 2019
- 2020 member update table

Newsletters and Press Releases from Hydrogen TCP:

https://www.ieahydrogen.org/newslleter-and-press-releases/

DGC nyheder:

Oktober 2020 https://www.dgc.dk/nyhed/2020/world-energy-outlook-2020

Juni 2020: https://www.dgc.dk/nyhed/2020/nyt-fra-iea-hydrogen-0

Maj 2020 https://www.dgc.dk/nyhed/2020/nyt-fra-iea-hydrogen

Maj 2019 https://www.dgc.dk/nyhed/2019/g20-topmoede-har-fokus-paa-brint

April 2019 https://www.dgc.dk/nyhed/2019/nyt-fra-iea-hydrogen

November 2018 https://www.dgc.dk/nyhed/2019/nyt-fra-iea-hydrogen

Posters på DBBD, november 2019

Furthermore, there is a large number of scientific articles and conference presentations from the task members on task findings and results