Task 44:
Hydrogen from Nuclear Energy

Task Manager: Gilles Rodriguez (CEA – France)

Version 2022/12/01
Version to be reviewed by the ExCo in Dec. 2022.

Hydrogen TCP

Table of contents

Background and rationale

The Energy world is changing and is fast moving towards an uncertain new Energy paradigm which is not based on Massive Crude Oil and coal Consumption: we need to pave the way towards the decarbonization of all energies and industrial process according to the net zero objective in 2050.

In this global energy trade, we are in a particular transition phase where i) we cannot exactly forecast what will be the future energy scenarios, ii) we cannot trust to the old patterns, and we need to investigate all scenarios including multiple scenarios and combined ones., and iii) the transition to net zero emissions is a very tough challenge, therefore we have to investigate all solutions, fitting general or specific (local) needs .

In this coming decarbonized society, the future energy model could be preferentially centered on two primary energy vectors: Electricity and Heat. But the challenge of a decarbonized society is not focused only on energy producers, it must also concern all energy end-users: industrial hubs, heavy industries, transportation...

In this context, Hydrogen is appealed to get a promising future as energy vector in storage, energy regulator, and as based chemical product to decarbonize the society (fabrication of synthetic fuel or ammonia for instance). And Nuclear energy could provide a key position in this energy mix because it has the potentiality to supply all the future energy needs in particular due to its high energy density.

Thus, the future of nuclear energy cannot be only identified as a massive electricity supplier. Its portfolio shall significantly increase and must include for the future several energetic services, including hydrogen production, synthetic fuels and valuable chemical products (ammonia, urea…).

Beyond the need for decarbonization, we can today add in this worldwide context the increasingly and urgent need for energy security (diversification of energy sources), the need for countries to regain energy sovereignty (the 2022 gas crisis in Europe is the most significant example), plus new industrial and economical challenges like technology leadership, high skill jobs, energy network and distribution, ...

The principle of using nuclear energy to produce hydrogen is not recent. It has been the subject for instance of several past IEA H_2 TCP Tasks. Last one was in 2011. But the IEA H_2 TCP Board recently raised the necessity to get a new task on that subject because the context and the transition to a net zero world has considerably changed the deal. Nuclear energy has to be taken into account as a massive energy supply, and we need to re-evaluate its potentialities using its electricity production and/or coupling its heat source to processes to produce massively hydrogen. The technico-economic situation has also changed and conclusions provided in the past Task has to be reconsidered under new energy paradigm, new global and environmental context, and new constraints too

(regulation, green hydrogen,…). Therefore this sum of uncertainties oblige all International organisations to investigate new paths, define challenges, make new assumptions… The role of this task will be to help and advice decision makers and at the same time to get a role as aggregator of information and facilitator to reduce the time to market for some relevant solutions.

Task Description

This Task aims to identify and provide analysis on the development of Hydrogen production from Nuclear Energy. The acronym HYNE (Hydrogen from Nuclear Energy) will be used for the continuation of this document and during the Task organization.

This acronym is important because we will really considering Hydrogen coming from any Nuclear Energy systems (GENIII & GENIV systems) and nuclear energy production (electricity, heat, hybride solutions). The often seen definition as "Nuclear hydrogen" is too abusive, leading to large misunderstanding and not reflecting the exact objectives of this Task.

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 an holistic analysis of the situation, context and constraints to identify all conditions to fulfill for this technology to be deployed.

We intend to serve this Task with an agile management approach. We will largely prefer to provide short note analyses that could be quickly integrated by decision-maker[1]. We aim to provide non-partisan position and fair analysis because this Task is not defined to promote Nuclear Energy but to identify in what situation and according to which conditions, nuclear energy could be one of the solutions to the massive production of hydrogen.

Objectives

The objectives targeted to this Task are multiple and listed below:

- Carry out technical and economic analysis and survey on the key points to develop a competitive hydrogen production from nuclear energy in different contexts.

[1] *In opposition to large file deliverables, where everything is in but nobody has the time to read them completely.*

  - Identify barriers and hurdles from of a rapid progress of hydrogen from nuclear energy systems.
  - Identify R&D needs, demonstrations and recent progresses.
  - Provide global analysis on the implementation of a nuclear system in a regional energy ecosystem (including the nuclear reactor, the hydrogen production process, storage, transport, and distribution as well as its final utilization, especially for heat and/or hydrogen consuming industries).

- Deliver general guidelines and recommendations to both business developers and policymakers:
  - Comprehensive analysis, tools, guidelines to inform and facilitate decisions processes (investment decisions, policy measures…) and to propose also recommendations to allow current and future hydrogen deployment coming from nuclear energy.
  - Enhance HYNE deployment on energy markets and the development of international trade.
  - Develop nuclear energy for hydrogen production as a key energy carrier for a sustainable and smart energy system.
  - The collected data and results would enable this task force to deliver advices to policy makers, industrials, licensing authorities and investors in IEA member states as to which nuclear systems are best suited (i.e., affordable, efficient, reliable, resilient, timeline for deployment) for meeting specific policy goals; how much these options would cost, and how much economic benefit they would produce (from short to long term vision).

The objectives of this Task is:

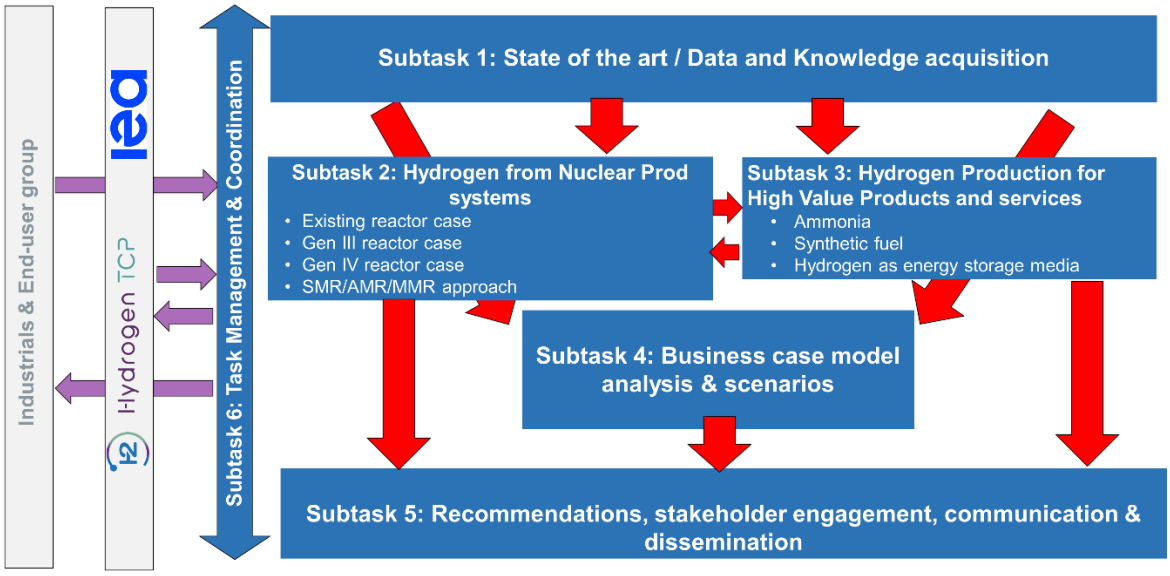
- Being an integration of HYNE studies carried out worldwide.
- Being a well-balance Task between:
  - on one side: the Nuclear development, Hydrogen process production, and all coupling aspects.
  - on the other side: The techniques / The economy / The market approach / The socio-economial impact.
- Being a recognized Task of experts able to:
  - Assess scenarios with a fair analysis[2],
  - Advice IEA in all scenarios for a future decarbonized society,
  - Provide key data and recommendations to accelerate the time to market,
  - Provide regular and sharp notes rather than one unique large file document at the end of the three year-time,
  - Being efficient with a regular work, well balanced among all partners.
- All experts opinion will be taken into consideration, and all specific aspects (local, geographical, social) will be investigated.

[2] : *This task is not the place to promote nuclear energy above all. It is a Task where we have to analyse in which conditions the hydrogen coming from nuclear energy can find its right place.*

Structure

The following statements are not definitive. They will be confirmed and/or completed after the Task Force discussions during the Kick-Off meeting.

The Definition of Task structure is including six subtasks. The interaction between all the Subtask is described in the following figure representing by the red and violet arrows.



Short description of the activities within each work area.

- **Subtask 1**: State of the art / Data and Knowledge Acquisition

We intend to organize this subtask as a shared community platform where recent progress and relevant achievements will be shared regularly among all Task members. We will focus on the two following items:

- Identification of existing achievement and real case R&D progress,
- Definition of the level of feasibilty, and approach of the scaling up analysis.

This subtask is the way to follow online and regularly the worldwide initiative on Hydrogen from Nuclear Energy. It is also a social media that keeps the link with all Members between meetings.

- **Subtask 2**: Process of hydrogen production systems from nuclear energy.

In this Subtask we intend to provide an updated portfolio of all the existing and in development processes of hydrogen from nuclear energy systems. We intend to provide a fair analysis of all listed solutions by identifying the maturity level (TRL / IRL / MRL[3]) and keeping in mind the review of the existing legal frameworks. The following family of nuclear reactors will be investigated:

[3] *TRL = Technological Readiness Level / IRL = integration Readiness Level / MRL = Manufacturing Readiness Level.*

- Existing and past reactor cases
- Gen III type nuclear reactor
- Gen IV type nuclear reactor
- SMR / AMR / MMR specific approach

In all these families we will identify their respective challenges and technological breakthrough. If relevant, a technico-economical analysis will be provided in connection with the Subtask 4.

➢ **Subtask 3 :** Hydrogen production for high value products and services

In numerous cases the hydrogen molecule could be considered as a media to produce other services or other high value molecules. This Subtask is considering all these solutions where hydrogen could be including or part of the transformation chain of other chemical products. We will mainly consider:

- Ammonia production
- Synthetic fuels
- Hydrogen as energy storage media (in close interaction with the dedicated IEA/ H_2 Task)
- … (open to new solutions that could be submitted to the Task member experts).

➢ **Subtask 4**: Business case model analysis & scenarios.

This Subtask will focus on the technico economical approach of several HYNE scenarios. We will particularly identify in these scenarios if there is a specific geographical or political context influencing the proposed solutions.

Within this Task we intend to organize joint expert review of some relevant technical studies already provided by other international oreganizations (such as OECD/NEA).

➢ **Subtask 5**: Recommendations, stakeholder engagement, communication & dissemination.

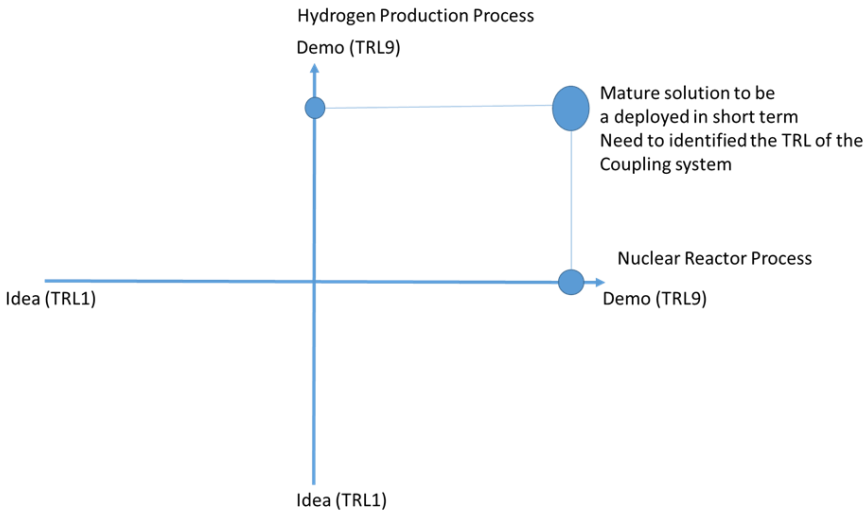
This Subtask is dedicated to all the communications aspects of the analysis and results provided be this Task. It is also the way provide the unique interface and network between this Task and the other organizations (IAEA, OECD, IEA / H_2 TCP other Tasks,…). This Task will develop a dissemination plan of the Task recommendations to relevant intergovernmental organizations. It will work with all subtasks to ensure their knowledge dissemanition and key messages and recommendations. It is in close interaction with Subtask 6 (Task management and coordination).

➢ **Subtask 6**: Task management and coordination.

The management and coordination of this Task is a cross-cutting activity in interaction with all other Subtasks. We have a strong willing to provide an agile approach of this Task management by the following (but not exhaustive) actions:

- A large preference is given to short reactive notes and position papers than large documents. We will focus on producing impact documents, touching and being read by a maximum of key persons.

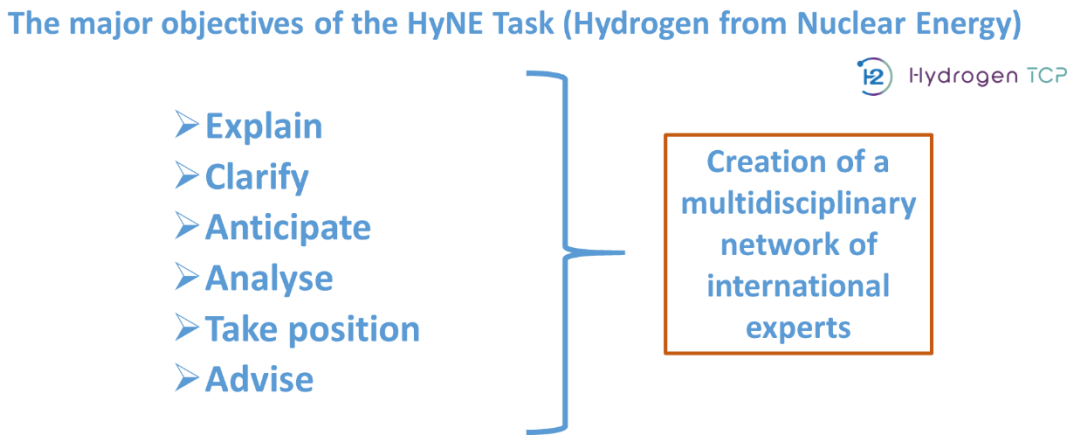
- We will regularly identify key questions that we will try to provide an expert position quickly. These key questions could be for instance: analysis of a real case (hairbour, industrial hub), a new Technico-Economical study, a recent document produced by an international organisation, an expert question[4]…
- We will develop agility in all the management approach by using shared platforms for an efficient management and communication circulation within all members.
- We will try to incorporate end-users participations in all of our meetings. The objective is to avoid forgetting our final target and to incorporate in any of our analysis the end-users' point of view.
- We will use share tools to evaluate the process (TRL / IRL / MRL), not only technico-economic analysis but also enlarge to socio economical tools (such as PESTEL analysis[5]) and a particular attention to the visual approach of our results (i.e. use of mind graphs, use of simple cartography).



- If necessary and required we will adapt and adjust our management processes to any unexpected initiative or specific expertise coming from an international organization (question, expertise, peer review,…).
- A well balanced organization between in person and virtual meetings to perform Task progress with a permanent willing to limit the CO_2 impacts of members travelling.
- This Task is starting with some initial members but we will welcome other candidates during all the Task duration. This Task must be identified as the core of a large network, not as a restricted club !

[4] : *For instance Question raised in meeting n°3 (April 2022) : Where the finance is going to come, where the market is going to go? Is it a push or a pull market we envision in the coming years? Other question raised at the same meeting : How going from small scale testing to large-scale application?*

[5] *A PESTEL analysis is an acronym for a tool used to identify the macro (external) forces facing an organisation. The letters stand for Political, Economic, Social, Technological, Environmental and Legal.*



Subtask 5 and 6 will be animated by the Task Manager.
Leadership of Subtasks 1 to 4 remains to be determined. Some have been identified for Subtask 4 and 2.

Participants

Confirmed /active participants

Note : This information will be updated after the Workplan approval and Kick Off meeting. It shall be regularly updated according to participants joining this Task with time.

The following parties have show and confirmed their interest in joining the Task.

Organization	Country
Tractebel Inc. (https://tractebel-engie.fr/fr)	Belgium
Ministère de l'Economie et de l'Industrie de Belgique	Belgium
Electronuclear (https://www.eletronuclear.gov.br)	Brazil
Meije Development (https://meijedevelopment.eu/)	European Community
Nuclear Europe (https://www.nuclearеurope.eu/)	European Community
CEA – French Atomic Commission (https://www.cea.fr/)	France
John Cockerill (https://johncockerill.com/fr/)	France
Institut de Radioprotection et de Sûreté Nucléaire (https://www.irsn.fr)	France
CNRS-ICARE (Centre National de la Recherche Scientifique) (https://icare.cnrs.fr/)	France
FRAMATOME (https://www.framatome.com/fr/	France
Electricité de France (EDF) (https://www.edf.fr/)	France
Ecole de Science Politique (https://www.sciencespo.fr)	France
Walter Tosto SpA (https://www.waltertosto.it/en)	Italy

Indonesian LPG Association	Indonesia
Japan Atomic Energy Agency (https://www.jaea.go.jp/english/)	Japan
Directoraat General Klimaat & Energie	Nederlands
TECNATOM (https://www.tecnatom.es/en/)	Spain
Monaco Engineering Solutions (MES) (http://www.mes-international.com/)	United Kingdom
UK National Nuclear Laboratory (https://www.nnl.co.uk/)	United Kingdom
Abbott Risk Consulting Ltd. (https://www.consultarc.com/)	United Kingdom
Clean Air Task Force (https://www.catf.us/fr/)	USA

The detailed list of all participants will be provided after the Task Kick Off meeting. Today it is based on the recording of the registration done on the IEA / H2 TCP website open from May to October 2022.

Potentially Interested parties

The following parties have shown interests in joining the Task by participating in preliminary Task definition meetings (three meetings in March/April 2022), dedicated workshops (IAEA/IEA joint workshop in June 2022) or contacting the Task Manager. We are either still awaiting responses (confirmation, registration on the IEA/H_2 TCP website) from these partners.

Organization	Country
NRC	Canada
HYDROGEN EUROPE RESEARCH	European Community
SFEN	France
SETEC	France
ENGIE	France
CRIEPI	Japan
KAERI	ROK
IJS	Slovenia
UCLM	Spain
Alcazar	Spain
FNC	UK
UK NNL	UK
BEIS	UK
NIRO	UK
PNNL	USA
INL	USA
DOE	USA

Networks

The following partnerships, associations and networks are linked to the HYNE Task initiative. They represent members/organizations who will be connected in the HYNE Task because they have common or complementary expertise in this field. These entities will be engaged for collaboration or joint MoU when the HYNE Task will start.

Organization
OECD/NEA – Division of Nuclear Technology Development and Economics
IAEA – Non-electric applications Division
GENIV International Forum - Non-electric application of Nucleat Heat Task Force - Hydrogen Progen Project Management Board (in the VHTR System Steering Committee)
IEA / Hydrogen TCP Tasks: - Task 40: Energy storage and conversión base don hydrogen - Task 41: Analysis and Modelling o Hydrogen Technologies. - Task 43: Safety and RCS of Large Scale Hydrogen Energy Applications.

Timeline

Timeline of planned task meeting and general events and activities are described in the following Table. It can be subject to modification according to the feedback of the Task Kick Off meeting. If so, the HYNE Task WorkPlan will be revised regularly.

Date	Milestone/Action/Event	Document/Deliverable	Actions
March 29th, April 14th & 20th, 2022	Virtual meetings dedicated to a large audience for a first contact with potential future Task participation		
May 16th & 17th 2022	Presentation to the 89th ExCO meeting of the progress of the HYNE Task definition		
7th December 2022	HYNE Task pre-Kick Off meeting	Meeting minutes	Complete / Revised and validate the HYNE draft workplan. Confirm members participation and involvement in subtasks
15th December 2022	ExCo review & approval of HYNE Task Workplan	HYNE Workplan	Validate the HYNE Workplan or adjuste it according the ExCo comments
March 2023	Task implementation & Kick Off meeting.	Meeting minutes + Completion of the HYNE Worplan Rev1	Tentatively done in person or hybrid in France
June 2023	Implementation of the Task Shared platform		Create the shared platform to all HYNE Task members
June 2023	ExCo approval workplan update	HYNE Worplan Revised	
October 2023	1st HYNE Task general meeting and Technology review workshop (Automn meeting)		

March/April 2024	2nd HYNE Task general meeting and Subtasks action review (Spring meeting)	Provide a detailed analysis of the HYNE Task progress	
Oct/Nov 2024	3rd HYNE Task general meeting and Subtasks action review	Task briefing to the ExCO meeting (December 2024)	
March/April 2025	4th HYNE Task general meeting and Subtasks action review (Spring meeting)	Provide a detailed analysis of the HYNE Task progress and start the discussion on the Task potential continuation (lessons learned, progress and gaps).	
Oct/Nov 2025	5th and last HYNE Task general meeting and Subtasks action review	Task briefing to the ExCO meeting (December 2025)	Setup of final Task report. + general workshop of the Task main achievements, conclusions , recommendation and continuation.

Color legend : Light Grey = Action done / Light violet = Action to do

This table is only presenting some general milestones and timeline and they are not represented all meetings carried out by the corresponding Subtasks in person and in virtual modes.

A more detailed list of the Task deliverables will be produced after the Task Kick-off meeting and implemented in the revised version of the HYNE Workplan.