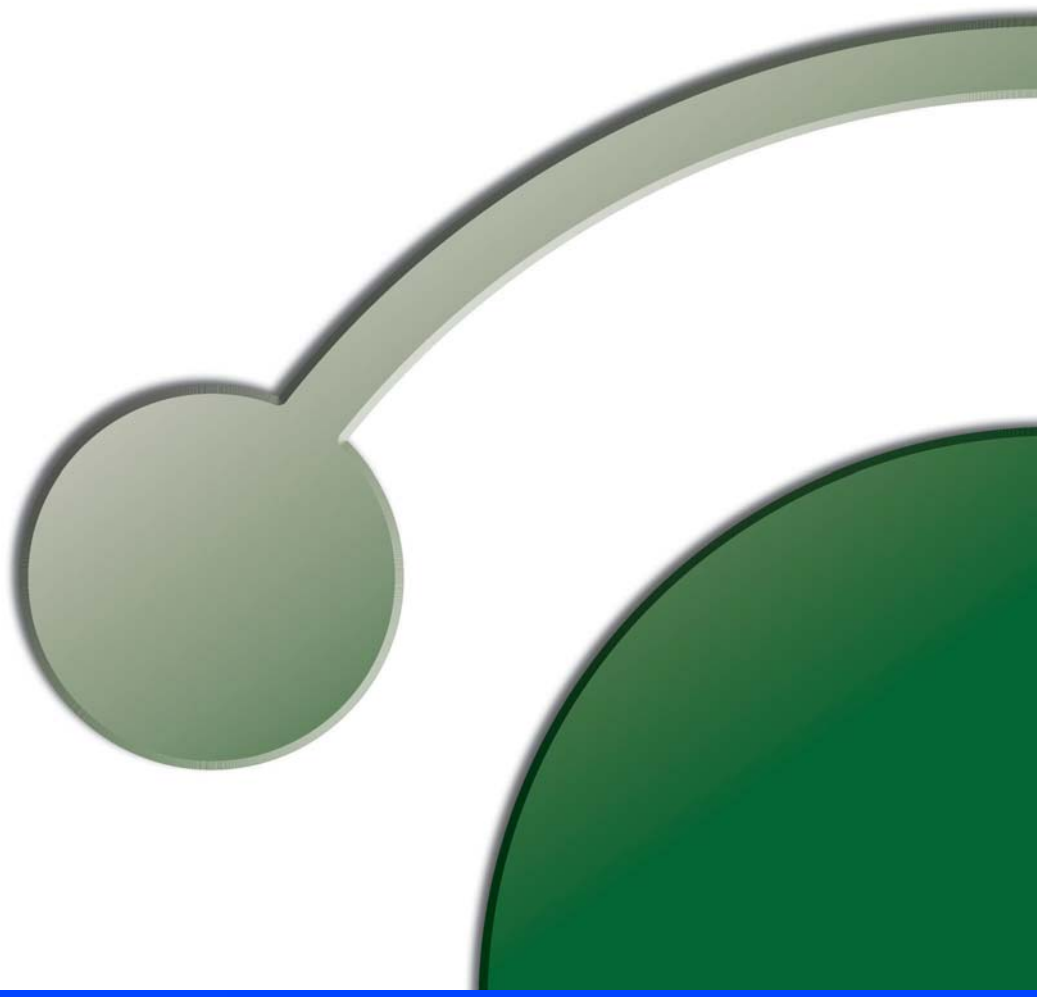
HYDROGEN TECHNOLOGY COLLABORATION PROGRAMME

STRATEGIC PLAN | 2020-2025



MARCH 2020

Technology Collaboration Programme
by IEA

IEA Hydrogen TCP 2020–2025 Strategic Plan

The *IEA Hydrogen Technology Collaboration Programme (TCP) 2020–2025 Strategic Work Plan* presents the strategic framework and work programme proposed for the coming five-year term. This 2020–2025 Strategic Work Plan was developed with the full participation and approval of the Hydrogen TCP Executive Committee. Since its creation in October 1977, the Hydrogen TCP has initiated and managed a comprehensive range of over 40 R,D&D and analysis tasks (with several tasks currently in definition), as well as a rich assortment of information dissemination and outreach activities. The Hydrogen TCP will also update its own internal management procedures in line with the IEA modernization initiative. The proposed work programme directly reflects our mission and vision, which aim to advance hydrogen science and technology, accelerating its diffusion at scale. The Hydrogen TCP is growing – it now numbers 31 Members, including Contracting Party UNIDO, and several Sponsors—among them, the Hydrogen Council. The Hydrogen TCP enjoys robust industry participation, and the debut of the Hydrogen Council consolidates the impact of industry in the energy space. The Hydrogen TCP's membership ranks and research operations span the globe, opening doors to emerging economies.

The Hydrogen TCP looks forward to cooperating with pertinent IEA initiatives and becoming the hub for hydrogen-related activities in the IEA technology network. In the coming years, spurred by decarbonization and the integration of renewables, the Hydrogen TCP expects hydrogen to play roles of increasing importance as an enabler for a global smart-energy system and as a recognized pathway for climate change mitigation. Innovation driven Hydrogen TCP research will contribute to the global clean energy transition, optimizing integrated systems and adding value to the global energy supply chain.

Strategic Framework

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

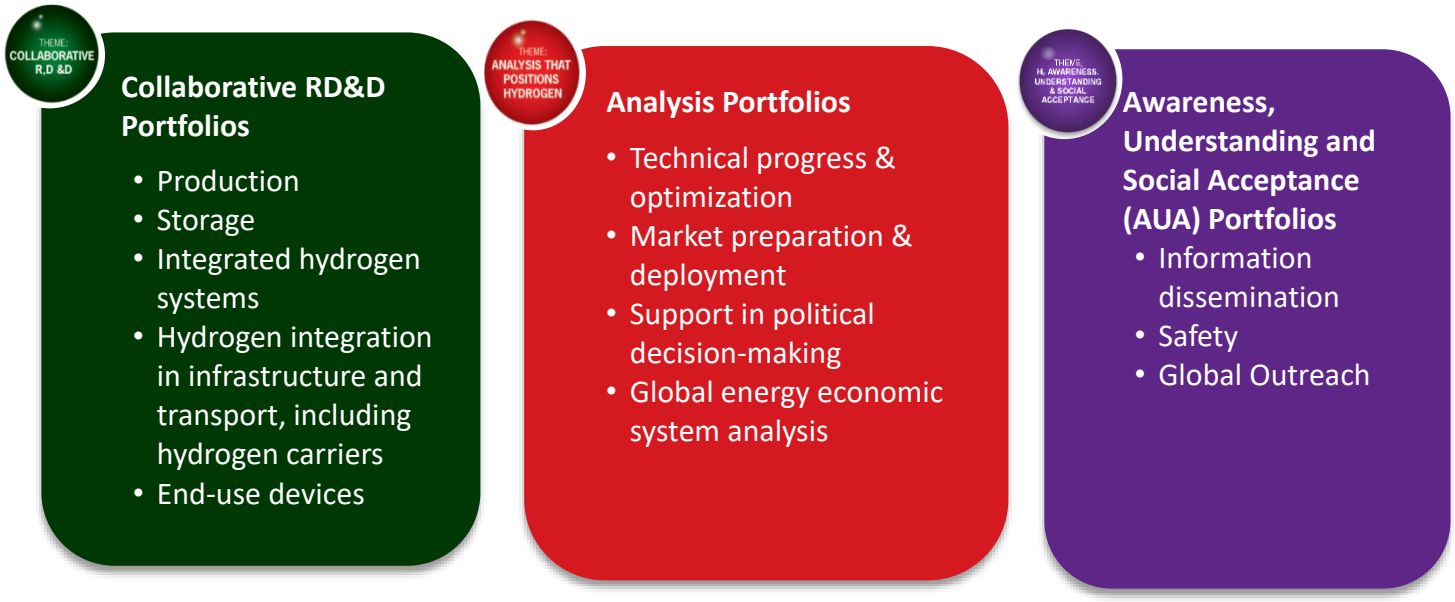
Mission
Accelerate hydrogen implementation and widespread utilization – for production, storage, distribution, power, mobility, heating and industry – to optimize environmental protection, improve energy security, transform global energy systems and grid management, and promote international economic development – while sustaining Hydrogen TCP as the premier global resource for hydrogen expertise.

Strategy
Facilitate, coordinate and maintain innovative research, development and demonstration activities as a hub for international cooperation and knowledge exchange.

Overarching Objectives that inform Strategic Plan for 2020-2025 Term

Special focus	**Place special focus on the role of hydrogen as a facilitator for a smart, sustainable energy system based on renewables**: hydrogen as an energy carrier; hydrogen as an energy storage medium; hydrogen as an intermediate for e-fuels and chemicals; hydrogen for smart cities.
Climate	**Elaborate the role of hydrogen in deep decarbonization and sustainability of the energy system** for transport, power, heating/cooling and industrial uses, highlighting hydrogen's importance in sector-coupling and energy storage, as well as infrastructure.
Core	**Sustain the focus on the Hydrogen TCP's core business of R,D&D cooperation** on production, storage, infrastructure, distribution, and safety—enlarging the spectrum of hydrogen applications.
Global analysis	**Consolidate reference database and global sector analysis**, maintaining a "living document" on technology development and learning experiences, including roadmaps and modeling results.
Outreach	**Communicate Hydrogen TCP knowledge and results, as well as hydrogen information from governments, industries and academe** to policy-makers, decision-makers, and the greater public.
Demand and trade	**Grow global demand for hydrogen and power to gas,** while paying special attention to high-growth economies and supporting development of a long-distance supply chain and hydrogen trade.
Hydrogen TCP role	**Position Hydrogen TCP as a hub for international collaboration on hydrogen R,D&D within the IEA Technology Network,** as well as in the greater energy community, while cooperating closely with the new IEA hydrogen initiative.
Hydrogen TCP capacity	**Enlarge Hydrogen TCP expert network and grow Hydrogen TCP membership**, thus enhancing resources and capabilities.

Themes and Portfolios – Organizing Principles for the Strategic Plan



Hydrogen TCP Relevance to Key Areas in IEA Mission & Alignment with IEA Medium-Term Strategy for Research and Technology, 2018—2022

Energy security – A versatile fuel and a flexible energy carrier complementary to electricity, hydrogen has a cross-cutting function that takes a whole system perspective, helping to ensure supply of clean energy while enhancing grid balance and management. Hydrogen TCP research and innovation directly supports the IEA's evolving mandate on mission critical energy security. Notably, our analysis focus on development of an H2 database and improved modeling approach is expected to inform IEA understanding of hydrogen's contribution to the global energy system.

Economic development – Hydrogen has significant economic development potential. It can be produced from diverse resources; stored to optimize not just the hydrogen value chain but the whole, integrated energy system; traded and delivered over vast distances; and used in all sectors for multiple applications (transport, power, heat, industry). The Hydrogen TCP is committed to scale-up and industrialization, and its comprehensive, collaborative approach to R,D&D and Analysis challenges is facilitating realization of hydrogen's impressive potential.

Environmental awareness and climate policies – Production (via use of renewables, nuclear energy and fossil with CCS) and use of hydrogen can reduce emissions, thereby improving air quality and mitigating climate change. The TCP's strategic framework and activities emphasize hydrogen's contribution to environmental protection and sustainability.

Engagement worldwide – The Hydrogen TCP is a global hydrogen hub with worldwide engagement that strengthens the entire IEA energy technology network. The Hydrogen TCP has had significant interaction with several IEA Associate countries, and some are expected to join the Hydrogen TCP in the near term. China is already a Hydrogen TCP member. Our first Indian and Latin American Sponsors recently joined, and our first Latin American Contracting Party is now in accession. UNIDO membership provides a bridge to developing economies. Industry participation at the task level is vigorous, and with the Hydrogen Council's accession, further growth is anticipated.

2020-2025 Work Programme with RD&D Theme and Priorities

Themes	Priorities	Current Approach (Tasks and Activities, Ongoing and in Definition)	Proposed/Potential Approach
THEME: COLLABORATIVE R,D &D i	**In general, support research and innovation that elaborates and promotes the role of hydrogen in a climate-sensitive energy transition and a future decarbonized and integrated energy system.**	• Carry out R&D tasks (Tasks 39 and 40). • Continue electrolysis and fuel cell system research.	• Contribute to realization of H2 projects and facilities (production, storage, delivery and HRS). • Expand electrolysis and fuel cell system research. • Construct roadmaps and pathways. • Cooperate with other TCPs. • Broaden external cooperation on low-carbon, renewable hydrogen. • Formulate messages from R,D&D activities for delivery to IEA and other decision-makers.
ii	**Specifically,** • **continue advanced research** on renewable electrolysis, photo-electrochemical water-splitting [PEC], solar thermochemical water-splitting [STCH]; • **expand research** on biological conversion of H2 for energy and chemicals and advanced hydrogen storage (solid, liquid, energy carriers); • **deepen research on development, deployment and delivery challenges** (including hydrogen energy carriers) related to hydrogen safety and infrastructure.	• Define successor to Task 35 (Renewable hydrogen production), including SolarPACES, PVPS, AFC, Energy Storage TCPs. • Define successor to Task 34 (Biological production and conversion of H2 for energy and chemicals). • Execute Task 40 (Energy storage and conversion based on hydrogen). • Carry out Task 37 (Hydrogen safety).	• Approve and carry out successor tasks. • Assess opportunities and barriers to development and deployment. • Investigate industrial research (e.g., for steel, chemicals) via use of hydrogen and hydrogen energy carriers. • Continue to expand infrastructure work.
iii	**Pursue opportunities for hydrogen as an integrator and a smart-grid facilitator, as well as an intermediate for electrofuel production and chemicals.**	• Continue investigation via Task 38 - Power to hydrogen; hydrogen to X.	• Cooperate with other TCPs and their activities: Wind, Bioenergy, ISGAN, AFC, and IETS TCPs. • Investigate use of H2 as a source of methane and electrofuel production. • Accelerate transport and stationary power fuel cell applications.
iv	**Explore P2H and P2X, examining the potential for storage of intermittent renewable generated power** in the natural gas grid for energy balancing.	• Valorize Task 38 - Power to hydrogen; hydrogen to X.	• Build on H21 North of England project and other Hydrogen Valleys on hydrogen in the gas grid, cooperating with fossil TCPs – GHG, GO. • Explore storage of RE power in grid for stability and energy balance. • Raise stakeholder attention on need for Power2X regulation.
v	**Investigate decarbonization of industrial production activities** (e.g., for iron, steel, chemicals) via use of hydrogen and hydrogen energy carriers**.**	• Continue laying groundwork for future activities.	• Scope inclusive and sustainable development worldwide, including developing countries and island/remote locations prone to climate change • Team with other TCPS, where possible, on reducing CO2 emissions in industrial electrification through use of hydrogen.

2020-2025 Work Programme with Analysis Theme and Priorities

Themes	Priorities	Current Approach (Tasks and Activities, Ongoing and in Definition)	Proposed/Potential Approach
 ii	**Develop a data validation and quality assurance process, a database and related analysis; facilitate use by IEA as well as Hydrogen TCP** to assure a common analytic foundation.	• Launch Subtask 41c with ESTAP. • Complete definition of Task 41 (Modeling and analysis).	• Deepen cooperation with IEA analysts on all aspects of modeling (temporal and spatial) and IEA use of our data. • Embed cooperation with IEA analysis through TCP analysis task(s) and techno-economic analysis. • Aim to incorporate database maintenance and modeling across supply chains (resources permitting) as Secretariat function. • Engage other TCPs.
iii	**Elaborate role of hydrogen scale–up in energy transition** as a facilitator for renewable and sustainable energy.	• Complete definition of market deployment and pathways to scale task.	• Elaborate pathway analysis and road-mapping; consolidate in Hydrogen TCP member states; include middle- and high-income developing countries. • Perform competitive analysis. • Investigate hydrogen carriers (e.g., LOHC, Methanol, Ammonia) using hydrogen as source.
iv	**Support commercialization of (renewable) hydrogen production, storage and end-use technologies, as well as infrastructure, through:** • **market analysis** that assesses hydrogen technology's maturity and state of the art, and identifies market barriers (i.e., technical, economic, legal); • **market conditioning** that formulates tools to foster market adoption and penetration.	• Continue Technology Readiness Level (TRL) assessment.	• Benchmark and profile technologies. • Perform LCSA of hydrogen systems. • Assess hydrogen for heat (buildings and/or industrial applications). • Assess hydrogen in gas infrastructure (value chain hydrogen from electrolysis and SMR+CCS) to grid and other end-use devices. • Valorize results of Task 38. • Apply Market Readiness Level (MRL) Assessment tool. • Formulate messages from analytic work for delivery to IEA and other decision-makers.
v	**Facilitate development of trade and export markets** through comprehensive supply chain analysis.	• Continue definition of hydrogen export value chains task.	• Analyze hydrogen in the mining, agriculture, and resources sectors. • Analyze hydrogen export value chains. • Explore role of financing.

2020-2025 Work Programme with Awareness, Understanding & Social Acceptance Theme and Priorities

Themes	Priorities	Current Approach (Tasks and Activities, Ongoing and in Definition)	Proposed/Potential Approach
 iii	**Maintain strong liaison with IEA in Paris.**	• Continue to participate in IEA meetings and workshops (WP, CERT, TCP Universal) and activities that concern H2, such as the IEA G20 Report; and, more broadly, the TCPS; foster cooperation with IEA analysis. • Participate in IEA initiatives, such as CEM.	• Contribute to IEA business model as hub for hydrogen at the Agency. • Cooperate with Action Plan for TCP Enhancement. • Cooperate with pertinent IEA initiatives.
iv	**Support and facilitate formulation of regulations, codes and standards, particularly in safety matters.**	• Continue to support current R,C,S efforts in Task 37 (Safety) and Task 39 (Maritime).	• Include R,C,S support in new tasks as appropriate. • Expand cooperation, teaming with relevant organizations.
v	**Investigate development, deployment and delivery challenges and risks pertinent to hydrogen safety and infrastructure.**	• Continue to focus on issues such as tunnels in Task 37. • Incorporate/incubate infrastructure topics.	• Include all sectors in safety analyses; grow current aviation and maritime sector interest. • Expand *Hydrogen Safety Journal.*
vi	**Increase resources by growing membership and collaborations.**	• Continue to recruit Members and Experts for our tasks and activities, and continue to innovate approaches to cooperation.	• Broaden external network, including IEA associate Members. • Link with thought leaders around the world.