FUTURO, INNOVACION Y ENERGIA EN UN MUNDO INCIERTO E IMPREDECIBLE

ESTRATEGIAS NACIONALES Y COOPERACIÓN INTERNACIONAL
PAPEL DE LA I+D Y L'INNOVACION

Paul Lucchese

IEA Hydrogen TCP Chair

2° Congreso Internacional de Hidrogeno

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H2 Hydrogen TCP

OUTLINE

1. WHY HYDROGEN AND WHY HYDROGEN NOW ?
2. SHORT ANALYSIS OF NATIONAL STRATEGIES: OBJECTIVES, ROAD MAP, ACTION PLAN AND FUNDING
3. WHY INTERNATIONAL COLLABORATION IS KEY ELEMENT FOR A NZE BY 2050
4. WHY R&D, INNOVATION ARE KEY TO A NZE BY 2050
5. IEA HYDROGEN TCP: A GLOBAL COLLABORATIONPLAT FORM FOR RESEARCH AND INNOVATION IN HYDROGEN TECHNOLOGIES
6. CONCLUSIONS: HOW TO DESIGN A NATIONAL STRATEGY TO KEEP IT FLEXIBLE AND INTEGRATED IN INTERNATIONAL FRAMEWORK

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Why a Hydrogen Momentum? Why now?

- Why Hydrogen ? Main drivers
  - Energy transition towards a Net Zero Carbon World: Hydrogen useful for Hard to abate sector Mobility, Industry
  - Hydrogen is easy to store in large amounts Role in renewable integration (to reach 100% Renewable mix)
  - Hydrogen is a very flexible carrier, the « Swiss Knife » of energy transition
  - Hydrogen is a tool to promote Energy Security, Increasing energy diversification and decreasing dependence on fossil fuels
  - Hydrogen contribute to air cleaning in cities
  - Hydrogen could be useful to existing assets
  - Hydrogen could contribute to economic growth, creation of jobs, inclusivnes, fairness and SDG

- Why NOW ?
  - GHG emissions are growing despite un precedented growth of Renewables, electrification limitsHard to Abate sectors
  - Dramatic decrease of Wind and PV electricity costs cf Portugal 15€/Mwh, 2 GW Abu Dhabi 11,2€/MWh >> H2 from renewables could be comptitive
  - Technologies (1st generation) are ready and mature (continuous progress since 25 years) example 1st passenger car on market in 2014
  - Increase of variable renewable share in some countries >>> needs for storage
  - Awareness of climate change
  - Awareness of « flexibility » of hydrogen as a « SWISS KNIFE » of Energy Transition
  - Mobility: decouple energy and power demand
  - **COVID Crisis: one solution to relaunch sustainable economy after economic crisis**
  - **Energy crisis and Ukraine war: energy security priority**

Brief History of Hydrogen and fuel cell (1/3)

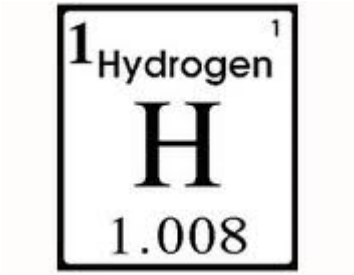
(Pre)-Historical Period

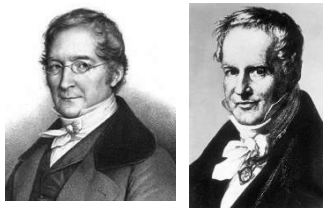
H Cavendish

1766

A-L Lavoisier

1781





1804

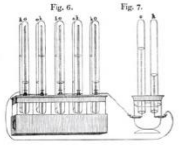
LJ Gay Lussac et A Von Humbolt

Hydrogen discovered in the 18th century

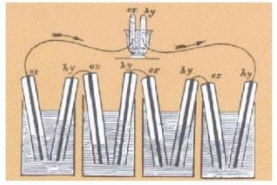
Fuel cells from 19th century

1838-1839
German Christian Schönbein
Fuel cell principle

1839-1942
UK William R. Grove built the first fuel cell

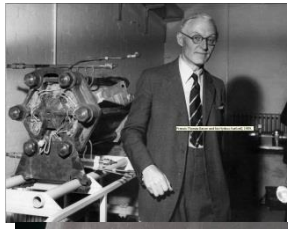


page 272 of the *Philosophical Magazine and Journal of Science*, **1843**, with William Grove's letter "On the Gas Voltaic Battery."



Philos. Mag., Ser. 3, **1839**, *14*, 127

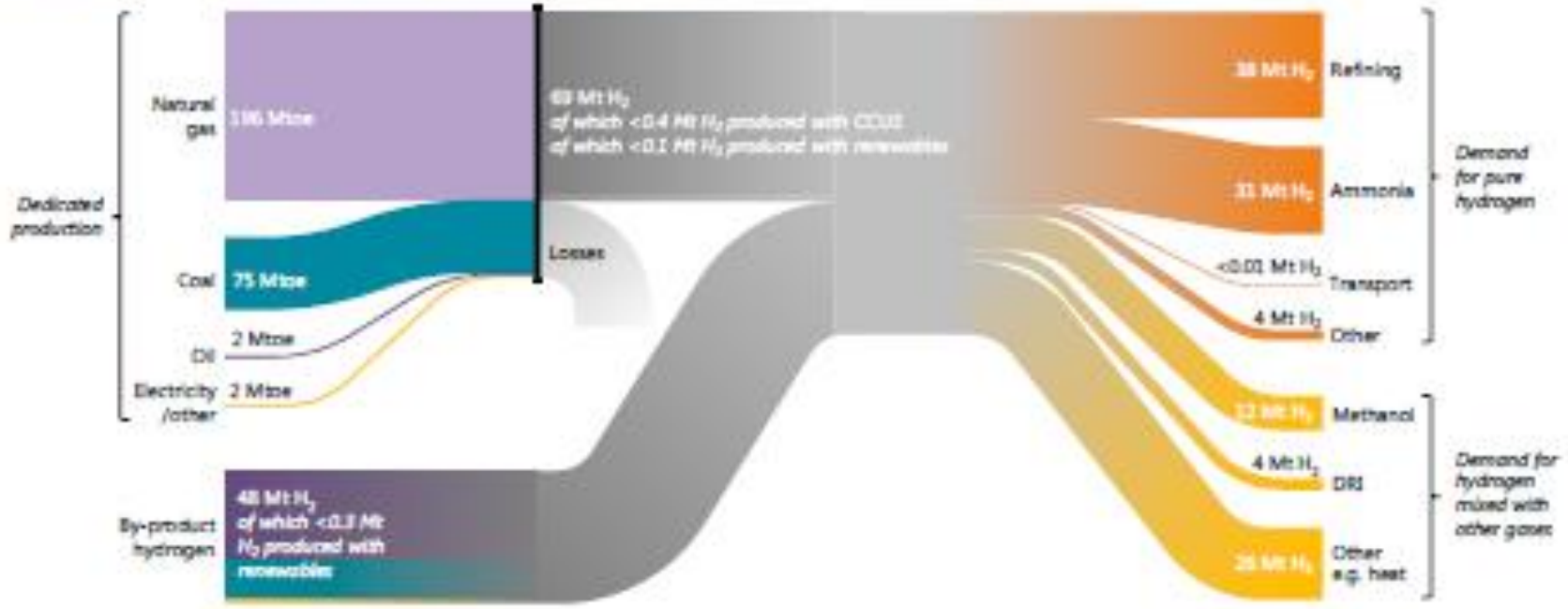
1939-1953
UK Francis T. Bacon built the first power fuel cell



1960
First application by Nasa (Gemini programme)

Hydrogen is massively produced and used in industry today

Figure 6. Today's hydrogen value chains

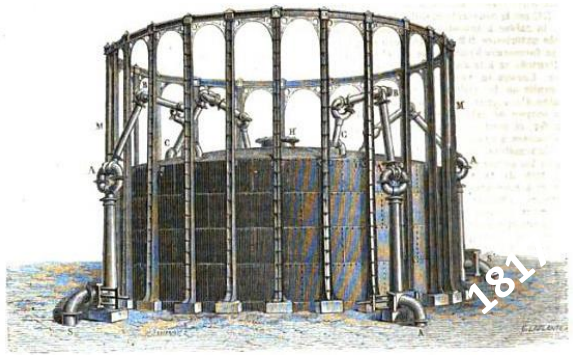


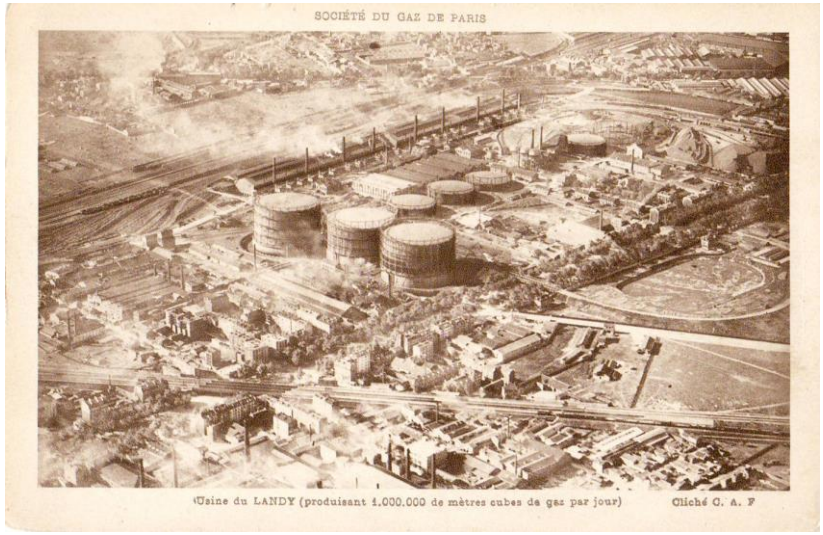
- Hydrogen Production 275 Mtoe, 2-3 % world energy consumption
- consumption:
  - 205 Bm3 Gaz nat (6%world consumption)
  - 107 Mt Coal (2% total)
  - 617 M m3 eau (1,3% world cons)
- If we switch to electrolysis:
  - 3600 TWhEurope production Europe)
- 1 Ton produces
  - 10 t CO2 from NG.
  - 12t CO2 from oil residues
  - 19t CO2 from coal

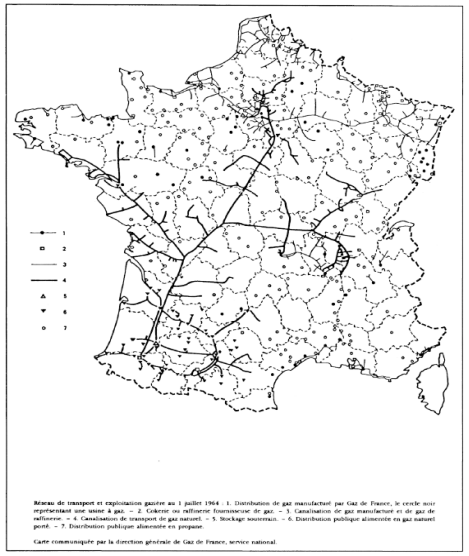
Source IEA, 2019
The future of Hydrogen, Webinar

Les positions exprimées dans cette présentation ni ne reflètent ni n'engagent celles de l IEA

HYDROGEN was used a lot from the XIX Century
Town gas from coal(50% Hydrogen)

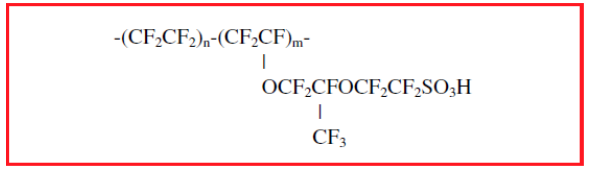






Brief History of Hydrogen and fuel cell (2/3)

- 1968 : Dupond Nemours Company invent Nafion membrane from Fundamental Research



- 1974-1980 First Oil Crisis a lot of effort on hydrogen and fuel cell; creation of IEA (OECD), then **creation of IEA Hydrogen TCP 1977**

- 1974 1976 « First Hydrogen Romantics » Pr Veziroglu &10 scientists created IAHE and First Whec Miami 1976

- 80's 90'S: Geoffrey Ballard Father of PEM Development (alone in the desert)

- 1995-2005: First Golden Age (and buble : **Fuel Cells Momentum**
  - Car makers announced Fuel cell cars on the market in 2005
  - Impressive R&D effort, both public and private
  - Unfortunately FC Cars are not ready
  - Decrease of hydrogen and FC communication, disappointment
  - 2003: G W Bush launched IPHE International Partnership on Hydrogen economy
  - 2005-2008 First NATO project « Science for Peace » on energy: hydrogen development in Morocco and Mauritania

BRIEF HISTORY OF HYDROGEN AND FUEL CELL (3/3)

Hydrogen and Fuel cell renewal(2010- 2018) &Hydrogen momentum (2018-2023)

1- In 2010 Technical feasibility for stationnary and mobility applications is proven

Industrial sector can envisage first generation technologies on the market

- First hydrogen car on the markets (from 2014) Hyundai, Toyota, Honda
- First Hydrogen infrastructure deployed in Germany, Japan Korea, California France UK with private public partnership,
- China start to work massively on Hydrogen and fuel cells
- Semi massive deployment of residential applications in Japan (200 000 houses equipped)
- Fisrt niche markets: back up system, Forklifts…
- Davos January 2017: Creation of a big industrial alliance: Hydrogen Council (18 big industrial companies)

2- from 2010:Increasing share of Renewables in electricity mix: in some part of the world: how to integrate larger and larger quantities of renewables: New idea of <u>« Power To Gas »:</u>

3- 2015: energy game changer: low cost of Renewable electricity costs (PV and Wind) in some areas: Possibility to produce Hydrogen at competitive cost SWITCH FROM FUEL CELL BASED VISION TO HYDROGEN BASED VISION

4- **from 2018:** IEA launches studies on hydrogen then « The future of Hydrogen » 2019 for G20 summit in japan, first national strategies(2018-2020), acceleration with post covid recovery plan, Green Deal, post Ukraine war Repower EU, IRA etc

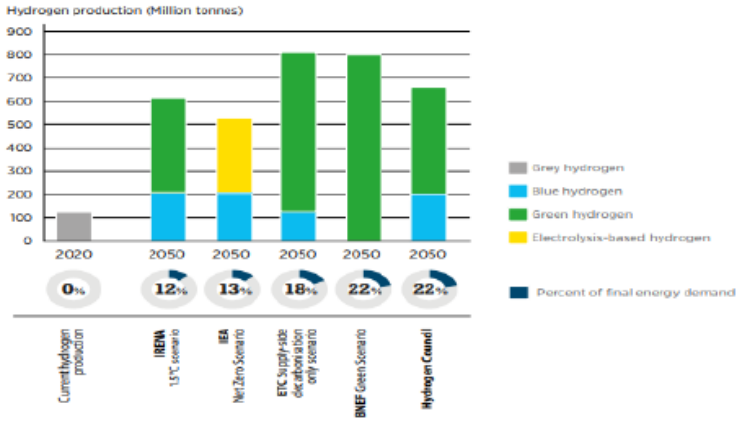
New paradigm: Smart energy system integrating electricity, gas and heat/cold network

Role of Hydrogen in a NZE Scenario in 2050

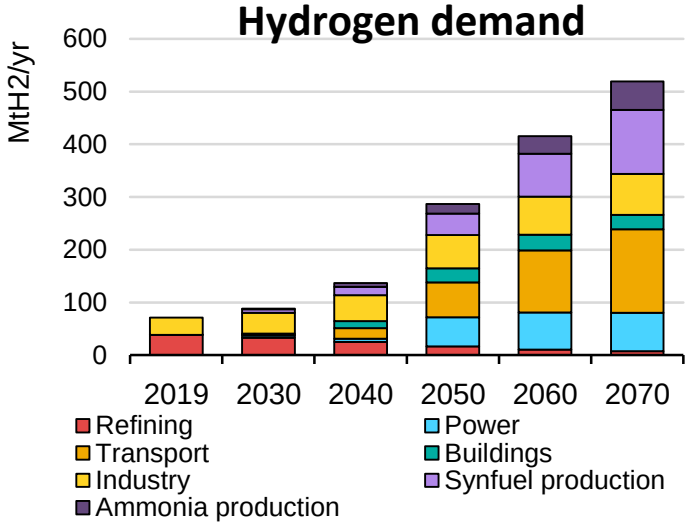
Challenge N°1: Impressive order of magnitude(GW and time)!!

Role of Hydrogen in energy scenarios:
Between 10 and 20 % in final energy consumption

- **Hydrogen in 2050 ou 2070**
  - 15 % final energy consumption
  - IEA:420 Millions tons (**x6 today's production**)
  - Electrolyser capacity 4000 GW (4 TW or **3,4 TW according to IEA)** full time equivalent
  - PV or wind park needed: between 12 and 30 TW
  - Nuclear needed: 5 TW



- **Hydrogen in 2030: objectives**
  - World 40 millions tons (equivalent 270 GW full time)
  - Europe: 40 GW ou 2x40 GW electrolysers 7 millions tonnes>>>
  - **RePower EU 10 mt + 10 Mt imported, + New objective Energy security: replacing 15-20 % NG from Russia**
  - France 6 GW 1 M tons >> 20-40 GW Wind PV or 6-8 GW nuclear

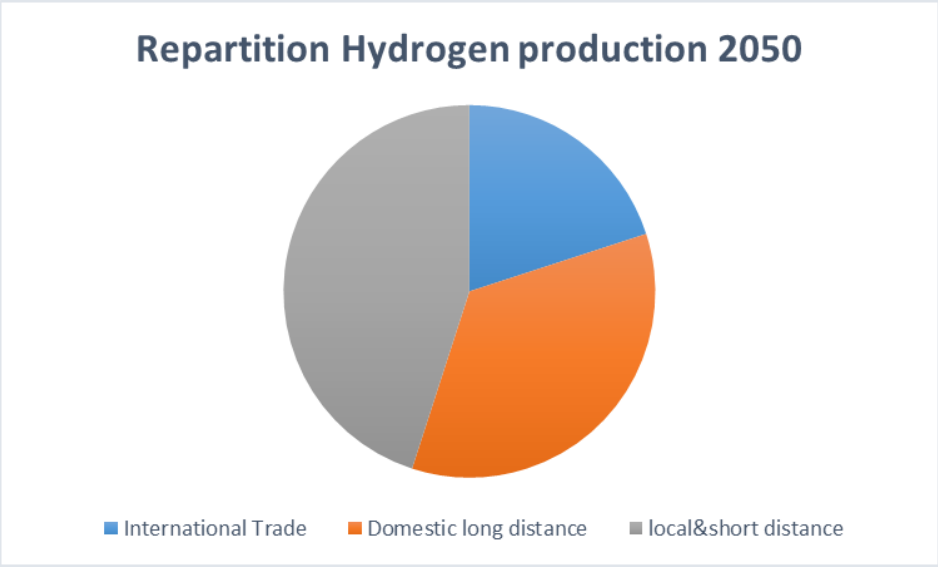


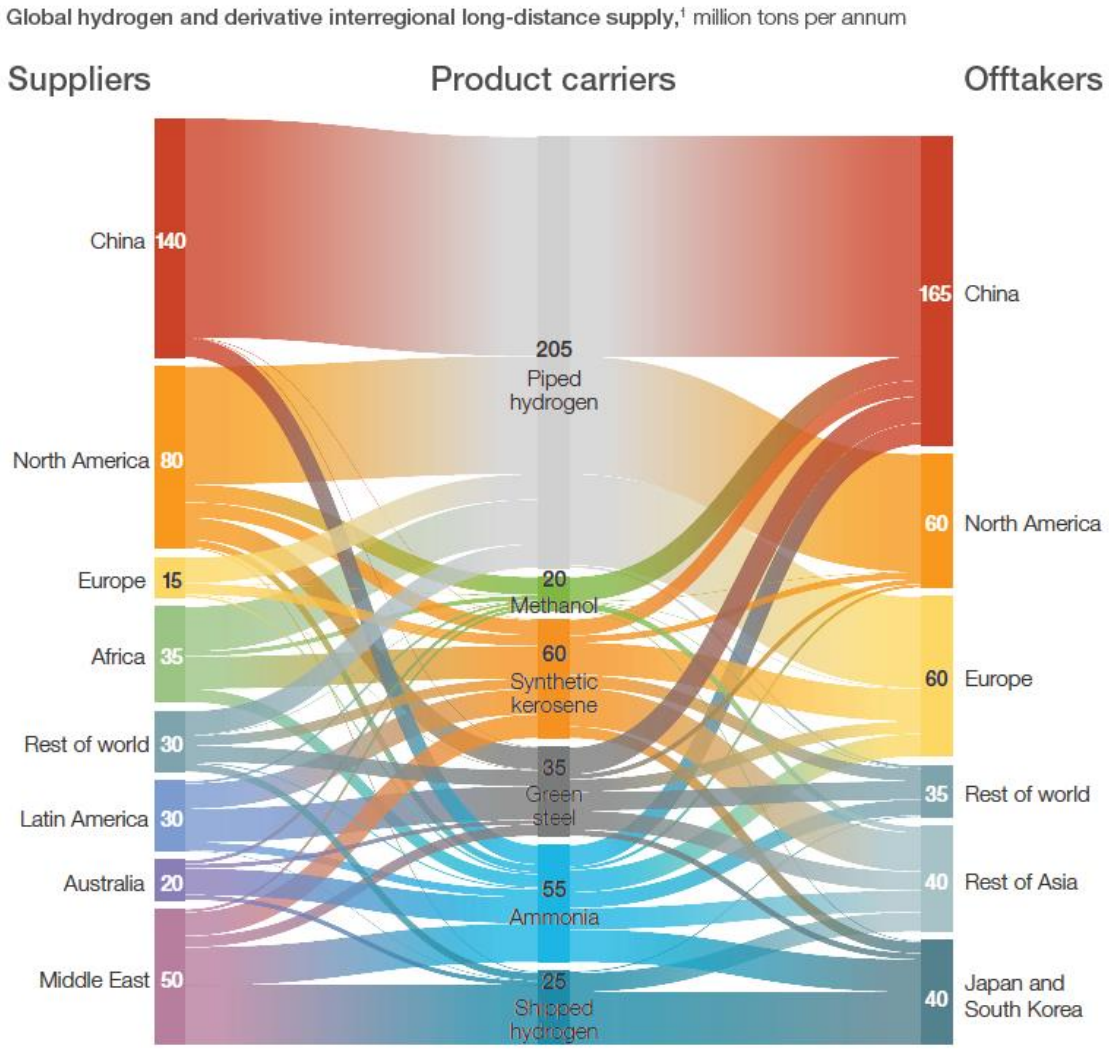
Long distance transport of Hydrogen and derivatives
Domestic production in large country + international trade

Hydrogen TCP

Order of Magnitude

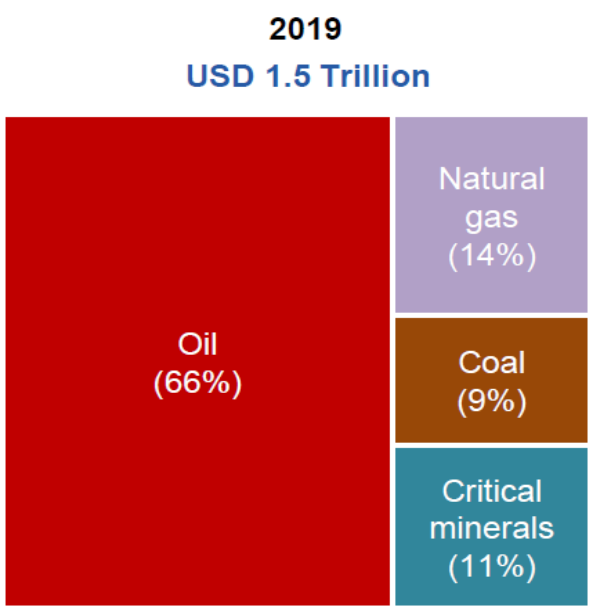
- International Trade: 15-25%, mainly H2 based products with a very small part for H2
- Domestic long distance trade: 20-40%
- Local &short distance production: 40—60%

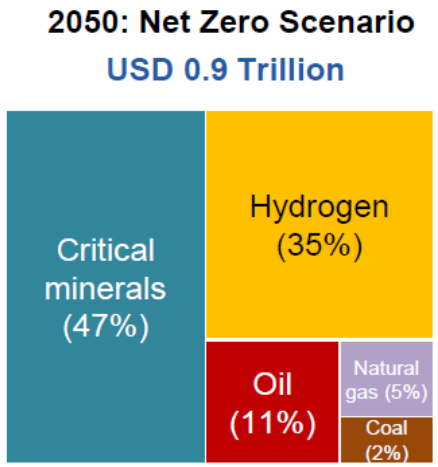




Source: Hydrogen Council Insights 2022

International Energy trade
Evolution in 2050 with a NZE scenario



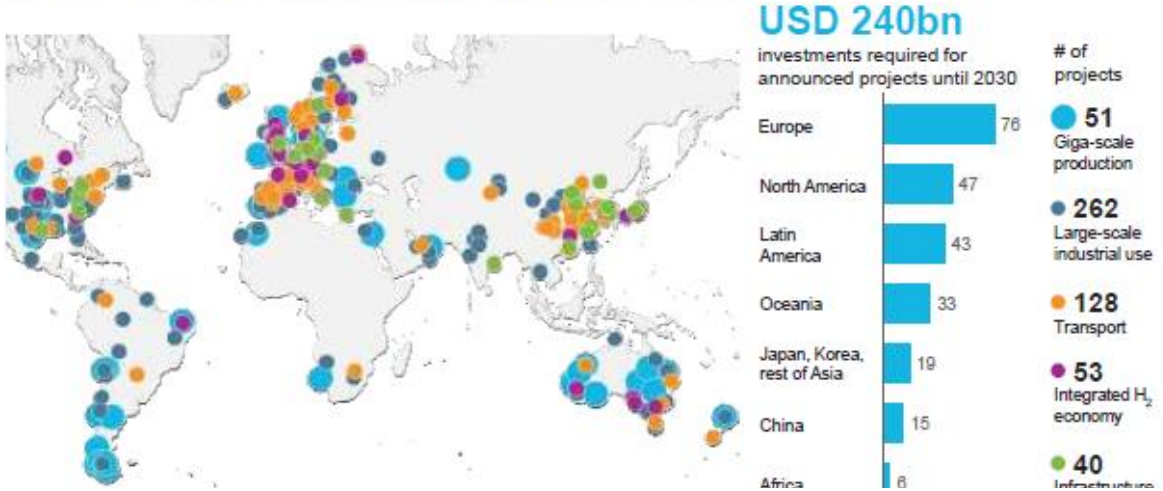


Source IEA WEO 2022

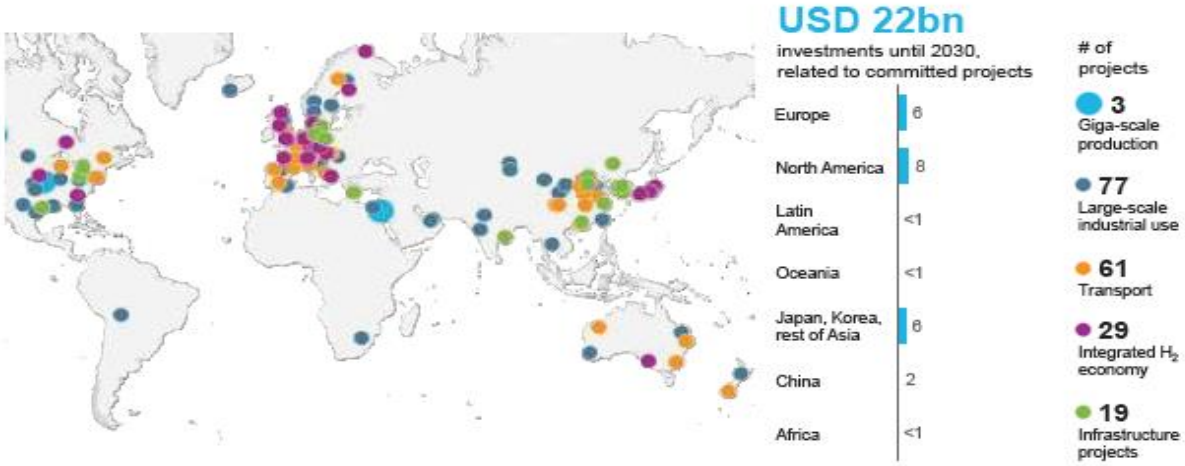
Ratio Hydrogen(and Hydrogen-based Products) internationally traded versus total hydrogen production:
15-25 % ?

680 Annouced projects,280GW
only 10 % reached FID stage: lack of demand to unlock investment

Out of 534[1] large-scale projects worth USD 240 bn announced globally …



… and only about 10% of investments have achieved final investment decision



1. **HyDeal Ambition (67GW)** ..... Western Europe
2. **Unnamed (30GW)** ..... Kazakhstan
3. **Western Green Energy Hub (28GW)** ..... Australia
4. **AMAN (16GW)[a]** ..... Mauritania
5. **Asian Renewable Energy Hub (14GW)** ... Australia
6. **Oman Green Energy Hub (14GW)[a]** ..... Oman
7. **AquaVentus (10GW)** ..... Germany
8. **NorthH2 (10GW)** ..... Netherlands
9. **H2 Magallanes (8GW)** ..... Chile
10. **Beijing Jingneng (5GW)** ..... China
11. **Project Nour (5GW)[a]** ..... Mauritania
12. **HyEnergy Zero Carbon Hydrogen (4GW)[a]**. Australia
13. **Pacific solar Hydrogen (3.6GW)** ..... Australia
14. **Green Marlin (3.2GW)**..... Ireland
15. **H2-Hub Gladstone (3GW)** ..... Australia
16. **Moolawatana Renewable Hydrogen Project (3GW)[a]** – Australia
17. **Murchison Renewable Hydrogen Project (3GW)** – Australia
18. **Unnamed (3GW)**..... Namibia
19. **Base One (2GW)[a]**..... Brazil
20. **Helios green Fuels Project (2GW)** ..... Saudi Arabia

Despite an impressive portfolio of projects… our pace is still too slow and subject to many hurdles

We need 160 GW/year during 30 years

Summary: Main challenges for massive H_2 deployment

Cost

- Technology (e.g. catalysts)
- Production?
- Transport, storage, distribution

Technology

- Scale up Manufacturing
- TRL for some technologies
- Safety Challenges

Resources

- Critical materials
- Water consumption
- Land Uses and scarcity

Framework

- Standards, GO, certification Carbon footprint SDG Goals
- Dedicated policies & regulatory framework
- Access to capital, investors trust
- Developped countries/developing /emerging/MI countries

What do we need?

- National strategies and **Action Plans**
- Public support, specially in **early years** **Manufacturing, demand creation** **Cost gap**
- R & D & **Innovation**
- **International collaboration** Regulatory framework Technology transfer, RD&I

H2 Hydrogen TCP

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National Strategies are adressing mainly 2020-2030:

The Key Decade of Hydrogen, with 2 mains objectives

- Scale up and decrease of technologies production costs,

- International Framework to be installed

Next decade 2030-2040 will be the scale up of deployment

45 Countries with National Strategy/Road Map

Jurisdiction	Key Documents	Type	Release Date
Algeria	Roadmap for the Development of Hydrogen	National roadmap	March 2023
Australia	Australia's National Hydrogen Strategy	National Strategy	November 2019
Austria	Hydrogen Strategy for Austria	National Strategy	June 2022
Belgium	Federal Hydrogen Vision and Strategy	National Strategy	October 2021
Canada	Hydrogen Strategy for Canada	National Strategy	December 2020
Chile	National Green Hydrogen Strategy	National Strategy	November 2020
China	China Fuel Cell Subsidy Policy / Medium and Long-Term Planning for the Development of Hydrogen Energy Industry (2021-2035)	Policy Statement / Planning Document	September 2020 / March 2022
Colombia	National Roadmap for Colombia	National Roadmap (draft)	August 2021
Croatia	Croatia Hydrogen Strategy	National Strategy	March 2022
Czech Republic	National Hydrogen Strategy of the Czech Republic	National Strategy	July 2021
Denmark	The Government's Strategy for Power-to-X	National Strategy	December 2021
European Commission	A Hydrogen Strategy for a Climate-Neutral Europe	Supranational Strategy	July 2020
Finland	National Hydrogen Roadmap for Finland	National Roadmap	November 2020
France	National Strategy for the Development of Decarbonised and Renewable Hydrogen in France	National Strategy	September 2020
Germany	The National Hydrogen Strategy	National Strategy	June 2020
Greece	National Strategy for the Promotion of Technologies – Applications of Hydrogen and Renewable Gases	National Strategy	November 2022
Hungary	National Hydrogen Strategy	National Strategy	May 2021
India	Green Hydrogen PolicyNational Green Hydrogen Mission	Policy Hydrogen Mission	February 2022 January 2023
Italy	National Hydrogen Strategy Preliminary Guidelines	Preliminary Guidelines	November 2020
Japan	Basic Hydrogen Strategy / The Strategic Roadmap for Hydrogen and Fuel Cells	National Strategy / National Roadmap	December 2017 / March 2019
Luxembourg	Luxembourg Hydrogen Strategy	National Strategy	September 2021
Morocco	National Hydrogen Development Strategy	National Strategy	August 2021

Jurisdiction	Key Documents	Type	Release Date
Namibia	Green Hydrogen Strategy	National Strategy	November 2022
Netherlands	Government Strategy on Hydrogen	National Strategy	April 2020
New Zealand	A Vision for Hydrogen in New Zealand	Vision	September 2019
Norway	The Norwegian Government's Hydrogen Strategy	National Strategy	June 2020
Oman	Net Zero Emissions in 2050 and Green Hydrogen Strategy	Policy Announcement	October 2022
Paraguay	Towards the Green Hydrogen Roadmap in Paraguay	National Roadmap	June 2021
Poland	Draft Polish Hydrogen Strategy until 2030 with an Outlook until 2040	Draft National Strategy	January 2021
Portugal	Portugal National Hydrogen Strategy	National Strategy	July 2020
Republic of Korea (South Korea)	Hydrogen Economy Roadmap of Korea	National Roadmap	January 2019
Russia	Roadmap for Development of Hydrogen Energy for 2020-2024 / Concept for the Development of Hydrogen Energy in Russia	National Roadmap / Policy Statement	October 2020 / August 2021
Singapore	Singapore's National Hydrogen Study	National Strategy	October 2022
Slovakia	National Hydrogen Strategy	National Strategy	June 2021
South Africa	Hydrogen Society Roadmap for South Africa 2021	National Roadmap	February 2022
Spain	Hydrogen Roadmap – A Commitment to Renewable Energy	National Roadmap	October 2020
Sweden	Proposal for a national strategy for fossil-free hydrogen, electric fuels and ammonia – Swedish Energy Agency	National Strategy	November 2021
Switzerland	Theses on the future importance of hydrogen in Swiss energy supply	Discussion Paper	September 2022
Turkiye	Hydrogen Technologies Strategy and Roadmap	Strategy and Roadmap	January 2023
Ukraine	Draft Roadmap for Production and Use of Hydrogen in Ukraine	Draft Roadmap	March 2021
United Arab Emirates	Hydrogen Leadership Roadmap	National Roadmap	November 2021
United Kingdom	UK Hydrogen Strategy	National Hydrogen Strategy	August 2021
United States	DOE National Clean Hydrogen Strategy and Roadmap	Strategy and Roadmap	September 2022
Uruguay	Green Hydrogen Roadmap in Uruguay	Draft National Roadmap	June 2022

Short analysis of national strategies

- Three main drivers
  - Climate change (low carbon technologies)
  - Economic growth/Creation of added value/ Jobs/ social criteria
  - Energy Security
- **Common objectives**
  - Focus on 2020-2030 period
  - Public funding to Decrease technologies cost until 2030
  - Support demand creation and incentive fo decreasing the gap
  - Support hydrogen usages in hard to abate sectors
  - Support to new reglementation implementation
  - Support to R&D and Innovation

- Differences
  - Order of the priorities
  - Industrial manufacturing policies whare will be produced the component ?
  - Production of low carbon hydrogen: Focus on domestic market and export/import of H2 and H2-based products
  - Uses of Hydrogen in gas network
  - Uses of Hydrogen in mobility
  - Integration of large share of Renewables
  - Focus on low carbon: nuclear, fossil with CCS, renewables
  - Uses in energy sector (combustion of H2, NH3 etc..) in turbine
  - International strategies

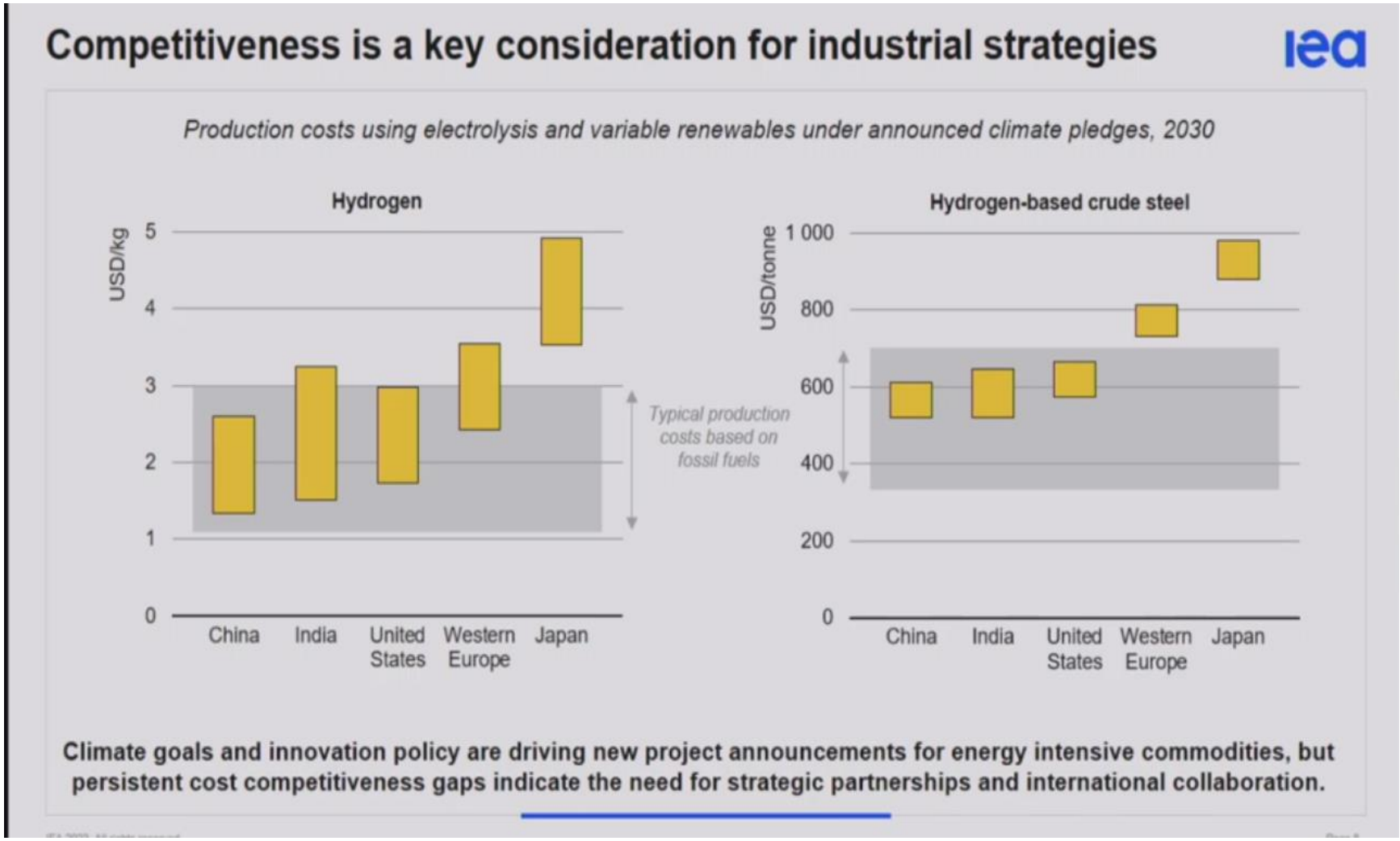
Uncertainties about hydrogen applications

- **Mobility: lot of uncertainties on H2/Fuel cells**
  - In one hand: Severe limitations to massive deployment of Li BEV; Hybrid battery/fuel cell architecture could emerge Hydrogen allows to decouple the power demand from the energy demand. Fast charging possible with Hydrogen
  - At the opposite breakthroughs on battery (new generation of batteries, no critical material, easy ultra fast charging) could lead to 100 % electric battery vehicules for all terrestrial vehicles
- **Mobility:**
  - hydrogen combustion and Internal combustion engine could play a role after 2035
- **Mobility: e-fuels**
  - Huge question mark on CO2 sourcing: CO2 from industry (cement or fossil fuels) not compatible with NZE scenario; Biogenic source too small; DAC ? Too expensive
  - Ammonia no needs for CO2
- **Industry:**
  - Hydrogen for High temperature heat supply and for chemical properties
  - Needs to accelerate R&D and maturation of new processes
  - E-fuels
- **Energy sector and massive storage of energy**
  - No alternative in many countries for a 100 % renewables energy mix (except countries with nuclear or large hydraulic resource)
  - Undergournd storage (H2 or Hydrogen carrier)
  - Hydrogen turbine

Some considerations about global context

- Macroeconomics and global political risks, future of globalization
  - « regional » globalization, sovereignty issues
- Competition about Hydrogen technologies manufacturing and jobs creation : USA (IRA), Europe, China
  - What about other countries non « EU, USA, China and Japan »?technology transfer policies?
- Impact of new frame for energy prices: towards a drastic change/revolution in industry location worldwide ?
- Export policy versus domestic development and societal needs (water, electricity…)
- Regulatory framework
  - Taken into account SDG criteria (not only carbon foot print)
  - Time to implement international framewor
  - Funding cost gap is expensive for public funding 1 gap for 1 Mt is 1 billion €/year!
- Societal evolution on environmental and societal aspects, impact of NGO,
  - On international trade, new « colonialism », land use and biodiversity,
  - On blue hydrogen, nuclear, CO2
  - Safety ?
  - Impact of hydrogen leakage on climate change

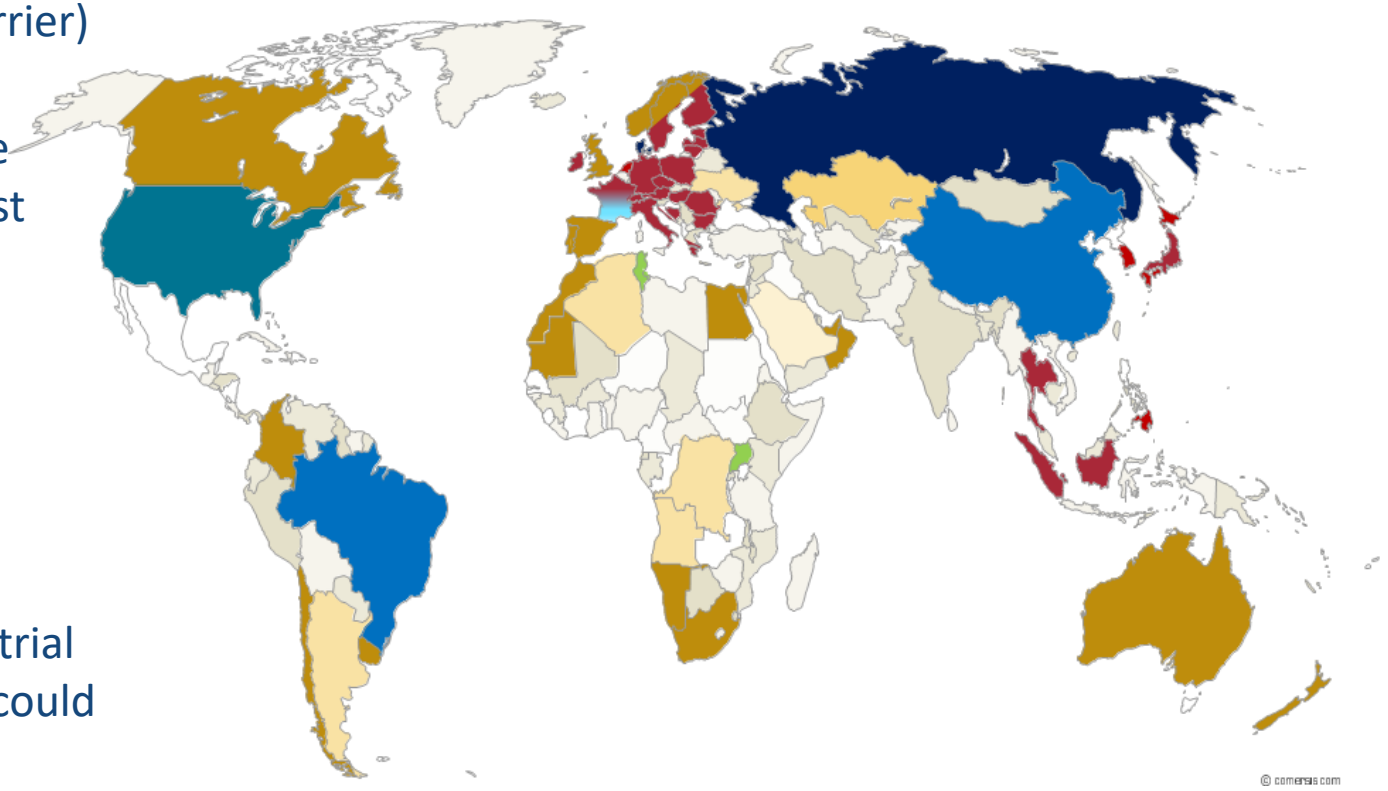
Exporting steel rather exporting hydrogen



Comments about geopolitics and Import/export policies

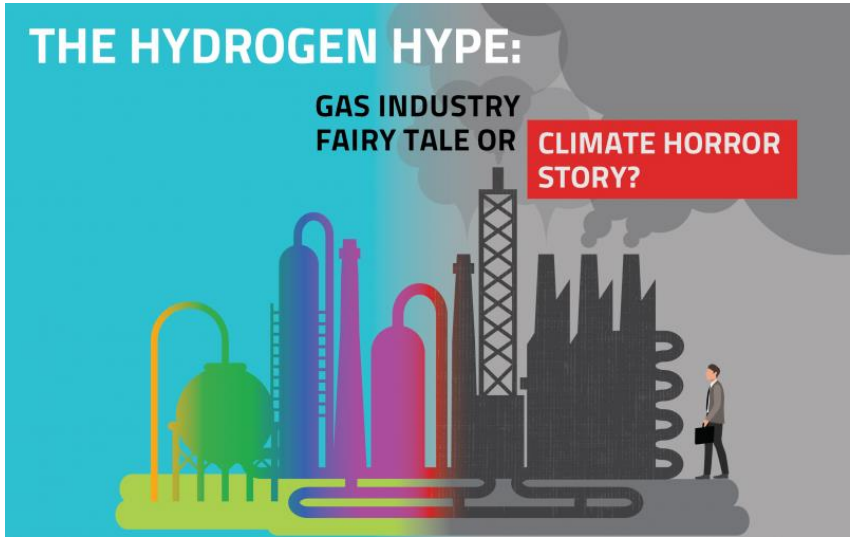
- Basic of Hydrogen and derivatives trade: costs of overseas hydrogen transport and delivery (including hydrogen carrier) are and will stay high
- Regional ecosystems with pipe lien network seems to be more efficient (for example Big Europe+Noth Africa+ east Ukraine…°

- R&D and Innovation on hydrogen carrier, transport and distribution technologies are very important
- Only a few import countries launched and are driving import/export policies for export countries: Germany, Nederland, Japan (Korea). Countries with a strong industrial sector. Overseas Export countries policy and strategies could be very dependant and sensitive to 3 countries policies
- New energy prices map could lead to a industry location revolution at the expense of Europe, Japan ?



Impact of NGOs

NGO BUND WWF DUH may 2022
“Currently, large parts of politics, industry and the media present hydrogen exports exclusively as an opportunity for the producing countries. The risks - such as negative climate impacts, destroyed ecosystems, illegal land grabbing and displacement - are almost completely ignored,” the NGOs said. “These risks are exacerbated when industrialised countries rely too heavily on imports, neglect self-sufficiency and projects in other countries are under pressure to quickly compensate for supply shortages.”



The hydrogen hype: Gas industry fairy tale or climate horror story?
The European Commission and its quest to let the gas industry write the book on hydrogen in Europe

Recommandations for national strategies

- Hydrogen value chain is a complex ecosystem with multiple applications where the added value could come to holistic approach and mutual benefits of different parts of the chain
- Develop more evaluation and assessment tolls and methodologies to improve decision-making
  - Multi criteria analysis, LCA, techno-economic analysis
  - Use more CBA Cost-Benefits Analysis methodology
  - Development of new economic modeling of hydrogen value chain
- Develop internal expertise (ministries, public agencies, academy) , not only relied of external consultants
- Support strong effort on R&D and innovation

- Develop in priority capacity building, education, training
- Develop strong and updated technology, economic, policy, geopolitic watch a
- Keep strategies flexible, robust and connected to others strategiesrelevant
- For export countries (especially overseas exportation)
  - Develop different scenarios with plan B, C alternative to exportation target and main stream scenario
  - Explore more integration of Hydrogen in local and national industry development in order to export H2 Based product(ex Low carbon steel) rather than H2
  - Explore « regional stratégies » to develop regional integration with Hydrogen

OUTLINE

1. WHY HYDROGEN AND WHY HYDROGEN NOW ?
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3. **WHY INTERNATIONAL COLLABORATION IS KEY ELEMENT FOR A NZE BY 2050**
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Why Developping International collaboration is vital?

1- Accelerate research & innovation, maximize the efficient use of resources within the short term frame

2- Developp international standards, set of coherent certificatior scheme for carbon footprint

3- Harmonize regulatory Framework in the frame of UNO/Sustainable Development Goals

4- Coordinate scale up deployment

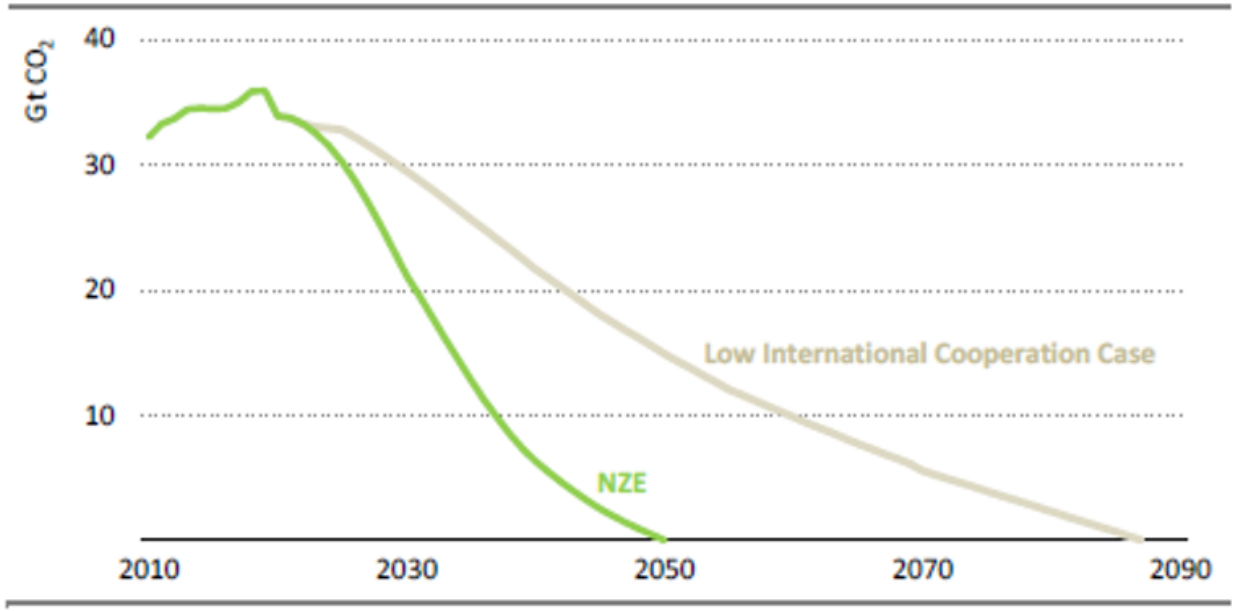
5- Share knowledge and facilitate technogies transfer

6- Decrease costs for developed countries

7- Less developped countries: technical and Financial support to implement Key technologies

8- Develop capacity buidling, education, training for suited workforce

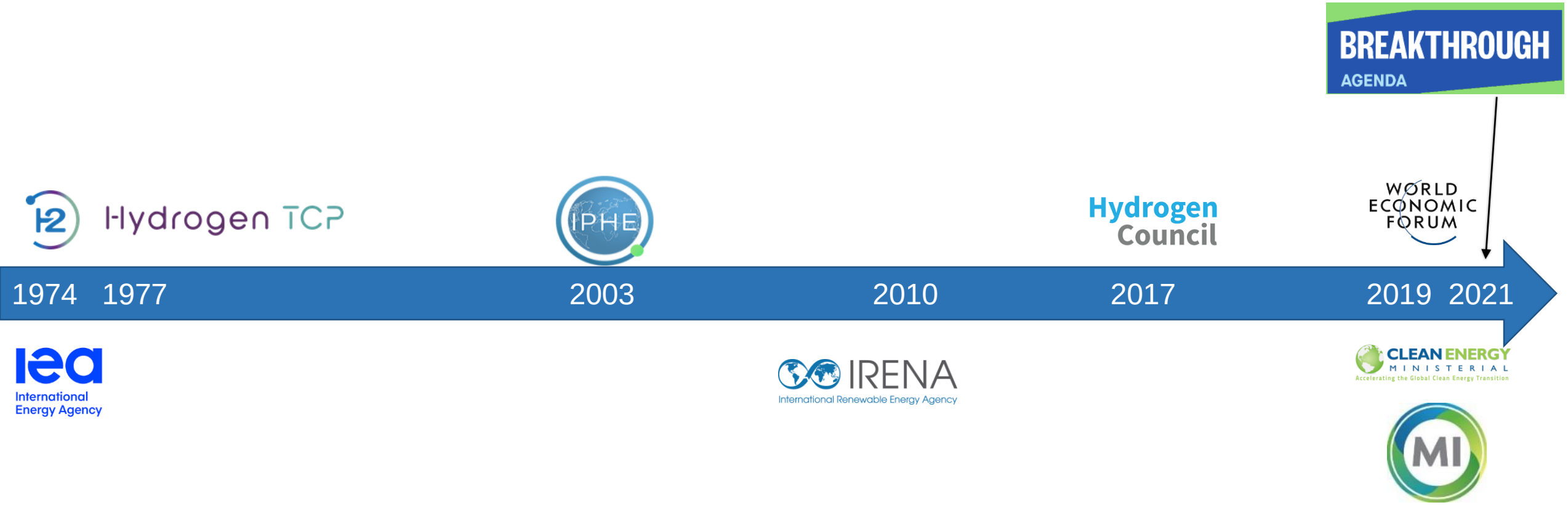
Global energy-related CO_2 emissions in the net zero pathway and Low International Co-operation Case



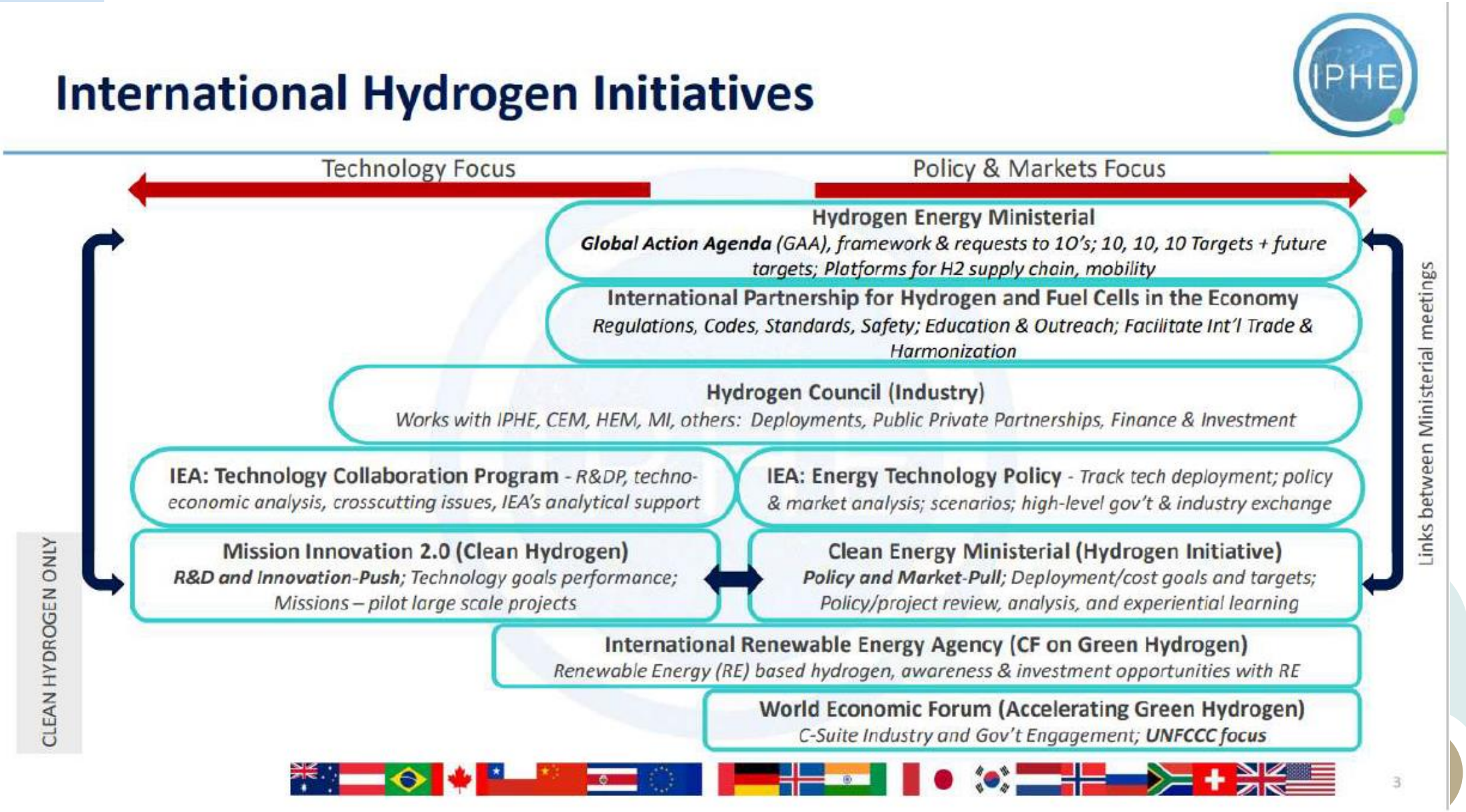
Note: Gt = gigatonnes.

Source NZE by 2050, IEA, 2021

Time line


BREAKTHROUGH
AGENDA
Hydrogen TCP
IPHE
Hydrogen
Council
WORLD
ECONOMIC
FORUM
1974
1977
2003
2010
2017
2019
2021
iea
International
Energy Agency
IRENA
International Renewable Energy Agency
CLEAN ENERGY
MINISTERIAL
Accelerating the Global Clean Energy Transition
MI

Many Multi-lateral initiatives on Hydrogen



International Hydrogen Initiatives

BREAKTHROUGH AGENDA

Public-sector-led global Hydrogen Initiatives	International Partnership for Hydrogen and Fuel Cells in the Economy	CEM Hydrogen Initiative	Mission Innovation's Clean Hydrogen Mission	G7's Hydrogen Action Pact	UNDP's Hydrogen Initiative
	Hydrogen Energy Ministerial (HEM)	UNIDO's Hydrogen Initiative	IEA's Hydrogen TCP	IEA's Fuel Cells TCP	
Private-sector-led Global Hydrogen Initiatives	Hydrogen Council	Green Hydrogen Organisation	First Movers Coalition	Green Hydrogen Catapult	
Public & Private-sector Global Hydrogen Initiatives	IRENA's Collaborative Framework on Green Hydrogen	WEF's Accelerating Clean Hydrogen Initiative	Breakthrough Energy Catalyst		
Country-led International Initiatives	H2Global (DE)	Quad Clean Hydrogen Partnership (US, JP, AU, IN)	[Others to be added]		
Regional Hydrogen Initiatives	African Green Hydrogen Alliance	Hydrogen Europe	H2 LAC	MENA Hydrogen Alliance	[Others to be added]
Global Initiatives working on related topics	CEM Investment and Finance Initiative	Mission Possible Partnership	Green Grids Initiative	Breakthrough Energy Catalyst	Development Banks

Not an exhaustive list – feedback welcomed on other initiatives to be added

Included in the landscape map

Not yet included in the landscape map

Hydrogen Breakthrough – Overview of the Priority Actions for 2023

BREAKTHROUGH AGENDA

Priority International Action	COP28 Goal	Coordinating initiative(s)
H1: Accelerate the development of standards for clean hydrogen	A programme should be fully resourced and underway by COP28 with progress reported annually at subsequent COP summits.	• IPHE • IEA's Hydrogen TCP • IRENA's Collaborative Framework on Green Hydrogen
H2: Coordinate internationally to drive demand for clean hydrogen	Aggregated commitments to be announced by COP28 and updated at subsequent COP summits.	• First Movers Coalition • Clean Energy Ministerial Hydrogen Initiative • Mission Innovation Clean Hydrogen Mission
H3: Expand the number and scope of innovative clean hydrogen projects	Progress to be reported on by COP28.	• Mission Innovation Clean Hydrogen Mission
H4: Scale and facilitate access to finance, particularly for developing countries	A broad coordinated portfolio of support mechanisms to be communicated by COP28.	• A partnership of donor countries and active financing institutions including the World Bank & the United Nations Industrial Development Organization (UNIDO)
H5: Enhance the coordination and transparency of international collaboration on clean hydrogen		• Breakthrough Agenda project team in close partnership with and in support of key international hydrogen initiatives.

G7 Declaration on Hydrogen, Sapporo Japan, 16th april 2023

67. Low-carbon and renewable hydrogen and its derivatives such as ammonia: We recognize
low-carbon and renewable hydrogen and its derivatives such as ammonia should be developed and used where they are impactful as effective emission reduction tools to advance decarbonization across sectors and industries, notably in hard-to-abate sectors in industry and transportation. We also note that some countries are exploring the use of low-carbon and renewable hydrogen and its derivatives in the power sector to work towards zero-emission thermal power generation if this can be aligned with a 1.5°C pathway and our collective goal for a fully or predominantly decarbonized power sector by 2035, while avoiding N2O as a GHG and NOx in general as a regional air pollutant and precursor to tropospheric ozone. Some countries also consider to utilize hydrogen for the conversion of electricity surplus from renewable energy. We affirm the importance of taking action to reduce the cost gap between low-carbon and renewable hydrogen and its
G7 Climate, Energy and Environment Ministers' Communiqué |Page26
derivatives and fossil fuels, including RD&D, and enabling infrastructure. We will enhance our efforts to develop the rule-based, transparent global market and supply chains based on reliable international standards and certification schemes while adhering to environmental and social standards, in particular with regard to water use conflict in diverse ways including liquefied hydrogen and liquid organic hydrogen carriers, and promote organic collaboration between supplier and consumer countries to reduce costs. We will build the enabling environment to encourage safety use of hydrogen, promote relevant regulations, safety codes, and standards in order to accelerate deployment and emissions reductions from hydrogen use. **We affirm the importance of developing international standards and certification including for a GHG calculation methodology for hydrogen production and mutual recognition mechanism for carbon intensity-based tradability, transparency, trustworthiness and sustainability. We welcome the IEA report "Towards hydrogen definitions based on their emissions intensity" as a contribution to the discussion towards reliable international standards and certification schemes on expanding low-emission hydrogen and its derivatives and fostering common understanding. We note with appreciation that the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE) has advanced progress of the hydrogen standards and certification action. We also stress that countries producing low-carbon and renewable hydrogen for export and domestic use should fully benefit from and advance its development.**

68.

RD 20: 20 research organization from G20 decide to collaborate

1) Argentina: Instituto Nacional de Tecnología Industrial (INTI)
2) Australia: Commonwealth Scientific and Industrial Research Organisation (CSIRO)
3) Brazil: Universidade Federal de Sao Carlos (UFSCar)
4) Canada: National Research Council Canada (NRC)
5) China: Chinese Academy of Sciences (CAS)
6) European Union: Joint Research Centre (JRC)
7) France: Commissariat à l'énergie atomique et aux énergies alternatives (CEA)
8) France: Centre national de la recherche scientifique(CNRS)
9) Germany: Fraunhofer-Gesellschaft(Fh-G)
10) Germany: Fraunhofer Institute for Solar Energy Systems (Fh-ISE)
11) India: The Energy and Resources Institute (TERI)
12) Indonesia: Badan Pengkajian dan Penerapan Teknologi (BPPT)
13) Italy: Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA)
14) Japan: National Institute of Advanced Industrial Science and Technology (AIST)
15) Japan: National Institute for Materials Science (NIMS)
16) Japan: RIKEN
17) Mexico: Center for Research and Advanced Studies of the National Polytechnic Institute (CINVESTAV)
18) Republic of Korea: Korea Institute of Energy Research (KIER)
19) Russian Federation: Technology Development Center, Ministry of Energy of Russian Federatio
20) Saudi Arabia: King Abdullah City for Atomic and Renewable Energy (KACARE)
21) South Africa: Council for Scientific and Industrial Research (CSIR)
22) Turkey: TUBITAK Marmara Research Center (MAM)
23) United Kingdom: UK Energy Research Centre (UKERC)
24) United States of America: National Renewable Energy Laboratory (NREL)

Terms of Use

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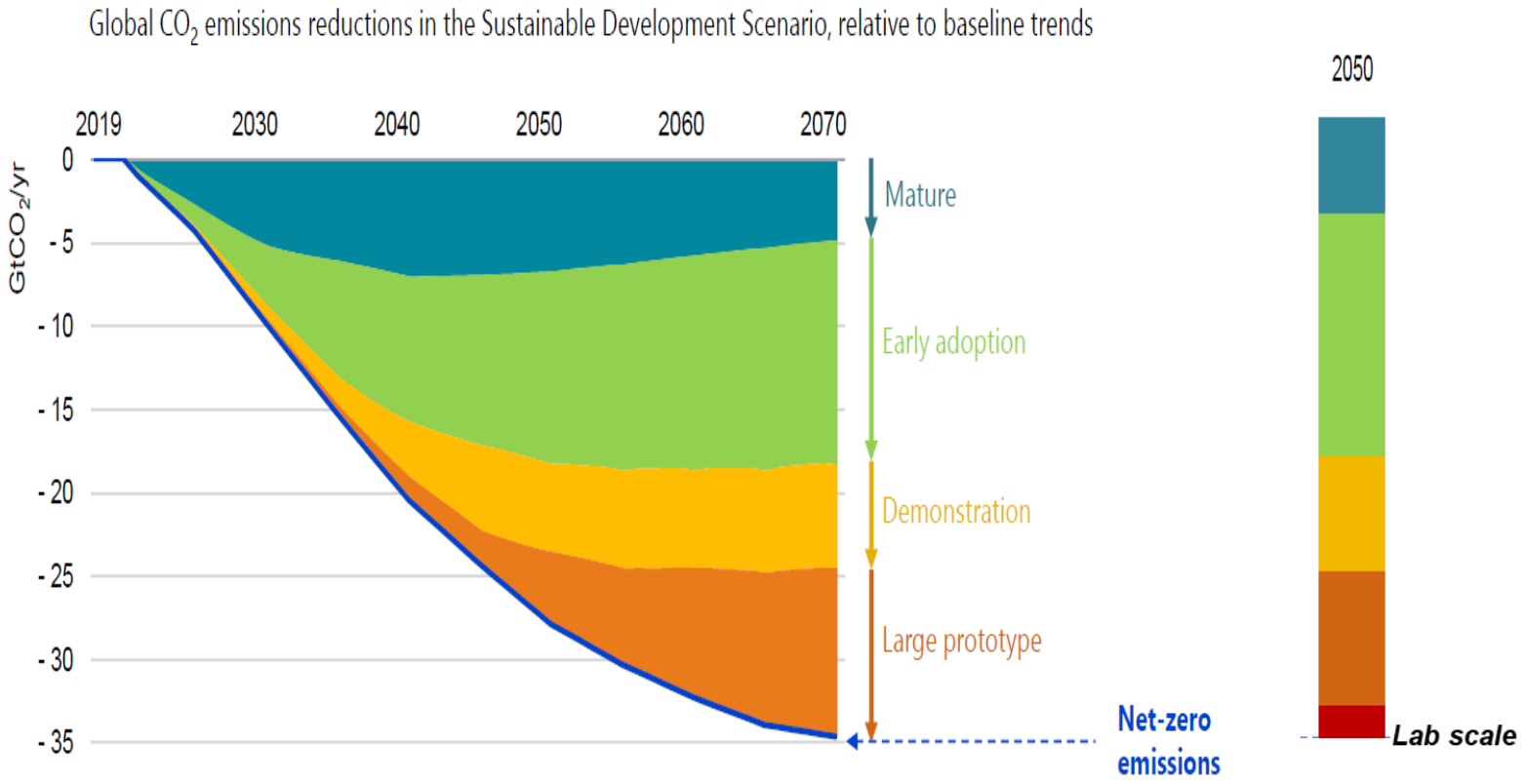
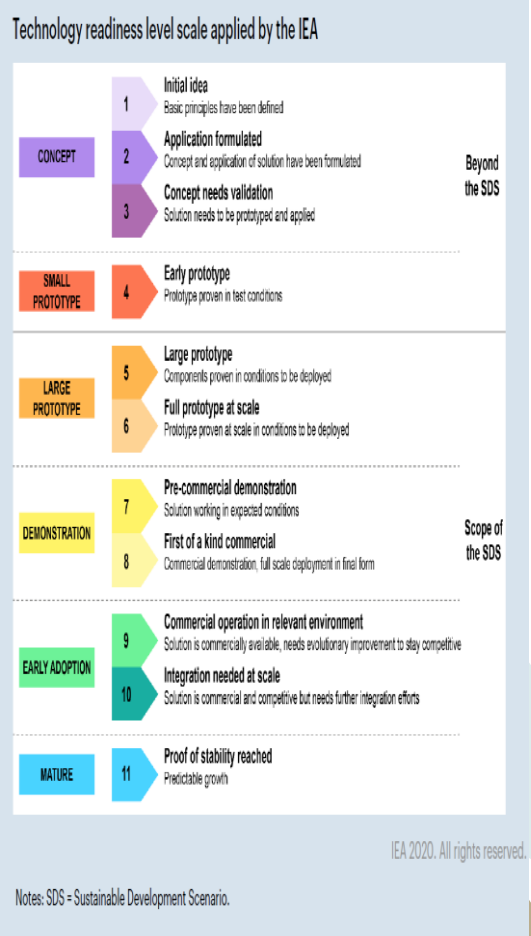
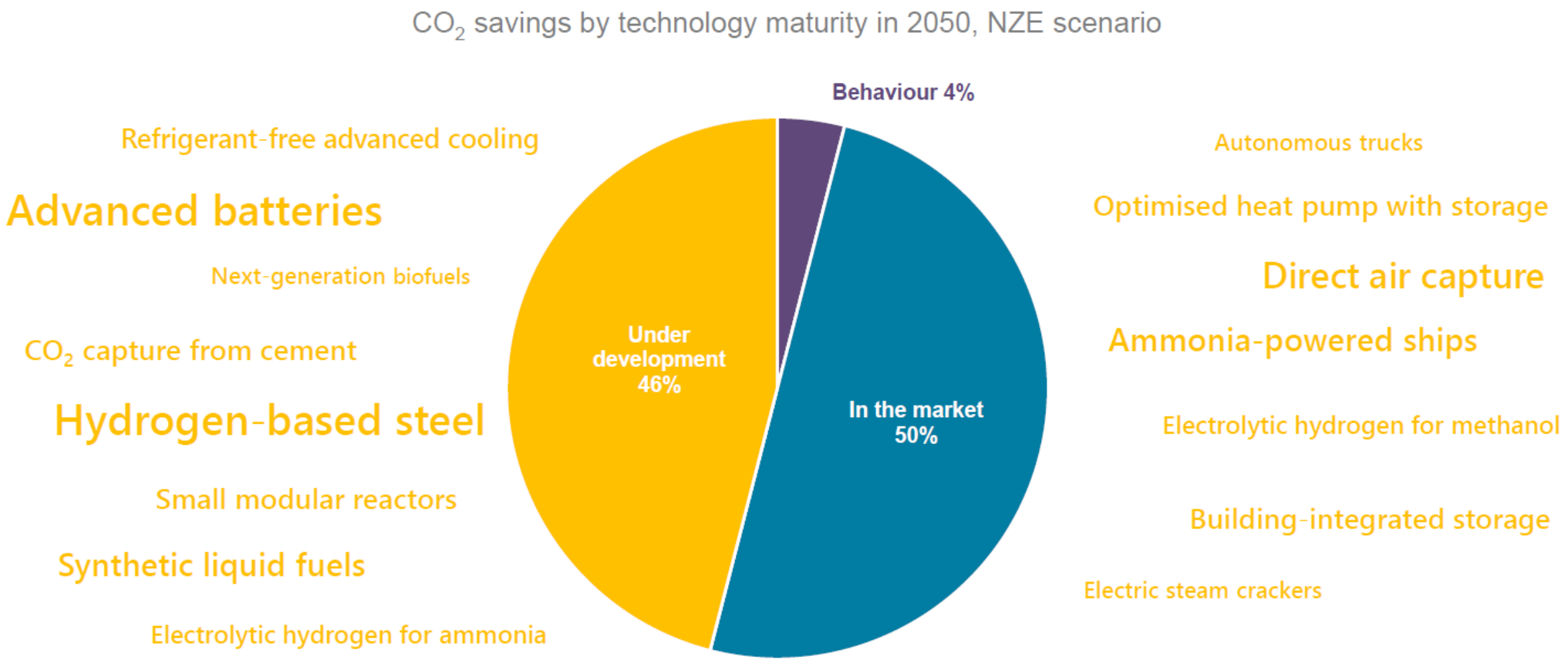
We need to accelerate R&D and innovation and reduce time to market





Reference;: IEA Clean Techologies Innovation report
Near 500 technologies analysed and tracked in term of TRL

Prepare for the next phase of the transition by boosting innovation



Unlocking the next generation of low-carbon technologies requires more clean energy R&D and $90 billion in demonstrations by 2030; without greater international co-operation, global CO_2 will not fall to net-zero by 2050.

Hydrogen TCP

Source IEA ETP 2021

Main challenges for rapid H_2 deployment

R&D is needed at all stages of development

R&D in lower TRL: alternative technologies that could be complementary in the future to our current technological landscape or even outperform some mature technologies. E.g. production pathways, alternatives for storage…

R&D in higher TRL: towards optimization, changes in materials, processes… that may result in improved efficiency and/or reduced costs. E.g. testing different catalysts or different quantities of catalyst under different conditions, new materials for the cells in the stacks or new material treatments that result in overall efficiency…

Why is R&D key for rapid / large –scale hydrogen deployment?

While we focus on implementing already proven and mature technology as soon and as quickly as possible we will need continuous work on **optimizing costs, reliability, durability, energy efficiency and flexibility, as well as scaling-up challenges**, that can only be faced with R&D and alternative thinking.

Additionally, studies to support policy making are important (choice/design policy instruments for effective support; market structure and development etc.) and R&D on cross-cutting issues such as development of safety standards.

Why is R&D key for retrofit existant assets?

Existing assets (power generation, heavy industry steel, chemical etc., most of them are in Asia and young.) will contribute to 1.6°C warming if they are used until end of economic life

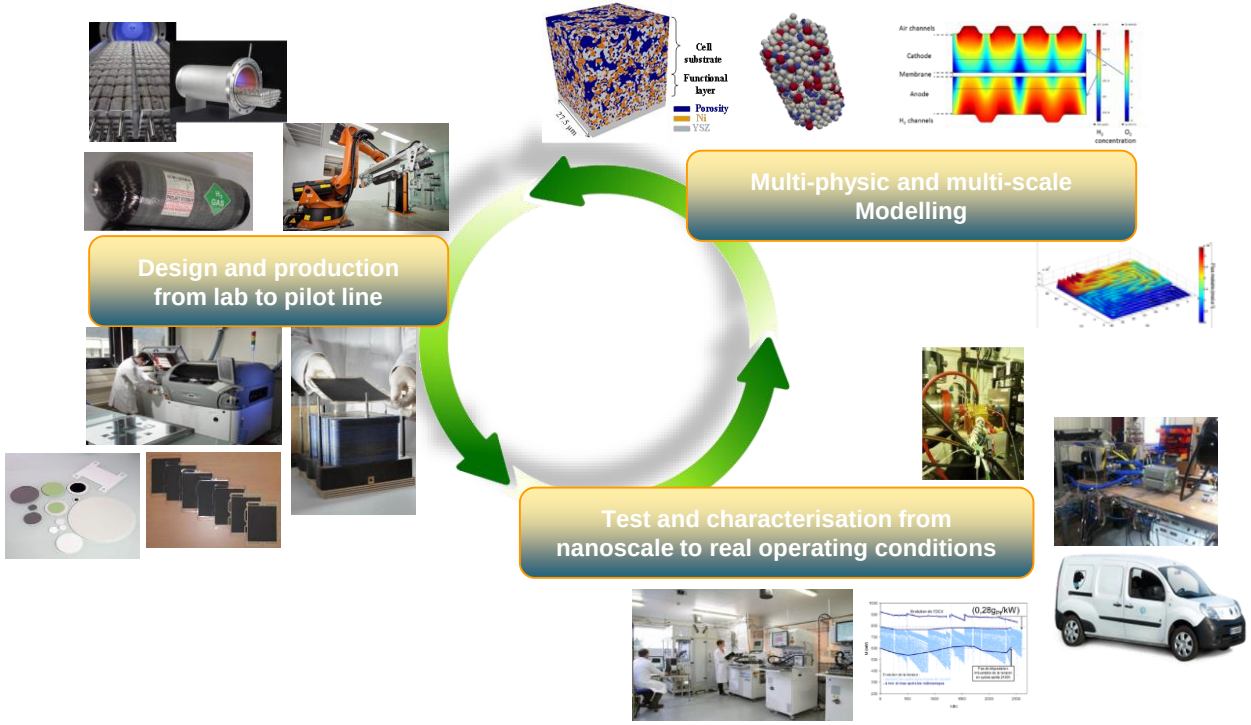
Hydrogen could play important role de retrofit (Flexible NG/H2 turbine, ICE, green steel..)

How to accelerate innovation

1. Increasing public R&D funding and demonstration projects budget
2. Promoting innovative R&D methodes for innovation cycle
3. Coupling « targeted fondamental research with applied research, demonstration and developpment
4. Coupling more Public R&D and industry
5. Enhancing international collaboration
6. Supporting Start up creation and growth

New approaches for R&D and Innovation

CEA approach - The virtuous triptych



Digital twin of hybrid electrical systems

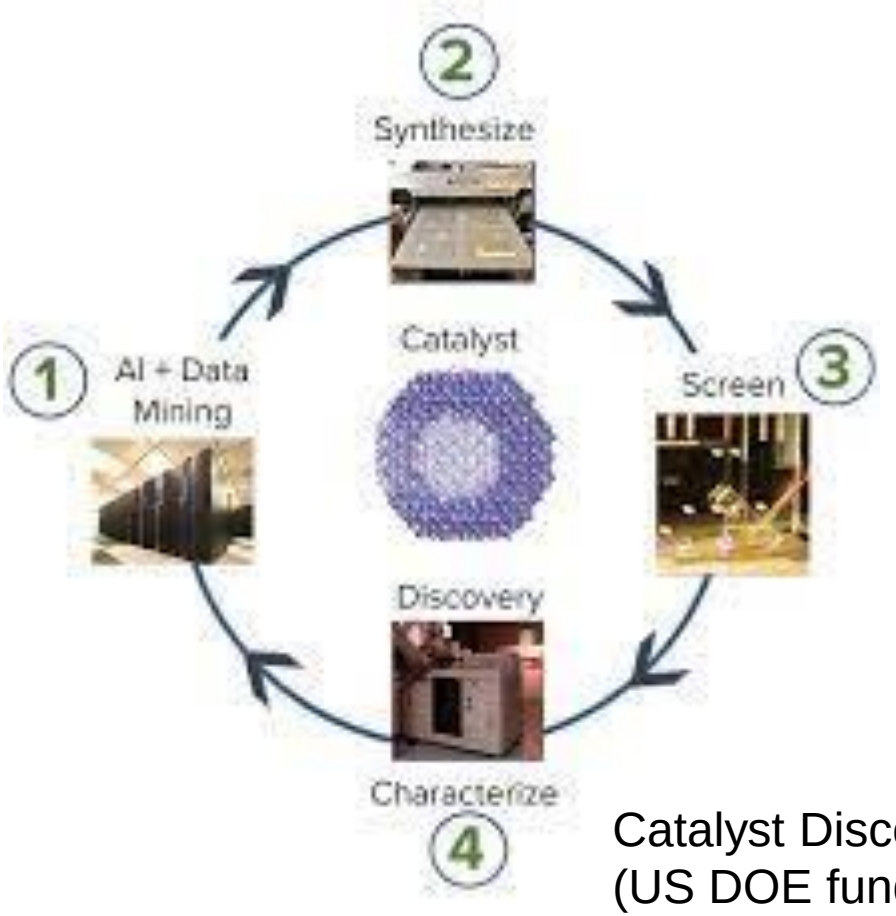
Get predictive models that interact in real-time with physical systems

Accelerate and “derisk” the hardware developments through fast prototyping

Get a complete and coherent software / hardware approach

New approaches for R&D and Innovation

Digital and AI/Data Mining Big Data support



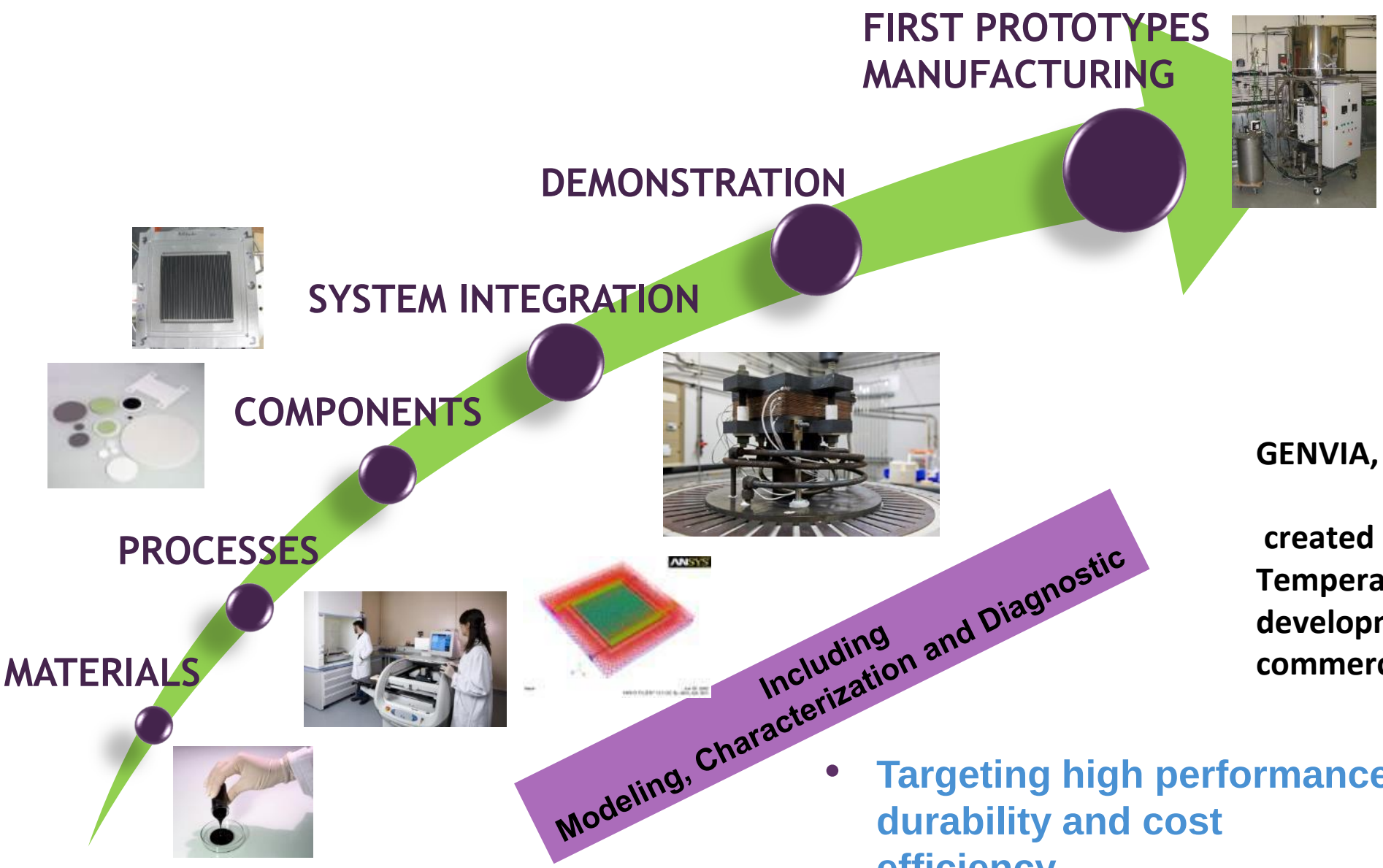
Catalyst Discovery Engine
(US DOE funded)
Screen/Analyse 10 000 faster
To discover non PGM catalyst

Hydrogen Living Labs in Germany

2020: a series of living lab projects for green hydrogen production and usage was started [3], which shall bridge the gap between demonstration and market and provide regulatory learnings.

« Regional, holistic and scalable »

GENVIA: SOEC from R&D(CEA) to market



GENVIA, a joint venture company:

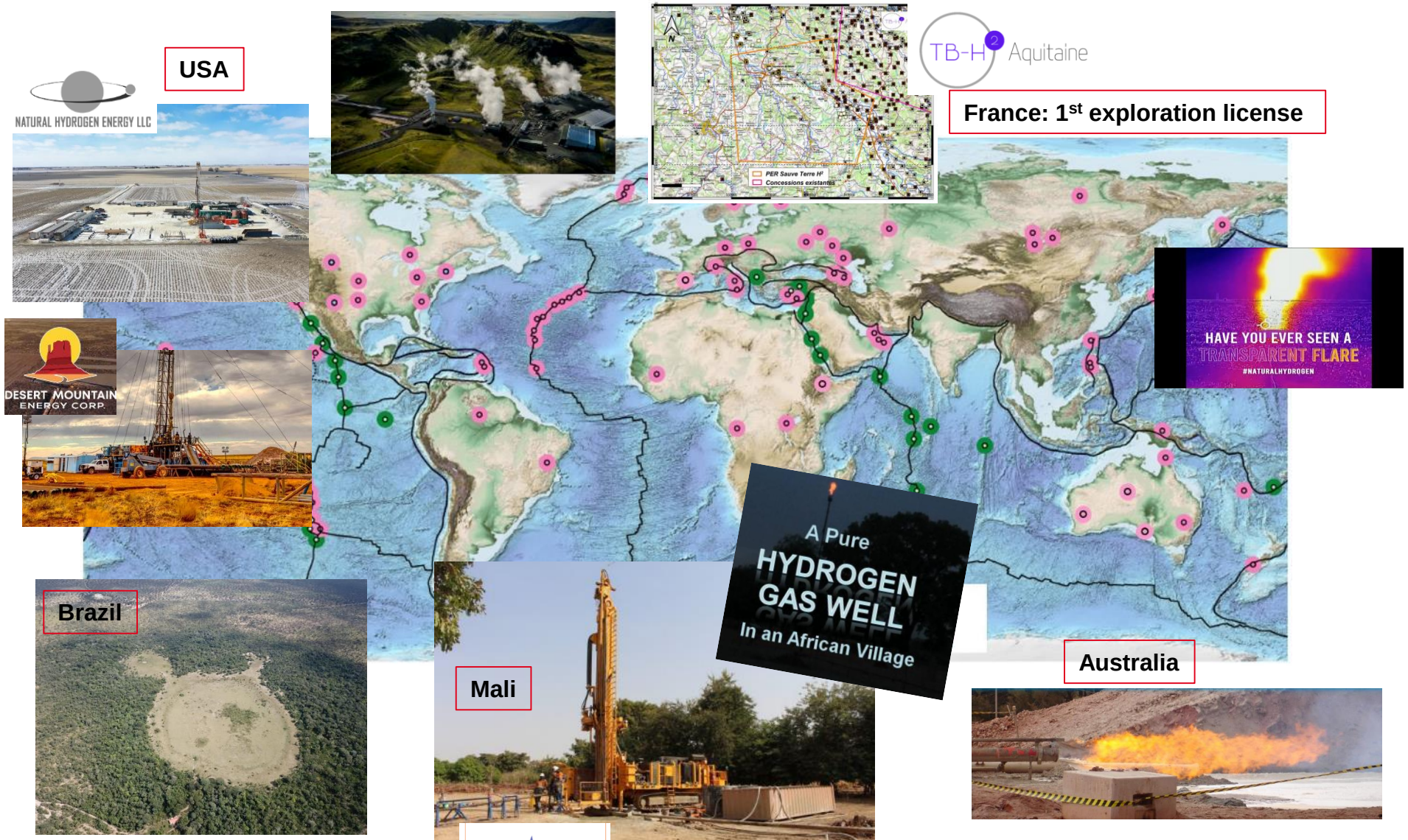
created in 2021 for High Temperature Electrolysis development and commercialization (<2030)

- Targeting high performance, durability and cost efficiency

Game changers

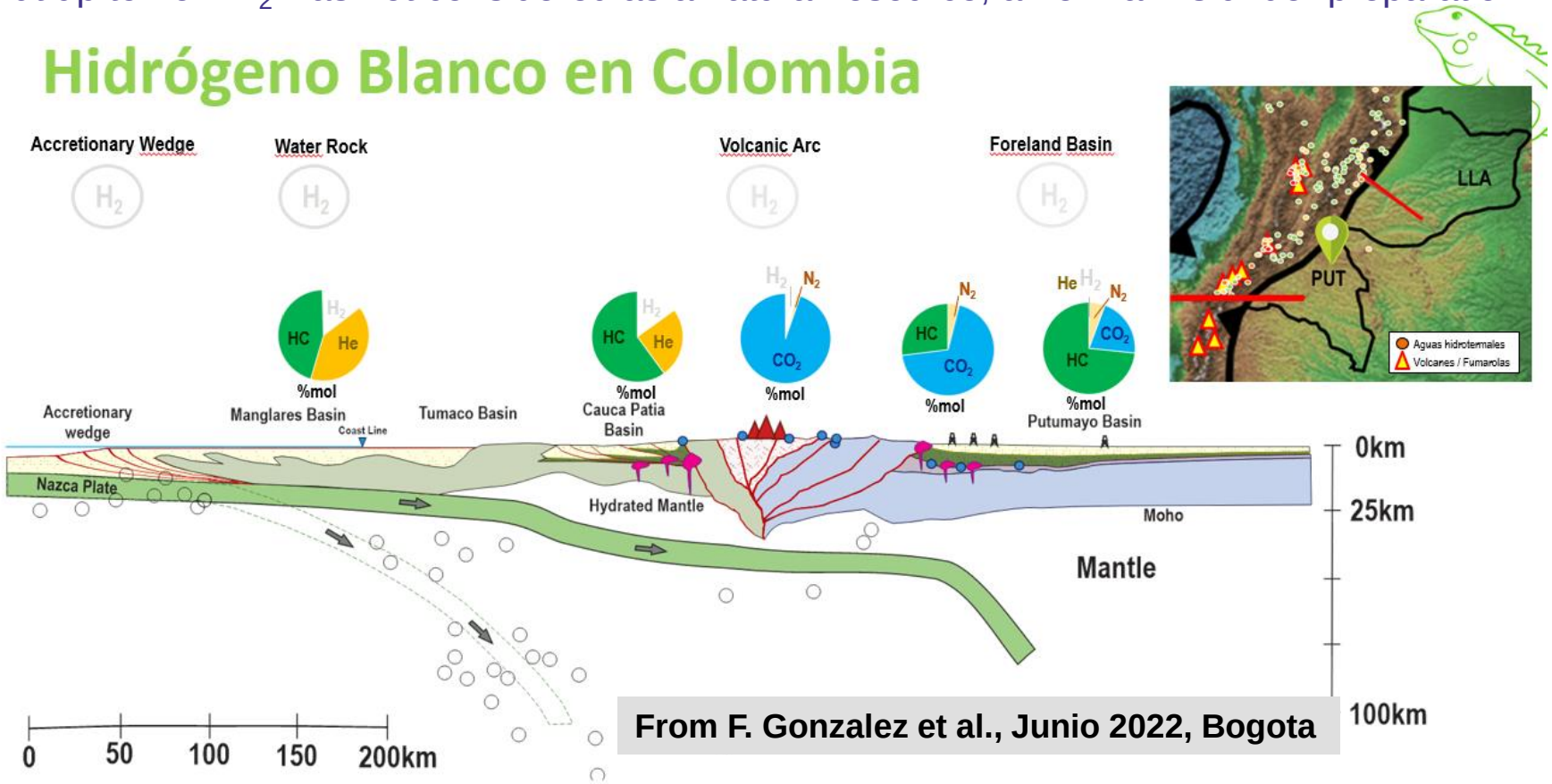
- Hydrogen production
  - Photoelectochemical, Photoelectri, Sunlight to H2
  - Photobilogiclaproduction
  - Natural Hydrogen
  - Methane pyrolysis cracking
  - Innovative electrolysis
- Hydrogen carrier
  - « Ideal carrier » non toxic, energy efficient, circular economy, cost efficient
- Fuel cells
  - Direct fuel (ethanol etc..)
  - Catalyst
  - Ethanol, Hydrogen value chain is a complex ecosystem with multiple applications where the added value could come to holistic approach and mutual benefits of different parts of the chain
- CO2
  - Dramatic reduction of DAC cost

Natural H_2 Exploration is starting in various part of the world



Potential: Colombia

- Geological contexts similar to areas where H_2 has been already confirmed (subduction, ophiolites, hydrated mantle wedge)
- Data collection and analysis have started (Ecopetrol, Uni Nacional…)
- But up to now H_2 was not considered as a natural resource, a new law is under preparation



From F. Gonzalez et al., Junio 2022, Bogota

OUTLINE

1- MAIN CHALLENGES OF ENERGY TRANSITION: SCALE AND TIME

2- WHY R&D, INNOVATION AND INTERNATIONAL COLLABORATION ARE KEY ELEMENTS FOR A NET ZERO CARBON BY 2050

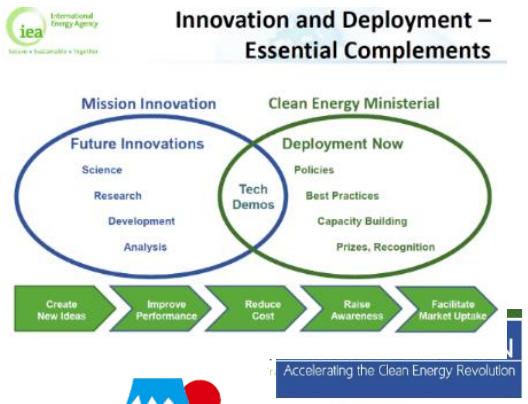
3- INTERNATIONAL LANDSCAPE FOR MULTILATERAL COLLABORATION

4- IEA HYDROGEN TCP: A GLOBAL COLLABORATION FOR RESEARCH AND INNOVATION IN HYDROGEN TECHNOLOGY

5- CONCLUSIONS

A three pillar organization
An unprecendented Modernization Plan

An Influent expert international organizations



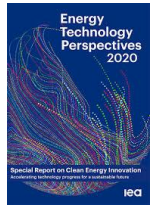
G20 2019 JAPAN

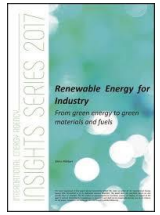
G7 FRANCE BIARRITZ 2019

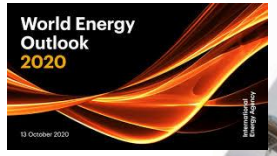
IRENA International Renewable Energy Agency

PARIS Secretariat Team (300 people)leaded by Fatih Birol

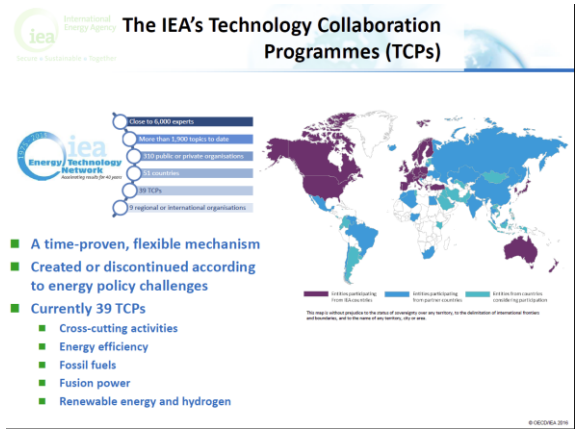
A referent expert
in Energy analysis Scenarios
Plus advisory or strategic







Network of 39 TCPs
6000 expert's network



Renewables, Smart Grid, oil gas, CCS, Hydrogen, Fuel cells, Electric vehicle, combustion, ICE, Fusion, Heat and Cooling, storage, heat pump…

Hydrogen TCP

In a nuthsell

34

Members

23 Member Countries
9 Sponsors
European Commission + UNIDO

40+

Tasks

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

250+

Experts involved

In collaborative research on hydrogen and hydrogen technologies

IEA HYDROGEN TCP
International collaboration Platform since 1977

- 25 countries+EC+Unido
- 9 sponsors
- Framework IEA
- 250 experts

Portefeuille de Tasks
(Projet 3 ans rassemblant experts académiques, industrie)

- H_2 LCA, societal and environmental impact
- H_2 for Marine Applications + Ports
- H_2 in Islands
- H_2 in the Mining, Mineral Processing, and Resource Sectors
- H_2 Certification
- Renewable H_2
- Natural H_2
- Off-shore H_2 Production
- H_2 in Industry
- International H_2 Supply Chains

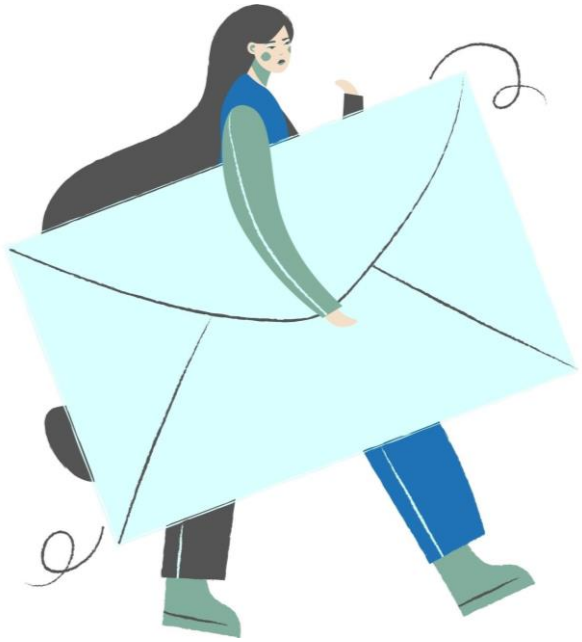
- Task 41 – Analysis and Modelling of H_2 Technologies
- Task 40 – Energy Storage and Conversion
- Task 42 - Underground H_2 Storage
- Task 43 - Safety and RCS of Large-Scale H_2 Energy
- Task 44 – HYNE Hydrogen from Nuclear
- Task 37 – H_2 Safety
- Task 38 – PtH & HtX
- Task 39 – H_2 in the Maritime

Strategic activities

- Evaluation Techologies IEA TRL assessment TCEP
- Annual Award on Projects
- Review IEA Reports and documents
- Thematic groups, task forces inside IEA: Transport, critical materials, industry..
- R&D recommandations for G7/G20/COP

(collaboration Mission Innovation, IEA, Breakthrough agenda, Irena)

Thank You!



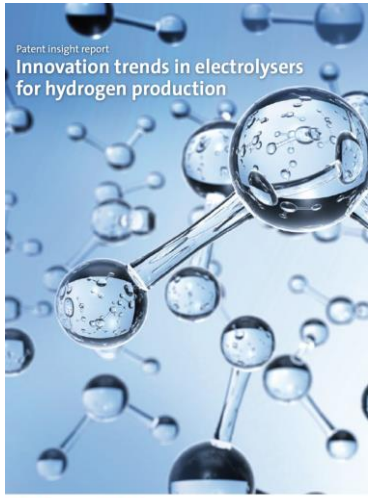
Paul Lucchese

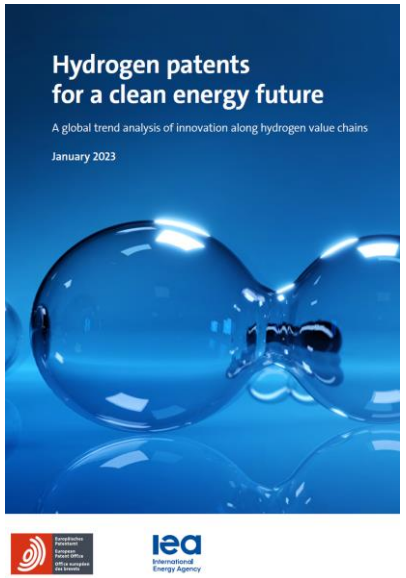
Paul.lucchese@cea.fr

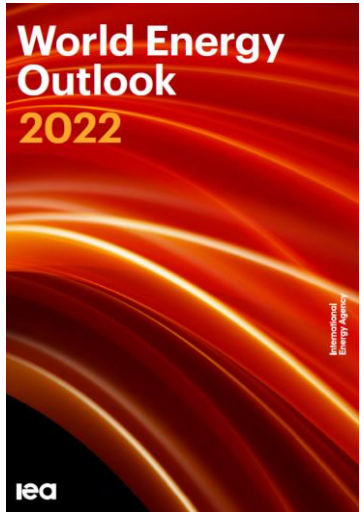
www.ieahydrogen.fr

Useful/recent reports for more info

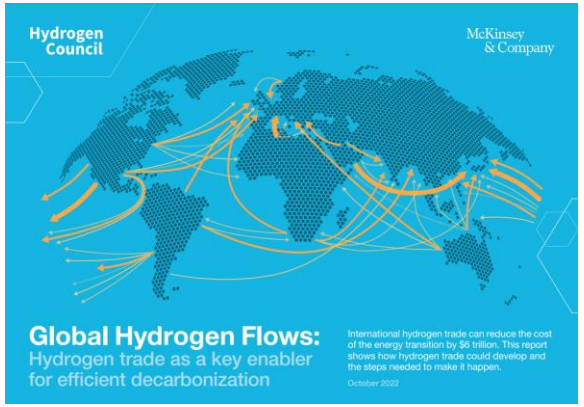
Global Hydrogen Review 2022

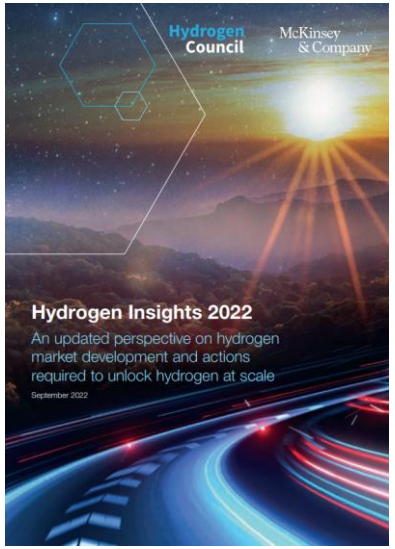


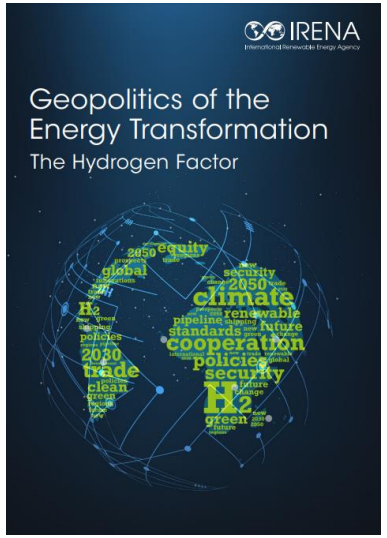


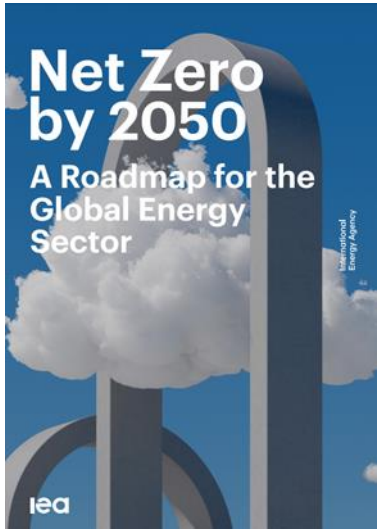


FUEL CELLS AND HYDROGEN OBSERVATORY









Hydrogen TCP