ROAD TO HYDROGEN FUTURE

Paul Lucchese,

IEA Hydrogen TCP Chairman

ERRA CHAIRMEN MEETING

26th November 2021

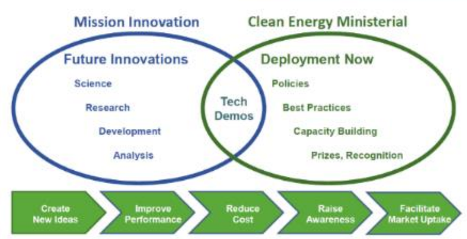
iea Family:

A three pillar organization

An unprecendented Modernization Plan

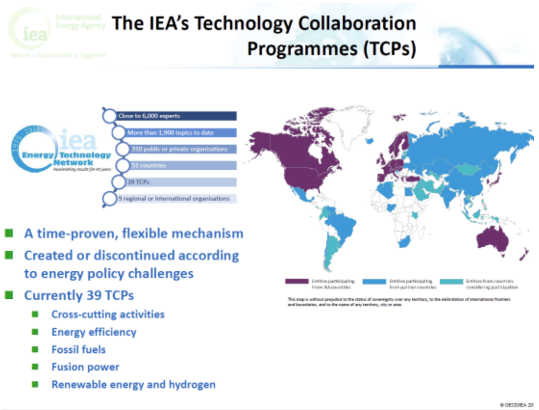
All technologies, beyond OECD and increase TCP network collaboration

An Influent expert international organization



PARIS Secretariat Team (300 people) leaded by Fatih Birol

Network of 39 TCPs 6000 expert's network



Topics covered (among others):

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

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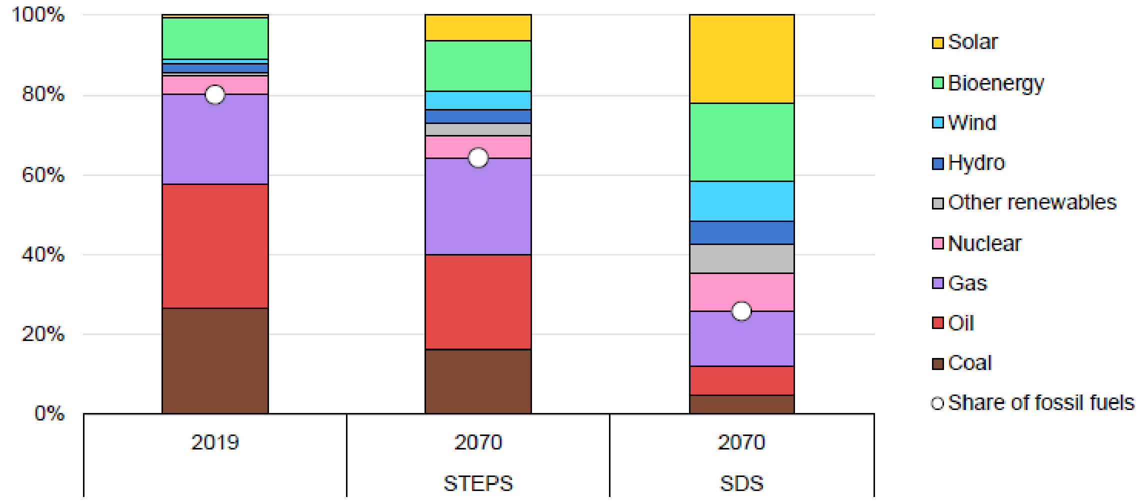
Energy mix in 2050-2070:
Trajectory to a zero carbon world in 2070 or 2050?

Main assumptions

- IEA SDS Scenario: Final primary energy demand will remain stable:
  15280 MToe 2070 for 14600 Mtoe in 2020) despite economic growth (3% /Y, GDPx2,5) and population growth (9,9 Md Inhabitants by 2050)
- Energy efficiency gain, electrification etc
- Ratio Energy/GDP unit: divide by 2,8 in 2070(, 2,2% per year (-1,6 % between 1990 and 2020)
- Huge investment needed x4 - x8 relative to today's level
- PV + Wind: x25-x50 ≈ 50-100 TW ?

Source: IEA ETP 2020

Figure 2.5 Global primary energy demand by fuel share and scenario, 2019 and 2070



STEPS: Stated Policies scenarios
SDS Net Zero Emissions by 2070
SDS 2050: Net Zero in 2050

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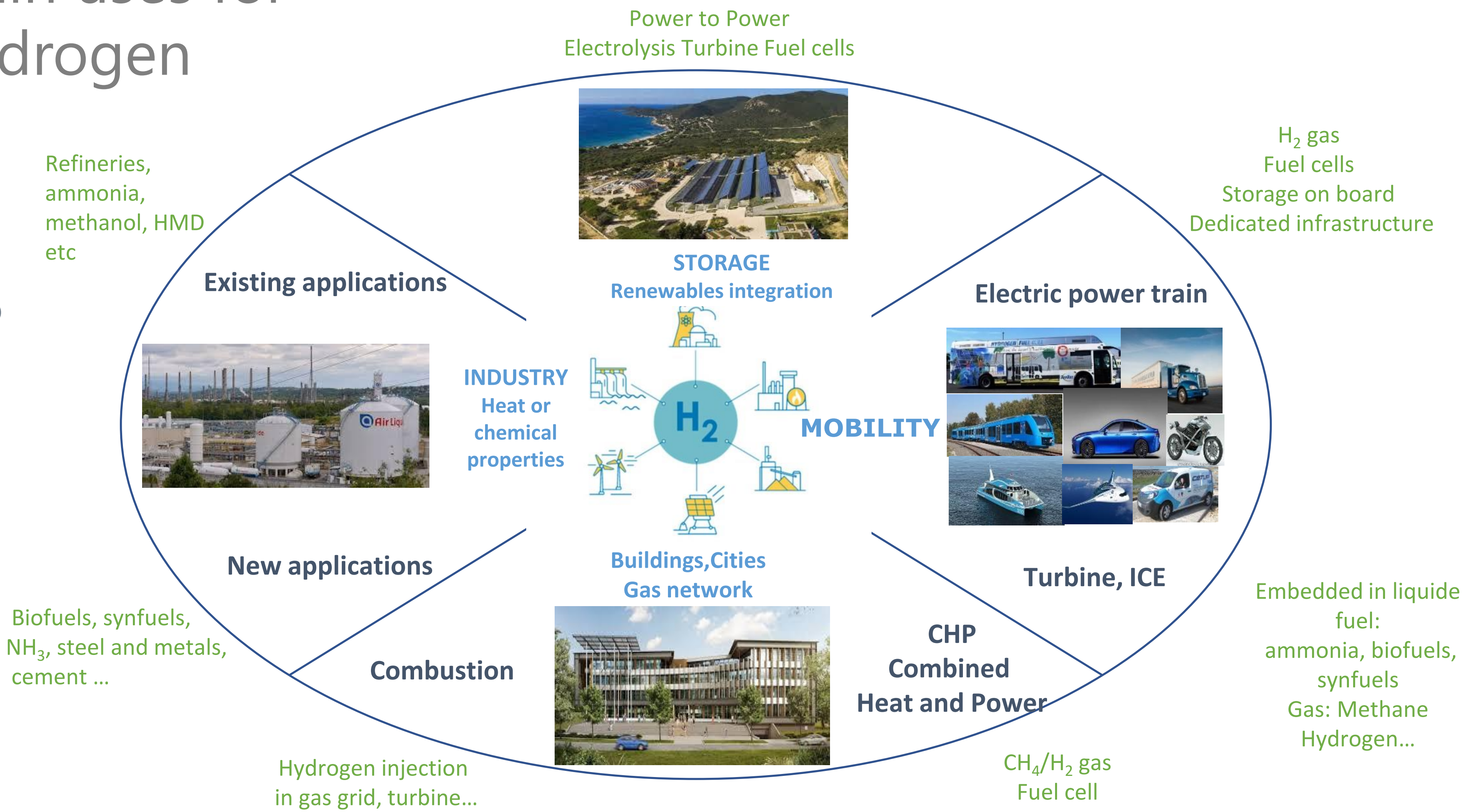
Reminder: 4 main uses for Low Carbon Hydrogen

Hydrogen will be key to:

- Sector coupling
- Flexibility
- Decarbonizing hard to abate sectors
- Optimizing existing assets
- Energy security and economic growth (local production)
- Energy access (isolated locations)



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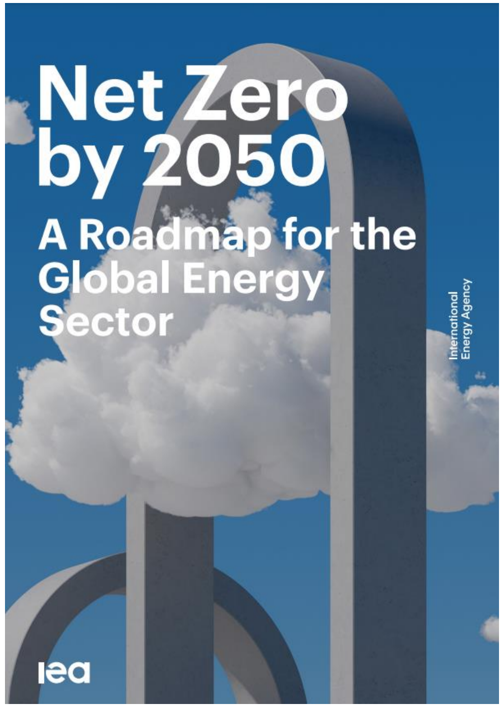
Why Hydrogen?

Global hydrogen use expands from
less than 90 Mt in 2020 to
To reach 400-600 Mt in 2050!!
And represent 10 to 20% of final energy demand



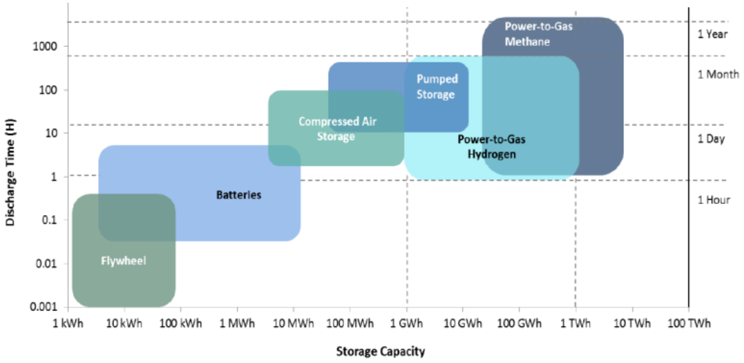
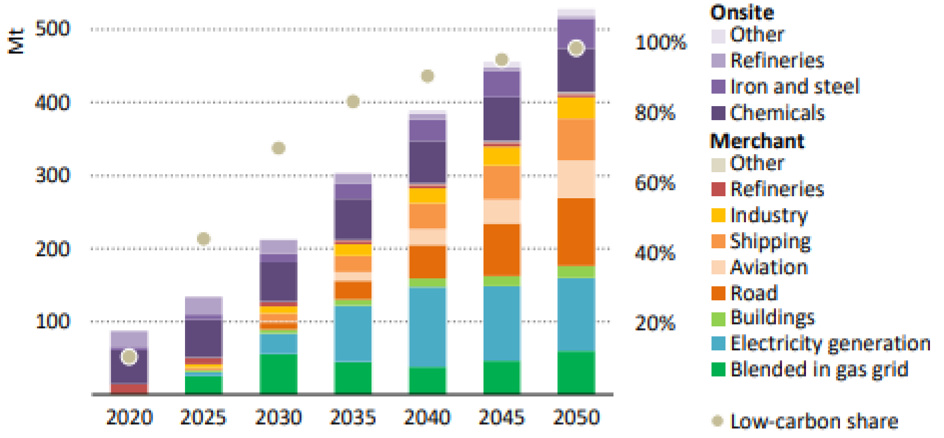


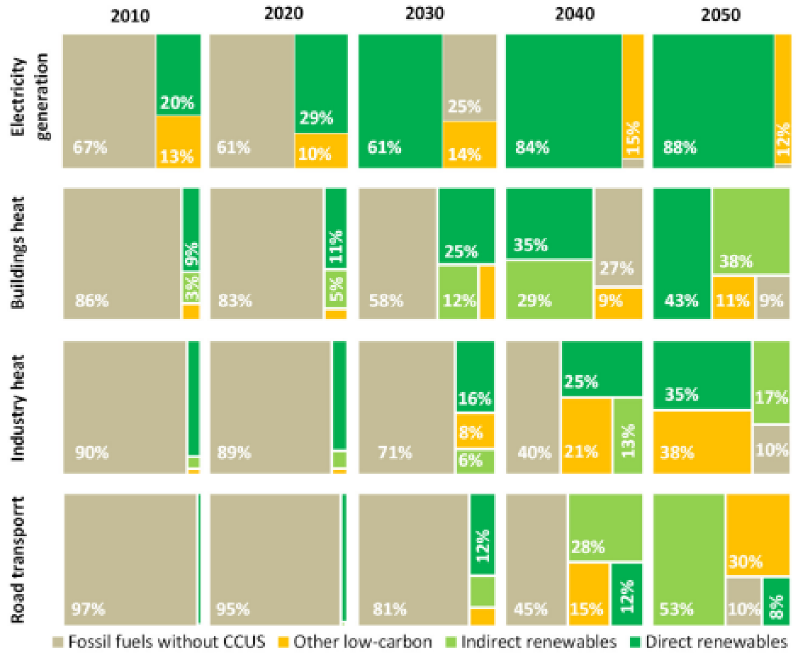
Figure 2.19 ▷ Global hydrogen and hydrogen-based fuel use in the NZE



The initial focus for hydrogen is to convert existing uses to low-carbon hydrogen; hydrogen and hydrogen-based fuels then expand across all end-uses

Note: Includes hydrogen and hydrogen contained in ammonia and synthetic fuels.

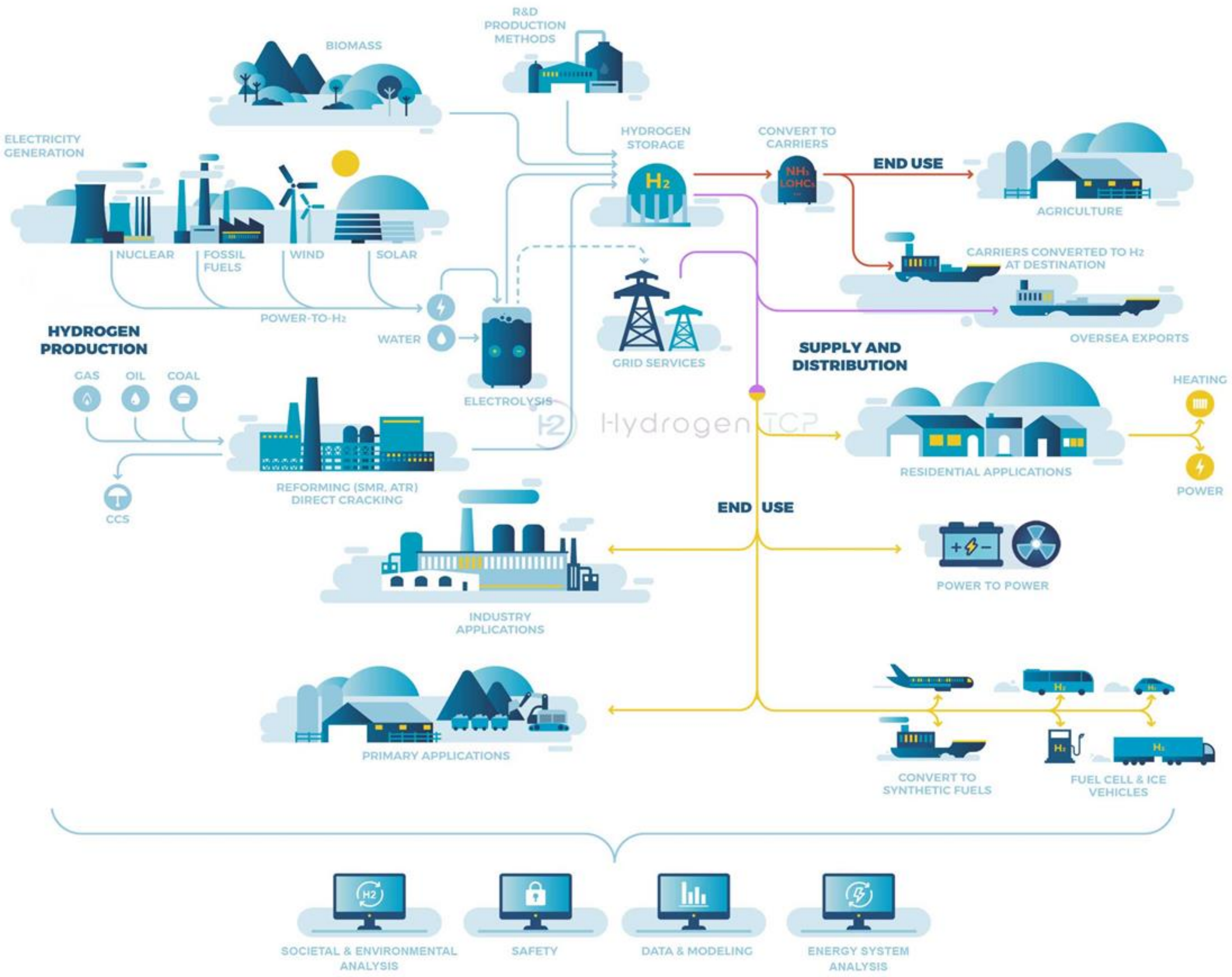
Figure 2.18 ▷ Fuel shares in total energy use in selected applications in the NZE



Renewables are central to emissions reductions in electricity, and they make major contributions to cut emissions in buildings, industry and transport both directly and indirectly

Notes: Indirect renewables = use of electricity and district heat produced by renewables. Other low-carbon = nuclear power, facilities equipped with CCUS, and low-carbon hydrogen and hydrogen-based fuels.

Hydrogen Value Chain



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What are the main challenges?

1. Scale up, Total cost of the whole hydrogen chain and business models
2. Regulatory framework: green, decarbonized hydrogen
3. New Geopolitics of Hydrogen: hydrogen as a commodity or limiting factors ?

What does scale-up mean if hydrogen represents 10 - 20 % of final energy demand ?

Renewables PV and Wind: 1 300 GW deployed

Climate change target : X by 30 to 60

From 1,3 TW to 50-100 TW (100 000 GW)

Investment from 380B $/year (2020) to 1 600B$/year 2030

<u>Hydrogen in 2030: objectives</u>

World 40 millions tons (equivalent 270 GW full time)

Europe: 40 GW ou 2x40 GW electrolysers near 7 millions tons

<u>Hydrogen in 2050 - 2070</u>

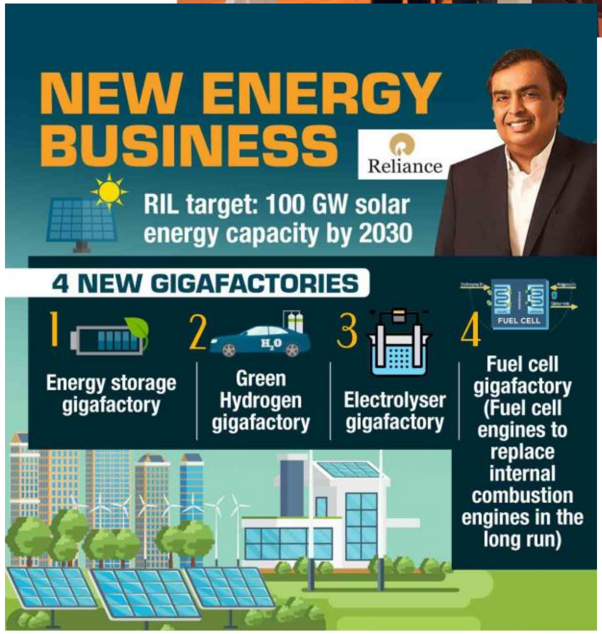
15 % final energy consumption

IEA: 420 Millions tons (**<u>x6 today's production</u>**)

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



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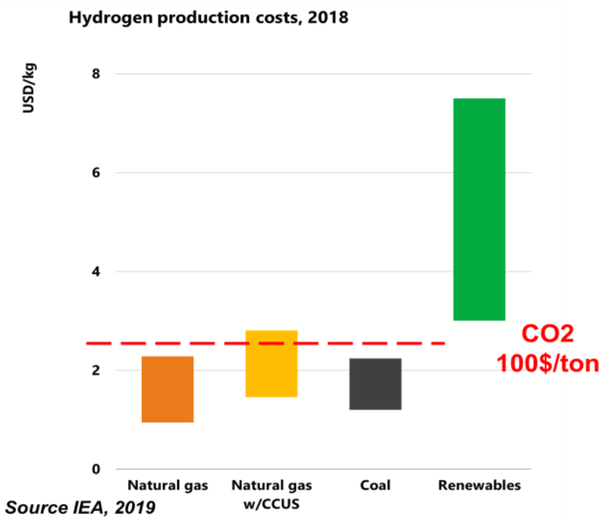
Total cost of hydrogen

Basic Equation

Total cost (LCOH) = cost of production + cost of transport/storage + cost distribution/storage + cost CO_2 taxes

Cost of production (Electrolyzer pathway) = Function (electricity cost, capex, load factor)

TCO (Total Cost of ownership) = Cost of Hydrogen + Capex (vehicle, process, etc) + OPEX



Source IEA, 2019
The future of Hydrogen, Webinar

A wide range for infrastructure, transport, distribution and storage costs

Elements	New pipe line Long distance (5000t/d)	Adapting existing pipe lines Long distance(5000t/d)	Salt cavern storage	Liquid H2, NH3 LOHC Hydrogen carrier	Local pipe line (100t/d)	Regional distribution (50-300km)
Cost/Kg H2* 2020-2030	0,2 $/1000km	0,1$ /1000 km	0,25-0,5 $ /cycle month	**3-7 $**	0,1 $ (100km)	**1-3,5 $**
Cost/Kg H2* 2050	0,1 $/1000km	-	0,1$/cycle month		0,06$	

- **Low carbon Hydrogen costs are country-dependent, costs of local energy, local electricity cost, existence of CCS possibilities, CO2 price, and also distance of an end-use application, industrial H-based process etc…**

Business models are application-dependent

- BM: Order of merit: Easier for transport than industry, gas grid injection and Power To Power

- Importance of public funding and incentives

- Debate on business model local ecosystem, semi-centralized production hub or centralized/Import model

- Question of transport infrastructure will be key

- Matter of time and deployment

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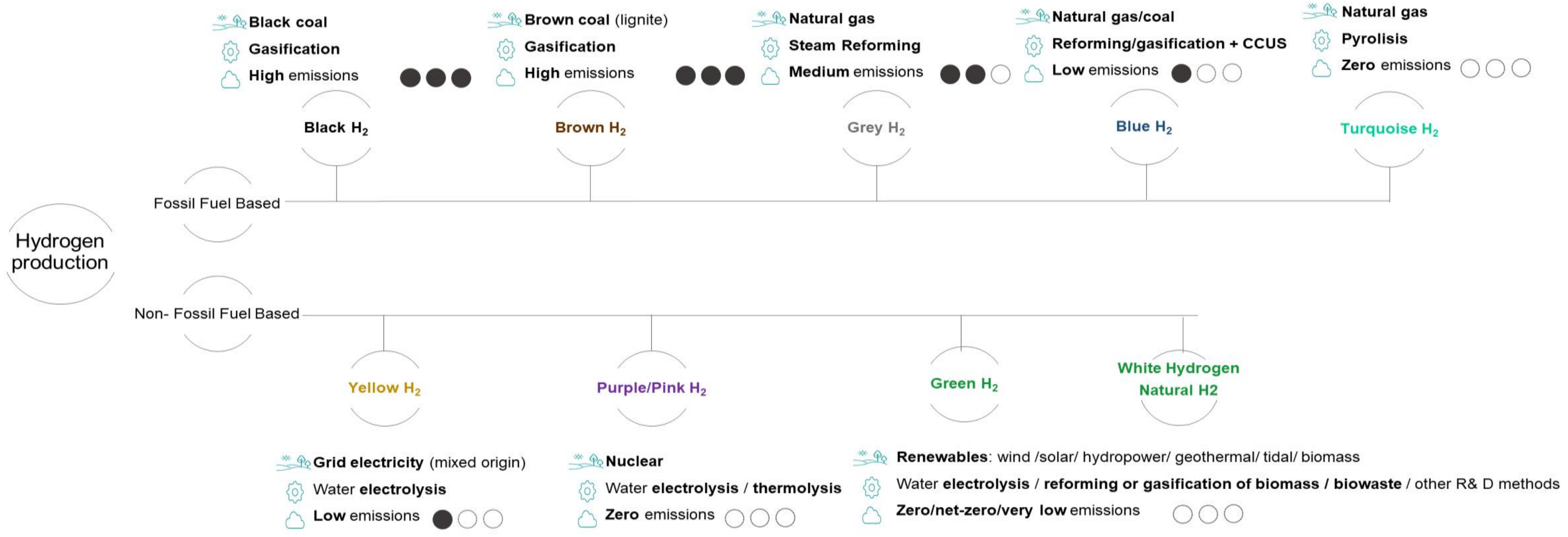
Need for an appropriate Regulatory Framework

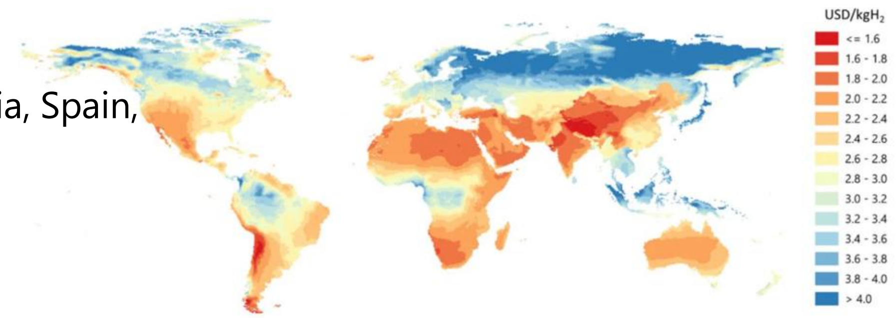
The colours of hydrogen



1. Guarantee of Origin, low carbon or Renewable Certificate
2. Complex contractual framework (PPA…) Risks for investors
3. CO_2 price
4. E-fuels certification
5. Safety
6. Codes and Standards

New geopolitics of hydrogen

Hydrogen costs from hybrid solar PV and onshore wind systems in the long term



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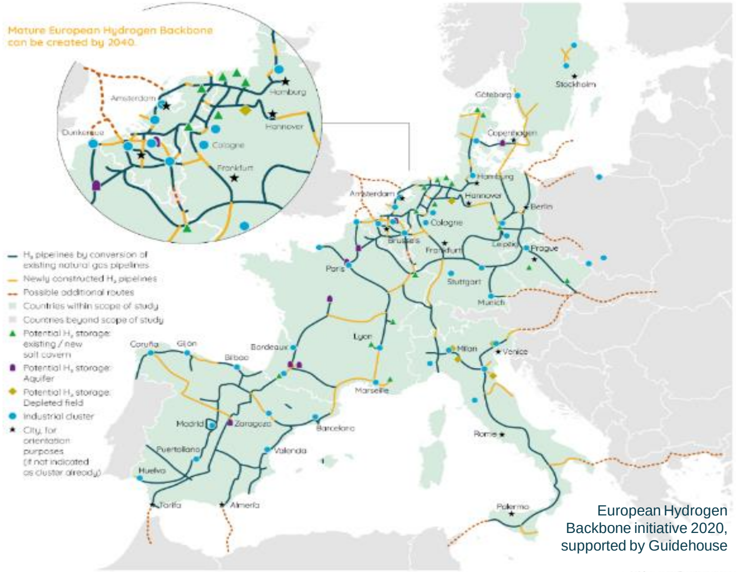
The future of Hydrogen, Webinar

- Reaching 1€/Kg or less is more than likely in medium term in some areas
- Many projects and bilateral Agreements between Governments (Japan, Germany, Australia, Spain, The Netherlands, Persic Gulf, Chile, etc)
- Main Bottlenecks for Hydrogen export:
  - Cost and efficiency of hydrogen carriers (LOHC, NH_3, Methanol) for overseas transport
  - Large pipes transport grid at inter-regional level
  - Hydrogen carrier must be more energy intensive at Export port than in Import Port
  - International regulation and framework for international trade
  - Renewables projects at scale will take decades ?
- Producing and exporting hydrogen-based products used as such (avoiding one transformation step)

  >> New industrial Landscape
  - Ammonia for direct combustion, E-fuels for ICE and turbines, Steel industry delocalized ?
- What will be the trade off between pure H_2 use and indirect use?



European Hydrogen Backbone initiative 2020, supported by Guidehouse

Hydrogen TCP

Which could be the limiting factors for renewable hydrogen?

- Critical or current materials, circular economy
- Security of supply and geopolitics
- Land use and social acceptance
- Technological breakthroughs
- Safety

Cumulative demand 2050 compared to proved reserve in 2010

Ratio maximum de la demande cumulée de matériaux à l'horizon 2050 rapporté aux ressources prouvées 2010*

	Scénario 4 °C	Scénario 2 °C
Cobalt	62,2 %	93,6 %
Cuivre	82,7 %	96,1 %
Lithium	17,1 %	26 %
Nickel	48,5 %	56,6 %
Terres rares	1,6 %	3,8 %

Land usage: Nuclear 4-10 ha/TWh, PV 500-800 ha/TWh
Concrete and steel: A nuclear plant need 8 to 10 times less concrete and 10 to 20 times less steel per TWh

Limiting factors

- Critical materials Pt Ir Sc Y La Ce Zr Gd)
- Plus PV Wind critical material Cu …
- Land use: 1 TW= 10 000 km2
- Long distance transport infrastructure

Hydrogen TCP: Current Members

32 Members

24 Member Countries
6 Sponsors
European Commission + UNIDO

40+ Tasks

4 Ongoing
38 Finished
≅ **10** in definition

250+ Experts involved

In collaborative research on hydrogen and hydrogen technologies

Status + Strategic Plan (2020-2025)

32

Members

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6 Sponsors

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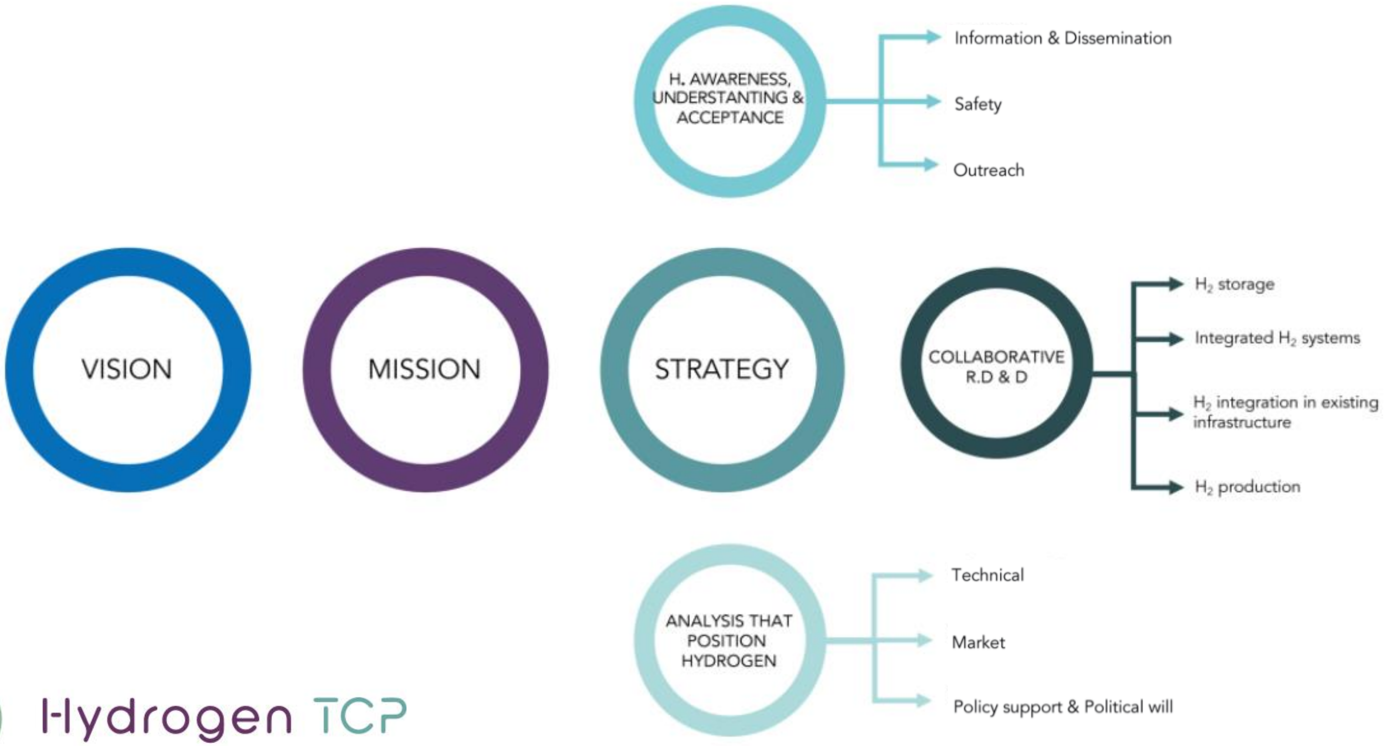


Vision

A hydrogen future based on a clean, sustainable energy supply of global proportions that plays a key role in all sectors of the economy

Mission

Accelerate H_2 implementation and utilization to optimize environmental protection, improve energy security and economic development

Strategy

Facilitate, coordinate and maintain innovative research, development and demonstration activities through international cooperation and information exchange

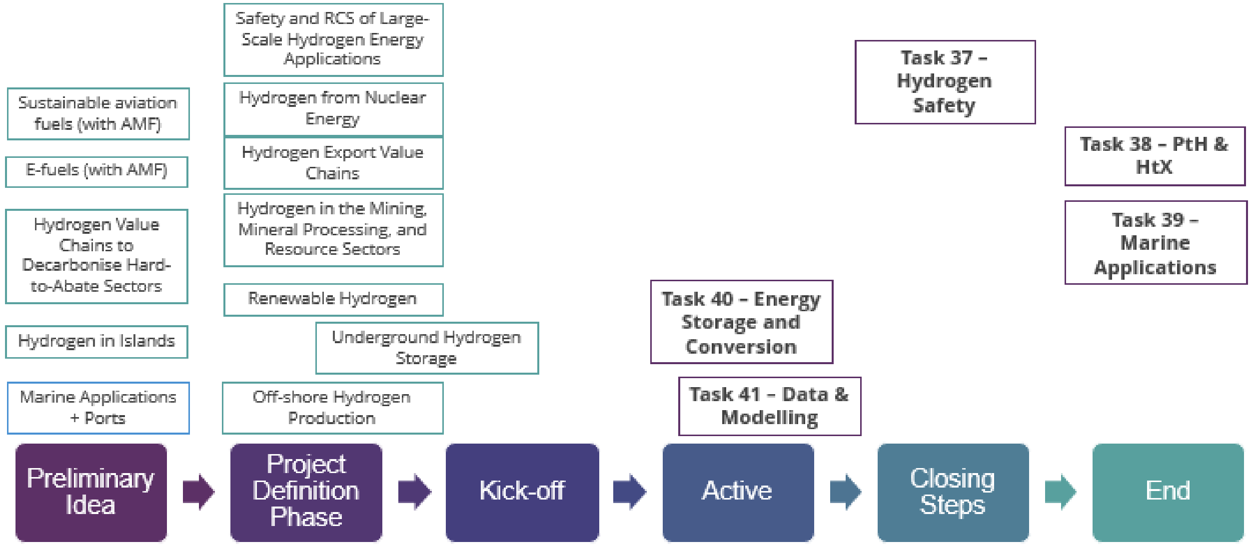
Perspectives

- Publish **Final Report** Task 37 - Hydrogen Safety and other **Task deliverables** (Task 40 and Task 41). *Task 38 and 39 Final Reports already available in our website.*
- Start new **Tasks** (currently in definition)
- Welcome new **members**
- Boost **collaboration** both within and outside the IEA Network

Hydrogen TCP

Tasks Portfolio Status

October 2021



Hydrogen Coordination Group

With other TCPs...

With other organizations...

Thank You!

For more information, please contact Marina Holgado, Technical Secretariat Coordinator:
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