GOVERNANCE OF GREEN HYDROGEN IN LATIN AMERICA

Sector Network GADeR-ALC
Environment and Rural Development in Latin America and the Caribbean

cooperación alemana

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Universidad de La Sabana

Welcome

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Environment and Rural Development
in Latin America and the Caribbean

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TEAM PRESENTATION

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ANDREA ZAPATA
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Materias Primas y Clima (MaPriC)

TEAM PRESENTATION

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JAVIER SALAS
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TEAM PRESENTATION

MÁXIMO FERNÁNDEZ
COSTA RICA
Utilización del Calor Geotérmico en Procesos Industriales en los Países Miembros del SICA (GEO II)
Mitigación de emisiones en el sector transporte de Costa Rica (MiTransporte**)**

MYRIAN MELLO
PARAGUAY

Portafolio de Cooperación Triangular de GIZ Paraguay

CLAUS-BERNHARDT JOHST
EL SALVADOR
Utilización del Calor Geotérmico en Procesos Industriales en los Países Miembros del SICA
(GEO II)

TEAM PRESENTATION
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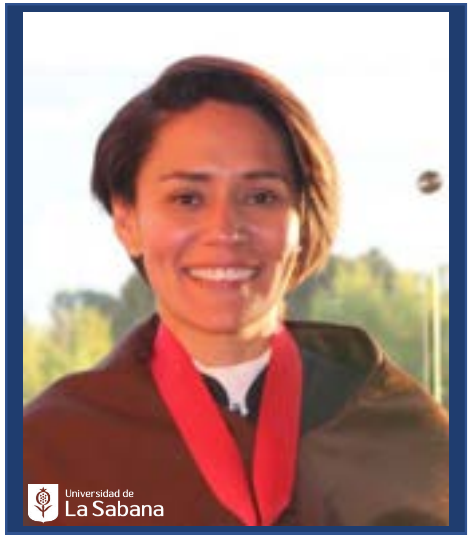

MARTHA ISABEL COBO ÁNGEL
PhD in ENGINEERING
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PhD in MECHANICAL ENGINEERING
Professor

NELLY MARGARETH CANTILLO CUELLO
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PAULA NATALIA RIVEROS MELO
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COURSE'S TOPICS

01 GREEN HYDROGEN IN LATIN AMERICA

02 PUBLIC POLICIES FOR GREEN HYDROGEN

03 REGULATORY FRAMEWORK FOR GREEN HYDROGEN

04 GREEN HYDROGEN GOVERNANCE

05 RECOMMENDATIONS FOR GREEN HYDROGEN

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CASE STUDIES

During our sessions, we will study the cases of

- Chile → National Green Hydrogen Strategy → It will give us a perspective at the local level (Latin America)
- Germany → National Hydrogen Strategy → Will give us a global perspective

PLATFORMS

wooclap

MURAL

GREEN HYDROGEN IN LATIN AMERICA

AGENDA

01 ENERGY (9:00 am)
IN OUR LIFE

02 PARTICIPATORY ACTIVITY N°1 (9:05 am)
TYPES OF HYDROGEN

03 GENERAL CONCEPTS (9:10 am)
OF GREEN HYDROGEN

04 PARTICIPATORY ACTIVITY N° 2 (9:30 am)
HYDROGEN VALUE CHAIN

05 GREEN HYDROGEN (9:35 am)
VALUE CHAIN

AGENDA

06 STATUS QUO (9:50 am)
OF GREEN HYDROGEN

07 BREAK (10:05- 10:20 am)

08 MAIN CHALLENGES (10:20 am)

09 POTENTIAL (10:25 am)

10 PARTICIPATORY ACTIVITY N°3 (10:30 am)
MAIN CHALLENGES AND POTENTIAL
(SWOT MATRIX)

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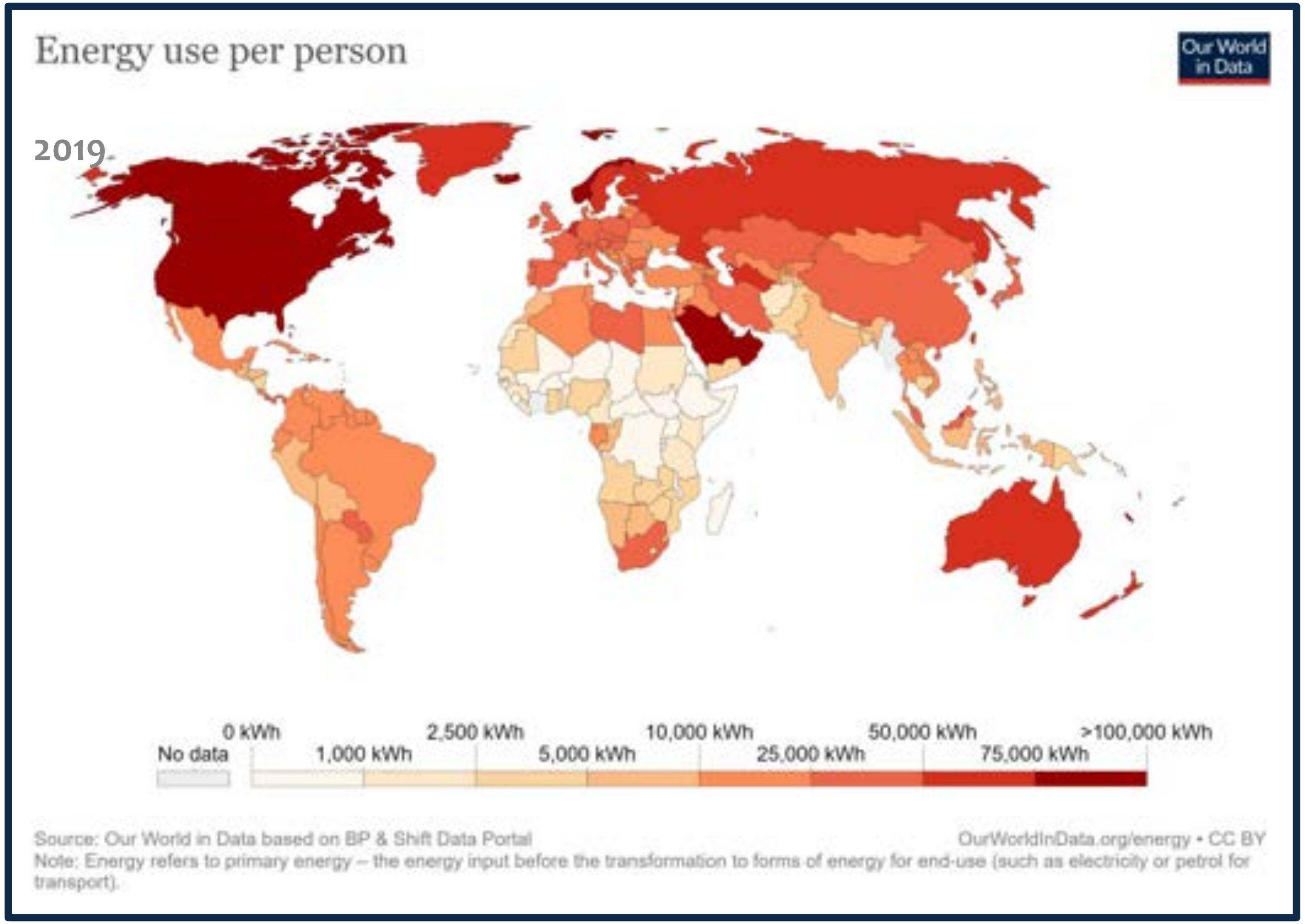
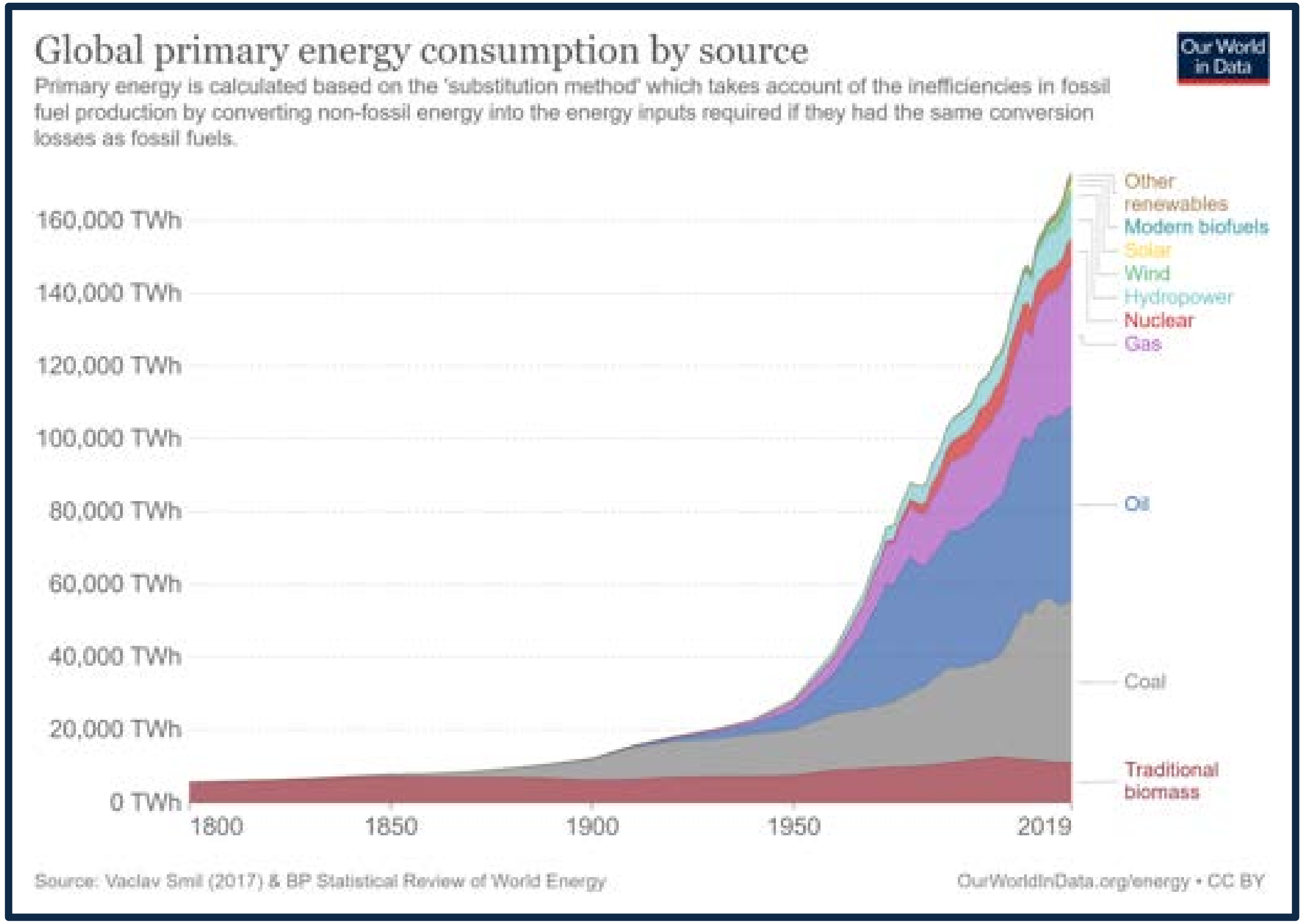
Energy is needed for economic and social growth

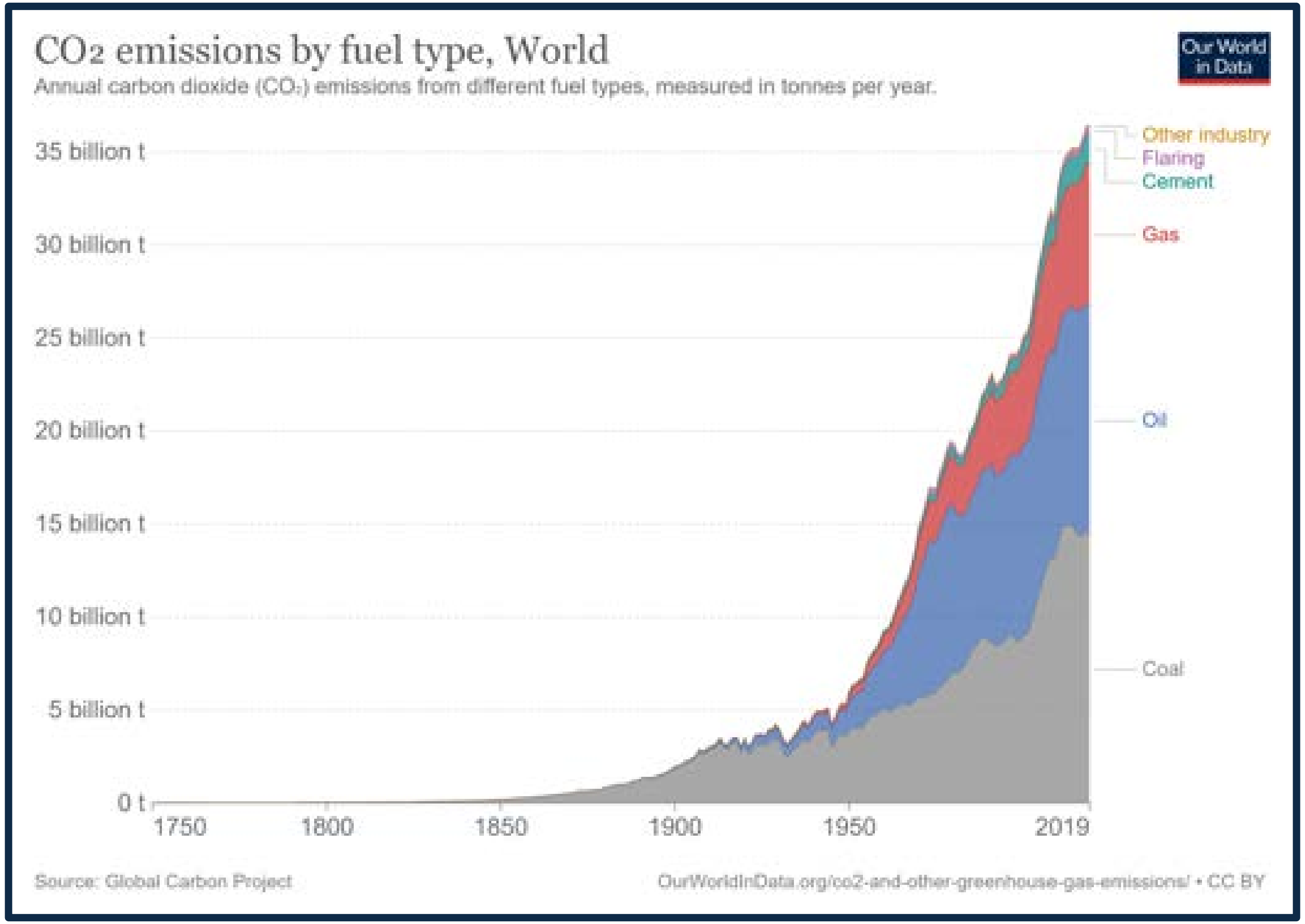


ENERGY IN OUR LIFE



ENERGY IN OUR LIFE

The last decades, green house gases have continuously increased in the environment. It is desirable and necessary to reverse this trend.



energies2050.org

carbonbrief.org/

GOAL

Prevent the global temperature from rising more than 2 °C

TARGET

For 2030 cutting emissions to at least 50% below 1990 levels

COP 21 & COP 25

Promote the development of sustainable energies

PARTICIPATORY ACTIVITY N°1

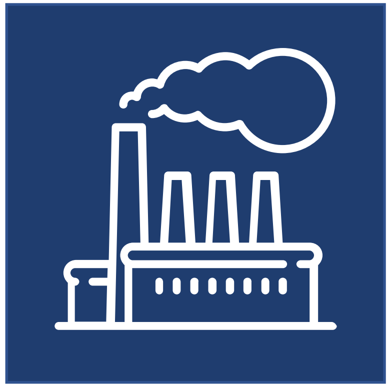
LINK www.wooclap.com/RNCYGS

What is green H_2?

GENERAL CONCEPTS

HYDROGEN

Hydrogen is the most abundant element in the universe



It is used as an input in the:

- Refining of petroleum,
- Production of ammonia
- Methanol industry
- Steel industry

Demand of 70 million tons per year.

It is produced mainly from fossil fuels, releasing polluting emissions.

Hydrogen classification

↓

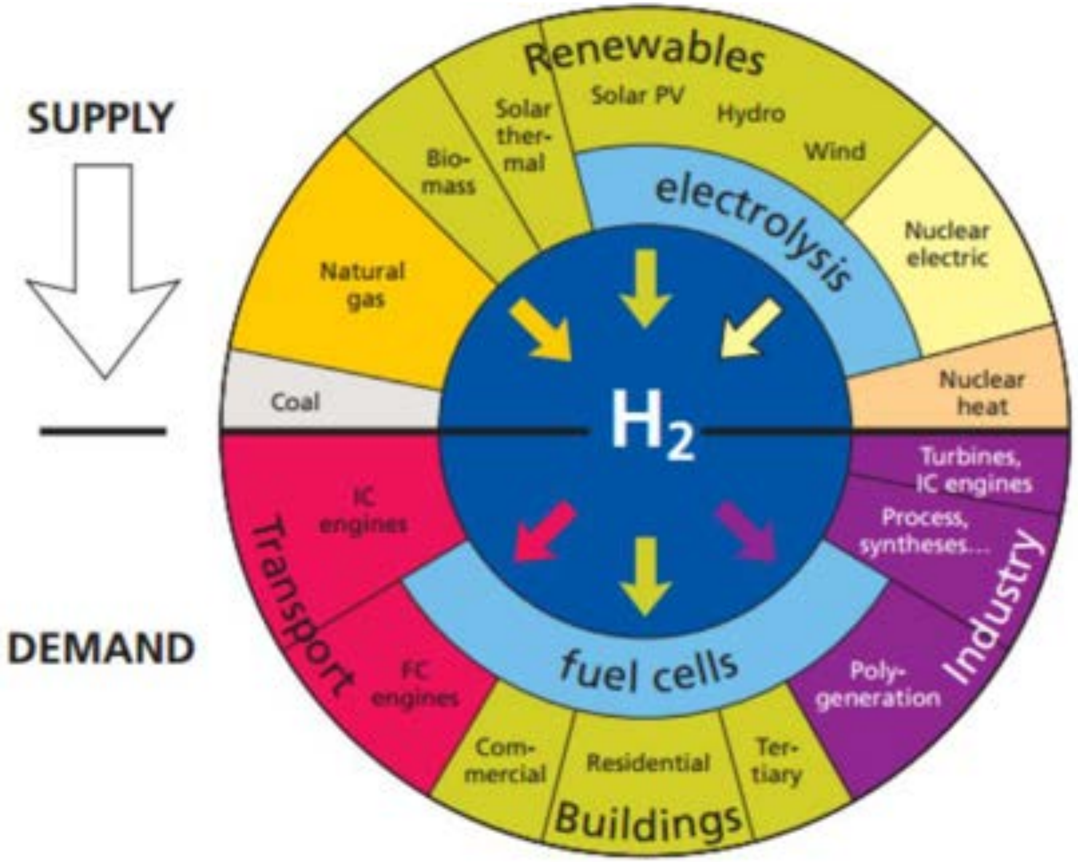
According to the degree of contamination of each type

- Gray hydrogen → It is the most polluting, it comes from non-renewable sources
- Blue hydrogen → Comes from non-renewable sources, carbon capture technologies are usually implemented to mitigate the impacts
- Green hydrogen → Comes entirely from renewable energy, low emissions

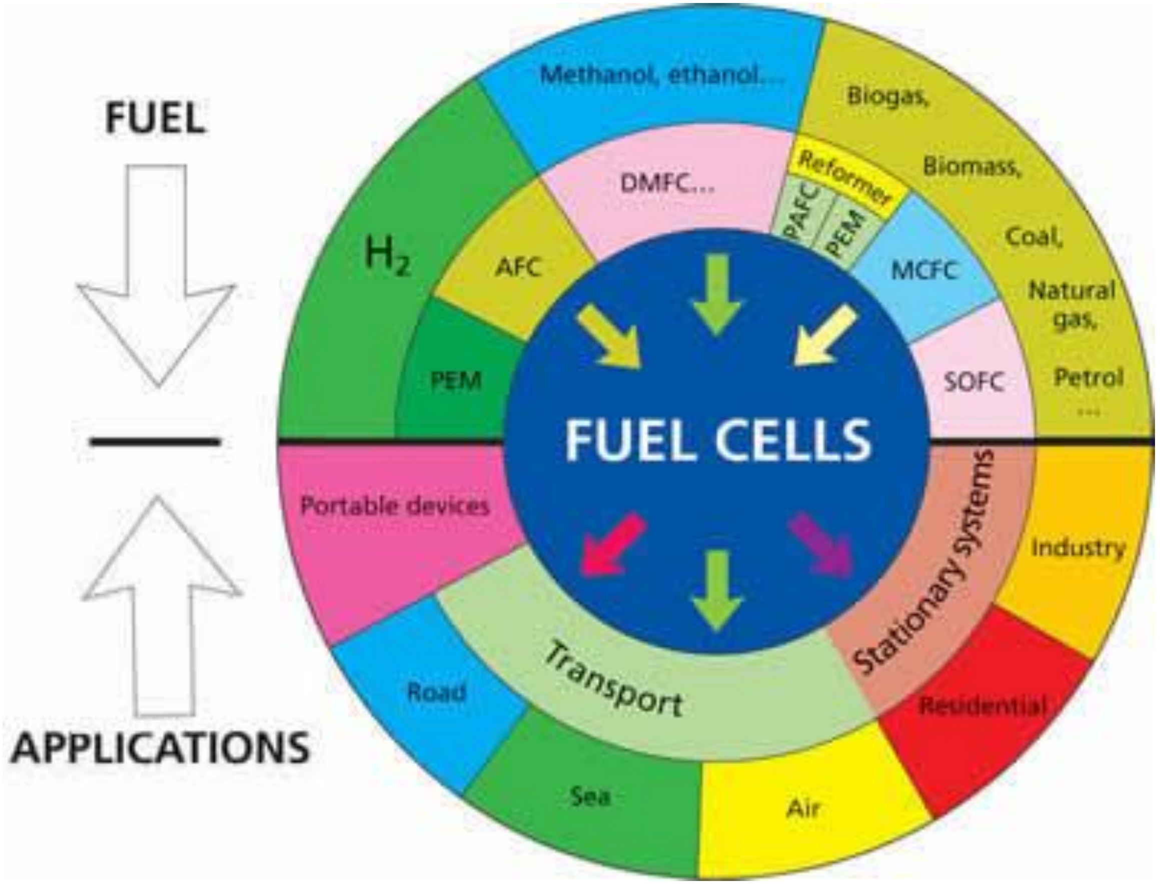
GENERAL CONCEPTS

THE HYDROGEN ECONOMY

Hydrogen: primary sources, energy converters and applications[3]



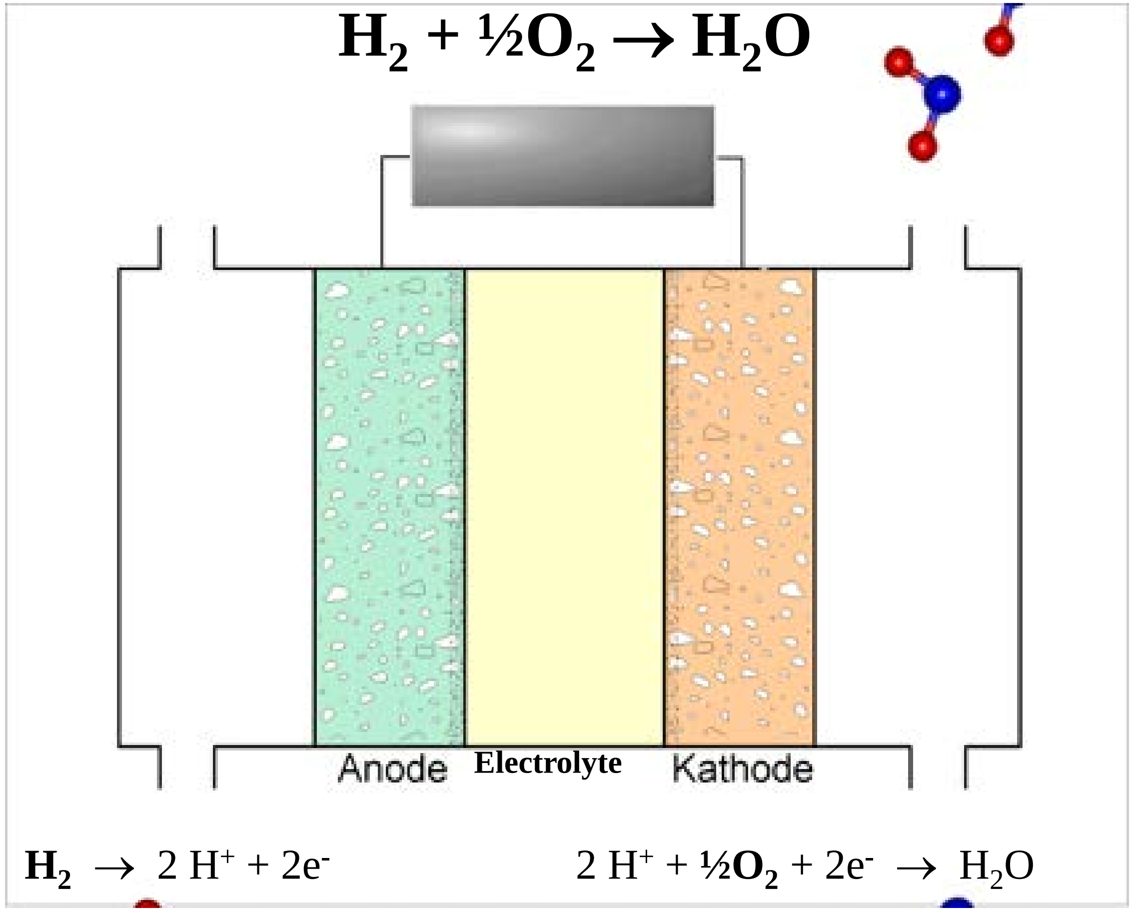
Taken form: European Commission. Hydrogen energy and fuel cells. A vision of our future. 2003.



Powering:

- Homes
- Buildings
- Spaceships
- Cars
- Trucks

PRINCIPLE OF A PEFC

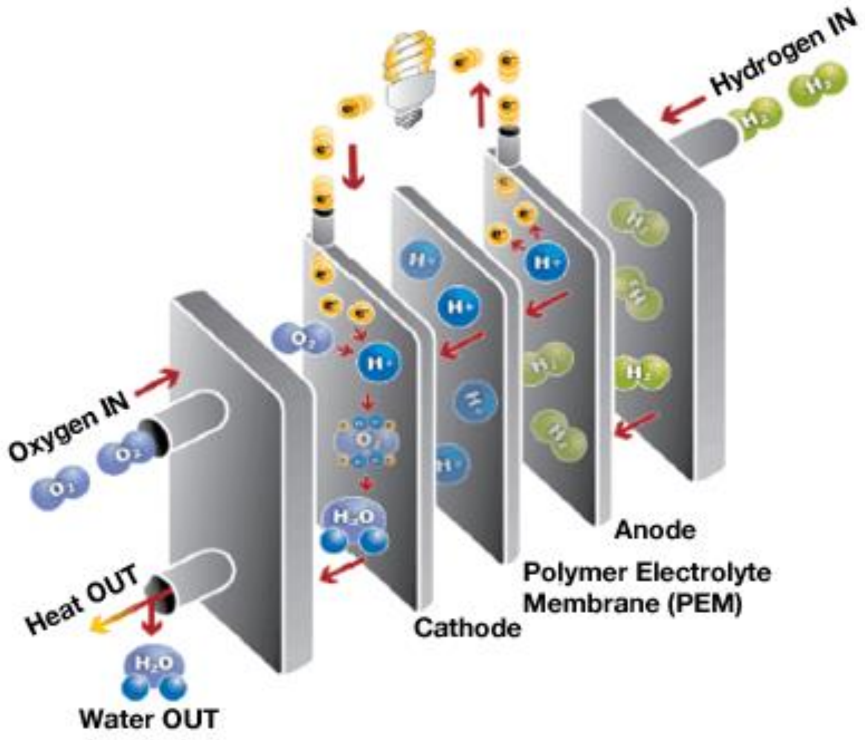


Hydrogen

Oxygen

GENERAL CONCEPTS

FUEL CELLS FED WITH H_2

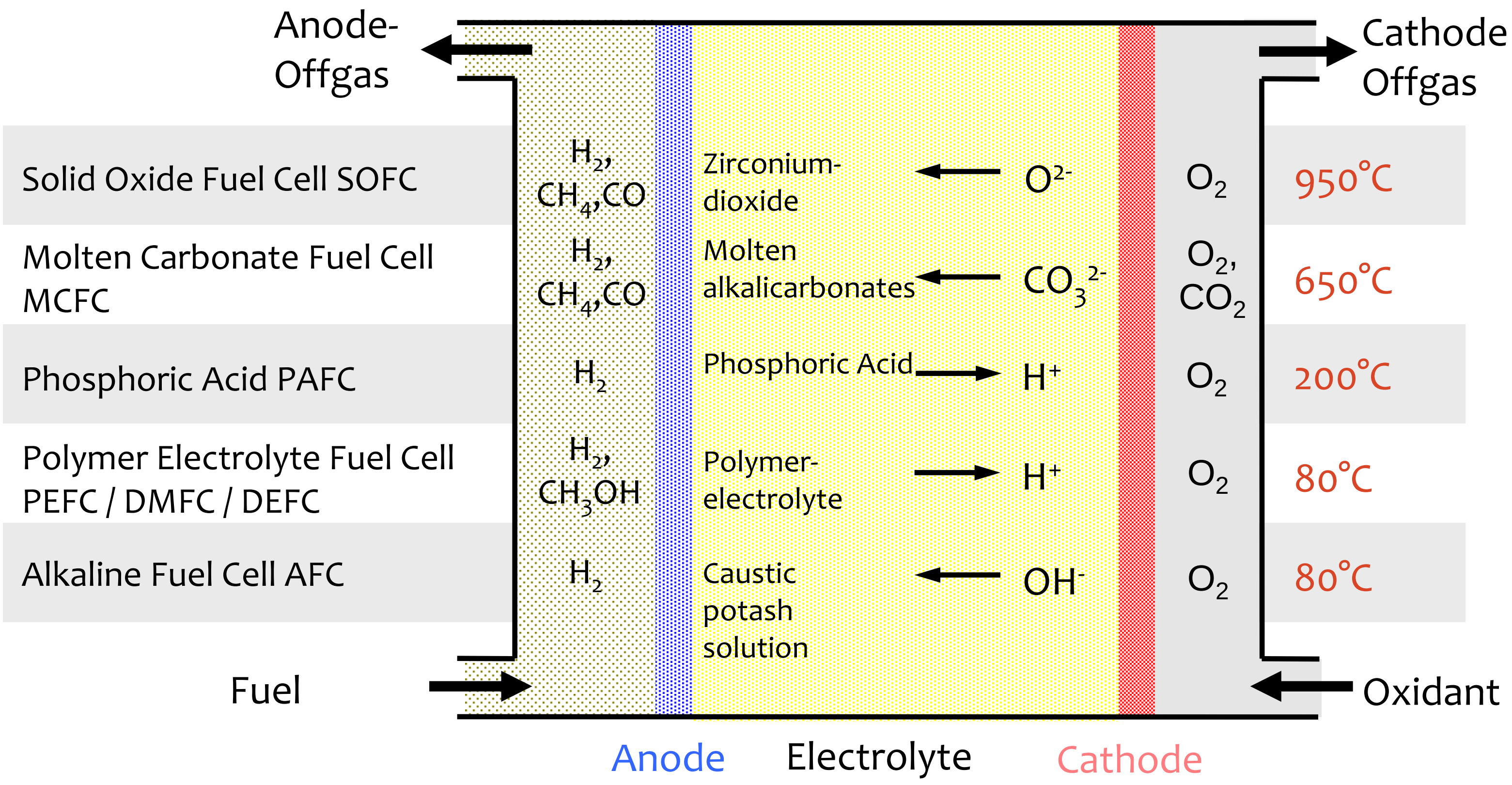


Taken from: http://ttsilogistics.com/sustainability/hydrogen.html

Directly convert the chemical energy into hydrogen to electricity, with pure water and potentially useful heat as the only byproducts.

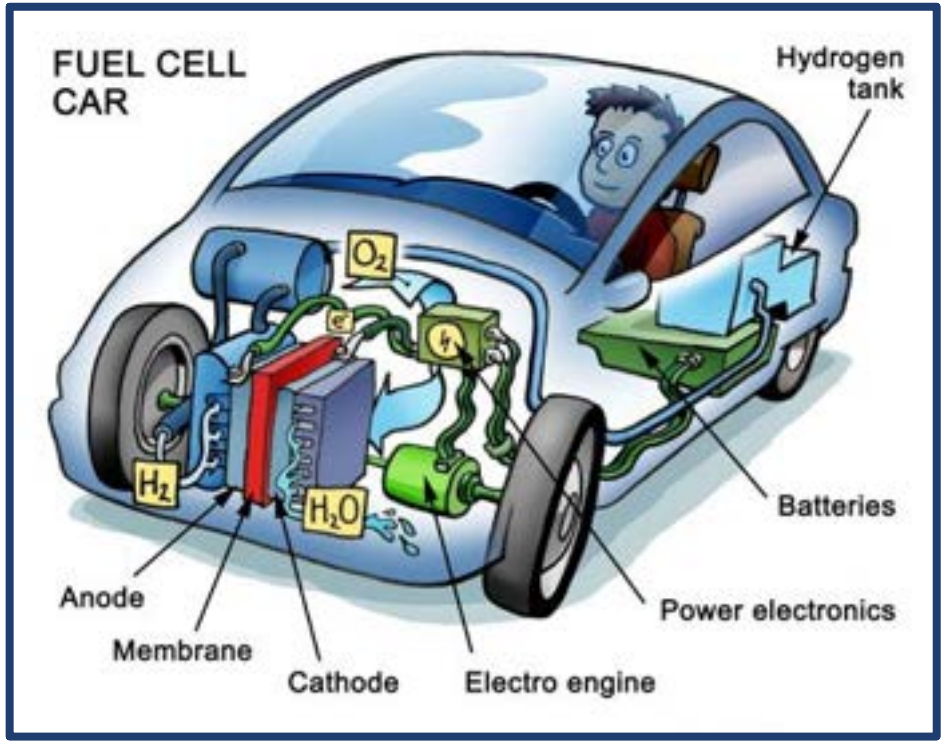
Hydrogen-powered fuel cells are not only pollution-free but can also double the efficiency of traditional combustion technologies.

TYPES OF FUEL CELLS



GENERAL CONCEPTS

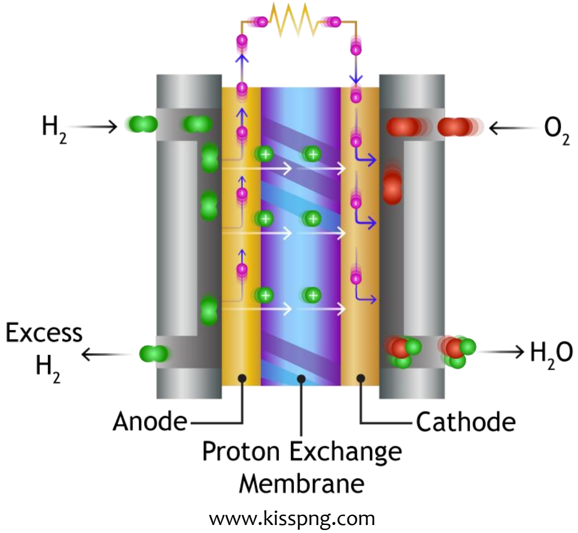
FUEL CELL VEHICLES



Taken from: https://en.wikipedia.org/wiki/Fuel_cell and http://www.caranddriver.com/photo-gallery/hyundai-tucson-ix35-hydrogen-fuel-cell-electric-vehicle

GENERAL CONCEPTS

FUEL CELL ADVANTAGES & DISADVANTAGES



ADVANTAGES [1]

- Fuel cells have higher efficiency (~70%) than internal combustion engines.
- Fuel cells do not pollute.
- Fuel cells can be integrated to several commercial devices

DISADVANTAGES [2]

- It is an emerging technology with high cost.
- Several units (equipment) are required to produce and purify hydrogen.

[1] Junye Wang, Hualin Wang, Yi Fan; Engineering, 4, 3 (2018) 352 - 360.

[2] Bernay Cifuentes, Felipe Bustamante, Juan A. Conesa, Luis F. Córdoba, Martha Cobo; Int J Hydrogen Energy, 43, 36 (2018) 17216 - 17229,

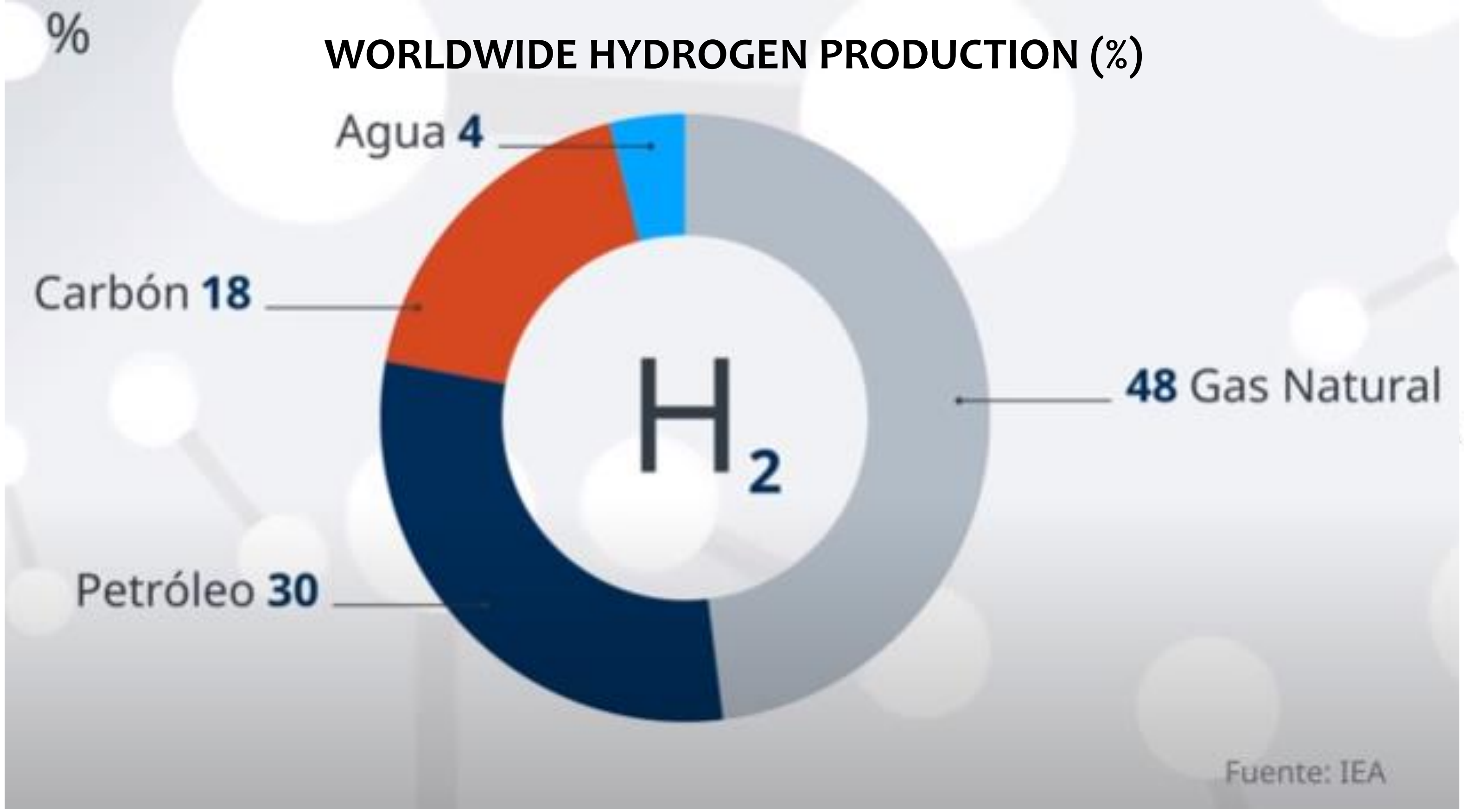
QUESTIONS AND ANSWERS

PARTICIPATORY ACTIVITY N°2

wooclap

In which sectors can green hydrogen be implemented?

LINK: www.wooclap.com/**RNCYGS**



TAKEN FROM: DEUTSCHE WELLE: GREEN HYDROGEN: A TURNING POINT FOR LATIN AMERICA?

Most of the hydrogen produced worldwide comes from fossil fuels and it is used in applications that generate negative impacts on the environment.

VALUE CHAIN

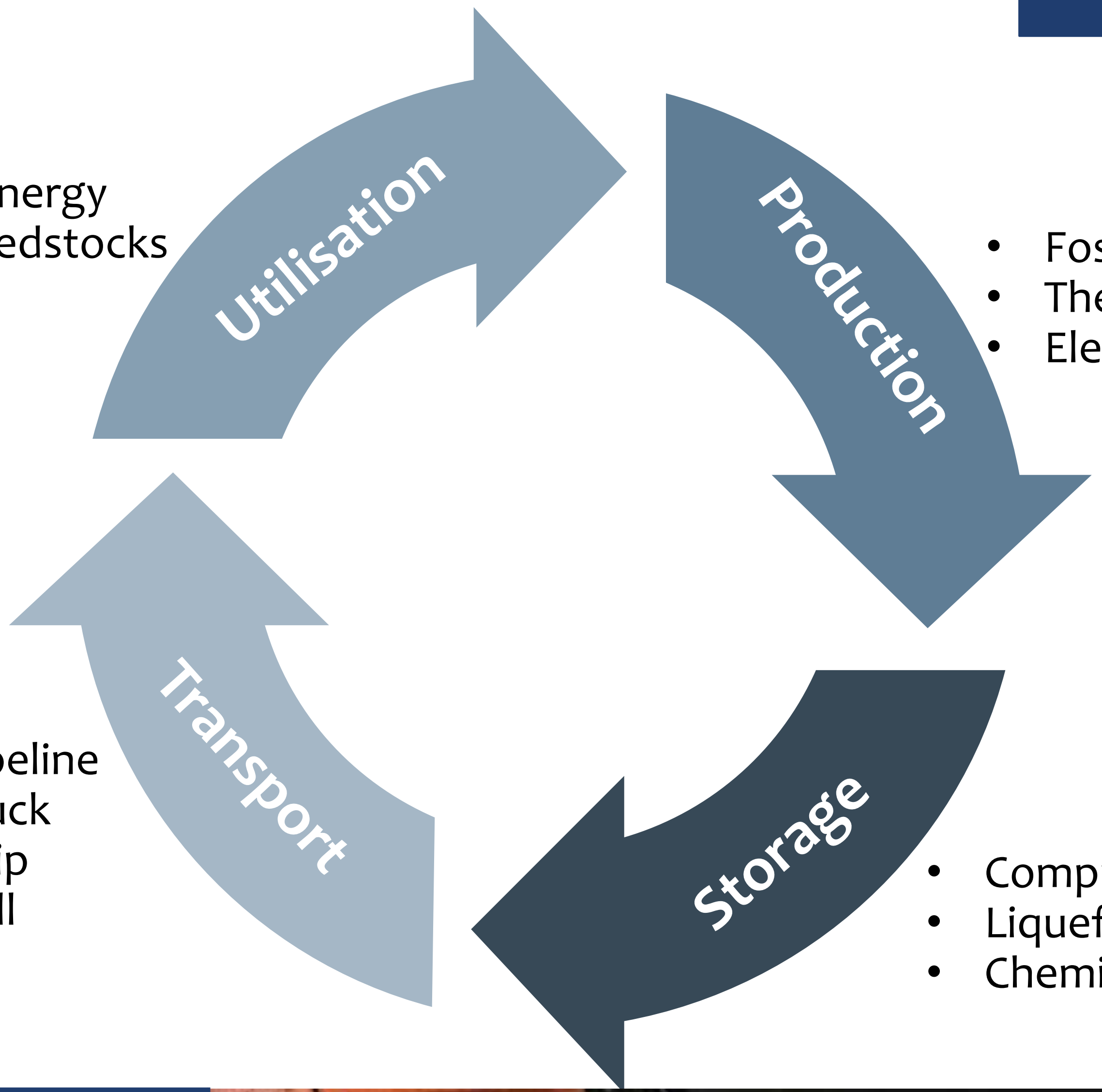
ENERGY SECTOR

TRANSPORTATION SECTOR

INDUSTRIAL SECTOR

VALUE CHAIN

- Heat
- Stationary energy
- Industrial feedstocks
- Transport



- Fossil Fuel
- Thermochemical
- Electrochemical

- Pipeline
- Truck
- Ship
- Rall

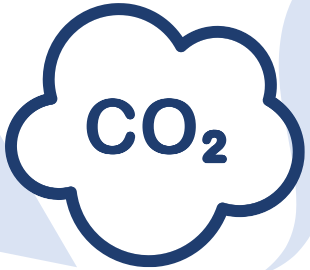
- Compression
- Liquefaction
- Chemical

VALUE CHAIN

PRODUCTION

TERMOCHEMICAL

Use fossil fuels

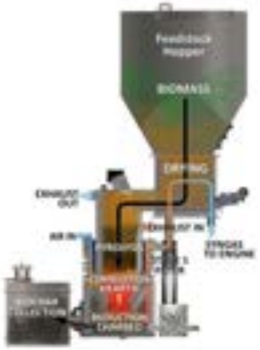


With carbon capture and storage (CCS)

Clean hydrogen

Mature technologies

Depends on gas or biomass gasification



https://www.allpowerlabs.com/gasification-explained

Steam reforming of methane

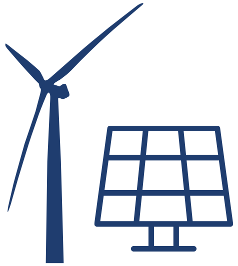
https://www.engineering-airliquide.com/es/produccion-hidrogeno-por-reformado-metano-con-vapor

VALUE CHAIN

PRODUCTION

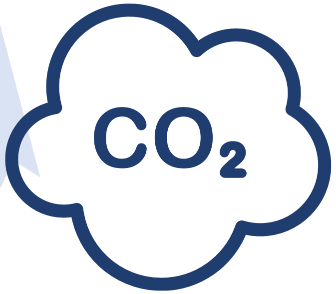
ELECTROCHEMICAL
(Electrolysis)

Use electrical current



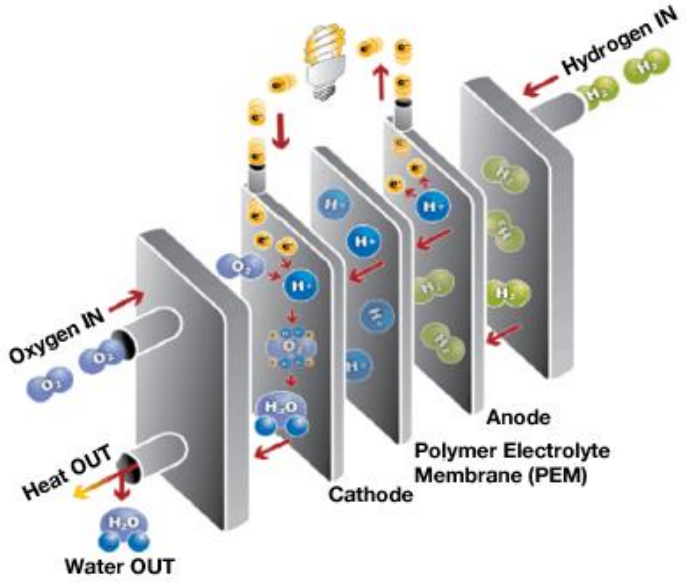
If the electricity comes from renewable sources

Zero-emission hydrogen (green)

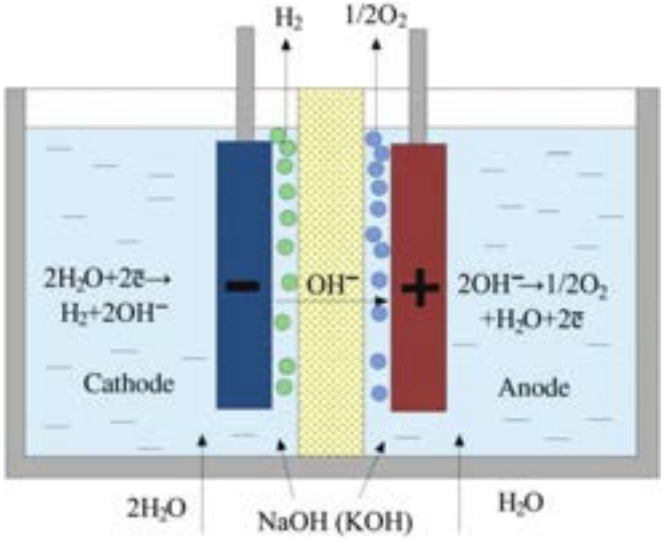


Mature technologies

Polymer electrolyte membrane (PEM)

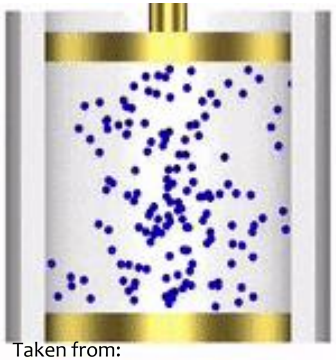


Alkaline Electrolysis (AE)



STORAGE

COMPRESSION



Taken from: https://thumbs.gfycat.com/ImpressiveIckyBison-max-1mb.gif

Compression occurs when a gas decreases in volume with increasing pressure exerted.

Pressurization in steel or carbon compound cylinders

- 35 Bar (more expensive)
- 150 Bar
- 350 Bar

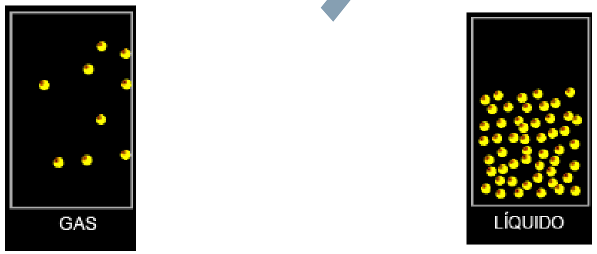
Electrolyzers work better

STORAGE

LIQUEFACTION

Is the change of state

Gaseous state → Liquid state



Taken from:https://usuarios.aulafacil.com/uploads/cursos/3261/editor/materia02.gif

Due to

- ↓ Decrease in temperature (adiabatic expansión)
- ↑ Increase in pressure (isothermal compression)

It is more expensive than compression → RD&D → Improve efficiencies

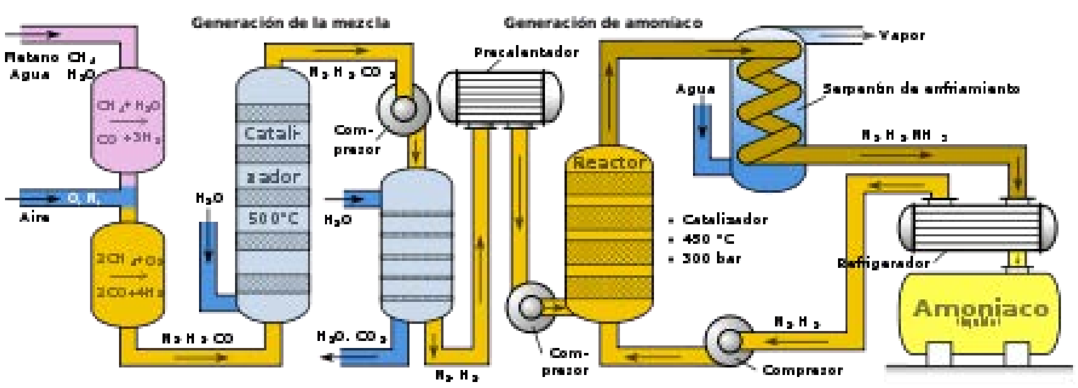
STORAGE

AMMONIA (NH3)

Mainly for export

Requires more energy than liquefaction

Haber Bosch plants are expensive



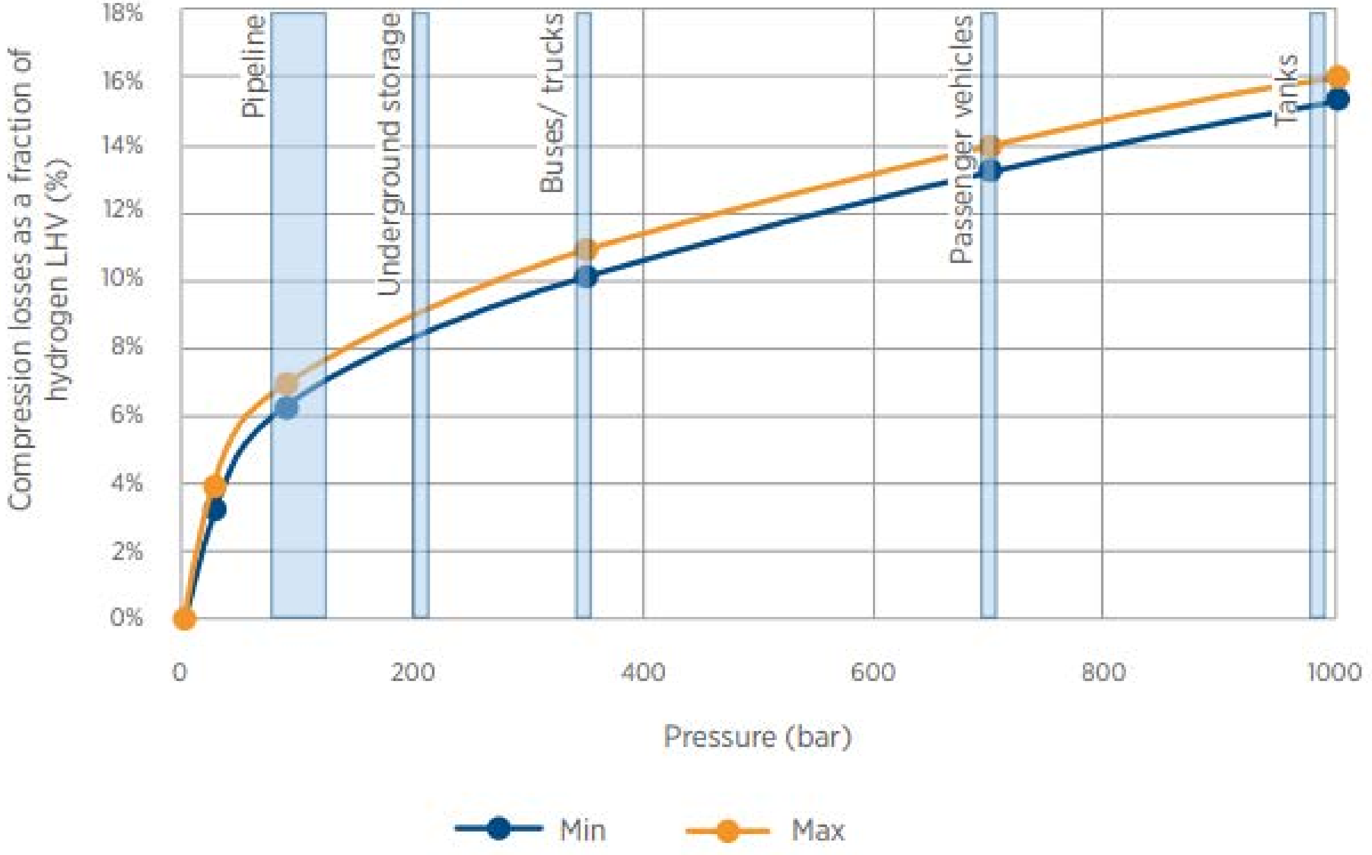
Taken from: https://upload.wikimedia.org/wikipedia/commons/thumb/4/4a/Haber-Bosch-es.svg/450px-Haber-Bosch-es.svg.png

It is the reaction of gaseous nitrogen and hydrogen to produce ammonia.

$$N_{2(g)} + 3H_{2(g)} \leftrightarrow 2NH_{3(g)} + \Delta H$$

MAIN STORAGE METHODS

Energy losses for the multi-stage mechanical compression of hydrogen.

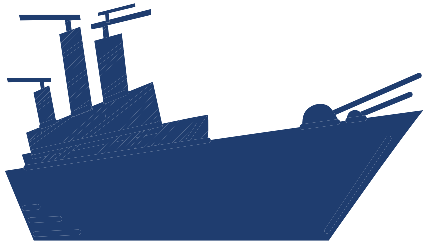


Based on IRENA analysis based on BNEF, 2019.

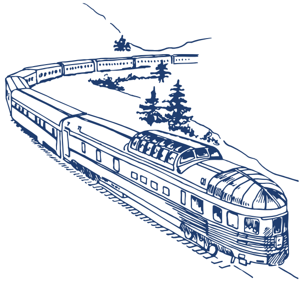
VALUE CHAIN

TRANSPORT

Truck



Ship



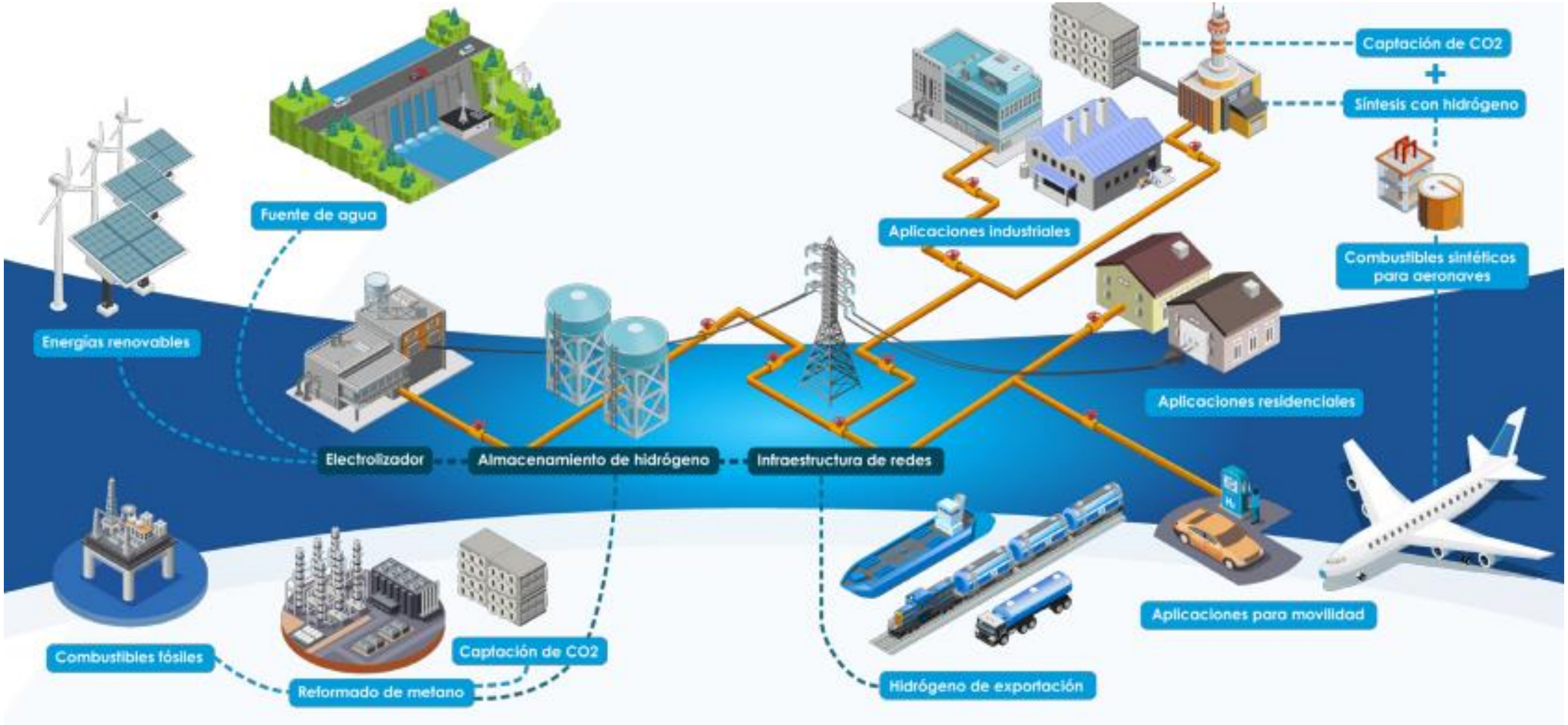
Rail

Compression and liquefaction technologies

Pipeline

- Transportation of large quantities distribution to multiple points of use in a network
- If it is transported through the pipes 100% hydrogen will become brittle

VALUE CHAIN



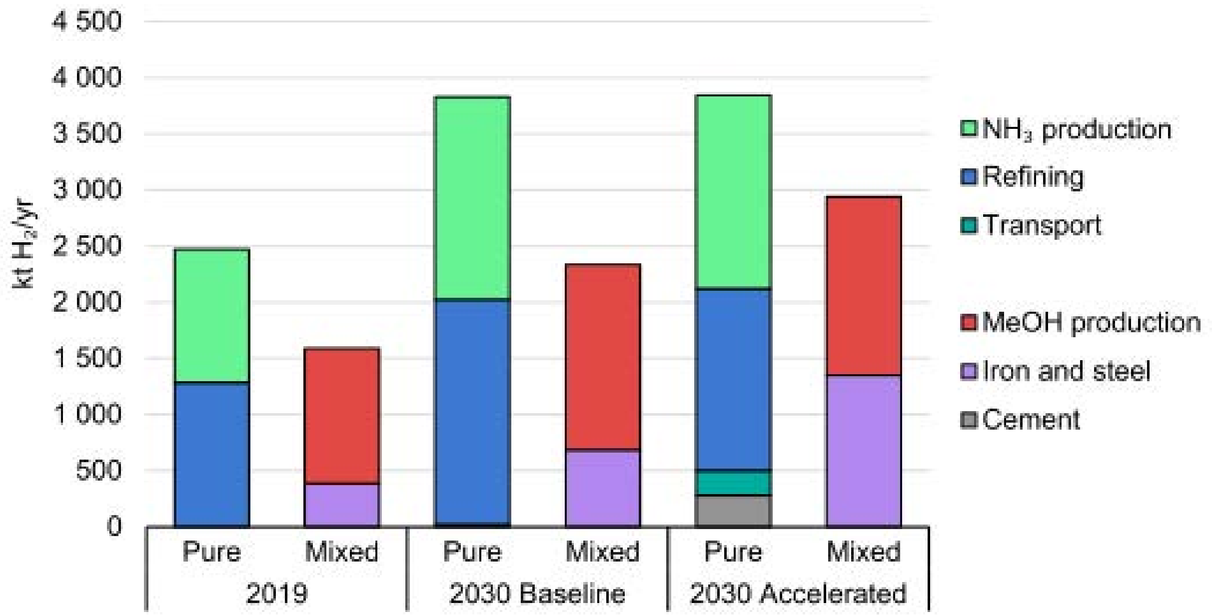
Taken from: Maio, P. (2020). Hidrógeno : Una revolución para impulsar los sectores de energía y transporte sostenible en América Latina. 1–7. https://bit.ly/3sR0YAZ

VALUE CHAIN

UTILISATION

Hydrogen demand to 2030

Figure 8 Hydrogen demand by application, Latin America, 2019-2030



REFINING AND INDUSTRIAL SECTORS

- Oil refinig
- Ammonia and methanol production
- Iron and steel production
- Mining

HYDROGEN IN TRANSPORT HYDROGEN

- Road transport
- Shipping
- Rail

HYDROGEN IN THE POWER SECTOR

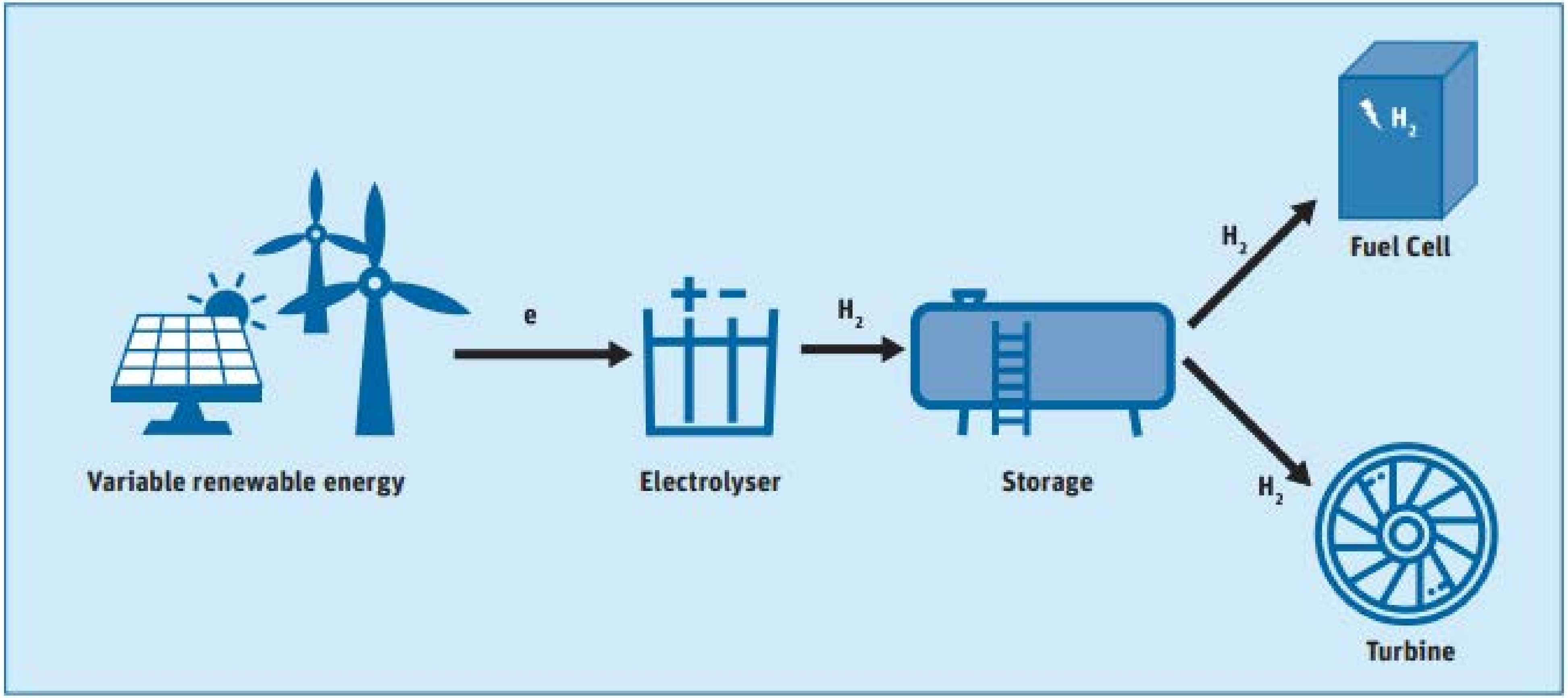
Could be one of the technologies needed to provide flexibility and store energy when other low-carbon sources of electricity are not available.

HYDROGEN IN THE POWER SECTOR

- Blending hydrogen in existing gas networks

IEA. (2021). Hydrogen in Latin America. 83.

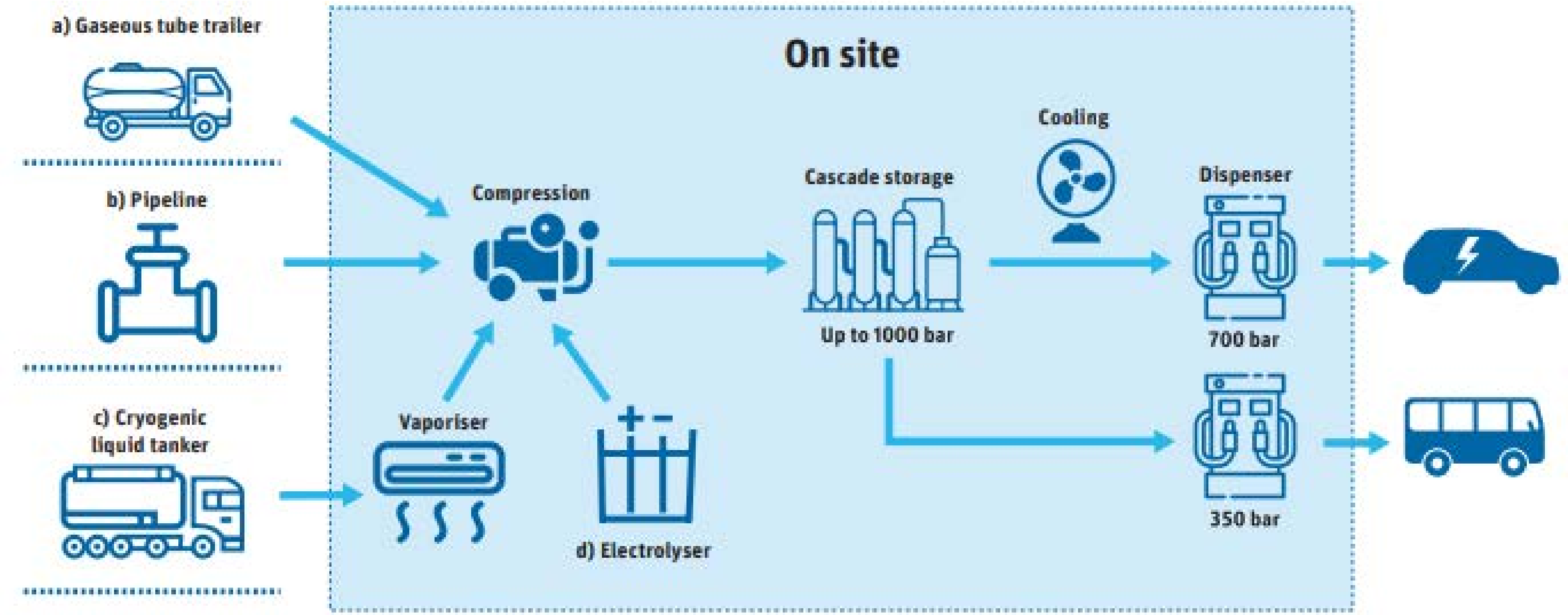
UTILISATION (Stationary Electricity)



[4] Bruce S, Temminghoff M, Hayward J, Schmidt E, Munnings C, Palfreyman D, & Hartley P. (2019). National Hydrogen Roadmap. 116. www.csiro.au

VALUE CHAIN

UTILISATION (Transport sector)



[4] Bruce S, Temminghoff M, Hayward J, Schmidt E, Munnings C, Palfreyman D, & Hartley P. (2019). National Hydrogen Roadmap. 116. www.csiro.au

QUESTIONS AND ANSWERS

STATUS QUO

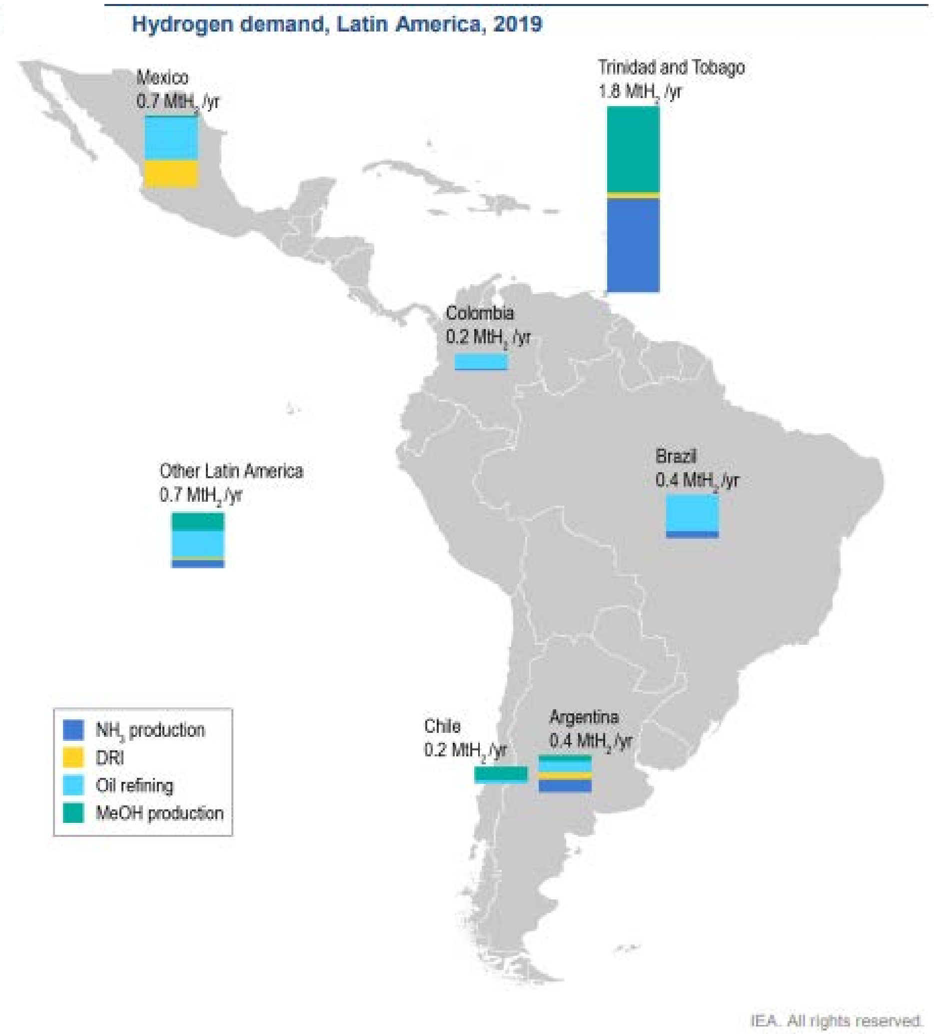
Policy discussions, official statements, Initial demonstration projects	• Argentina • Bolivia • Costa Rica • Panama • Paraguay • Peru • Trinidad and Tobago • Mexico
Strategy in preparation	• Brazil • Uruguay
Strategy available	• Chile • Colombia

[6] Bruce S, Temminghoff M, Hayward J, Schmidt E, Munnings C, Palfreyman D, & Hartley P. (2019). National Hydrogen Roadmap. 116. www.csiro.au
Set, A. (n.d.). WORKING PAPER | NATIONAL.

Latin America is one of the leading regions in the world in the use of renewable energy today and one that can play an important role in the international push for low carbon emissions.

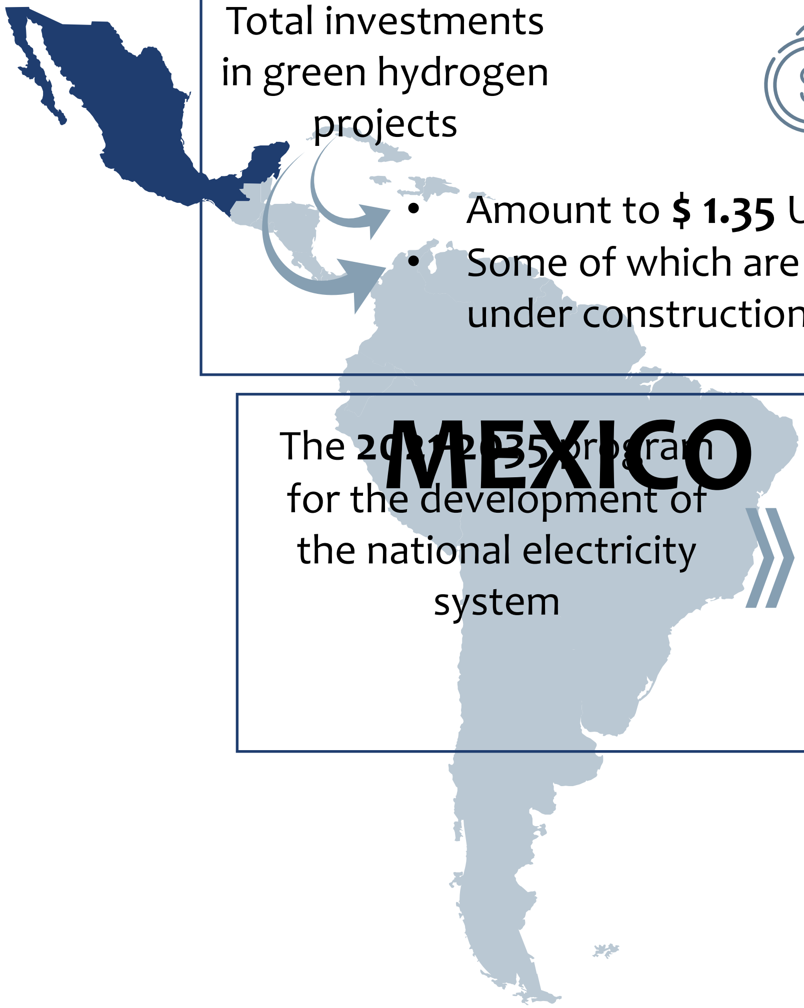
PORTFOLIO OF PROJECTS IN LATAM → MORE THAN **25** → **5** LARGE GIGAWATT-SCALE PROJECTS

STATUS QUO



Notes: This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

STATUS QUO



Total investments in green hydrogen projects

- Amount to **$ 1.35** USD billion
- Some of which are almost under construction

Hydrogen produced in renewable facilities could be used

- For self-supply and energy storage
- It could also be injected into a network of natural gas pipelines

The **2021-2035** program for the development of the national electricity system

» Mentions the replacement of natural gas turbines with **green hydrogen**

» Ones as some of the emerging technologies that will be implemented towards **cleaner energy in the coming years**

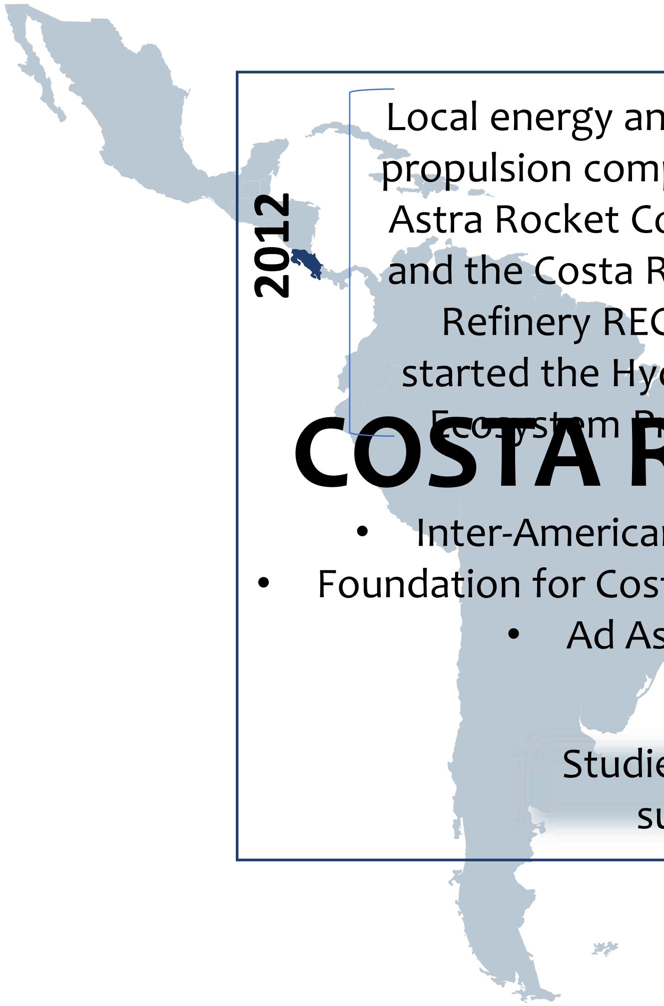
STATUS QUO

EL SALVADOR

They established in their national energy policy 2020-2050

In the strategic axis of research development and innovation the production of green hydrogen

STATUS QUO



2012

Local energy and space propulsion company Ad Astra Rocket Company and the Costa Rican Oil Refinery RECOPE started the Hydrogen Ecosystem Project

COSTA RICA

Results

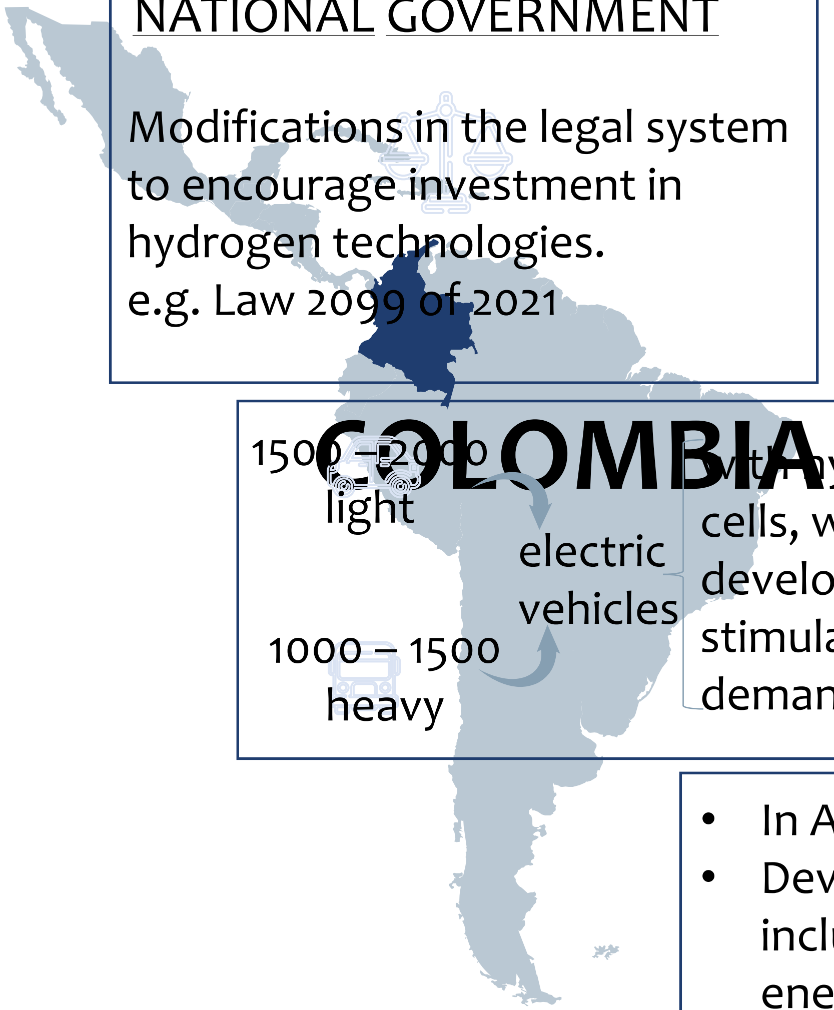
- Hydrogen storage system
- Hydrogen and biogas storage system
- Demonstration of buses powered by fuel cells

- Inter-American Development Bank
- Foundation for Costa Rica-United States
- Ad Astra Rocket Company

Project to advance the use of hydrogen in the transport system

Studies are being carried out on e-mobility and the hydrogen supply chain, and a policy roadmap is being planned.

STATUS QUO



NATIONAL GOVERNMENT

Modifications in the legal system to encourage investment in hydrogen technologies.
e.g. Law 2099 of 2021

$ 2.5USD billion national hydrogen strategy

Objective
- 1Gw of H2V production capacity
- 50,000 tons/year of production of blue hydrogen

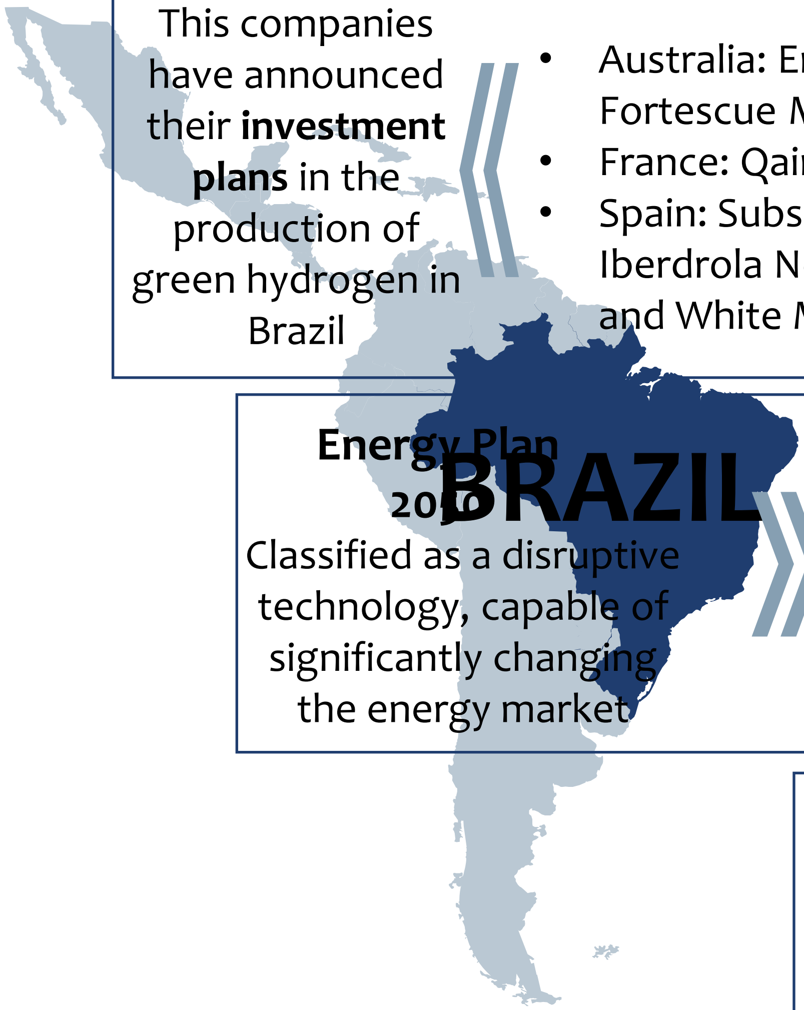
1500 – 2000 light
1000 – 1500 heavy
electric vehicles

with hydrogen fuel cells, will be developed to stimulate domestic demand

ECOPETROL
- Will develop a H2V pilot test 50 KW
- Allow the development of a project at industrial scale in 2022

- In August 2021 the hydrogen strategy was published
- Development of a planning model with scenarios to include blue and green hydrogen in the country's energy matrix.

STATUS QUO



This companies have announced their **investment plans** in the production of green hydrogen in Brazil

- Australia: Enegix and Fortescue Metals
- France: Qair
- Spain: Subsidiary of Iberdrola Neoenergia and White Martins

National Energy Policy Council » Plans to publish a new regulation on hydrogen in 2021

Allow a competitive hydrogen market in Brazil

- Safety standards
- Regulatory design
- Structures

Energy Plan 2050

Classified as a disruptive technology, capable of significantly changing the energy market

» Hydrogen can help solve energy challenges

- Reduction of carbon emissions in sectors that are difficult to decarbonize
- The storage of renewable energies
- The security of energy supply due to the flexibility in the production of hydrogen
- Diversity in their use cases

Commissioning of a green hydrogen hub in the port of Pecém » Investment is estimated at about 5,400 USD million » Including the construction of an electrolysis plant.

STATUS QUO

The Minister of Hydrocarbons and Energies of Bolivia announced a strategic plan for the generation of green hydrogen to increase the country's energy potential and reduce greenhouse gas emissions

STATUS QUO

The country expects hydrogen to fuel heavy cargo

Mainly the trucks that transport Paraguay's agricultural products.

IEA

The cost of hydrogen production in Paraguay will be one of the cheapest in the world 》 2 USD/ kg of H_2

Hydrogen technology and infrastructure expected to be ready 》 **2035**

2040-2050 《 Full capacity will be reached.

STATUS QUO

National Green Hydrogen Strategy (2020)

First in Latin American

40 hydrogen projects under development

5 on a large scale

Government

Committed $ 50 USD million

Promote the development of pilot projects.

1.5 GW of electrolysis capacity (2025)

Produce the most profitable green hydrogen (2030)

Objectives

Be among the top 3 exporters (2040)

Chilean-German Consortium

- Investment of 38 USD million
- First hydrogen pilot project will be operational at the end of 2021
- Commercial production in 2022

In February 2021, the Chilean generator AES Gener SA signed a memorandum of understanding with an international producer of hydrogen to carry out a feasibility study for the first large green hydrogen-based ammonia project in Chile.

STATUS QUO

New World Trade Center:

Liberty Tower

6 Megawatts of Fuel cell Power

Fuel cell (alkaline)
space shuttle
liquid hydrogen
and oxygen

VEHICLES IN THE MARKET

Toyota Mirai

Hyundai ix35 FC


Honda Clarity

STATUS QUO

OTHER USES

www.elmundo.es

First commercial train fueled with hydrogen (Germany).

Small hydrogen powered aircraft are already on the market (Europe).

150 homes in the housing communities in Maebaru City are powered by hydrogen (Japan).

www.greencarreports.com

There are 6,500 hydrogen fuel cell cars worldwide (USA and Japan).

BREAK

15 MIN

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MAIN CHALLENGES

Technology availability

Some technologies are still in development and are currently not commercial.

Efficiencies and costs

Less favorable for hydrogen technologies than other renewable technologies such as direct conversion (wind and solar).

Stationary power generation

With turbines (similar to conventional gas turbines) high combustion temperatures generate nitrous oxides.

Logistics

Between the implementation of recharging stations and the commercial entry of fuel cell or hydrogen powered vehicles

Public Policies

Are necessary to make the adoption of hydrogen technologies feasible due to their high costs.

MAIN CHALLENGES

Sector	Challenges
OIL REFINING	Availability of CO_2 transport and storage sites (NG w/CCUS)
	Close integration of hydrogen production and use with other refinery processes
	Hydrogen production cost influence on refining margins
CHEMICAL PRODUCTION	Hydrogen storage is needed to use electrolytic hydrogen beyond process flexibility limits
	Urea and methanol production will still require a source of carbon
IRON & STEEL	Impact on margins in a sector facing strong competition from producers outside the region
TRANSPORT	Further technological improvements needed
	Infrastructure requirements
	High impact of fuel costs on margins
	Regional compatibility for cross-border applications

IEA. (2021). Hydrogen in Latin America. 83.

QUESTIONS AND ANSWERS

POTENTIAL OF THE HYDROGEN ECONOMY IN LATAM

VOSTOCKCAPITAL

‘Chile could produce up to 160 megatons a year of green hydrogen and become the main low-cost exporter by 2040, when the local market will be worth an estimated $ 33 billion, including $ 24 billion in exports’

HYDROGEN COUNCIL

‘Low-carbon hydrogen may be cost competitive in 22 end applications by 2030 is projected to decrease by up to 50% by 2030’

CEPAL

“Many countries in Latin America and the Caribbean have advantages in entering this market because their electrical matrices are relatively clean or are in the process of decarbonizing. these advantages are in themselves opportunities, which give rise to others "

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POTENTIAL OF THE HYDROGEN ECONOMY IN LATAM

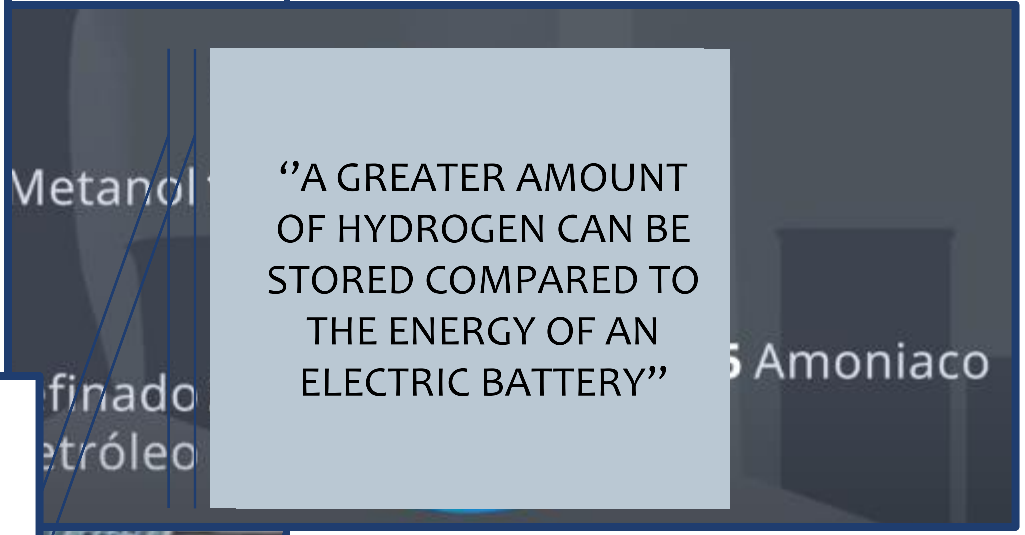
DEUTSCHE WELLE: GREEN HYDROGEN: A TURNING POINT FOR LATIN AMERICA?

CURR

Energy storage

Transport

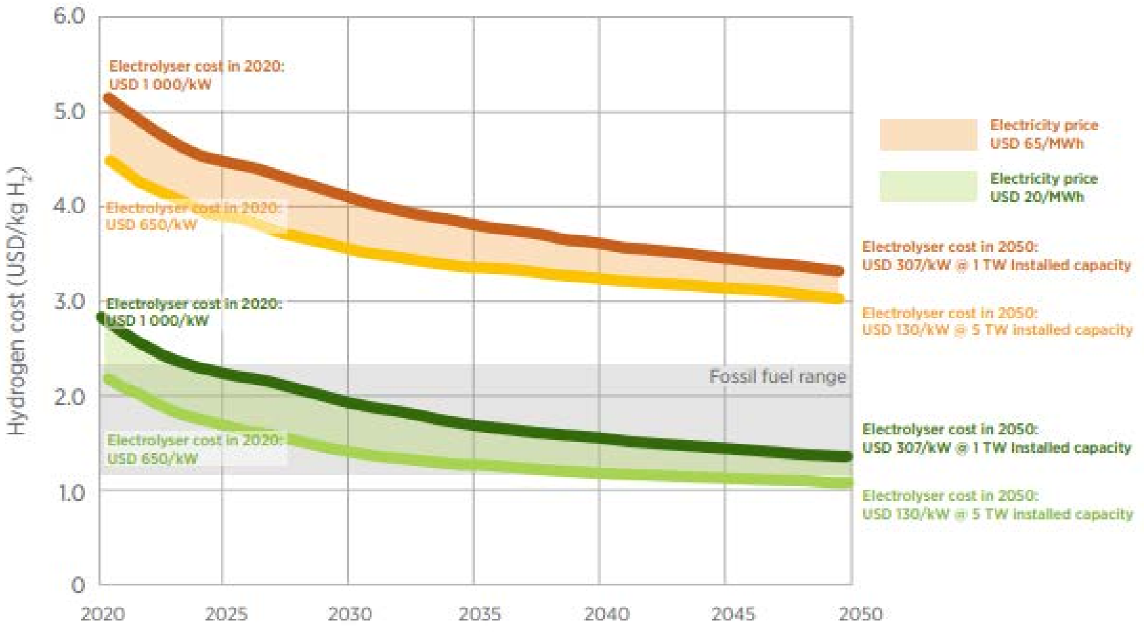
PRESIDENT OF THE GERMAN FUEL AND HYDROGEN CELLS ASSOCIATION



"A GREATER AMOUNT OF HYDROGEN CAN BE STORED COMPARED TO THE ENERGY OF AN ELECTRIC BATTERY"

POTENTIAL OF THE HYDROGEN ECONOMY IN LATAM

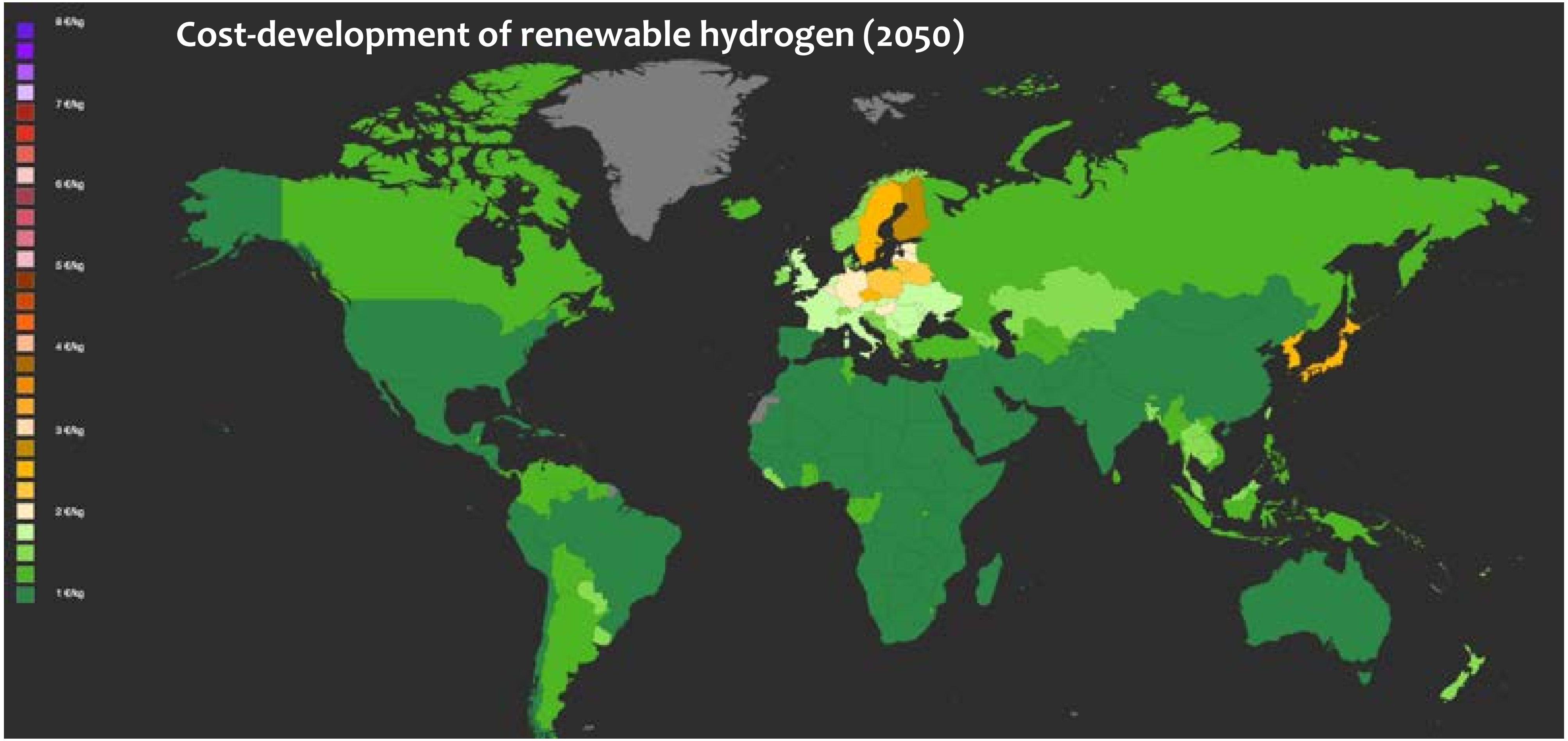
Cost of green hydrogen production as a function of electrolyser deployment, using an average (USD 65/MWh) and a low (USD 20/MWh) electricity price, constant over the period 2020-2050.



Note: Efficiency at nominal capacity is 65%, with a LHV of 51.2 kilowatt hour/kilogramme of hydrogen (kWh/kg H2) in 2020 and 76% (at an LHV of 43.8 kWh/kg H2) in 2050, a discount rate of 8% and a stack lifetime of 80 000 hours. The electrolyser investment cost for 2020 is USD 650-1000/kW. Electrolyser costs reach USD 130-307/kW as a result of 1-5 TW of capacity deployed by 2050.

Based on IRENA analysis.

POTENTIAL OF THE HYDROGEN ECONOMY IN LATAM



TAKEN FROM: PwC research | based on an analysis of various renewable energy sources and electricity generation / hydrogen equipment cost reductions worldwide

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PRODUCTION POTENTIAL IN LATIN AMERICA

LATAM HAS

- Abundant renewable resources for energy generation
- Hydraulic sources

Two parameters necessary for the production of green hydrogen.

- Geographic location that facilitates the export of hydrogen to the Asian and European markets.

(HINICIO 2019)

Costa Rica, Uruguay, Paraguay: Generated more than 98% of their electricity using renewables

Brazil, Colombia, Ecuador: Generated more than 70% of their electricity using renewables

Their surpluses can be used for the development of pilot projects

(IEA 2021)

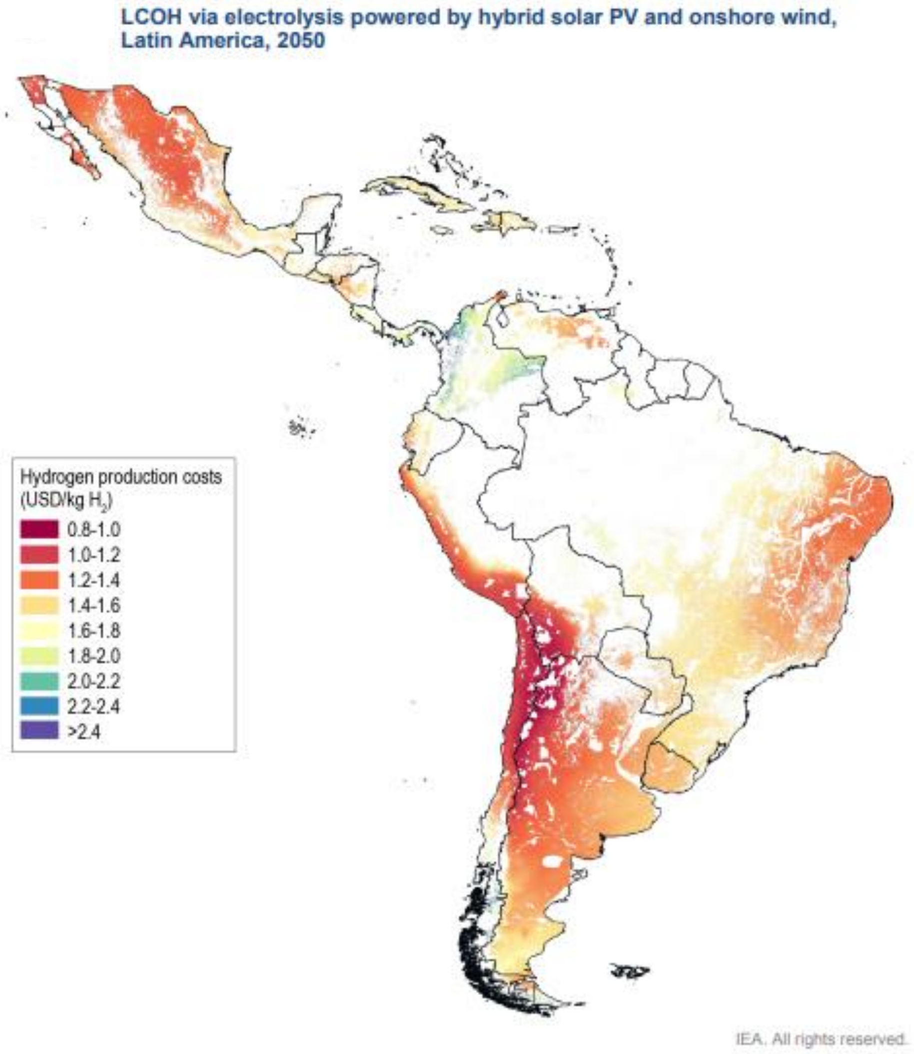
In the long term, Latin America could have a land area of over 800 000 km^2 in which the LCOH via electrolysis is under USD 1/kg H_2 using a hybrid energy supply. (IEA 2021)

Thanks to its abundant, high-quality and often complementary renewable resources, Latin America has the potential to produce large amounts of low-cost hydrogen from renewable electricity in the long term (2050).

(IEA 2021)

IEA. (2021). Hydrogen in Latin America. 83.
Maio, P. (2020). Hidrógeno : Una revolución para impulsar los sectores de energía y transporte sostenible en América Latina. 1–7. https://bit.ly/3sR0YAZ

PRODUCTION POTENTIAL IN LATIN AMERICA



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PARTICIPATORY ACTIVITY N°3

A rapporteur for each country team will share the main findings in a summarized way, each rapporteur will have 2 minutes

Development of a swot matrix to identify the weaknesses, opportunities, strengths and threats, that identify for the development of a hydrogen economy according to the context of each of their countries. (30 min)

<u>GIZ Roles:</u>

- Guarantee the appointment of the rapporteur by the participants
- Guide the development of participatory activity in breakout rooms
- Solve questions and doubts of the participants
- Manage time and timely progress of the activity.

QUESTIONS AND ANSWERS

PARTICIPATORY ACTIVITY N°3

Colombia:
https://shortest.link/1exU
Costa Rica:
https://shortest.link/1b8E
Brazil:
https://shortest.link/1b8F
México:
https://shortest.link/1b8G
Bolivia:
https://shortest.link/1b8J
El Salvador:
https://shortest.link/1bb-
Paraguay:
https://shortest.link/1bc0

PARTICIPATORY ACTIVITY N°3

- Main findings
- 2 minutes

CONCLUSIONS

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GREEN HYDROGEN IN LATIN AMERICA

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