

L'hidrogen a França. Situació de la plataforma de transport multimodal a la regió d'Occitània

JEAN-LUC MATE

5 Octubre 2024



MANY THANKS TO MY COLLEAGUES FOR BRINGING LATEST FRENCH FIGURES ON H2



bertrand.chauvet@seiya-consulting.com

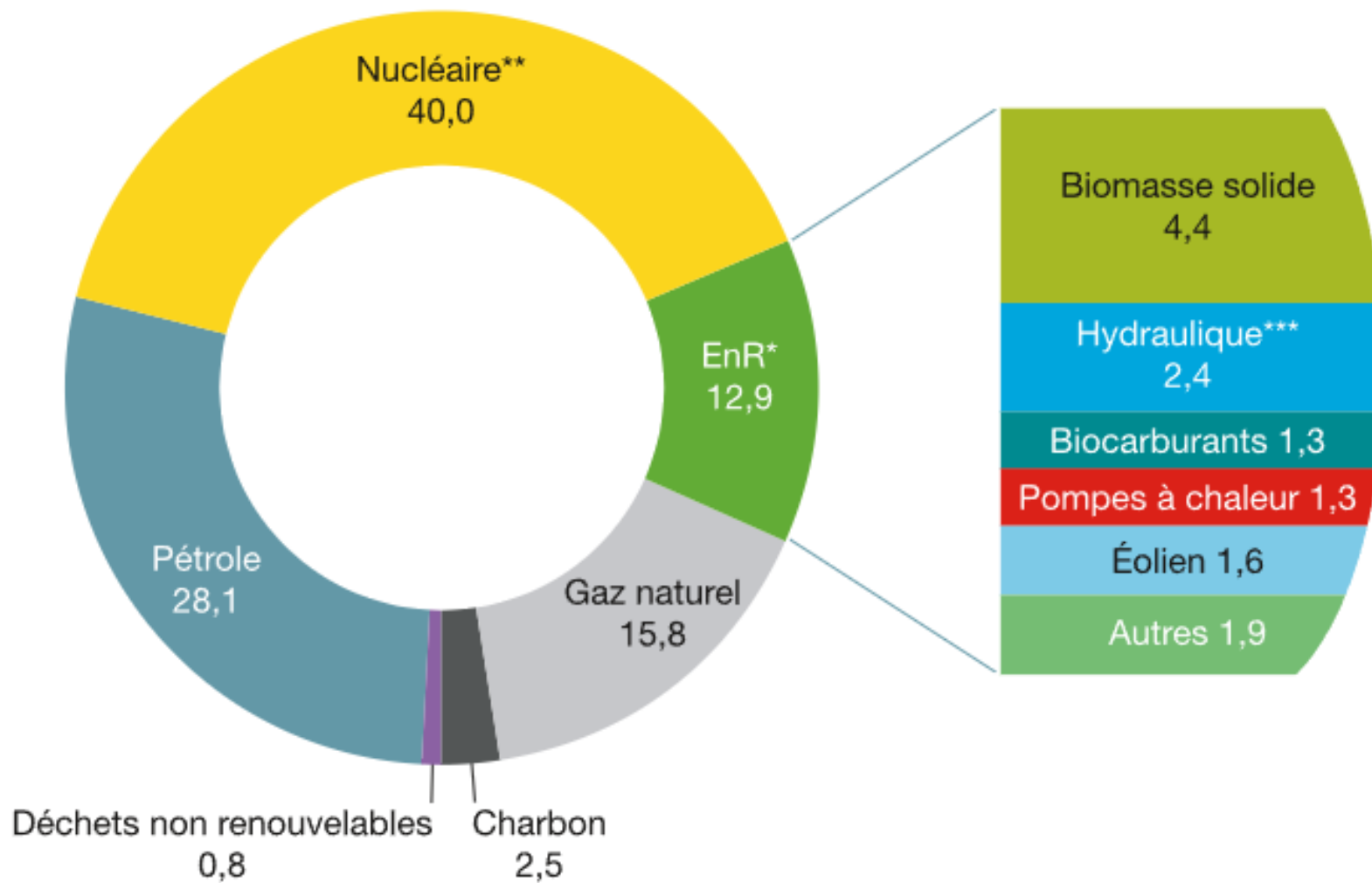
Jean Luc BROSSARD
Stellantis Tech Research Delegate



[Hydrogen Today - Accueil - le média référence de l'hydrogène](#)

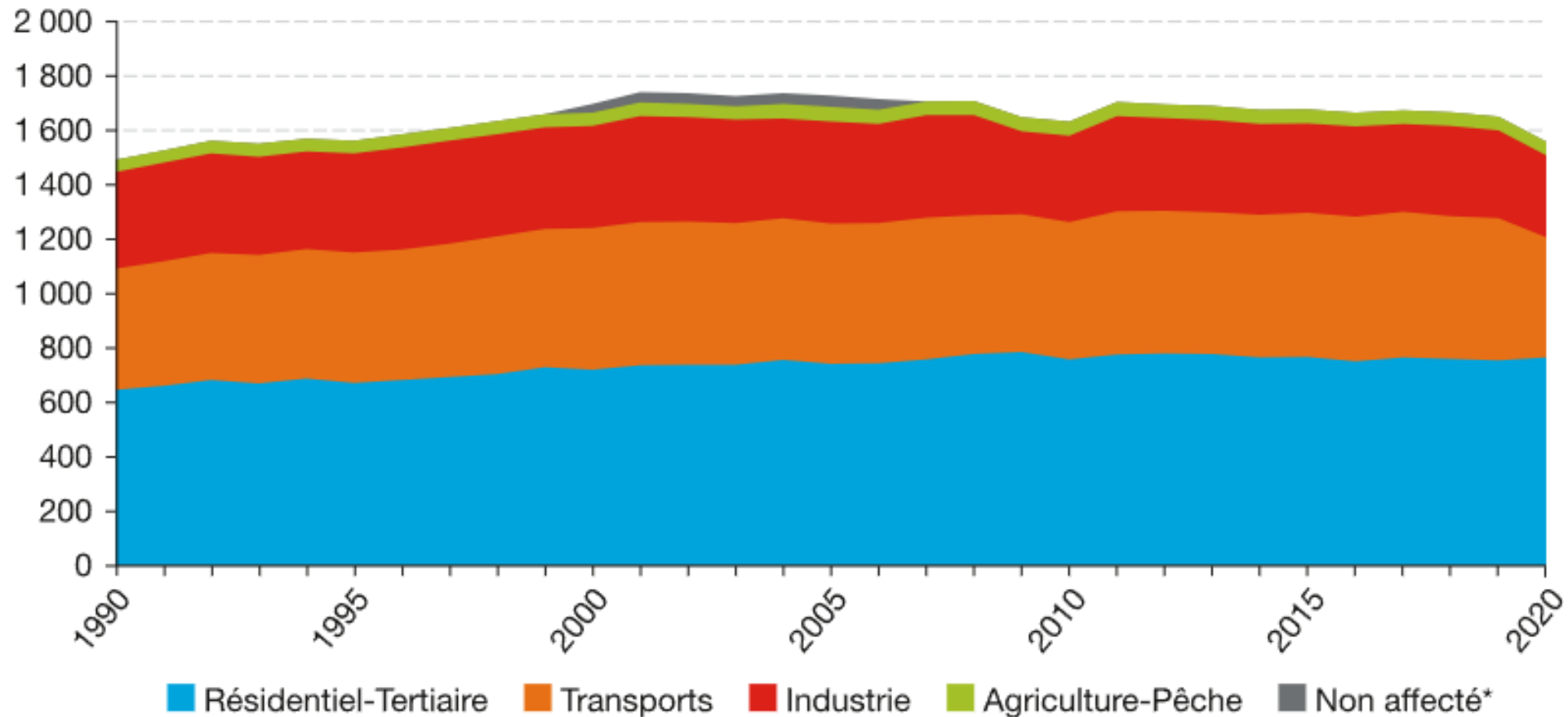
DISTRIBUTION OF PRIMARY ENERGY CONSUMPTION IN FRANCE

Total : 2 571 TWh in 2020



Total Energy consumption per domain : 1 562 TWh

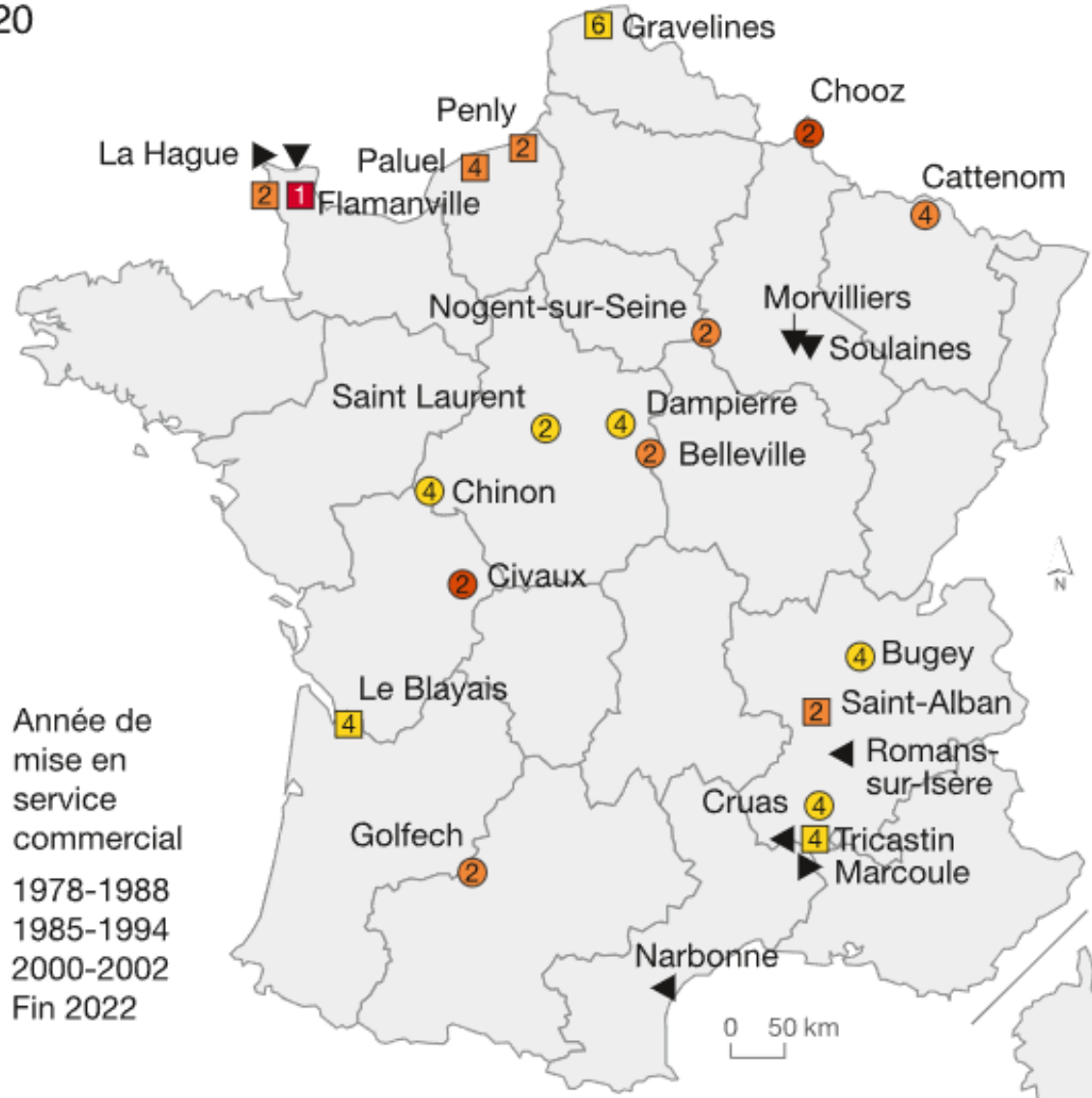
En TWh (données corrigées des variations climatiques)



In 2021: 69% of total electricity production in France come from nuclear fleet.

LES SITES NUCLÉAIRES EN FRANCE

Situation au 31 décembre 2020



Palier REP* standardisé

Puissance électrique nette

- 900 MW
- 1 300 MW
- 1 500 MW
- 1 600 MW (EPR**)

Nombre de tranche

- 32
- 20
- 4
- 1 (en construction)

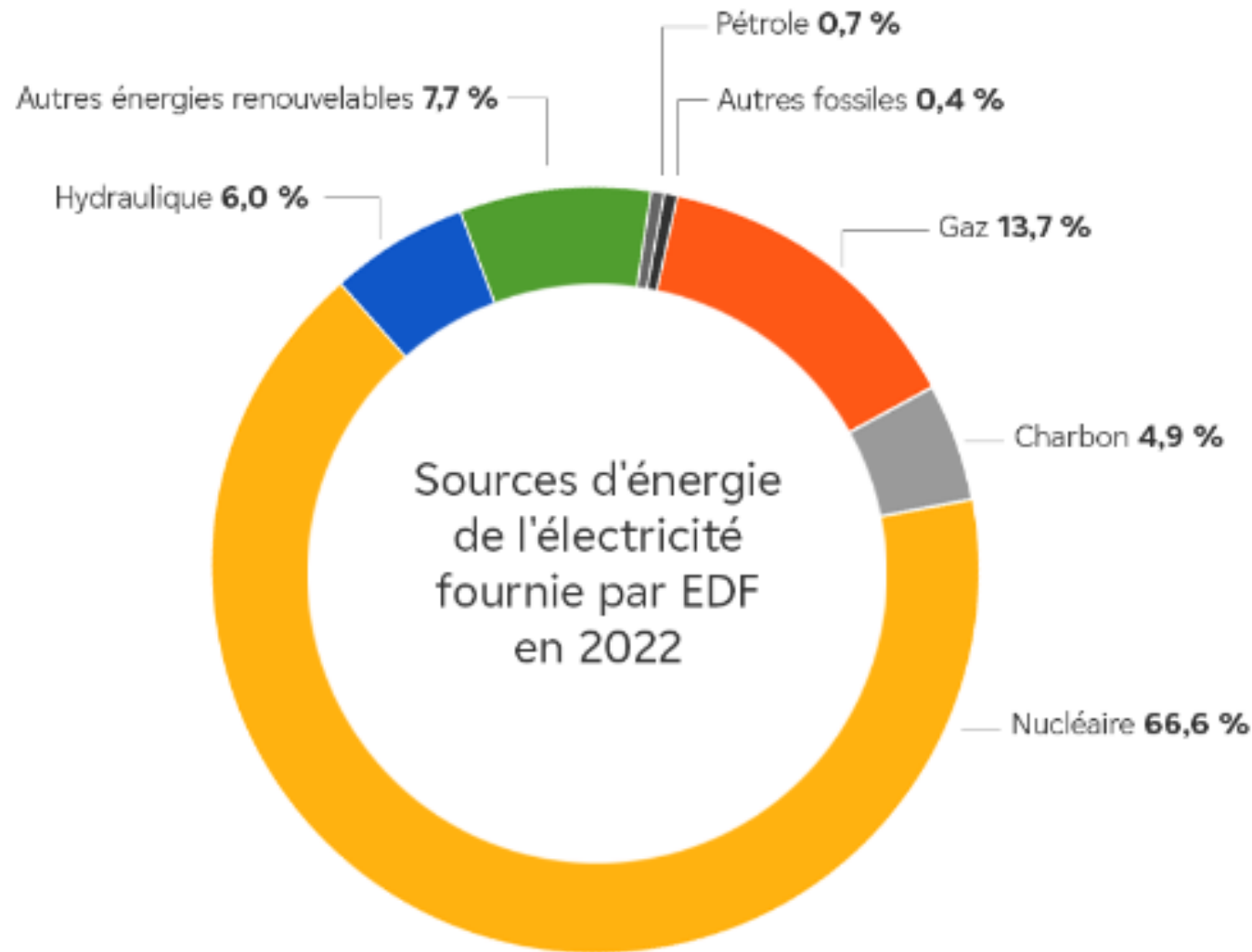
Année de mise en service commercial

- 1978-1988
- 1985-1994
- 2000-2002
- Fin 2022








4 Nombre de réacteurs

With an installed capacity of **61.4 GW**, the 56 French nuclear fleet is the second largest in the world in terms of power, behind that of the United States.

Electricity production by energy source in France



Today Hydrogen consumption is mainly for industry

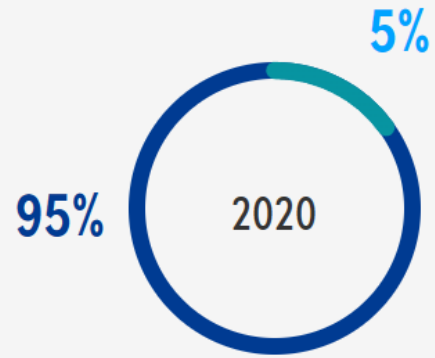
Utilisation: Quantité consommée	 France (milliers de tonnes /an)	%	 Europe (millions de tonnes /an)	%	 Monde (millions de tonnes /an)	%
 oil refining	544	59	3,9	47	26,4	44
 ammonia & fertilizer	240	26	3,2	39	22,8	38
 chemical industry (inc Methanol)	92	10	1,15	14	4,8	8
 metallurgy	9,2	1			6	10
Divers	36,8	4				
TOTAL	922	100	8,25	100	60	100

 Rappel: ceci émet chaque année 10 millions de tonnes de CO₂ en France

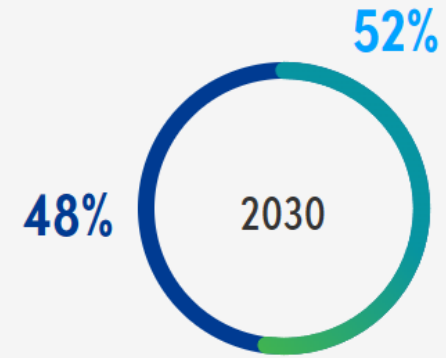
2023



2030



45 000 T H
sur un total de 880 000 T



700 000 T H
sur un total de 1 345 000 T

30 MW
d'électrolyse déployée



6,5 GW
d'électrolyse déployée

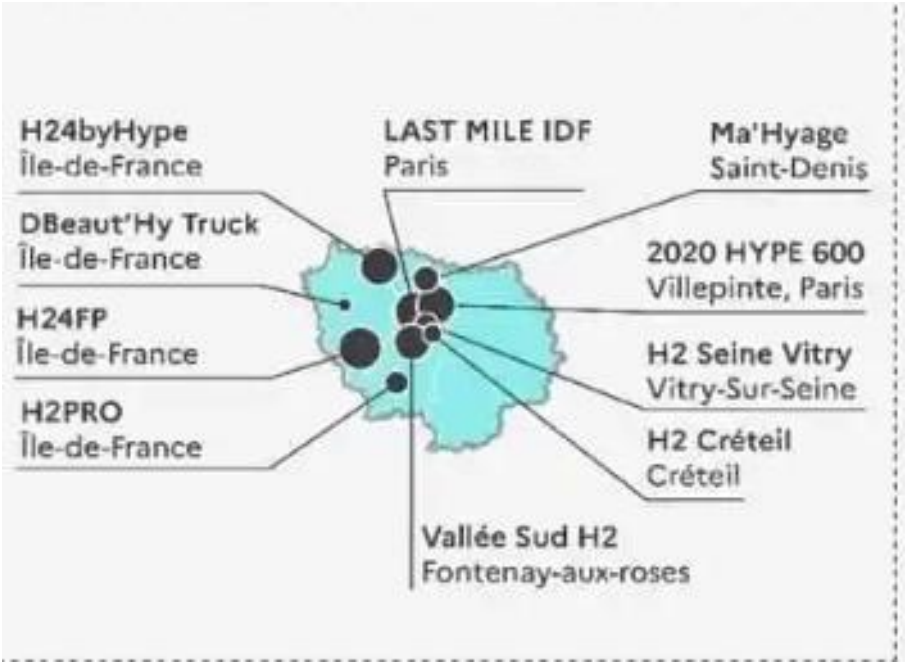
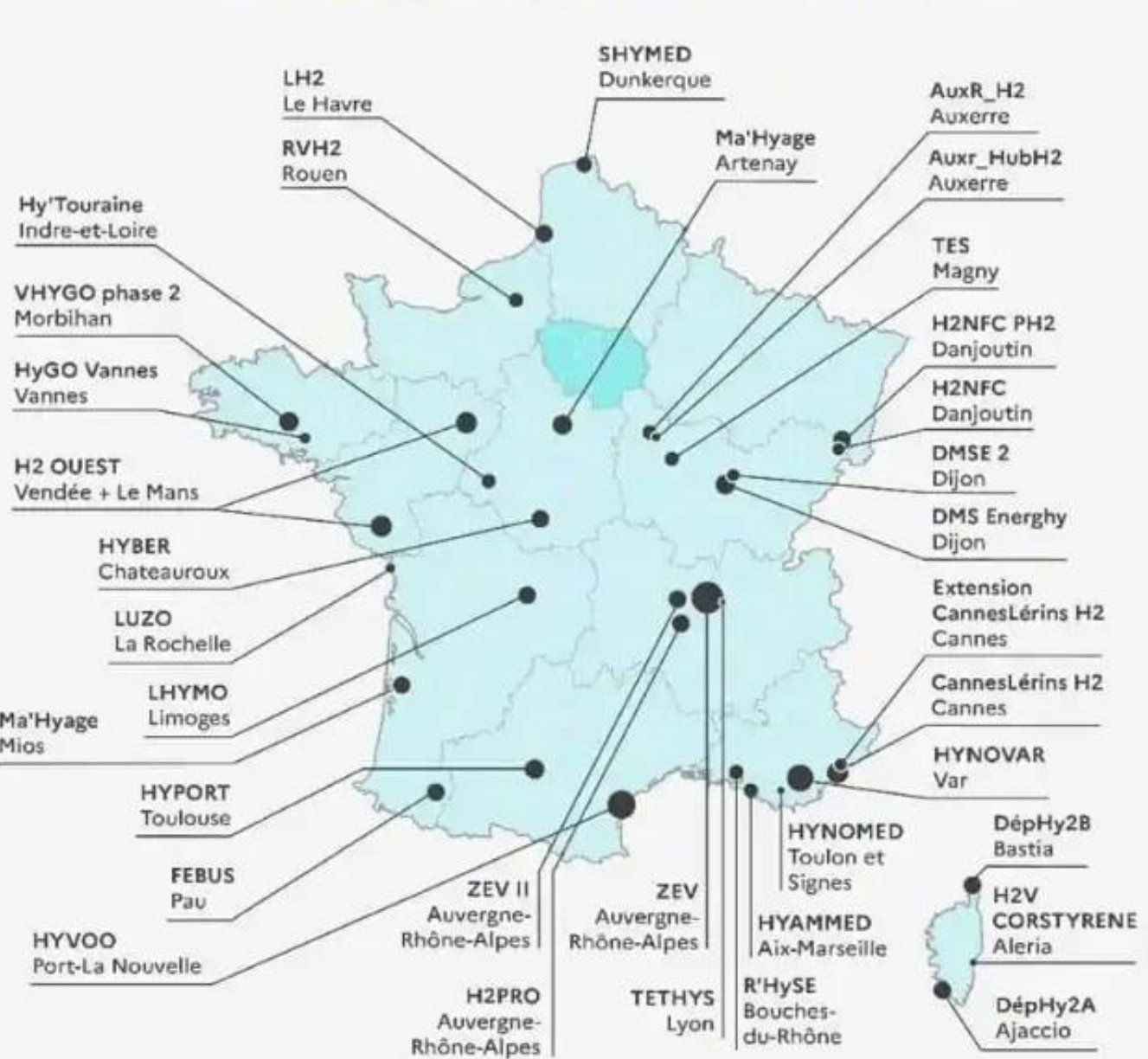
955
véhicules légers

59
bus en service

150 000
véhicules légers

9000
véhicules lourds

Ecosystems in France supported by national energy agency and region

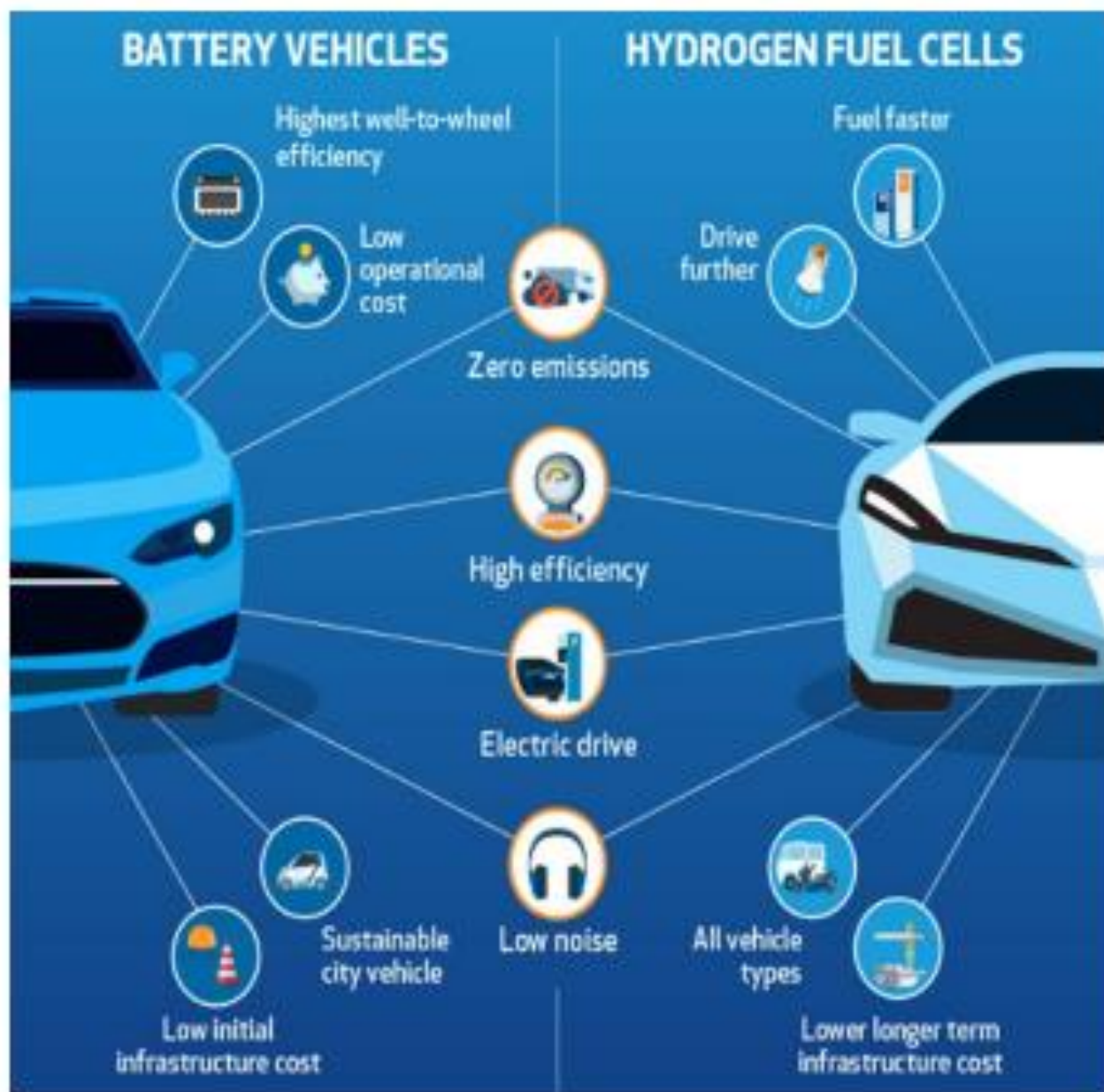


H2 MOBILITY ROADMAP FOR THE FRENCH AUTOMOTIVE INDUSTRY

Jean Luc BROSSARD
Stellantis Tech Research Delegate



President and CEO of the CCFA
(Committee of French Automobile
Manufacturers)
Vice-President R&D&I of NextMove,
PFA Programs Director, LCA & Low
Environmental Footprint Vehicles,



H2 Complementary to uses not covered by battery electric vehicles

Allows you to address segments to uses requiring:

- to be Zero Emission
- short refueling times,
- Long Range,
- transport of heavy loads, without meteorological impact on autonomy.
- requiring few critical materials like cobalt, nickel or manganese, **just platinum.**

Hydrogen mobility can be addressed either by a hydrogen fuel cell vehicle (FCEV) or by a hydrogen internal combustion vehicle, ICE H2 (standards currently applicable to heavy goods vehicles)

A TRICKLE DOWN EFFECT BENEFITING THE WHOLE INDUSTRIAL VALUE CHAIN

100 000 LCVs (1)



=



100 000 stacks

=



10 000 000
Bipolar plates(*)



10 000 000
MEA (*)



300 000 tanks → 1 800 t
H2 on board

3 H2 tanks = 6 kgs H2

4 000 trucks (1)



=



8 000 stacks

=



2 600 000
Bipolar plates(*)



2 600 000
MEA (*)



28 000 tanks → 40 à 60.000 t
H2 /y

7 H2 tanks per truck

Tier 1 and industrial champions will supply the key components based on dedicated giga factories



Hy2Tech IPCEI support : ARKEMA, FORVIA, HYVIA, PO, SYMBIO

LCVs production capacity



2023 capacity 1000 véhicules/y,
end 2024: 5000 véhicules/y
End 2025 10 000 veh/y
2030 : 30 000 veh/y

2023 capacity – 1,000
2030 – 30,000 veh/y

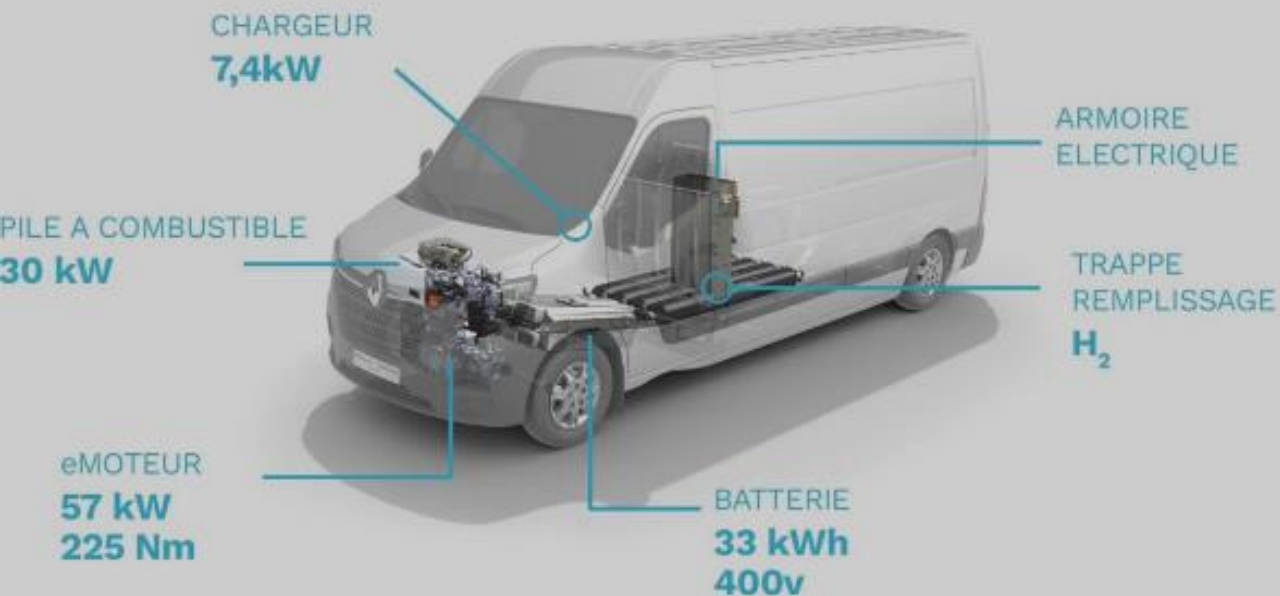
(1) dual power Architecture (battery/Fuel Cell)

(*) illustrative figures

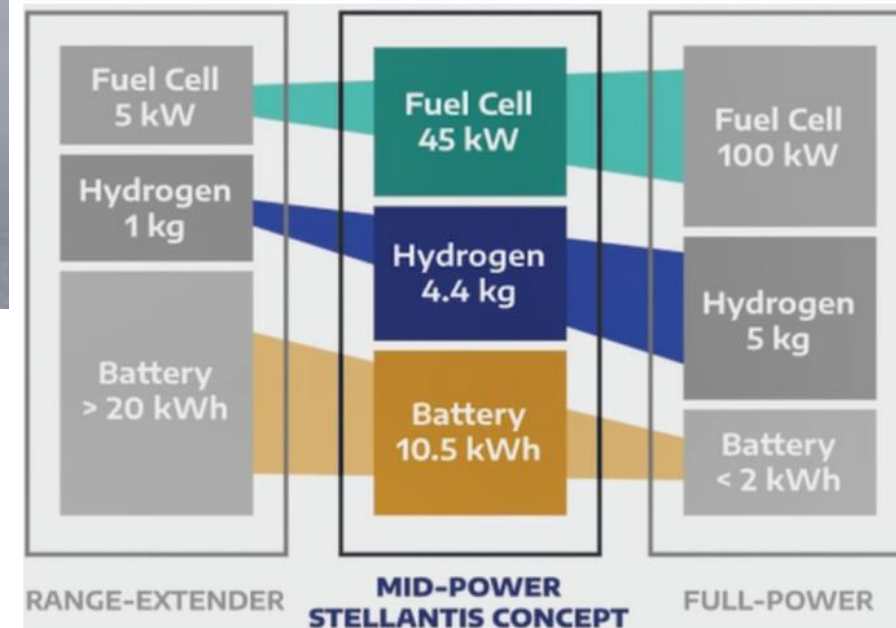
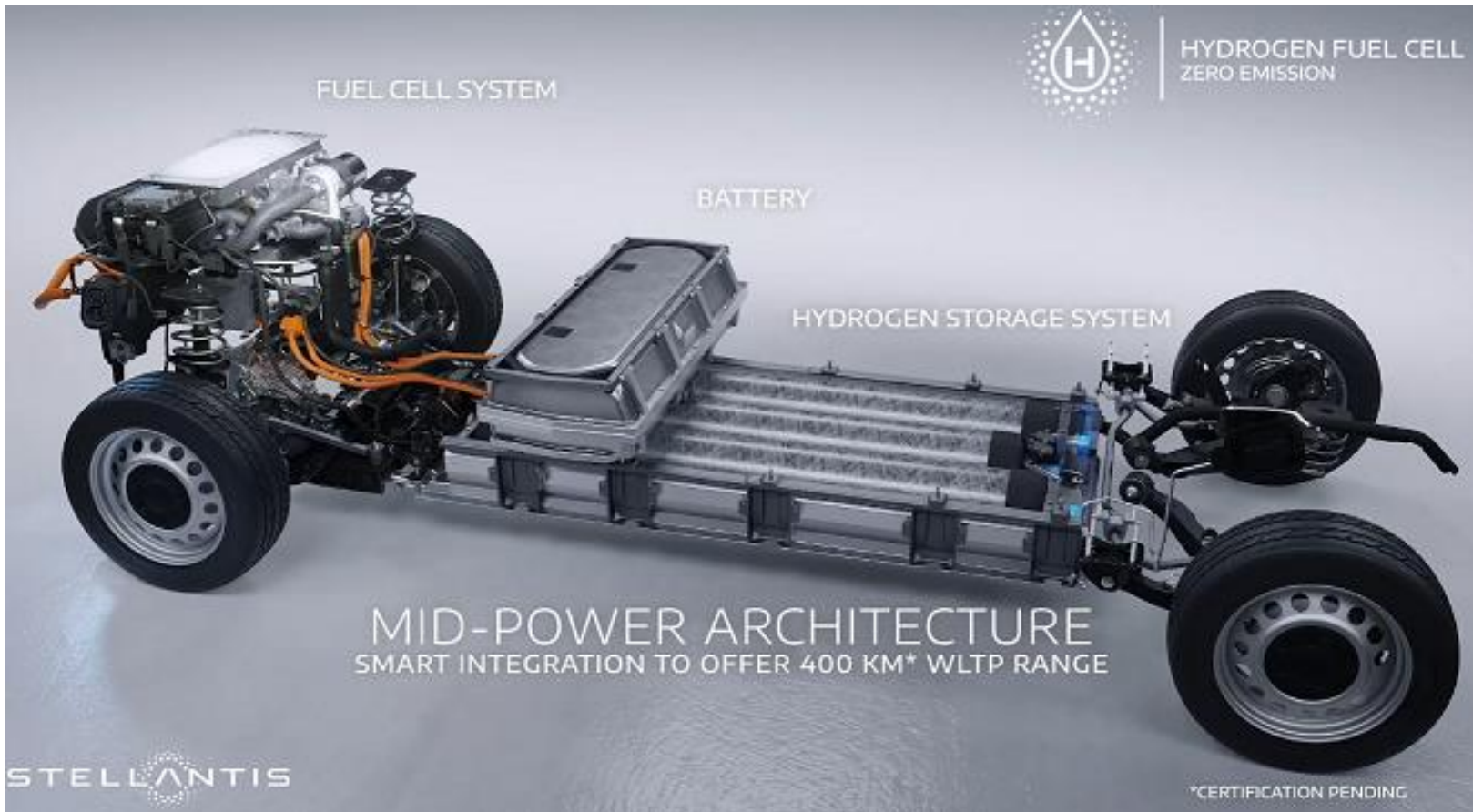
HYVIA

Renault
Group

PLUG
POWER



STELLANTIS H2 power train Architecture



Stellantis mid-power fuel cell system

Stellantis Hordain: First factory in the world to produce hydrogen, Electric and Thermal utilities

With this new investment the manufacturing of fuel cell light utility vehicles **Peugeot Expert, Citroën Jumpy, and Opel Vivaro** is moving to an industrial scale

From 2024, the site will have a production capacity of **5,000 vehicles** per year

Stellantis' ambition to be the **first mass-producer of hydrogen-powered utility vehicles.**



LCV MAIN CURRENT OFFERS FROM FRENCH MANUFACTURERS

LCV N1 – PTAC ≤ 3,5T

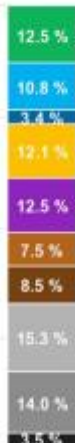
  <p>Kangoo ZE H2 Autonomie : 300 km Typologie : Véhicule électrique (range extender) Commercialisation : 2020</p> 	  <p>Peugeot Expert hydrogène Autonomie réelle (WLTP) : 400 km Typologie : Véhicule mid power PEMFC/batterie rechargeable Poids total autorisé en charge : < 3,5 t Capacité de transport : 15 passagers Volume de chargement : 5,3 et 6,1 m³ Commercialisation : fin 2021</p> 	  <p>Citroën e-Jumpy Hydrogen Autonomie réelle (WLTP) : 400 km Typologie : Véhicule mid power PEMFC/batterie rechargeable Poids total autorisé en charge : < 3,5 t Volume de chargement : 5,3 et 6,1 m³ Commercialisation : fin 2021</p> 	  <p>Opel Vivaro-e Hydrogen Autonomie réelle (WLTP) : 400 km Typologie : Véhicule mid power PEMFC/batterie rechargeable Poids total autorisé en charge : < 3,5 t Volume de chargement : 6,1 m³ Commercialisation : fin 2021</p> 
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LCV N2 – 3,5T ≤ PTAC ≤ 7,5T

  <p>Fourgon Master H2 Autonomie estimée : 300 à 500 km PTAC : 4,5t Typologie : Véhicule électrique (range extender) Commercialisation : 2022</p> 	 <p>Joint venture Renault Group Plug power</p>   <p>Master City Bus H2-TECH Autonomie réelle : 300 km Typologie : Véhicule PEMFC Capacité de transport : 15 passagers Commercialisation : 2023</p> 	 <p>Joint venture Renault Group Plug power</p>   <p>Master Van H2-TECH Autonomie réelle : 500 km Typologie : Véhicule PEMFC Volume de chargement : 12 m³ Commercialisation : 2023</p> 	 <p>Joint venture Renault Group Plug power</p>   <p>Master Châssis Cab H2-TECH Autonomie réelle : 300 km Typologie : Véhicule PEMFC Volume de chargement : 19 m³ Commercialisation : 2023</p> 
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INFRASTRUCTURE DEPLOYMENT PFA/FH/IRT Sx 2026-2030 FOR COMMERCIAL VEHICLES



- BEV
- Fuel Cell
- ICE H2
- PHEV
- CNG + LNG
- Biodiesel B100
- Biodiesel HVO
- 48V
- HEV
- Diesel ICE

Etude Vision Air
Mix 2030 VI

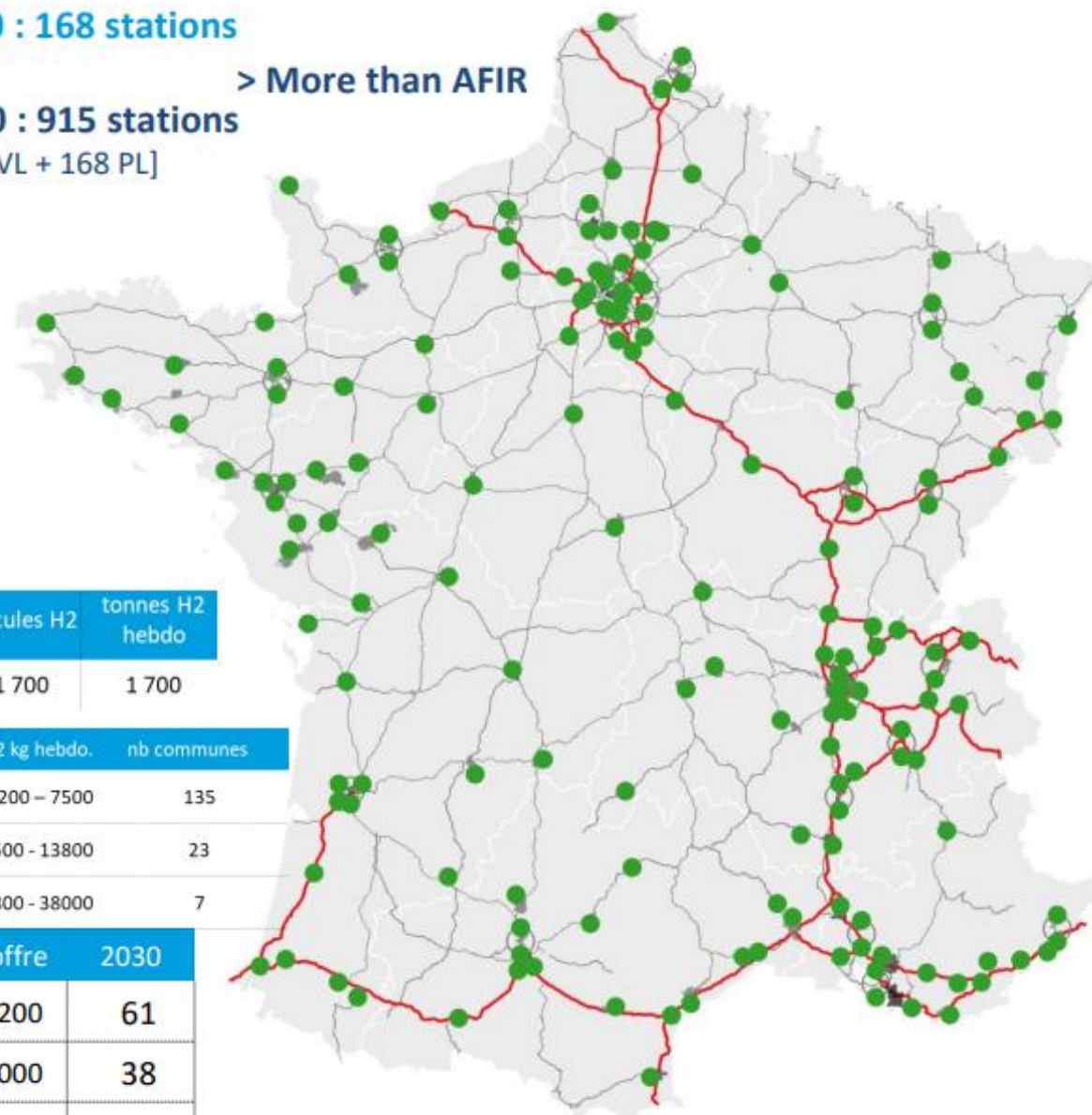
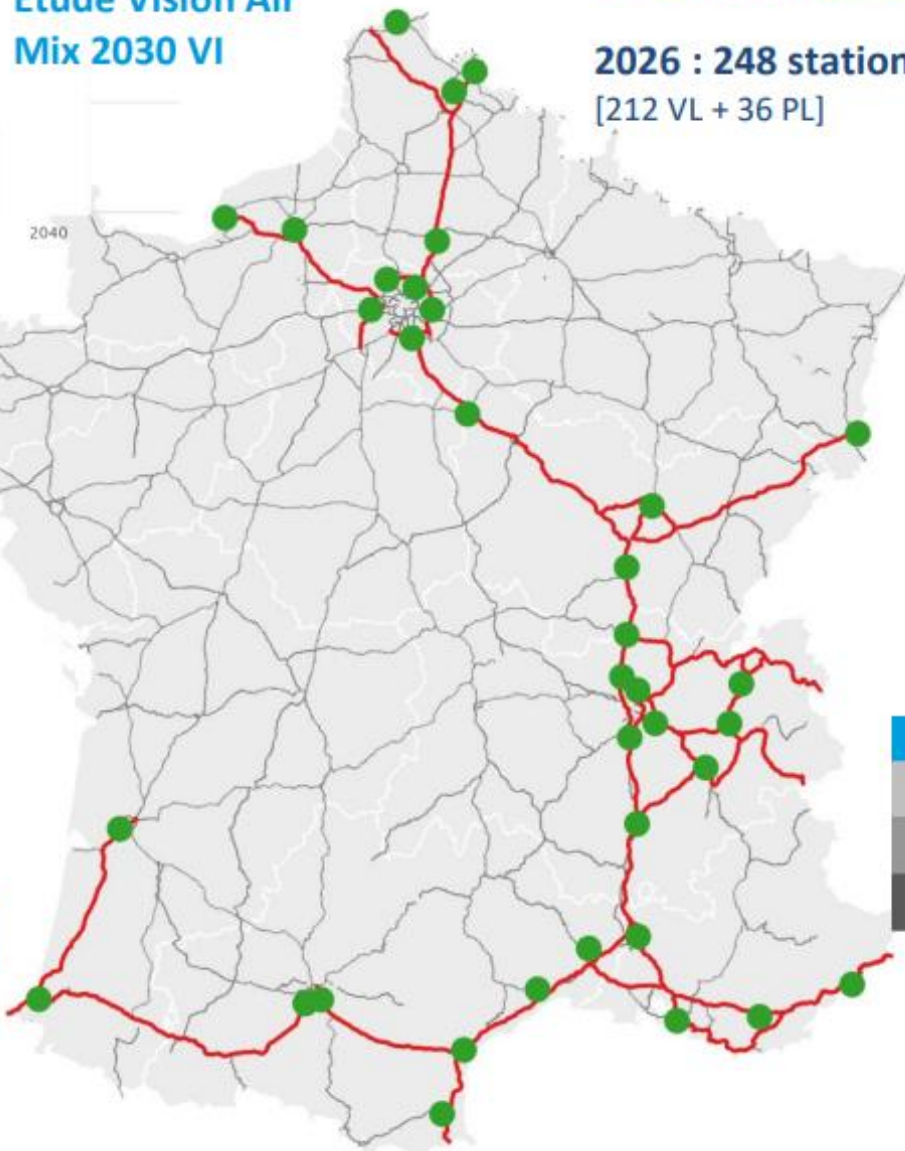
2026 : 36 stations

2030 : 168 stations

2026 : 248 stations
[212 VL + 36 PL]

2030 : 915 stations
[747 VL + 168 PL]

> More than AFIR



véhicules H2	tonnes H2 hebdo
11 700	1 700

demande H2 kg hebdo.	nb communes
3 200 - 7500	135
7500 - 13800	23
13800 - 38000	7

offre	2026
1 200	28
2 000	7
4 000	1

offre	2030
1 200	61
2 000	38
4 000	69

Fuel cell gigafactory opening : 50K to 100K per year



400 taxis hydrogen are operating in PARIS and Île-de-France



**+ 500 Toyota Mirai
during Paris olympic
games 2024
And 50 Stellantis light
utilities for handicaped**

Major H2 production investment to produce 28000 Tons H2 by 2026

- The Air Liquide **Normand'Hy** project consists in building an electrolyzer of at least **200 MW** in the Port-Jérôme industrial zone in Normandy.
- This electrolyzer, based on **Proton Exchange Membrane (PEM)** technology, will supply renewable hydrogen for industrial and heavy mobility applications.
- Commissioning is scheduled for **2026**

Co investors



Main customer

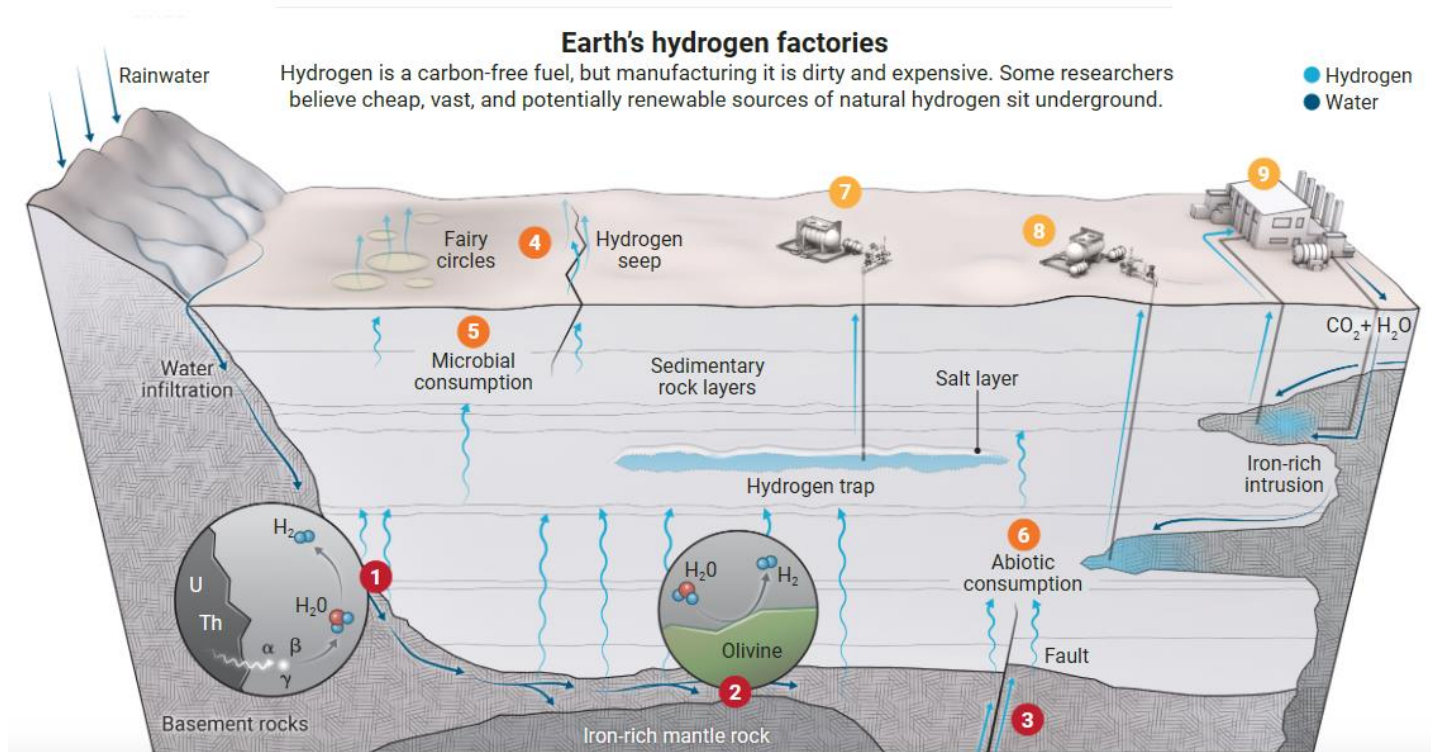


NATURAL HYDROGEN in France

In **April 2022**, as part of a series of amendments to its mining code, France added “**native hydrogen**” to the list of substances that could be mined.

Significant concentrations of natural hydrogen discovered in northeast France by local power and gas producer FDE has submitted an application for an exclusive mining exploration permit in the **Lorraine region** in bid to assess commercial potential

Fluids found within the Carboniferous rock formations contain 15% hydrogen at a depth of 1,093 metres, the scientists discovered, estimating that the concentration is **98% at 3,000 metres** underground.



[Hidden hydrogen: Earth may hold vast stores of a renewable, carbon-free fuel | Science | AAAS](#)

Occitanie Regionyour Neighbor

**6,1 millions
inhabitants**



72724 km²

**2nd largest
region in
France**

Occitanie Region a major provider of renewable energy

RENEWABLE ENERGIES in OCCITANIE

KEY FIGURES



12,500
jobs



275
businesses



Leading region for its development potential in offshore floating wind turbine (2 pilot farms out of 4 launched in France)



2,827 GWh
photovoltaic power generation per year*



10,172 GWh
hydroelectric production per year*



3,809 GWh
wind power production per year*



The most powerful **solare furnace** in the world



* June 2021





Once upon a time in **1999** a pioneer from Polytechnic institute of Toulouse launch major collaborative developments in hydrogen research

○

**Dr.-Ing. Christophe TURPIN, CNRS Research Director
Laboratory LAPLACE, turpin@laplace.univ-tlse.fr
Head of H₂ activities in Occitanie
Cofounder of H²Pulse engineering service company**

2010 : After 11 years of intensive research activities

Official opening of Toulouse Hydrogen platform



Activities around H₂ technologies:

- Hydrogen production (water electrolyse)
- Hydrogen storage (solid, liquid)
- Valorisation (fuel cells, combustion – boilers, engines)

Proposed services:

- Support for university research
- Industrial collaboration
- Testing service

≈ 20 technical staff

≈ 45
means of testing
€7M€

+€1.5M
for infrastructures



Occitanie, leader in the hydrogen sector

A regional strategy with appropriate financing for deployment and execution



Occitanie, leader in applying hydrogen in multimodal transport

The Occitanie Region is a unique living lab in the world testing innovative advanced Heavy mobility Simultaneously on **Road , Rail and Sea**

USES



liO Toulouse-Montréjeau-Luchon :
Deployment of 3 dual-mode Regiolis trains on the Toulouse-Montréjeau-Luchon line



HyDrOMer :
Construction of a hybrid H2/diesel dredge In partnership with LMG Marin and Piriou shipyards



liO coaches H2 :
Deployment of 15 retrofitted coaches in connection with the Corridor H2 project.



Corridor H2 Occitanie
€110 million of investment for the decarbonization of the truck transport of goods and fresh products in Europe.

- 2 renewable hydrogen production sites,
- 7 hydrogen refuelling station,
- 40 trucks
- 62 refrigerated units for trucks



Occitanie, leader in the hydrogen investments

INVESTMENTS



HY PORT

HyPort : Hydrogen mobility ecosystems in the airport areas of Toulouse and Tarbes



Hyd'Occ

Hyd'Occ: Mass production unit of renewable hydrogen in Port la Nouvelle



GENVIA:

Joint venture for the industrialization of high temperature solid-oxide electrolyser in Beziers



Techno Campus H2 Francazal :

10,000 m² planned to accommodate the largest European center for research, testing and technological innovation dedicated to renewable hydrogen.



Occitanie, leader in the hydrogen sector

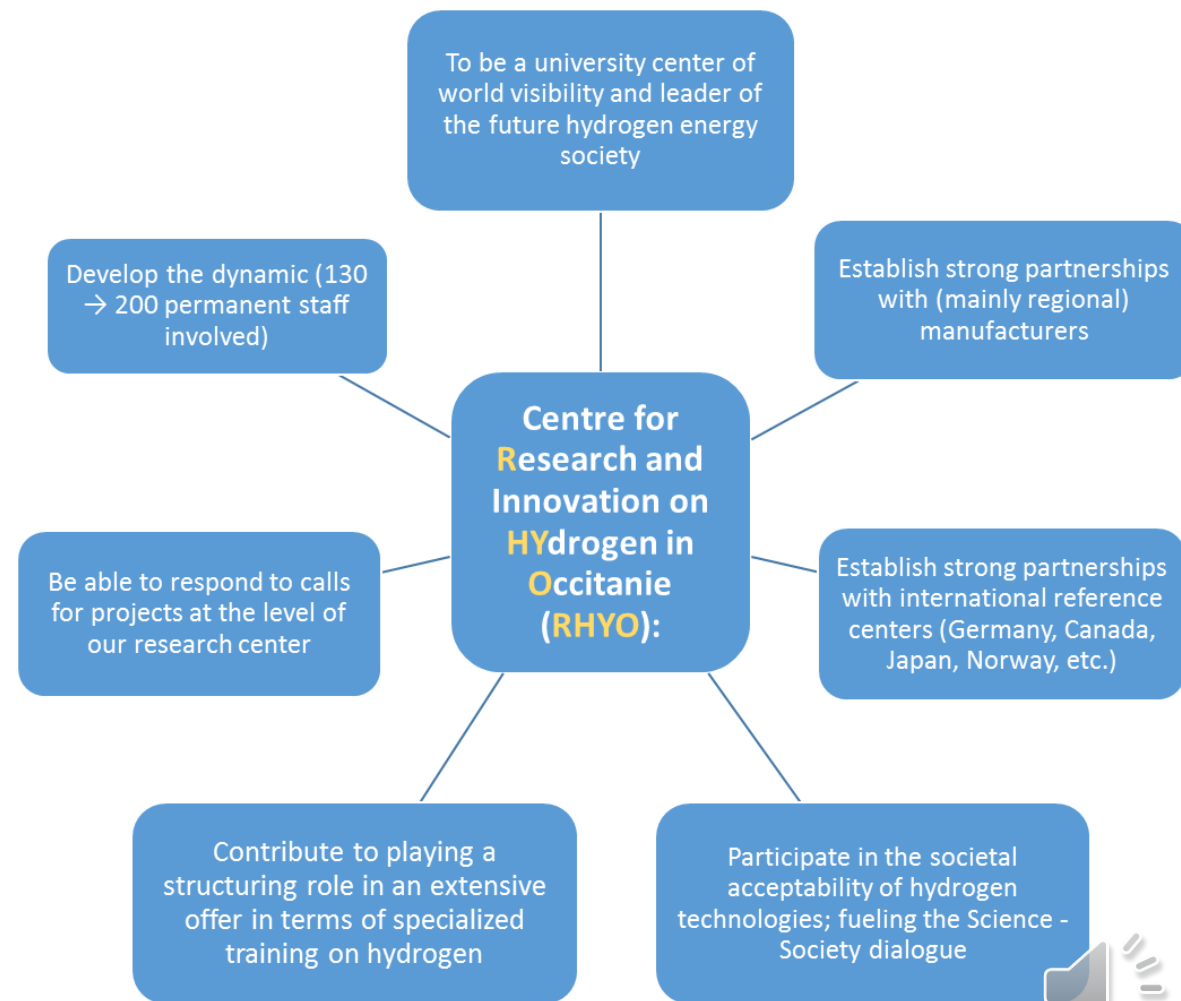
A regional strategy with appropriate financing for deployment and execution



Centre for **R**esearch and Innovation on **HY**drogen in **O**ccitanie

- Launching: 2021-2024
- +**20** region lab & schools
- +**150** permanent staff involved
- Attached to the federal University of Toulouse

Our partnership values:



A unique network of academic lab and engineering schools with incubators



Characterization, modelling, aging, diagnosis, prognosis of fuel cells / electrolyzers and associated systems.
H₂ cryogenic storage use study.
Grid integration / design.



Characterization and modeling, PEMFC water management.
H₂ combustion including engines and boilers.



Electrolysis of water assisted by magnetic induction.
Materials for solid storage H₂.



Photo-electrolysis of water.



Characterization, modeling combustion and engine H₂.



H₂ combustion modelling and detonical H₂.



Aqueous electrolyzers.
Materials for solid storage H₂.
Storage and H₂ production by LOHC.
Intensification of PEMFC systems.
Supply chains for H₂-energy.
Production of H₂ from biomass.



SOFC / SOWE materials and prototypes.
Photo-electrolysis of water.



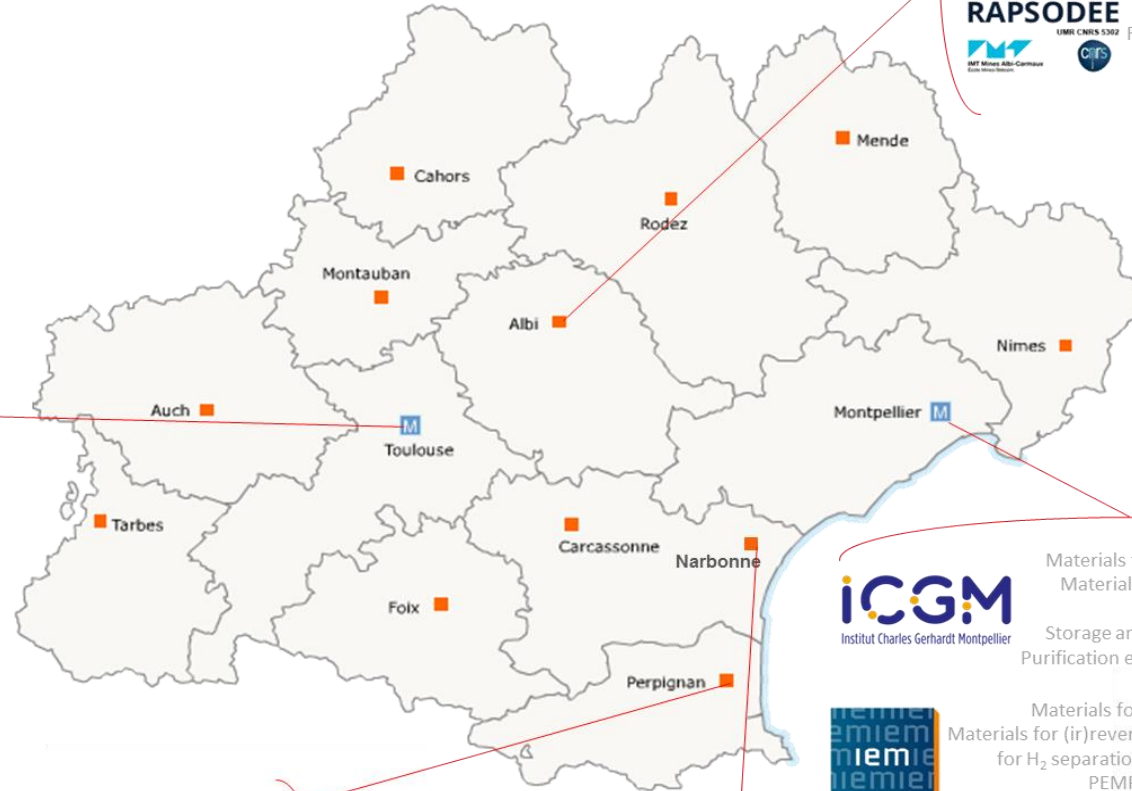
Materials for the production of H₂.
Materials for solid storage of H₂.



Production of H₂ by biological way.



H₂ vector integration in airports.



Production of H₂ by thermochemical solar methods.



Production of H₂ by biological way.



High pressure tanks: sizing, material degradation, development of new composites.



Production of H₂ from biomass by pyro-gasification.
Reforming of biogas to produce H₂.
Compression, transport and distribution of H₂.



Materials for AEMWE, PEMWE, SOWE.
Materials for PEMFC, AEMFC, PFCF.
H₂ sensors.
Storage and production of H₂ by LOHC.
Purification et electrochemical compression.



Materials for (photo)-electrolysis.
Materials for (ir)reversible storage of H₂. Membranes for H₂ separation/ purification/ detection.
PEMFC membranes.
Boron hydrides for dedicated fuel cells.



Production of H₂ from biomass by pyro-gasification.

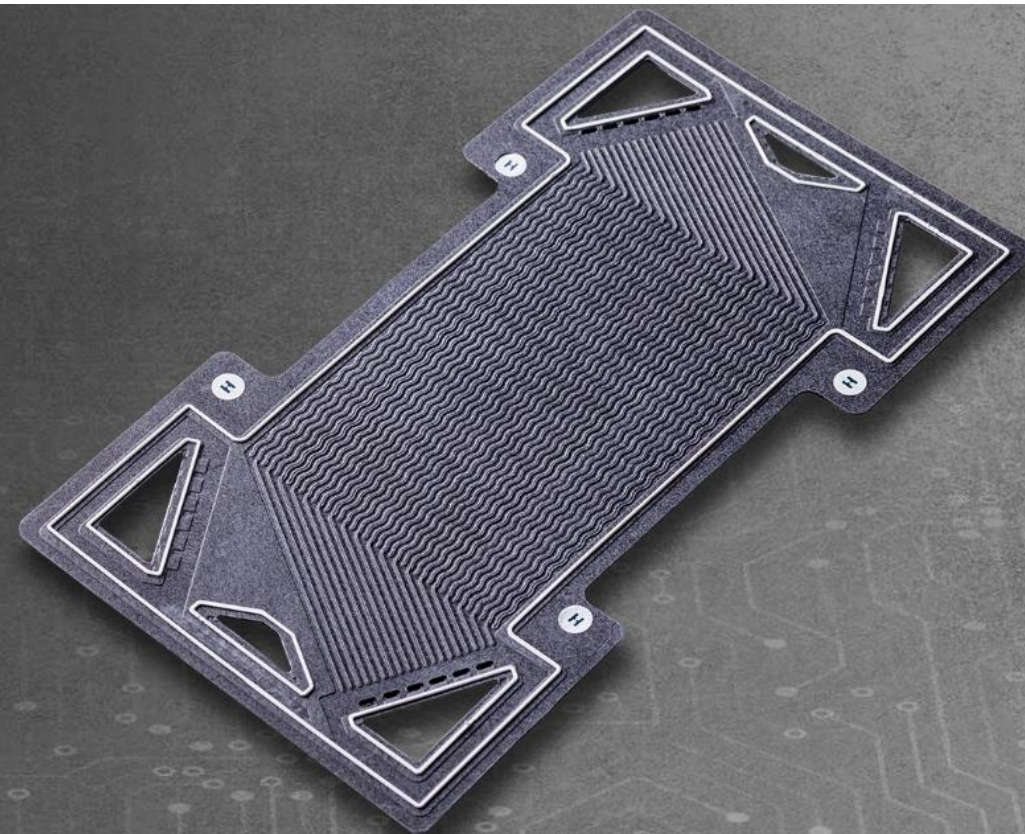


2017 a start up incubated @ IMT Albi Engineering school

2022 Assembly of prototype production line with 15 people
1 kW Fuel Cell demonstrator development

We are a bipolar plates manufacturer

THE NEW GENERATION OF
**BIPOLAR
PLATE**



Technology Campus Hydrogen Occitanie 2025

RESEARCH AND TESTING CENTER FOR HYDROGEN AND THE **MOBILITIES OF TOMORROW**

AIRBUS

SAFRAN
Safran Power Units

LIEBHERR

vitesco
TECHNOLOGIES



10,000 m² research center dedicated to hydrogen technologies.

Total investment of **55 million euros** co-financed by the State, the Occitanie Region, Toulouse Metropole and the CNRS for **commissioning in 2025.**

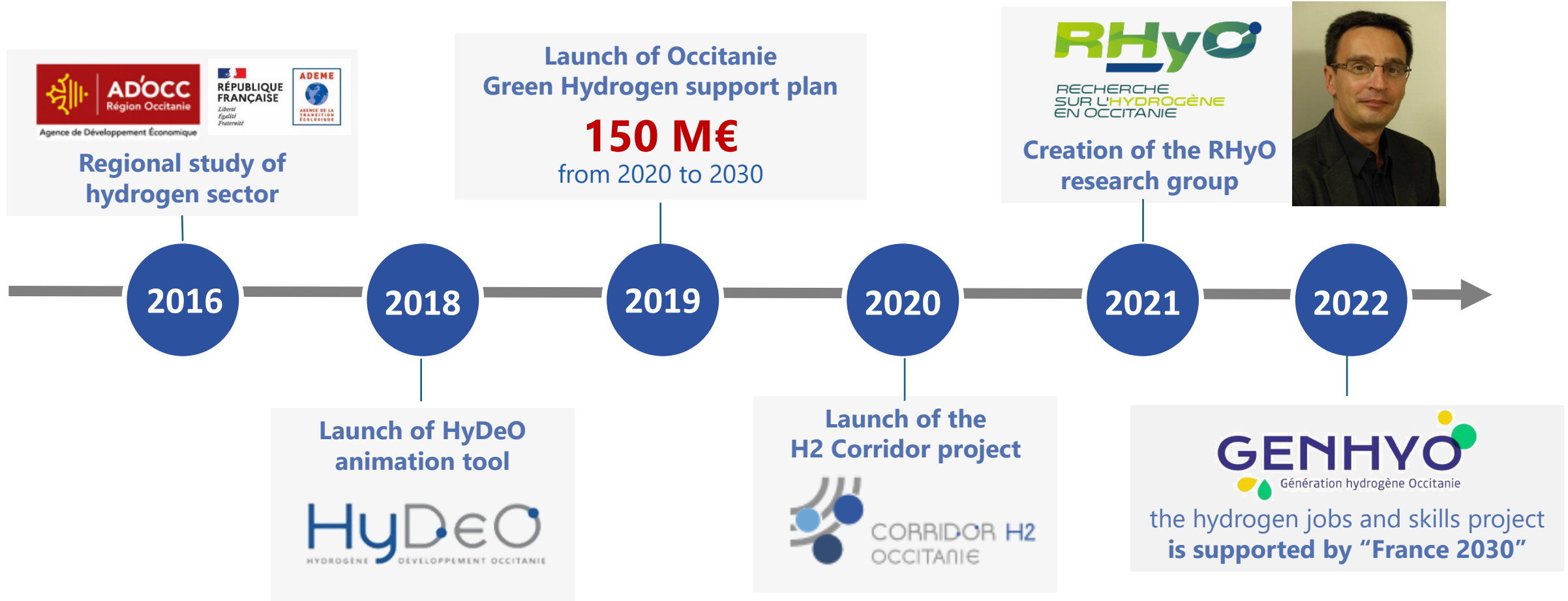
Meeting of the **hydrogen activities of four regional laboratories**

- Plasma and Energy Conversion Laboratory (Laplace)
- Materials Research Center (Cirimat)
- Chemical Engineering Laboratory (LGC)
- Institute of Fluid Mechanics of Toulouse (IMFT).

Combined with unique **test resources available for companies for the development of hydrogen technologies.** A dozen confidential boxes available for hire, as well as storage spaces and two secure bunkers suitable for high-power testing, up to **one megawatt**

Occitanie, leader in the hydrogen sector

A regional strategy with appropriate financing for training trainers & workforce





The implementation of training modules for different audiences :middle school students, high school students, students, job seekers, employees, elected officials, general public



The training of **1500 trainers** over **5 years**



The promotion of jobs in the H2 industry sector orientation and professional integration



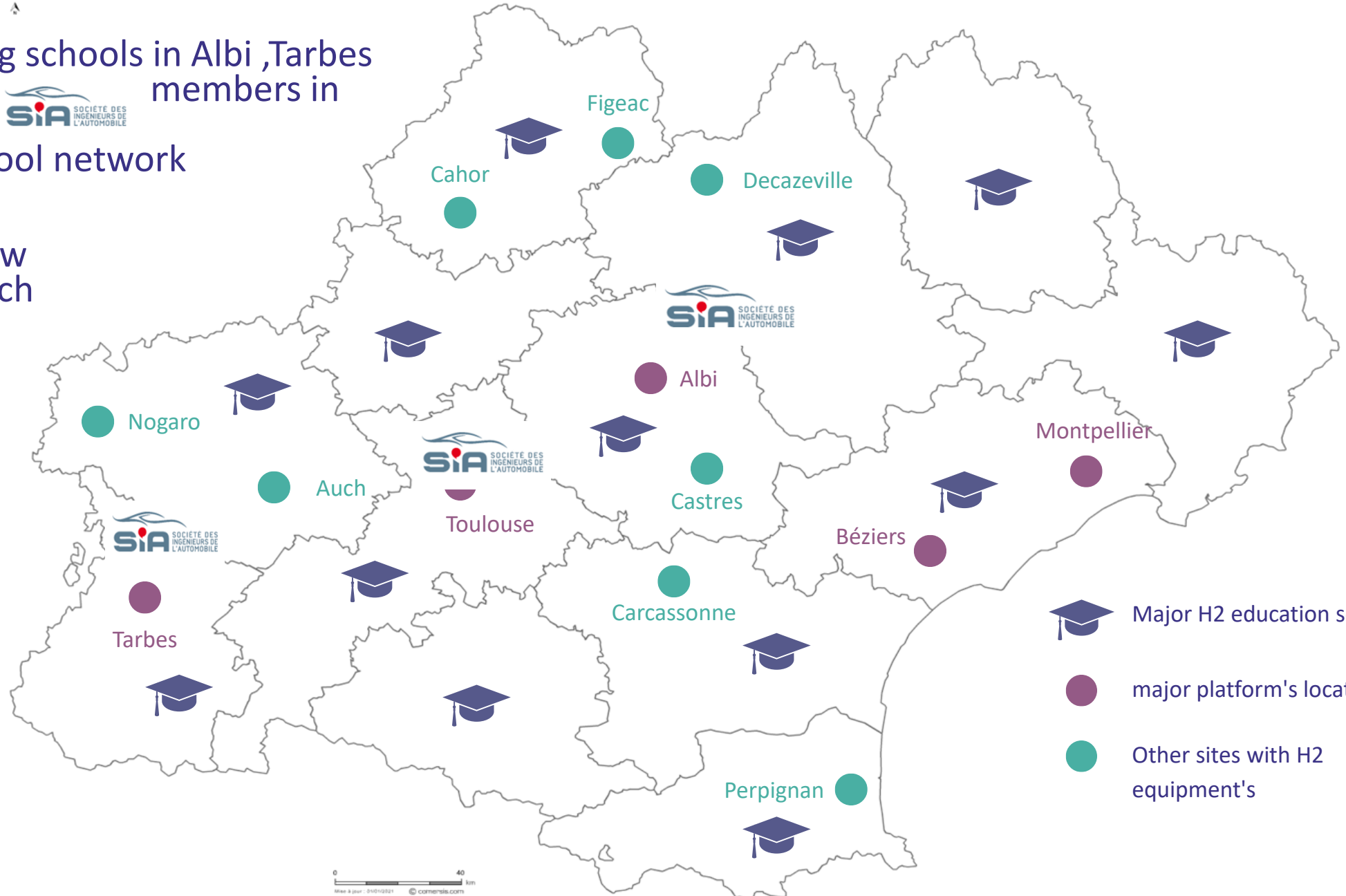
Observatory for prospective in professions, competencies and qualifications

All high engineering schools in Albi, Tarbes and Toulouse are members in



Toulouse Tech school network

170 educational low power H² Test Bench distributed across regional schools



- Major H2 education schools
- major platform's locations
- Other sites with H2 equipment's

Occitanie, leader in the hydrogen from basic technology up to full embedded systems

Industrial value chain



30 companies

produce components, technological bricks and hydrogen system



ALSTOM



Tarbes / Fuelcell traction system of Coradia iLint and Régiolis H2. Notified IPCEI Hy2Tech

SAFRA



Albi / Hydrogen bus manufacturer, hydrogen coaches retrofit

NEXEYA
A Hensoldt Company



Toulouse / Pressurized storage container and autonomous hydrogen system

HYCCO
BIPOLAR PLATES



Toulouse / Industrialization of bipolar graphite plate, key component of hydrogen fuelcell.

BOSCH



Rodez / fuel cell system for refrigeration unit transporting fresh products

GENVIA



Béziers / Industrialization of Solid-Oxide electrolyser at high temperature. Notified IPCEI Hy2Tech

bulane



Fabrègues / manufacturer of electrolyzers for combustion systems: welding, industrial process, heating

HYDROGEN IN AERONAUTICS



Many players are developing the hydrogen aviation of tomorrow in Occitanie.

27/2/2024: France's first manned hydrogen-electric flight

2024 Bleriot Aircraft : 85kW flying test bench for retrofitting a 2-seater from G1 aviation.

This cutting-edge aircraft propulsion system seamlessly integrates 66% hydrogen tanks and 30% batteries to power the propeller.



27/2/2024: France's first manned hydrogen-electric flight



2024 Bleriot Aircraft : 85kW flying test bench for retrofitting a 2-seater from G1 aviation.

This cutting-edge aircraft propulsion system seamlessly integrates 66% hydrogen tanks and 30% batteries to power the propeller.



2030 :Target Business jet
6 seats – 1000 Km.





Genvia's *thermally-charged electrolysis* process



www.cea.fr - www.
supernovainvest.com

Schlumberger



www.vinci-
construction.com



www.vicat.fr

> High Efficiency Solid Oxide Electrolyser Technology

> Thermally-Charged Electrolysis

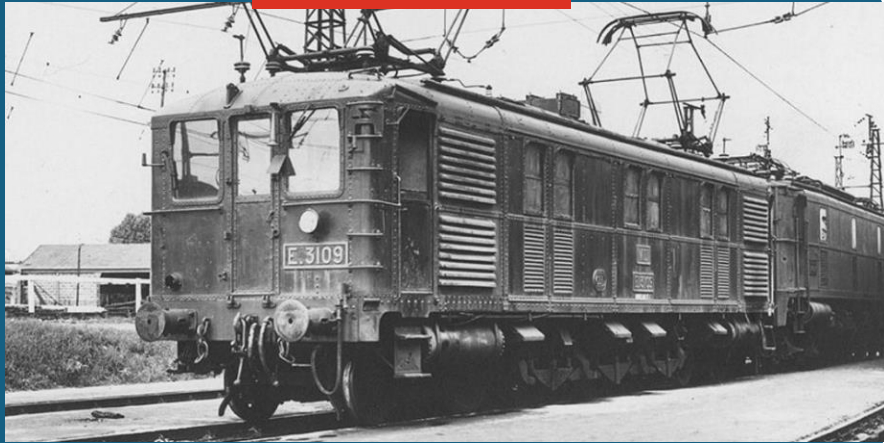
Actively consumes industrial heat
This approach delivers the most
energy-efficient electrolysis performance
available at scale, **with 28% more hydrogen produced for every kWh of electrical energy input.**

Gigafactory planned by 2026 - Target price H2 2030 2€/Kg





1921



1500 V DC

ALSTOM
• mobility by nature •



2016

**Hydrogen Solutions
for non-electrified lines**

ALSTOM
• mobility by nature •

Alstom Fuel Cell train for Suburban & Regional services

Traction designed in Tarbes Occitanie - center of excellence for Alstom **Green Traction**



Aventra FCMU

- 10 FCMU trains for Eversholt Rail (MoU)

Coradia iLint

- 14 FCMU trains for LNVG
- 27 FCMU trains for RMV

Coradia Stream

- 6 FCMU trains for FNM

Regiolis H2

- 12+2 trains Bi-mode Catenary-H2 for SNCF
 - Occitanie
 - Auvergne Rhône Alpes
 - Grand Est & Bourgogne Franche-Comté

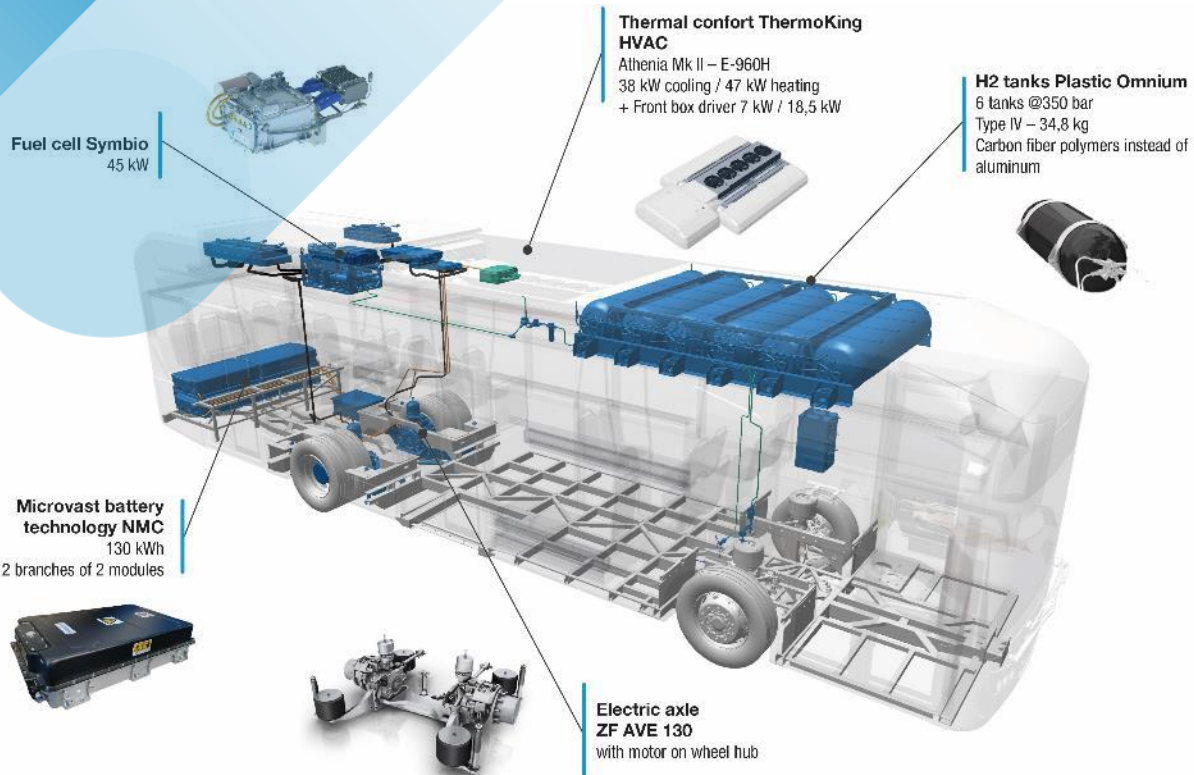


MANUFACTURER
HYDROGEN BUSES

2018



HYCITY: the 100% European hydrogen bus *



DESIGN

CAD/3D

Mechanics and electrics
Proprietary on-board systems
and software

100% Safra
software on board
(energy, connection to the
road, safety, operation,
comfort...)

INTEGRATION

Fuel cell, batteries,
components
and sub-components

MANUFACTURING

On-site assembly
Road test
Certification

BY SAFRA





RETROFIT HYDROGEN COACHES



H2-PACK

Hydrogen powered by SAFRA

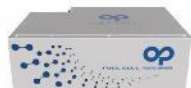
H2 Tanks
Plastic Omnium
6 tanks @350 bar
Type IV - 34.8 kg
Carbon fiber polymers



Microvast battery
NMC technology
71 kWh
2 branches of 2 packs



Fuel cell
Plastic Omnium
70 kW



Powertrain
Dana TM4
350 kW



SAFRA
Accélérateur de mobilité décarbonée

OP
PLASTIC OMNIUM

Electric drive

350 kW

Batteries

71 kWh

Fuel cell

70 kW

Hydrogen storage

35 kg



10/15 min
Refueling time



Range up to
500 km



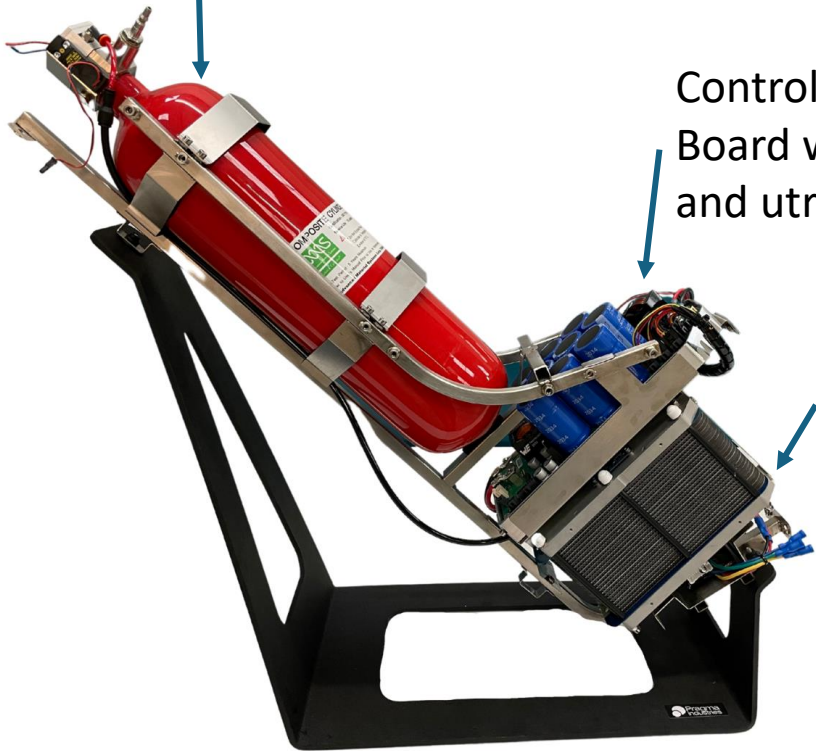
**FABRIQUÉ
EN FRANCE**

Hydrogen Multipurpose Power pack

3 liters tank (63g H₂)@ 300bars

Control Command electronic Board with DC/DC Converter and ultracapacitor buffer

480 W Fuel Cell



In Occitanie we speak fluently Hydrogen technical language and have know how to take off innovations in cooperationwith Catalonia!



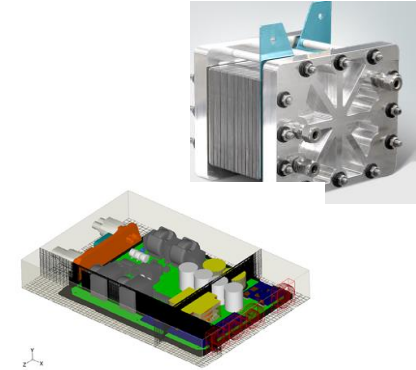
highly educated students



large number of test bench



H2 collaborative techno campus



all technologies available



**The place to be for
Automotive
hydrogen thermal
engine and Fuel
cell electrical
vehicle
innovations**



Thank you for your attention !

En caso
puedo ayudar

