L'HYDROGÈNE ET SON ÉCOSYSTÈME, ÉNERGIE DU FUTUR?

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Which energy for a green planet?

> Drivers :
- CO_2 emission pressure (global warming)
- Deployment of areas restricted to low emission vehicles in big cities
- Hybrids and electric vehicles purchase incentives
- Charging infrastructure availability and deployment
- Greenhouse gases are confirmed to be responsible for global warming
- Customers demands = green vehicles

CO_2 regulatory forecast per regions

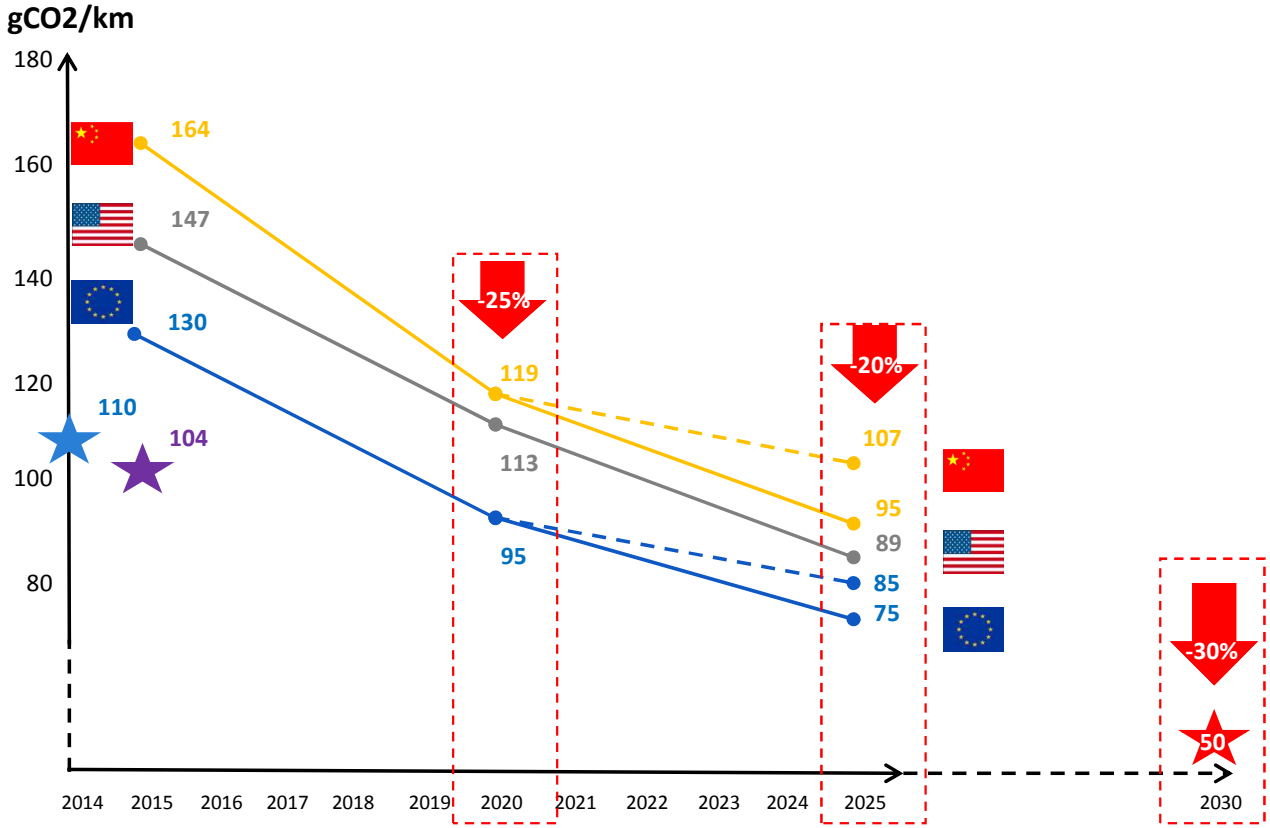
> Common text for PC & LCV

> CAFE targets:
-15% in 2025 vs 2021 and -30% in 2030 vs 2021

> Slope reduced by -15% in 2025 and -30% in 2030

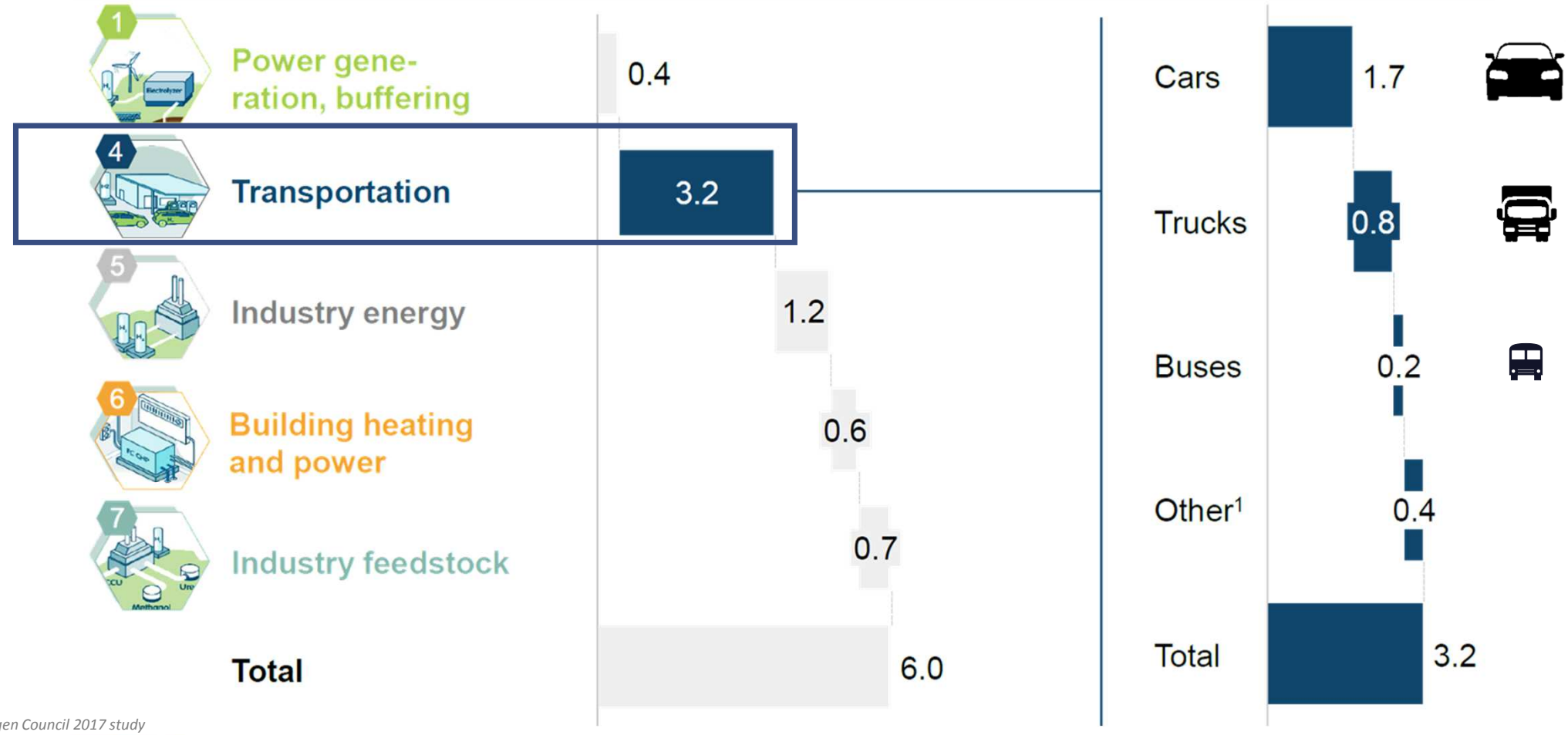
> LEV « Benchmark » 15% (2025) & 30% (2030)

> Penalties up to 95€/g !!!



2030 : European Comission proposal

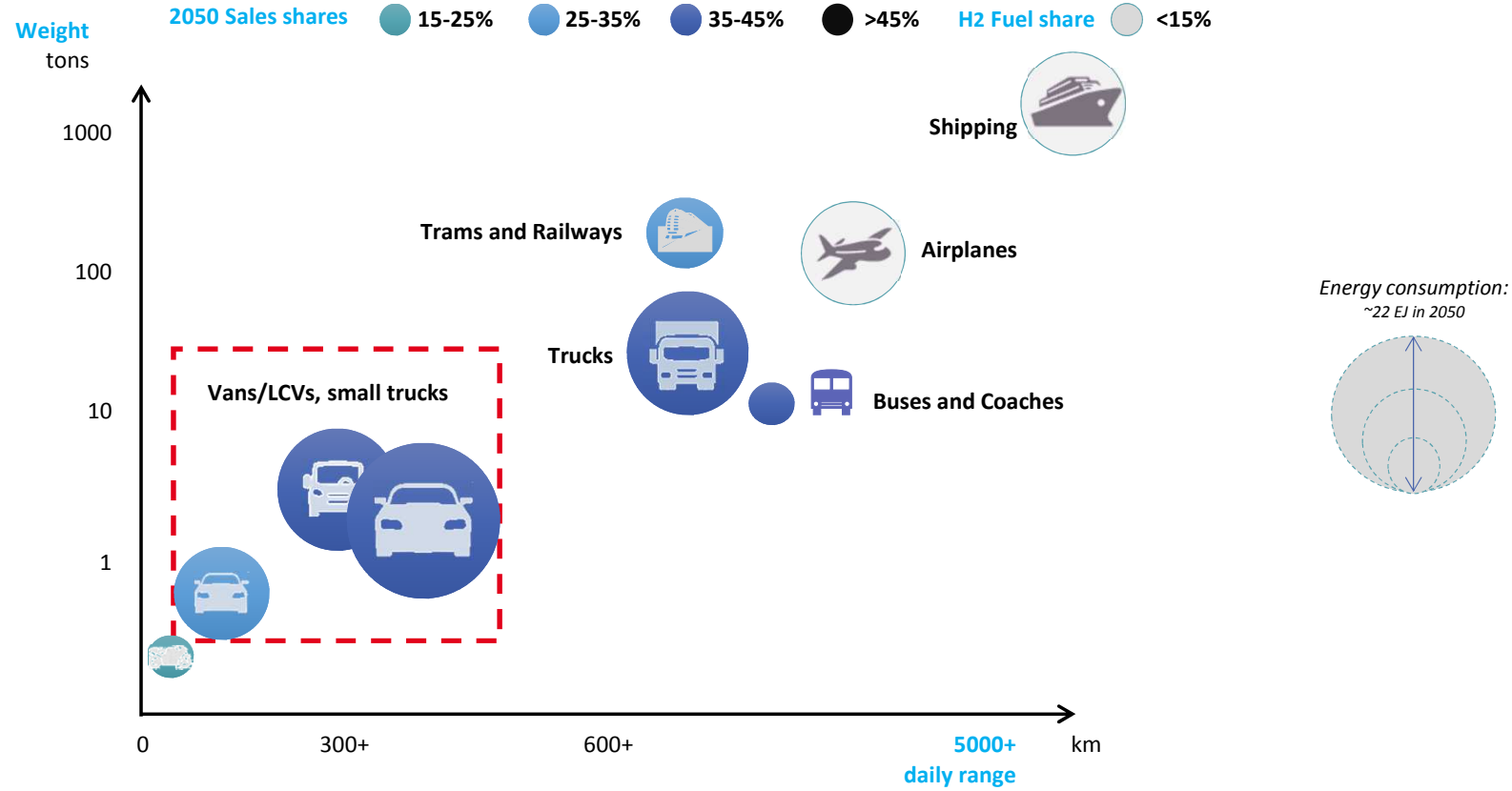
Breakdown of CO_2 reduction achievable in 2050 thanks to Hydrogen, for each industry sector (in Giga tons)



Source : Hydrogen Council 2017 study

1: Aviation, shipping, rail, material handling

Role of Hydrogen to decarbonize different segments of transport and mobility



Source : IEA ETP, HIS, Hydrogen Council 2017

Forecast of energy consumption and market share (% sales) in 2050

Technologies to comply with CO_2 regulations

- Improvement of ICE
- Hybrid Vehicle (MHEV, HEV)
- Plug-in Hybrid Vehicle (PHEV)
- Battery Electric Vehicle (BEV)
- Fuel Cell Electric Vehicle (FCEV)
- **FCEV & BEV are complementary !**

Actual PSA's strategy

- ✓ 15 new electrified vehicles between 2019 and 2021 (Opel included)
- ✓ 100% of the range electrified by 2025

Launch of the new Euro 6d temp engines

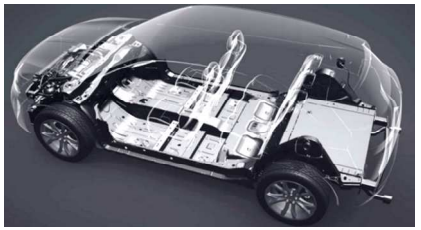
✓ Reduced emissions and fuel consumption:

✓ Pure Tech petrol engine (3 cyl.)

✓ 1.5L BlueHDi diesel engine (4 cyl.)

2 MULTI-ENERGY PLATFORMS
(PETROL, DIESEL, ELECTRIC OR HYBRID)

CMP



B & C segments

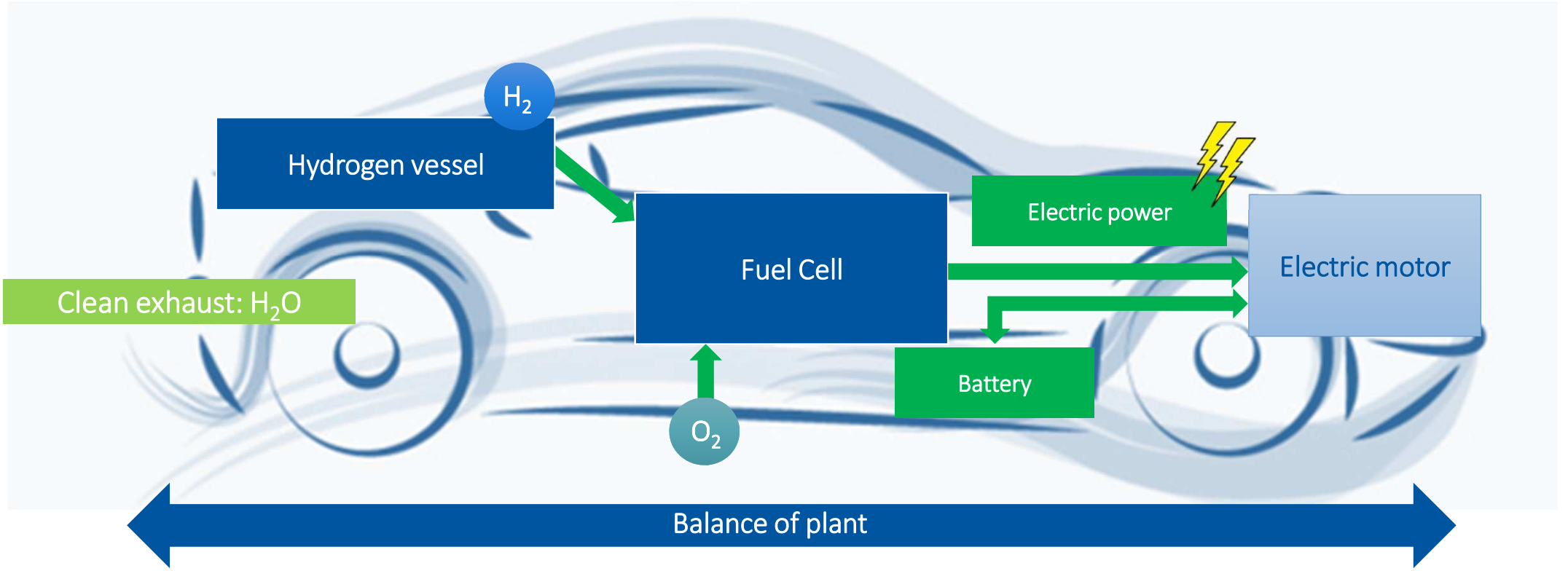
BEV from 2019

EMP2

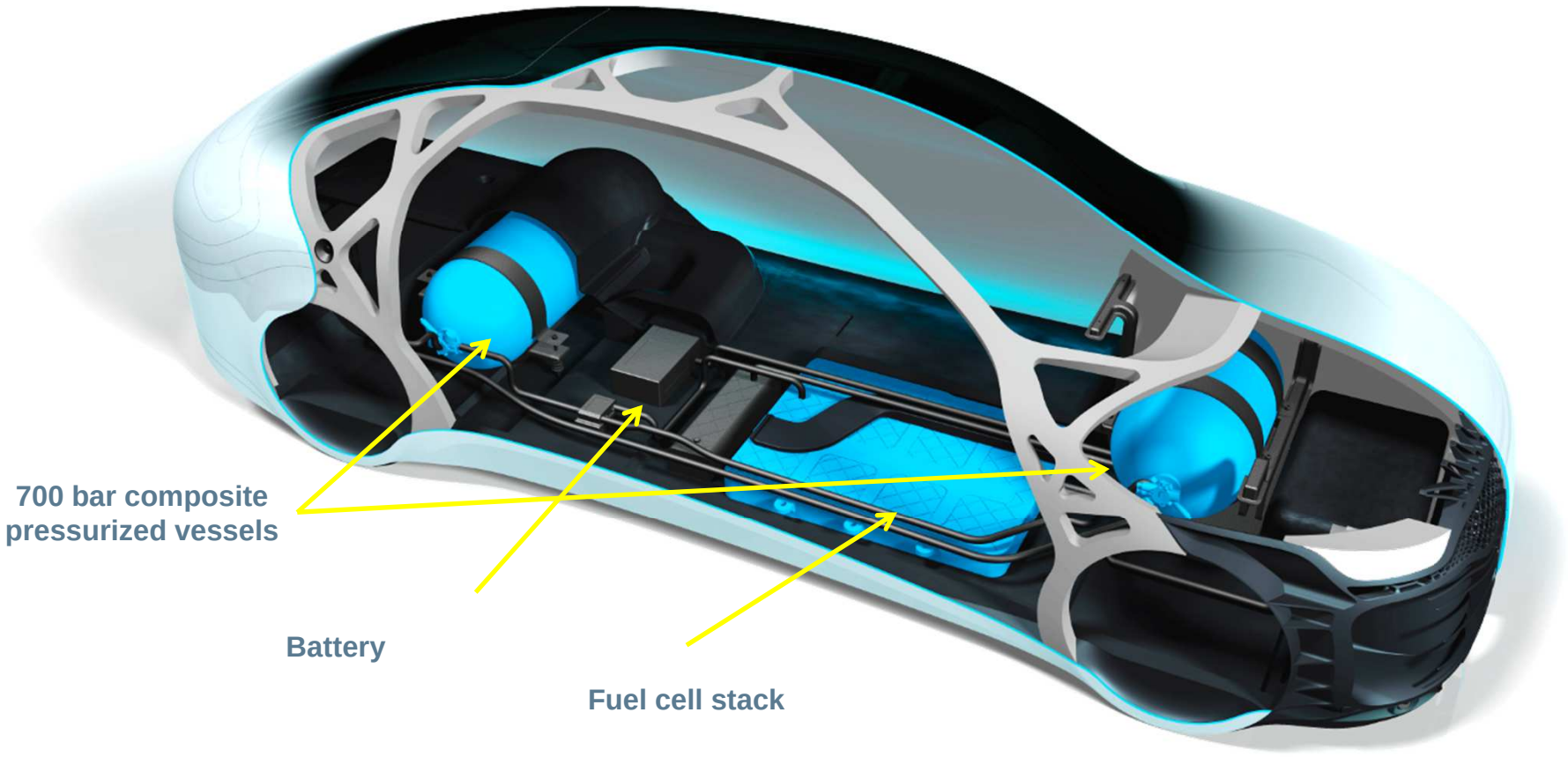
C & D segments

PHEV from 2019

What is a Fuel Cell Vehicle?

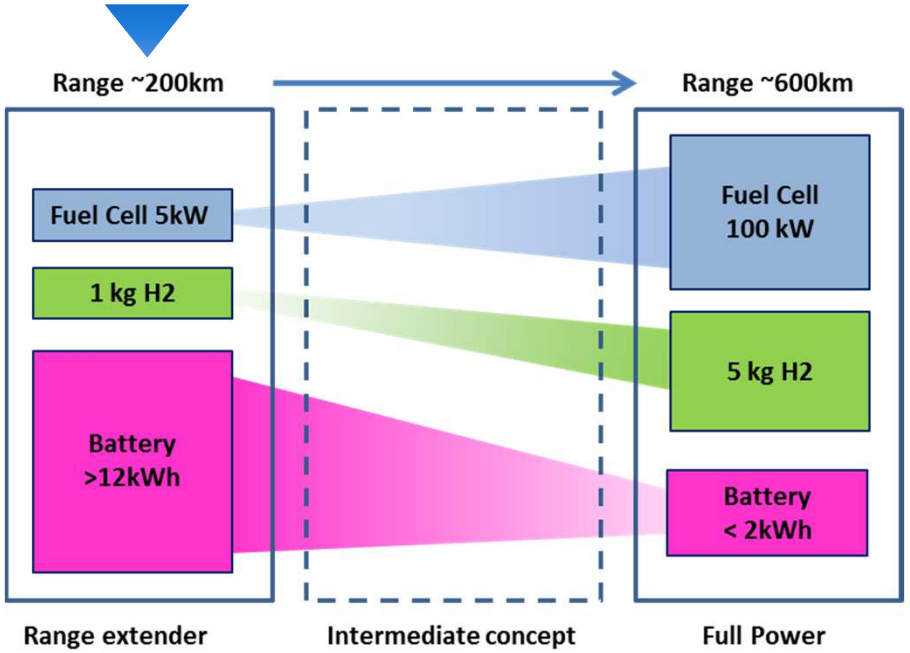


What is a Fuel Cell Vehicle?



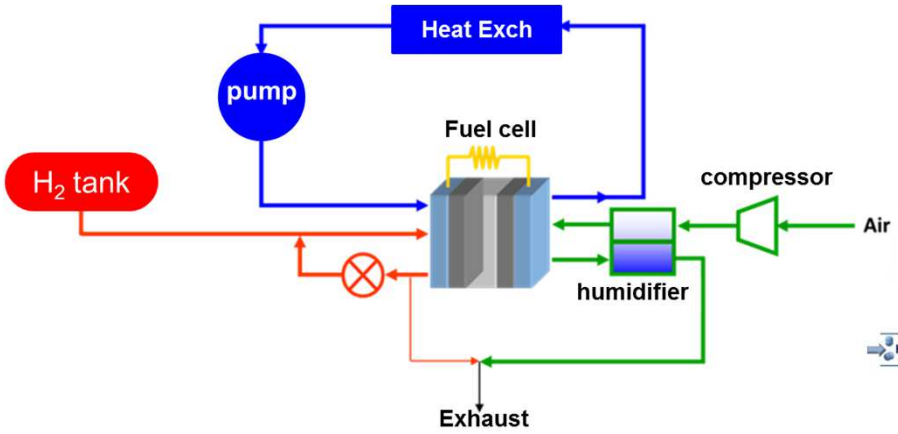
Different types of FCEVs are possible

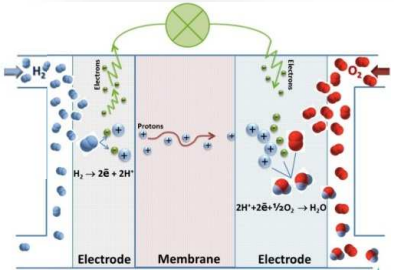
> An Electric Vehicle is based on a hybridization of the Electric Power Supply



Different architectures of Fuel cell systems

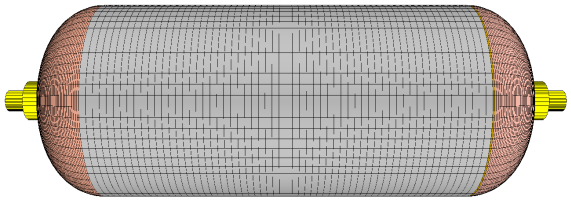
- How does a Fuel cell work?
- The full system comprizes the Fuel cell and surrounding peripherals: the Balance of plant
- The heart of the system: the Fuel cell stack
- The hydrogen storage: composite pressurized vessels





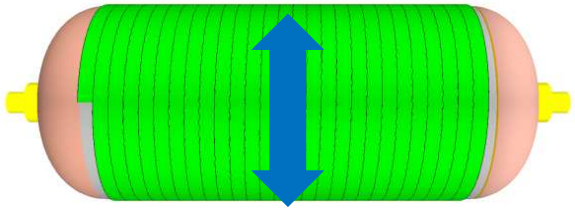
Manufacturing of composite pressurized vessels: an automatized process from simulation to production

1

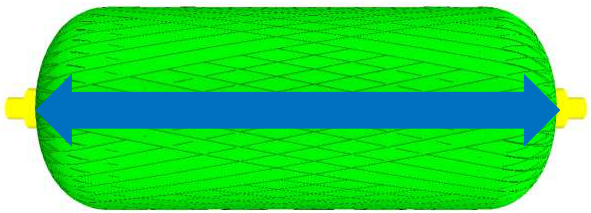


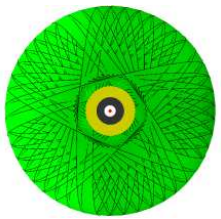
COMPOSICAD™
ULTIMATE FILAMENT WINDING™

Hoops = resist to radial expansion



Helicoils = Resist to axial expansion



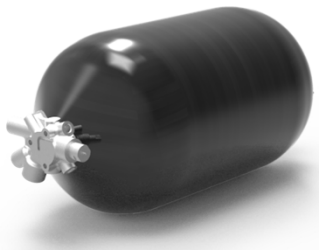


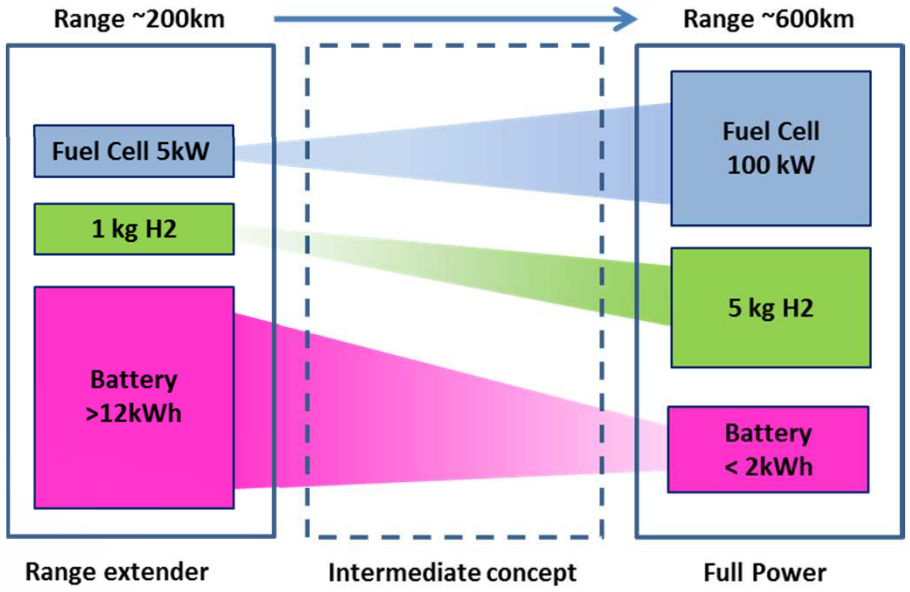
2

Different architecture of Fuel cell systems

> An Electric Vehicle based on the hybridization of the Power Supply for Urban / Suburban use: daily range ~200km.

> Range Extender
- HV Battery : >12kWh
- Fuel Cell System : <10kW
- Hydrogen Storage System : 1-2kg H_2
- E-drive : ~70kW

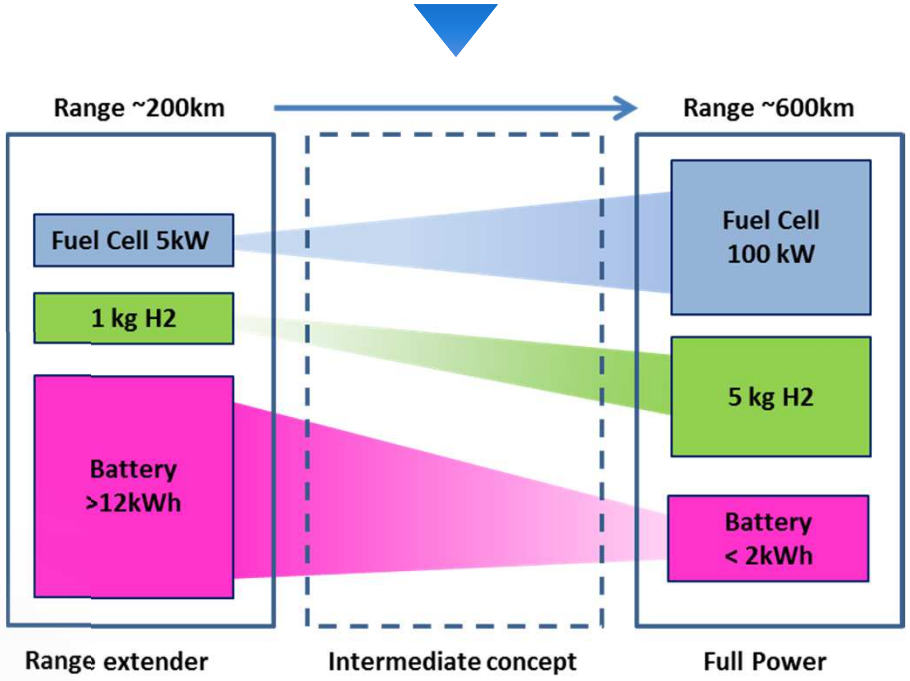




Different architecture of Fuel cell systems

> An Electric Vehicle based on the hybridization of the Power Supply for versatile use: daily range ~400km.

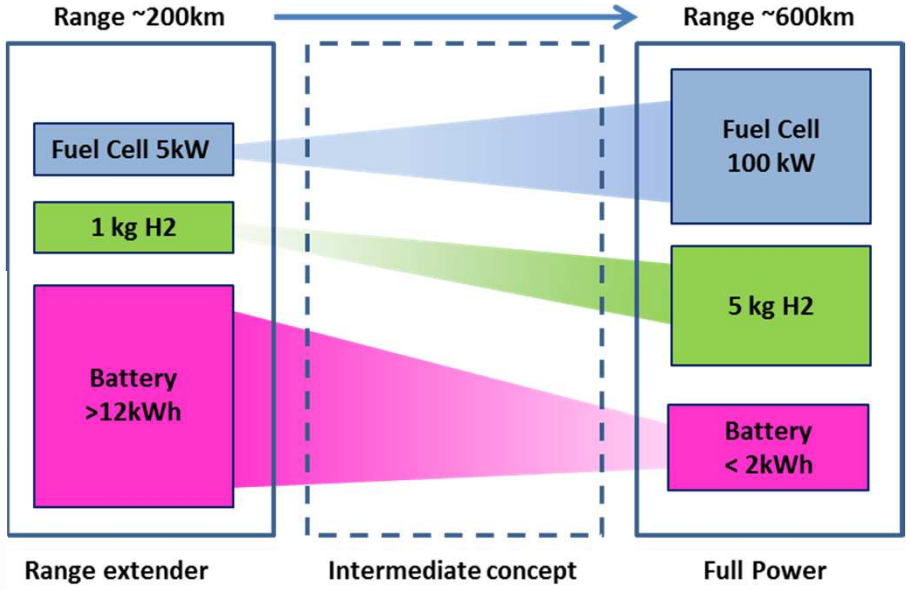
> Intermediate Concept
- HV Battery : ~8-9kWh
- Fuel Cell System : ~20 à 100kW
- Hydrogen Storage System : 3-4kg H_2
- E-drive : ~100kW



Different architecture of Fuel cell systems

- An Electric Vehicle based on the hybridization of the Power Supply for versatile and equivalent to today's vehicles: daily range ~600km.

- Full power concept
  - Batterie HT : < 2kWh
  - Fuel Cell System : ~100kW
  - Hydrogen Storage System : 5-6kg H_2
  - E-drive : ~100kW



FCEVs already commercially available in 2018

- Available FCEVs concepts are fully functional and validated (durability, safety).
- FCEVs are Zero Emission Vehicles, only emiting vapor water.
- FCEVs offer fast recovery of autonomy (H_2 refueling within ~ 3-5 minutes).
- Only limited number of models are proposed today by some car makers.

TOYOTA

HONDA

HYUNDAI

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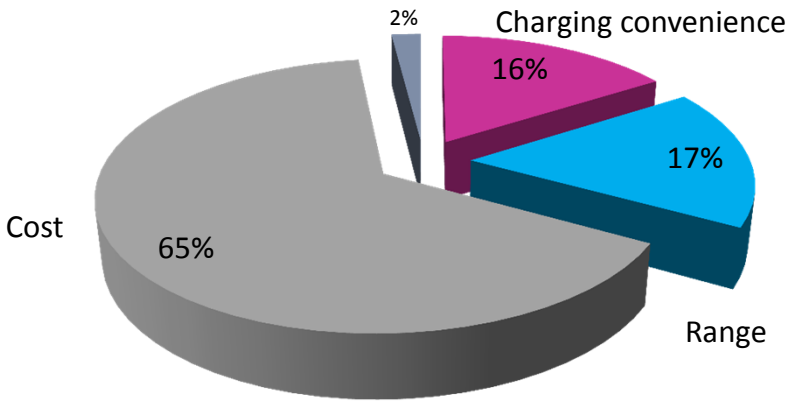
~ 1/3 of customers value range and charging more than cost and don't consider fast charging sufficient

Top factor when chossing a new car

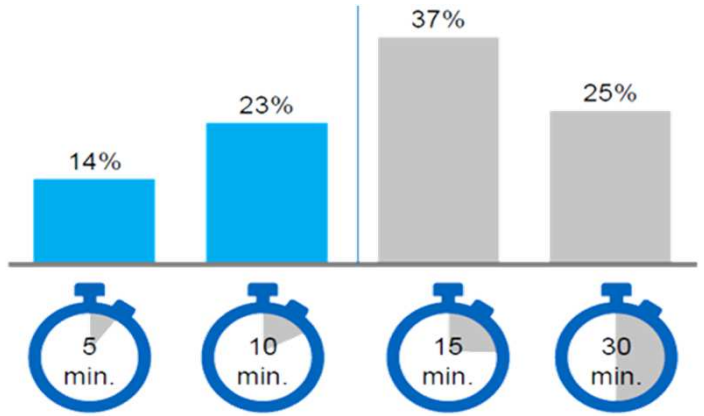
Share of respondents



Maximum acceptable time for charging

Percentage of respondents

Fast charging too slow ! **Fast charging sufficient**



Source : customers survey 2018 held by Mc Kinsey.

FCEV refueling, how does it work?

Why don’t we find more FCEVs on the roads then?

- Some challenges & questions about Hydrogen & FCEVs remain
  - Are FCEVs really green vehicles? ...
  - How to produce hydrogen? ...
  - What about CO_2 total emissions? ...
  - What is the effective Energy performance? ...
  - How do we manage the system integration? ...
  - What is the real cost of the technology? ...
  - What about the refueling infrastructure? ...
  - Is it a really safe technology? ...

How optimistic can we be for Hydrogen vehicles in the future?

If we remove all the road blocks, then the optimistic scenario shows:

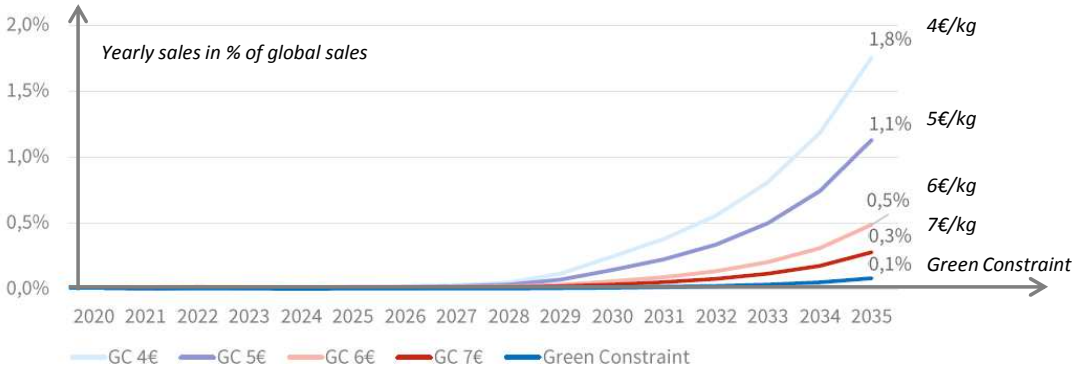
Source : Hydrogen Council 2017 study

BAU: Business As Usual

Deployment scenario: several drivers affect the market of FCEV

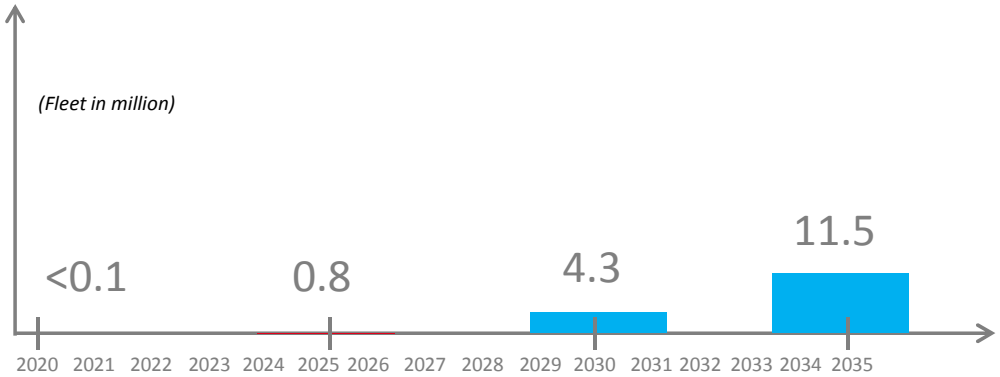
Etude de sensibilité au prix de l'hydrogène à la pompe

Source : BiPE 9.2018



Ambitious Scenario
"acceleration of H2 deployment"

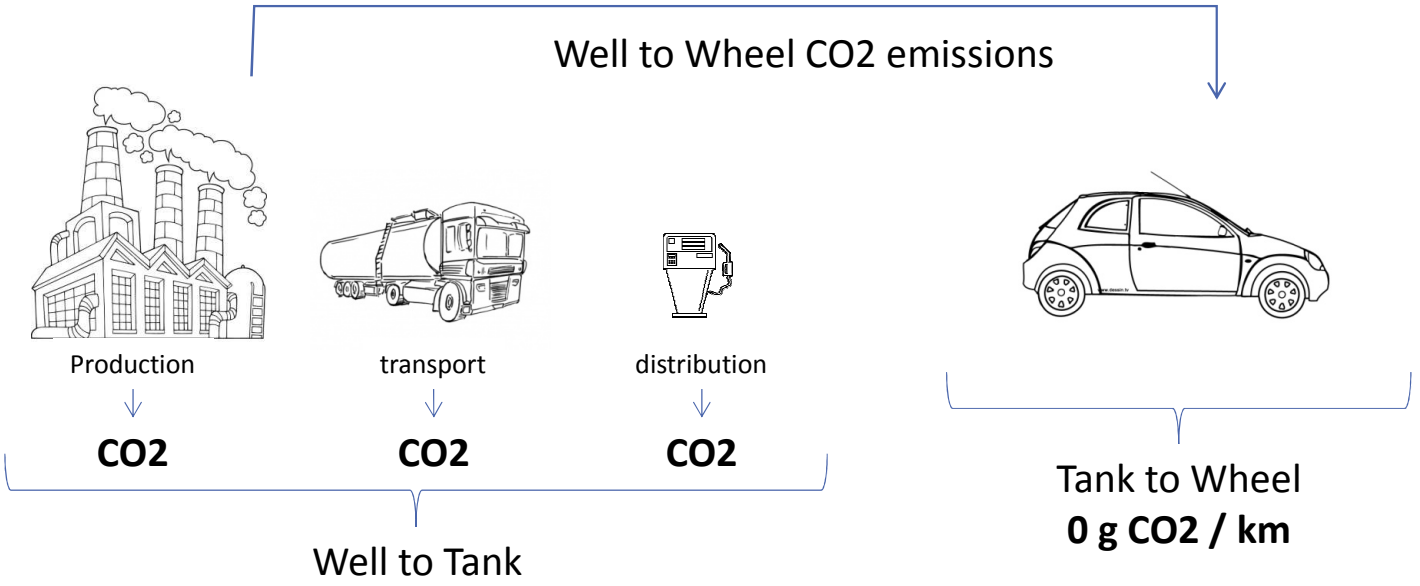
Source : Hydrogen Council 11.2017



- A partir de différents scénarii, les prix du Kg d'H2 ont été injectés dans le modèle du BiPE sur différents horizons temporels.
- Chaque région est simulée avec ses contraintes de mixte énergétique powertrain.
- Les ventes mondiales sont fortement influencées par le prix H2 à la pompe.
- Les ventes mondiales pourraient atteindre en 2035 de 3,8 million (BiPE) à 11.5 million (H2 Council).
- Jusqu'en 2025, on trouvera principalement des taxis, bus et véhicules utilitaires légers.

Is a FCEV a green vehicle?

> Yes but …



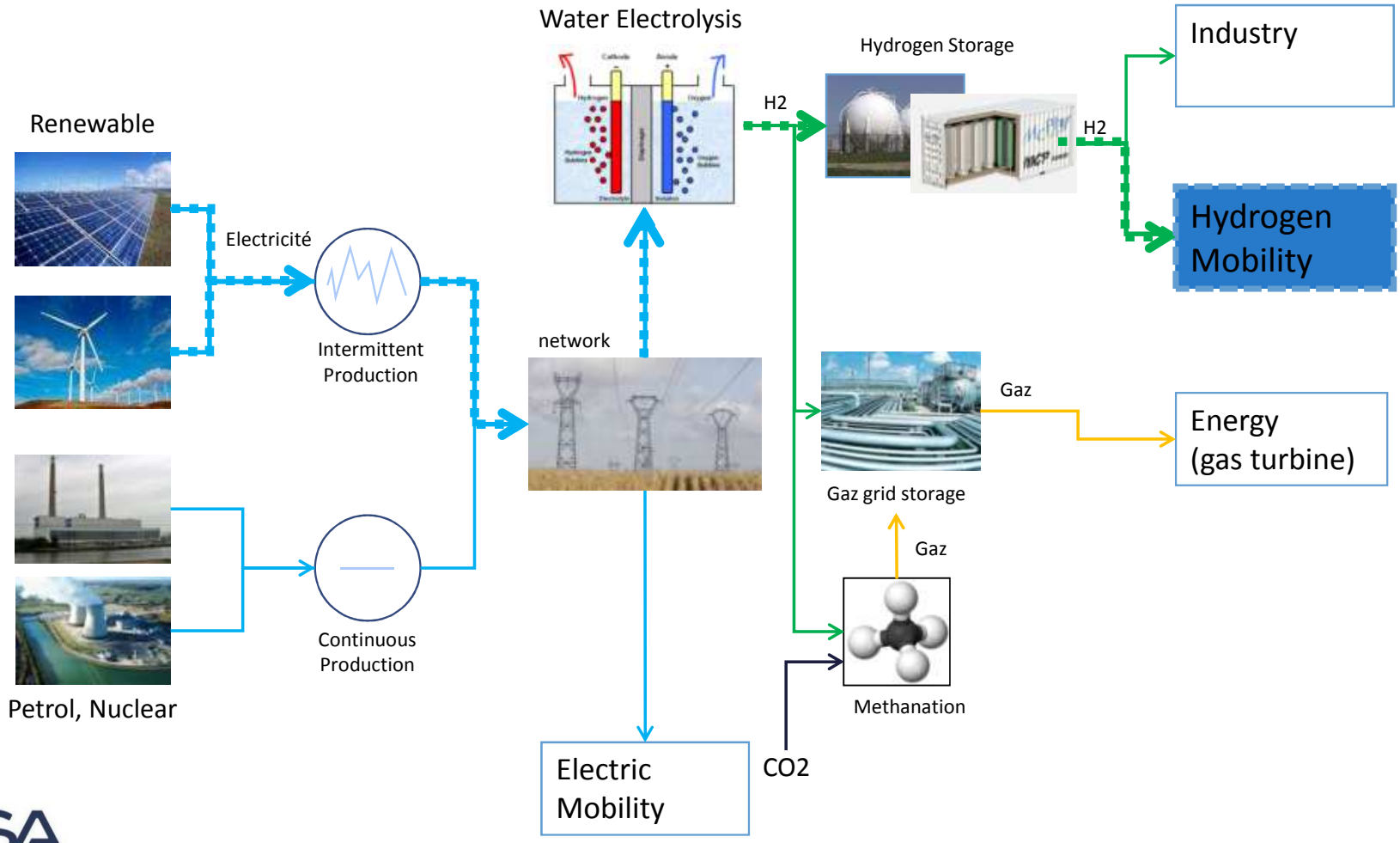
Huge need for decarbonised hydrogen!

> How to produce hydrogen?

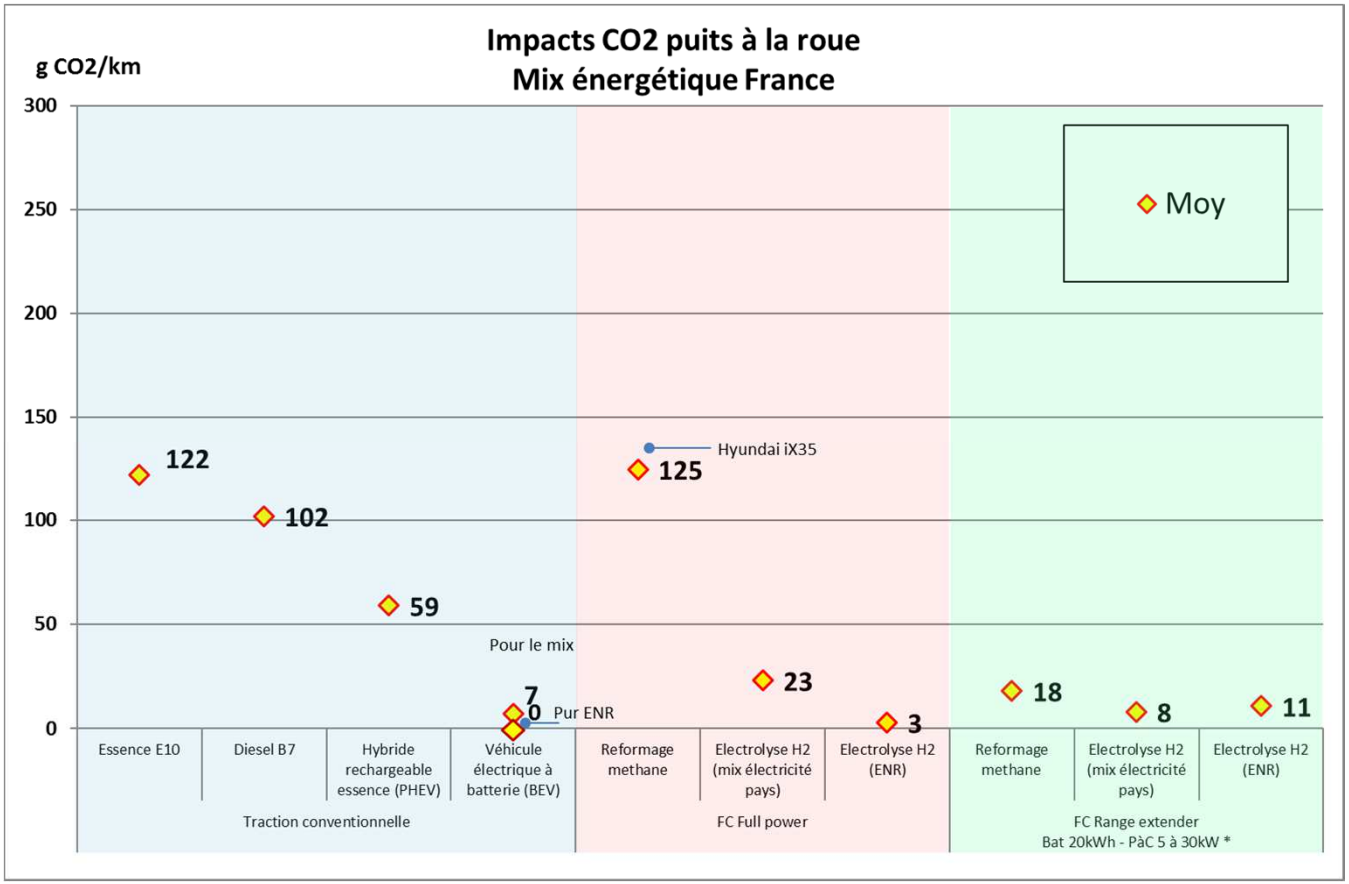
- Main way: use of carbon compound to produce hydrogen
  - o Steam reforming of natural gaz (SMR)
  - o 1kg H_2 produced by SMR = emission of ~10kg CO_2

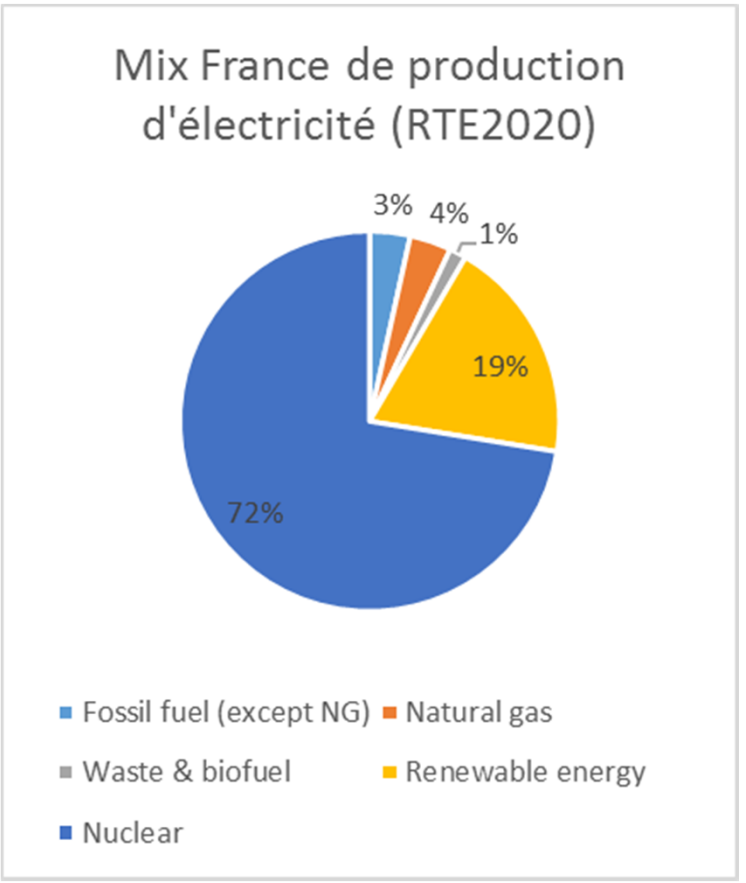
- But new processes can help to decrease CO_2 emissions
  - o Water Electrolysis but required electricity from renewable
  - o Carbon Capture & Sequestration (CCS) combined with SMR

The complete ecosytem needed for H_2 mobility

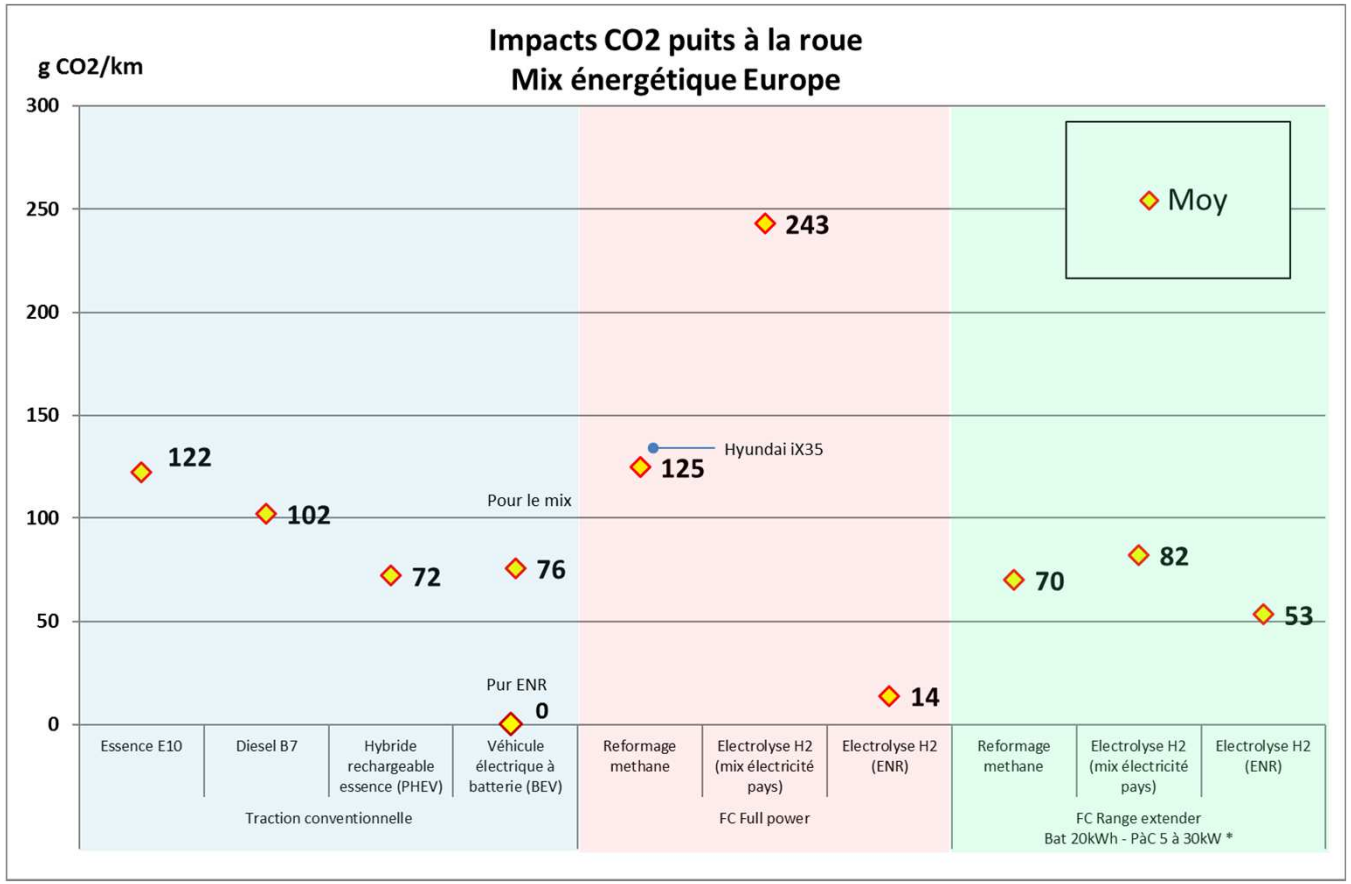


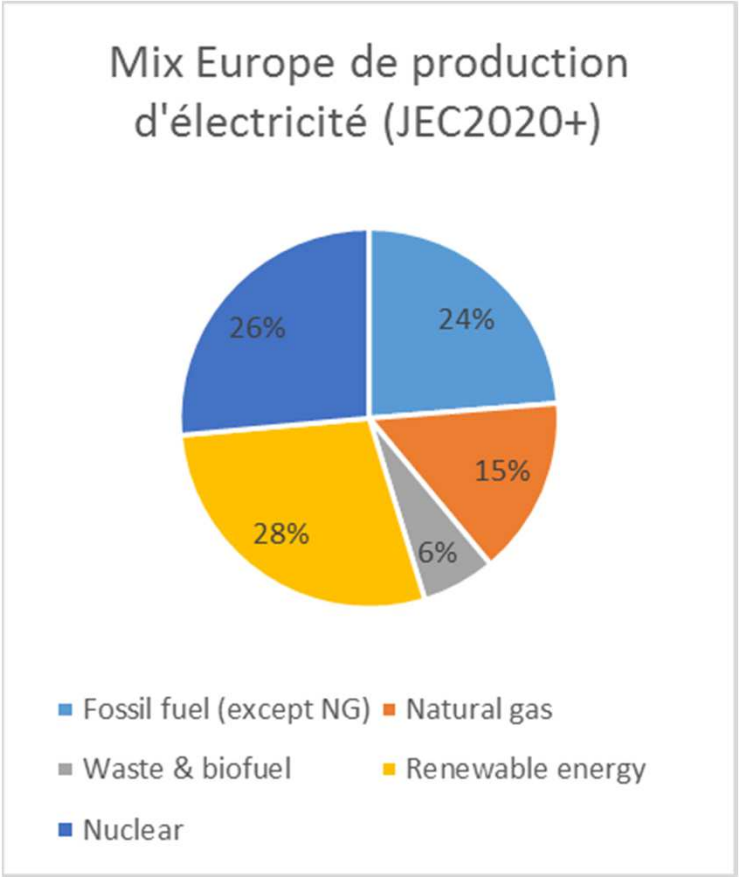
Well to wheel life cycle analysis of powertrain





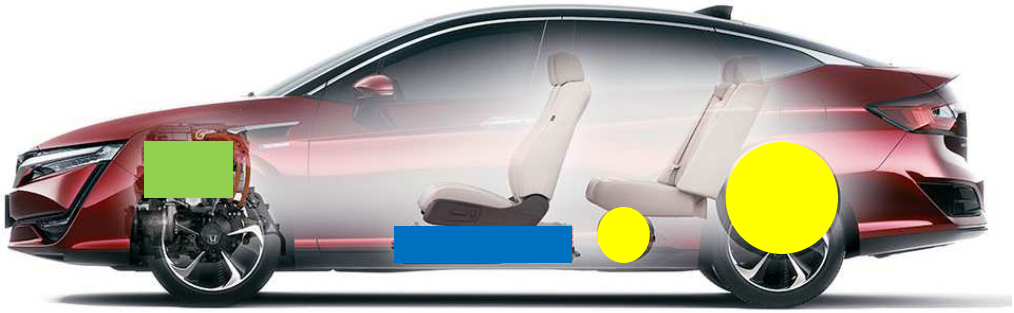
Well to wheel life cycle analysis of powertrain

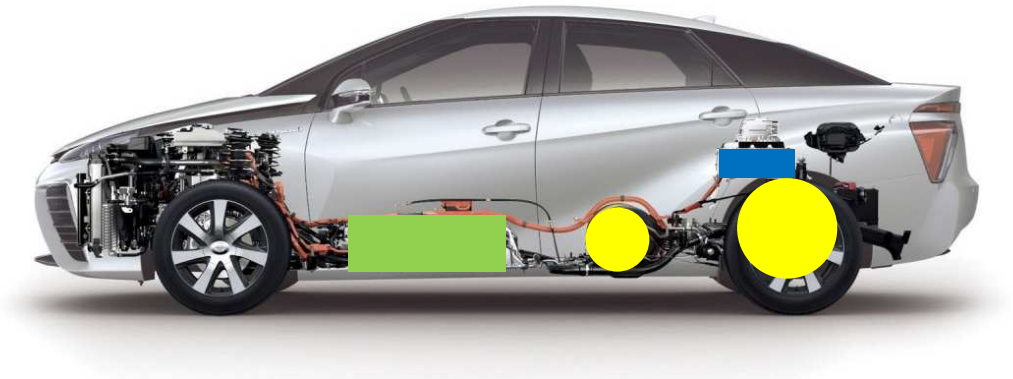




How is a Fuel cell integrated in the vehicle?

> A complex system to integrate in a vehicle…





> … without safety issue, and without prejudice on livability

How is a Fuel cell integrated in the vehicle?

> A complex system to integrate in a vehicle… thermal management

> Fuel Cell System efficiency ~50%: high thermal energy to dissipate by the front heat exchanger

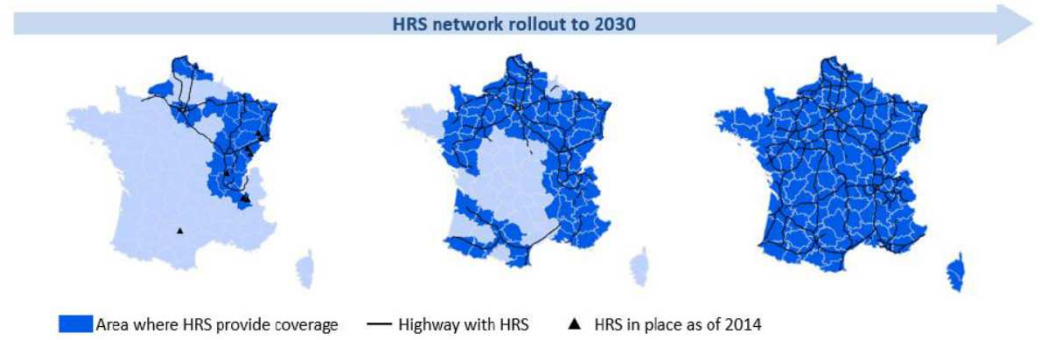
The cost of the technology needs to improve

- An economical challenge … on the vehicle
  - FCEVs cost ~ 60000€
  - Fuel Cell System & Hydrogen Storage System competitivity are required for FCEVs mass production

- An economical challenge… on hydrogen cost (@ Hydrogen Refueling Station)
  - Production, transport, retail
  - From 8 to 15€/kg H_2 (today)

The infrastructure has to grow

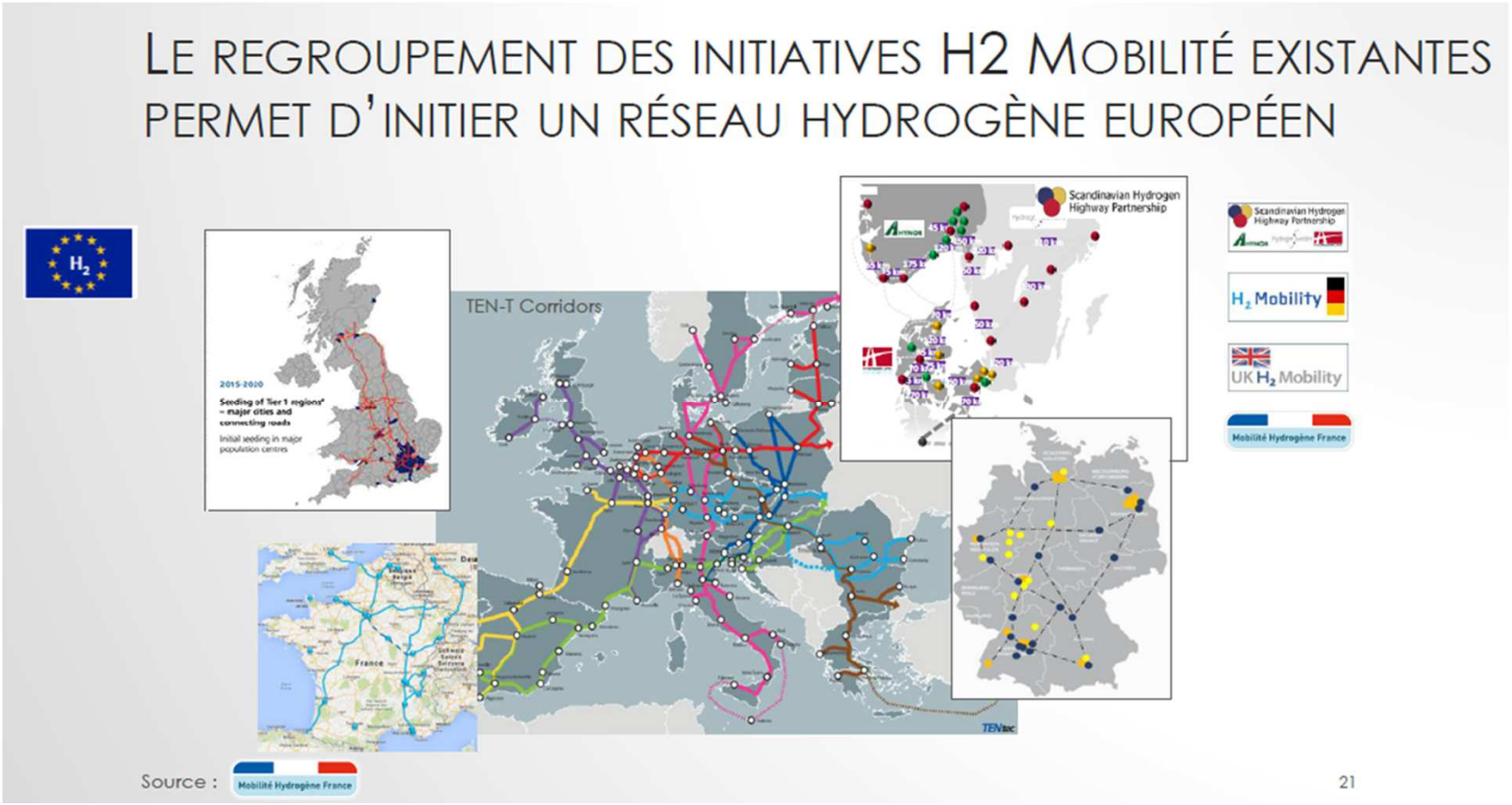
- H_2 mobilité France: to propose a risk limited deployment scenario of FCEVs using regional clusters:



H2MF strategy (2014): expansion of the HRS network up to 2030

- New hydrogen refueling station arrive in France: the last one openned in Orly!
- National target for 2023: 100 hydrogen refueling station
- H_2 mobility Germany: already 400 hydrogen refueling station expected by 2023.

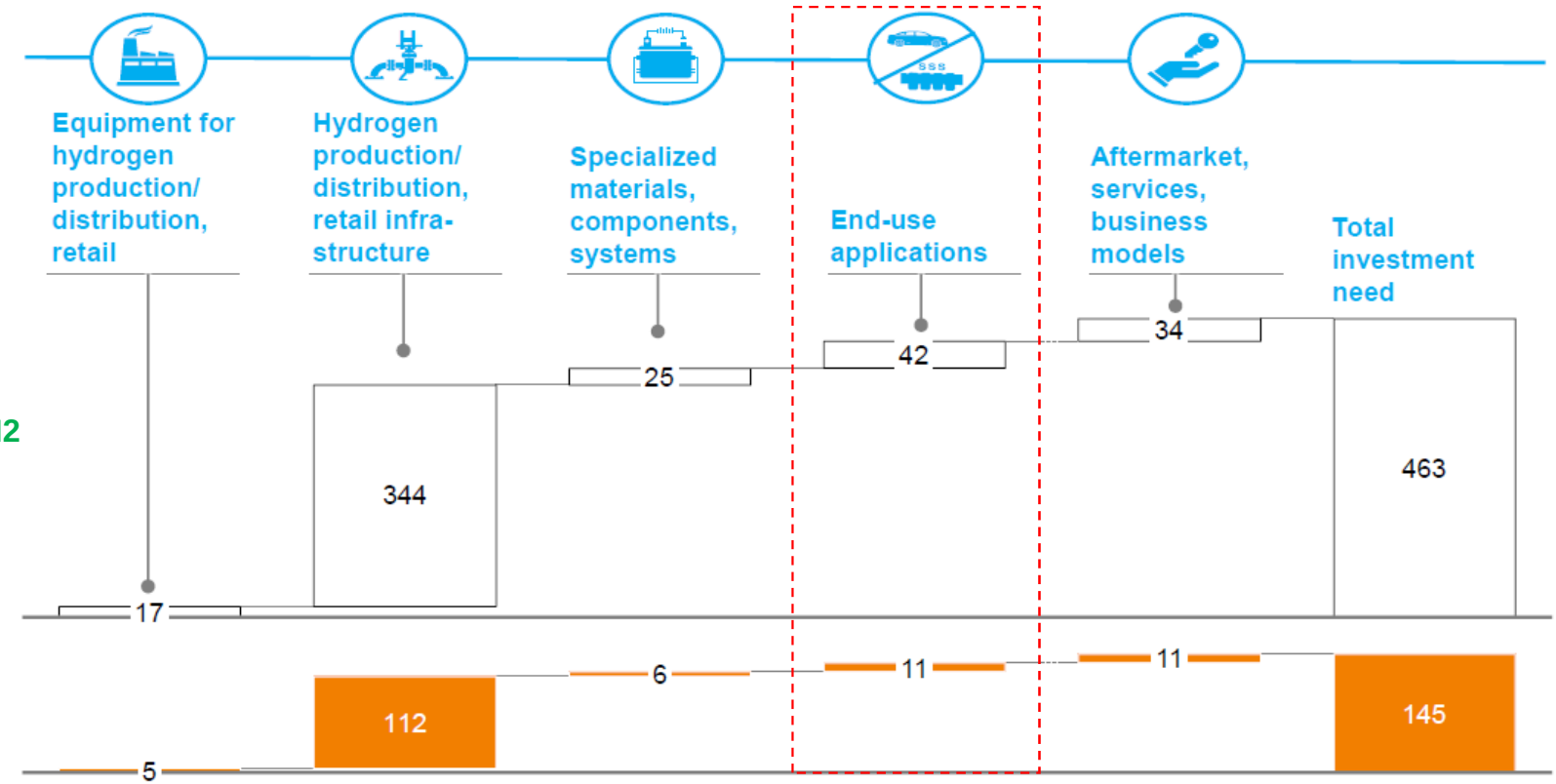
From National to European infrastructure expansion



Investment needs: in total, industry players need to invest between 130 and 450 bn EUR until 2050.

Total investment needs (estimation)

cumulative between 2018-2050, in EUR bn



Source : Hydrogen Council 2017 study

How is France competing in the global H_2 economy?

- Fixing 10% Hydrogen share by 2023
- Engaging 100 M€ to support the first initiatives of the plan, under the umbrella of the ADEME agency.
- 2018 and onwards new projects are labelled as “ECV” (Engagements pour la croissance verte), for the automotive and other industrial sectors.

PSA Groupe and hydrogen: a lot of technological demonstrator


06/2001


10/2004


01/2006


04/2008


09/2011

2019 :To be continued

04/2009


10/2006


01/2006


10/2002

06/2001

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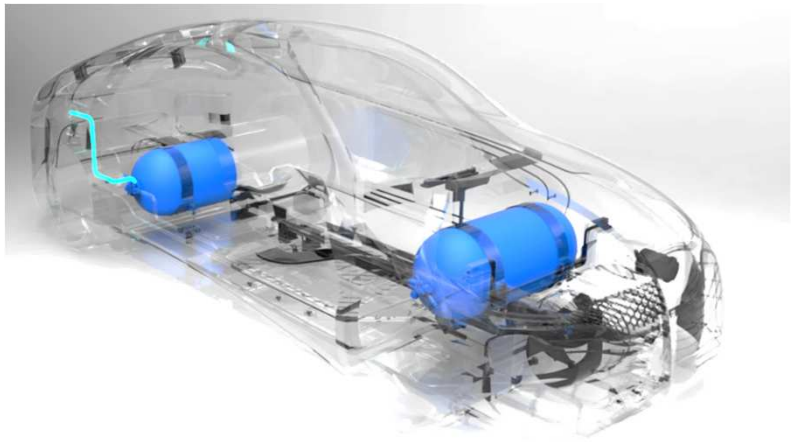
Plastic Omnium and hydrogen: preparing the scale up

- Active R&D in the design of systems that combines fuel cells and hydrogen tanks to enable the car to generate its own energy.
- Several developments at the vanguard of world electric propulsion research: creation of PO-CellTech, a JV company with a fuel-cell specialist, and a common research center in Israel.
- Acquiring companies specialized in tank production (Optimum CPV), and in fuel cell systems management (Swiss Hydrogen).
- A new research center dedicated to New Energies in Brussels (2019), and a development center with testing facilities in Wuhan China.
- Active participation to the Hydrogen Council with other key companies.



Conclusions

- **Hydrogen technologies are still in R&D phase with already available products in different segments of the market and some expanding fleet numbers.**
- **FCEV & BEV are complementary technologies**
- **The challenges of greenhouse gases and global warming make the use of hydrogen a necessity to decarbonize several areas of the industry, including mobility and transportation.**
- **Regulation authorities, politicians, OEMs and suppliers are preparing a number of initiatives and product launches to make Hydrogen become a reality for transportation.**
- **The key to succeed : R&D investment required from OEM & tier one suppliers to decrease technology cost (with industrial process).**

MOVING FORWARD TOGETHER*

*PROGRESSONS ENSEMBLE

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