



Renault
Group

H2 FUEL CELL FOR AUTOMOTIVE APPLICATION

JULY 5TH 2022

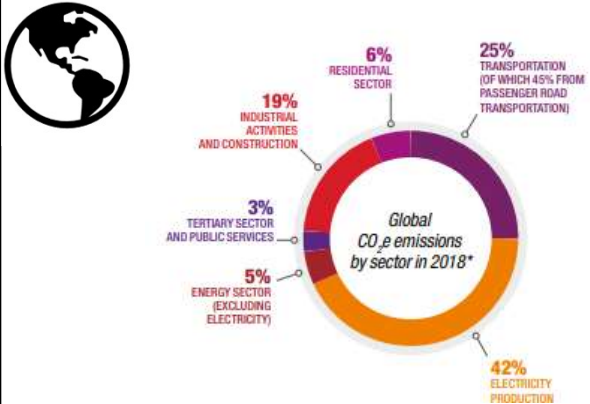
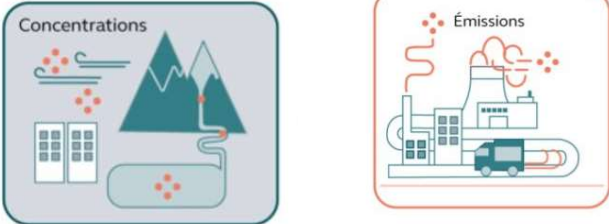

MARIELLE MARCHAND, H2 EXPERT

AGENDA

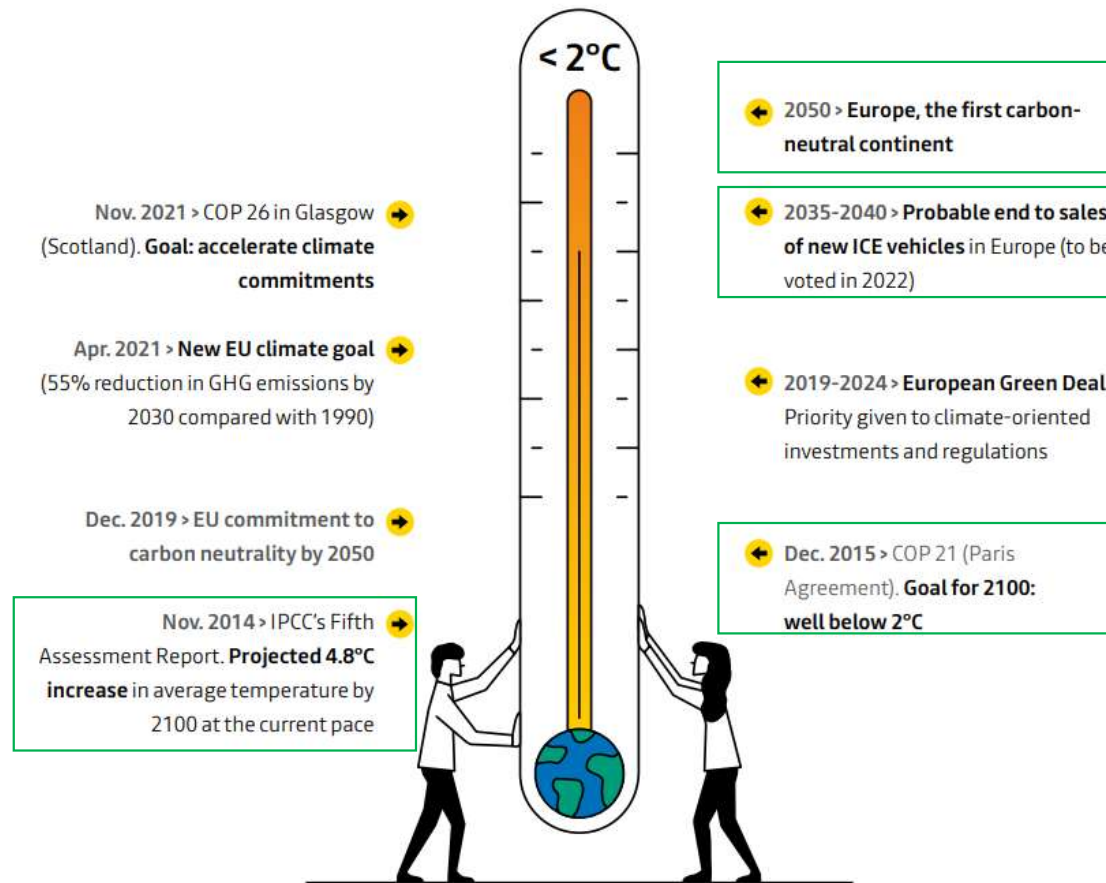
- 1 Context**
- 2 Fuel Cell : How does it work ?**
- 3 Stack and System**
- 4 Vehicle integration**
- 5 Conclusion**

1 Context

CONSTRAINTS ON THERMAL ENGINE

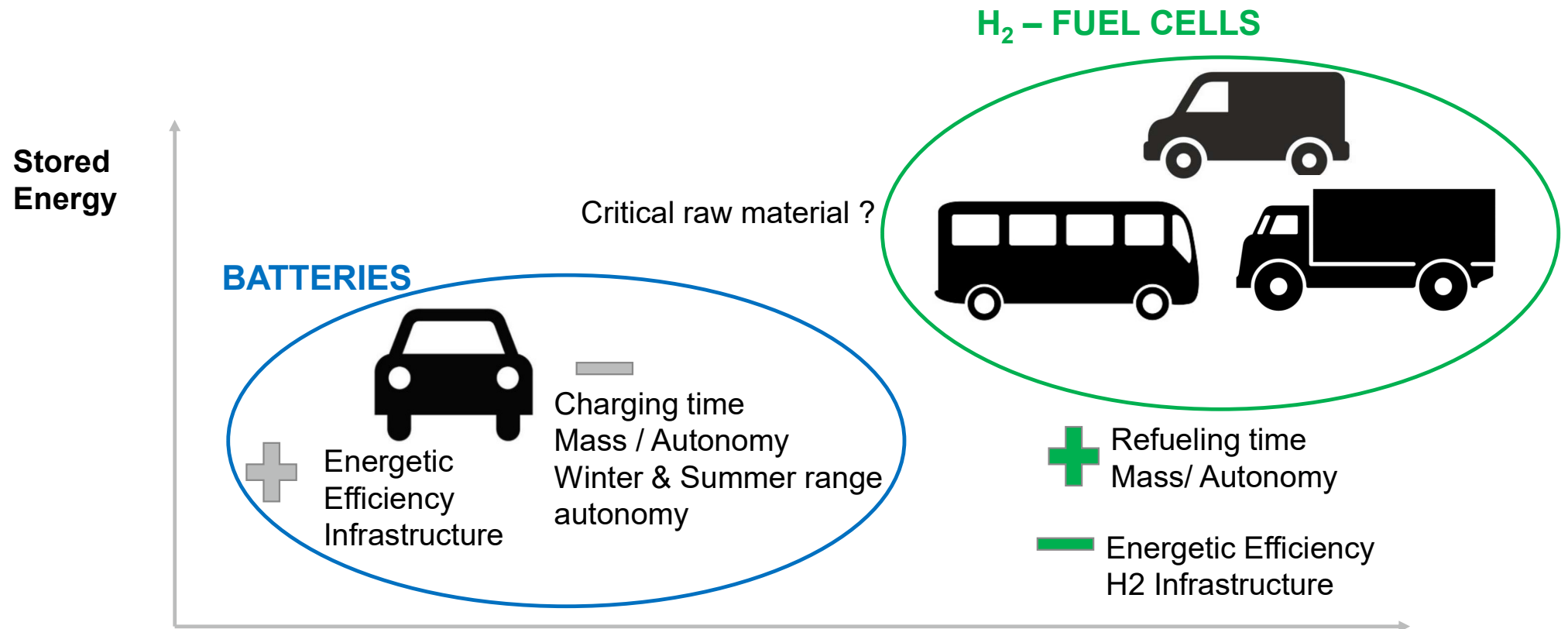
Global Warming	Air Quality	Traffic restrictions
 <p><i>Global CO₂ emissions by sector in 2018*</i></p> <ul style="list-style-type: none"> 42% ELECTRICITY PRODUCTION 25% TRANSPORTATION (OF WHICH 45% FROM PASSENGER ROAD TRANSPORTATION) 19% INDUSTRIAL ACTIVITIES AND CONSTRUCTION 6% RESIDENTIAL SECTOR 5% ENERGY SECTOR (EXCLUDING ELECTRICITY) 3% TERTIARY SECTOR AND PUBLIC SERVICES <p><small>*source AIE (Agence Internationale de l'Énergie)</small></p> <ul style="list-style-type: none"> • Transport : ¼ of CO₂ emissions • Standards more and more severe (CAFE) 	 <ul style="list-style-type: none"> • Pollutants : particles, NO_x, SO₂ → health effects revealed • WHO: reference thresholds not to be exceeded • Increasingly restrictive standards (Euro 6, Euro 7,...) 	<ul style="list-style-type: none"> • Current restrictions in urban areas  <ul style="list-style-type: none"> • Risk 2030: Traffic restrictions in certain areas for all thermal vehicles

CARBON NEUTRAL FOR 2050 IN EUROPE



220421_climate-report-renault-group_8mb.pdf

H2 : HUGE ONBOARD ENERGY



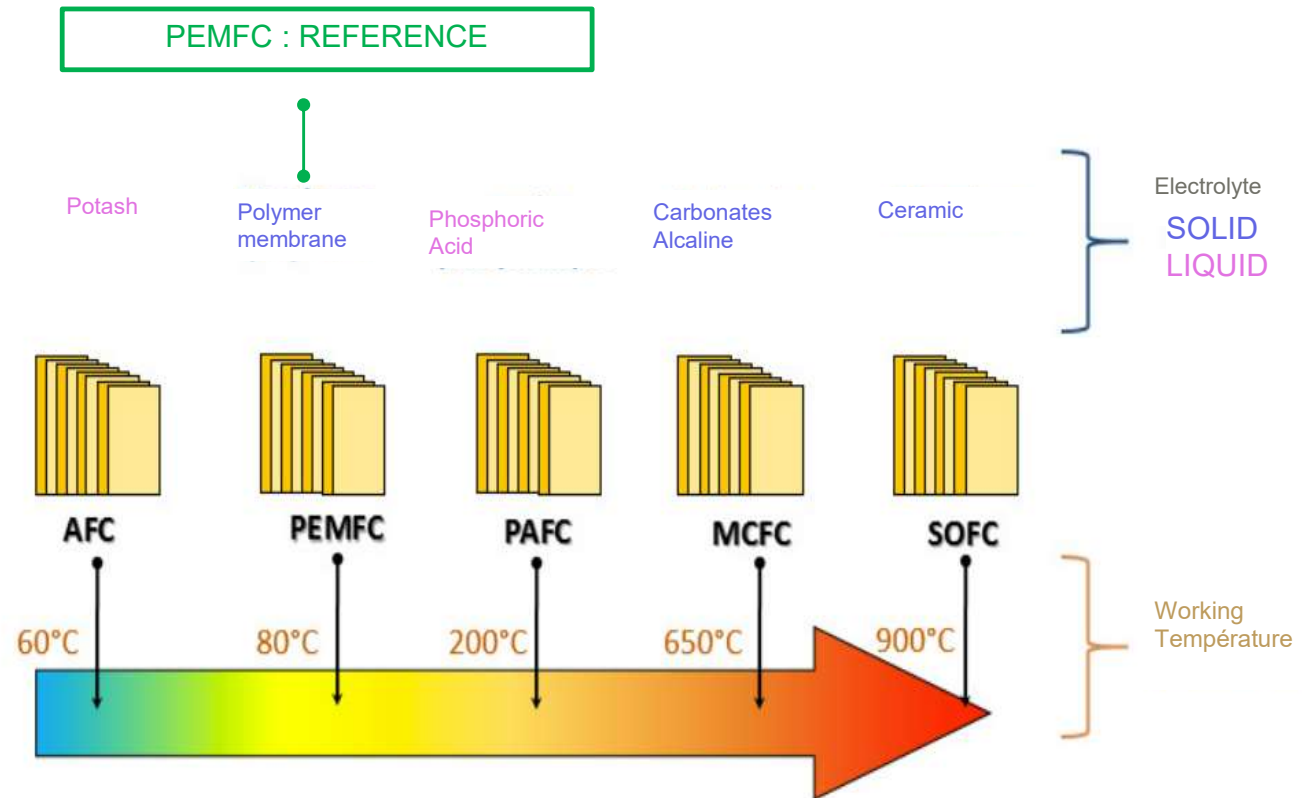
RENAULT GROUP : LEADER OF ELECTRIC MOBILITY IN EUROPE



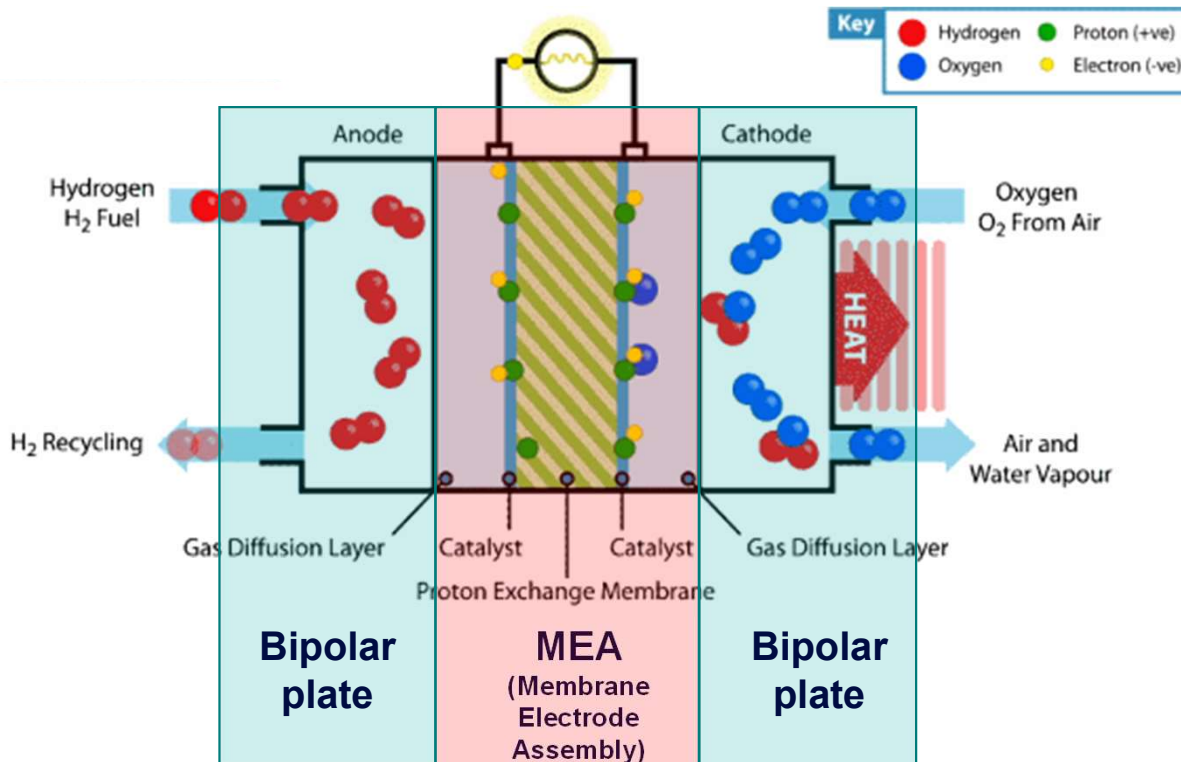
2 Fuel Cell : How does it work ?

PROTON EXCHANGE MEMBRANE FUEL CELL

- Automotive conditions
- Low T (<200 °C)
- Solid Electrolyte



HOW DOES IT WORK ?



Anode : H₂ oxidation

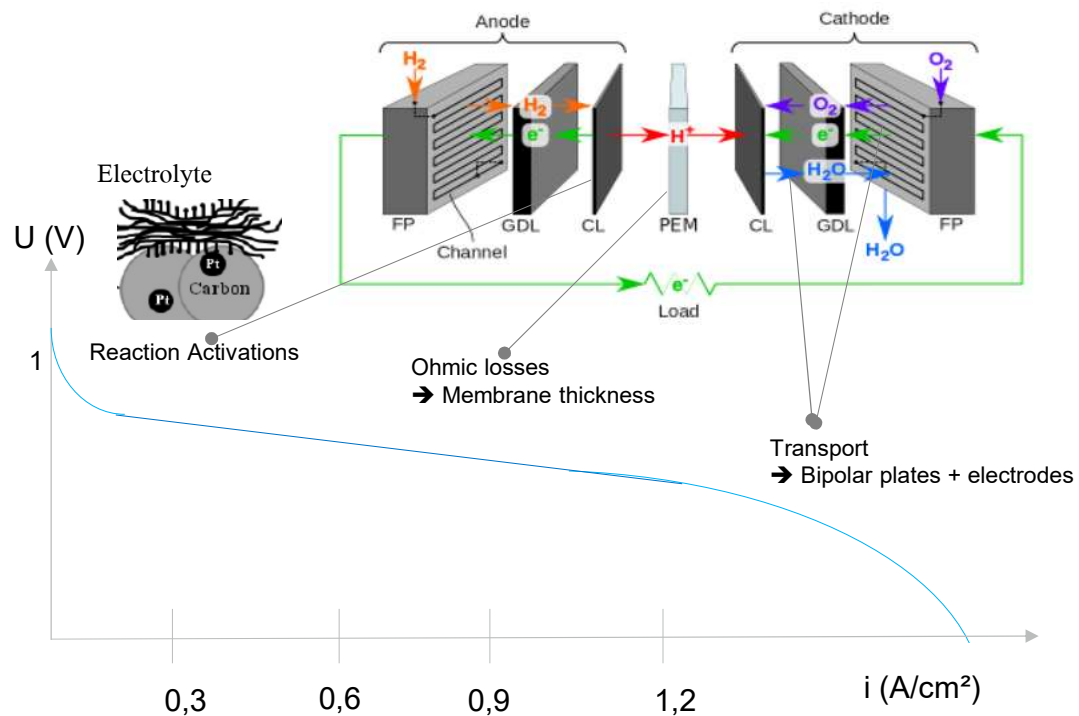


Cathode : O₂ Reduction



- Fuel cell = Open Generator
- → Transformation of **chemical energy** provided by a spontaneous oxidation-reduction reaction **into electrical energy**
- → Two separate compartments called **half-cells** each containing an electrode and an electrolyte
- Two Redox couples
 - Cathode : O₂ (g) / H₂O (l),
 - Anode : H⁺ (aq) / H₂ (g)

SOME ELECTROCHEMICAL NOTIONS



Open Circuit Voltage (OCV) : Nernst

$$\rightarrow E_{Nernst} = E^{\circ}(\text{H}_2 / \text{O}_2) + \frac{RT}{2F} \ln \left(\frac{P_{\text{H}_2} (P_{\text{O}_2})^{0,5}}{P_{\text{H}_2\text{O}}} \right)$$

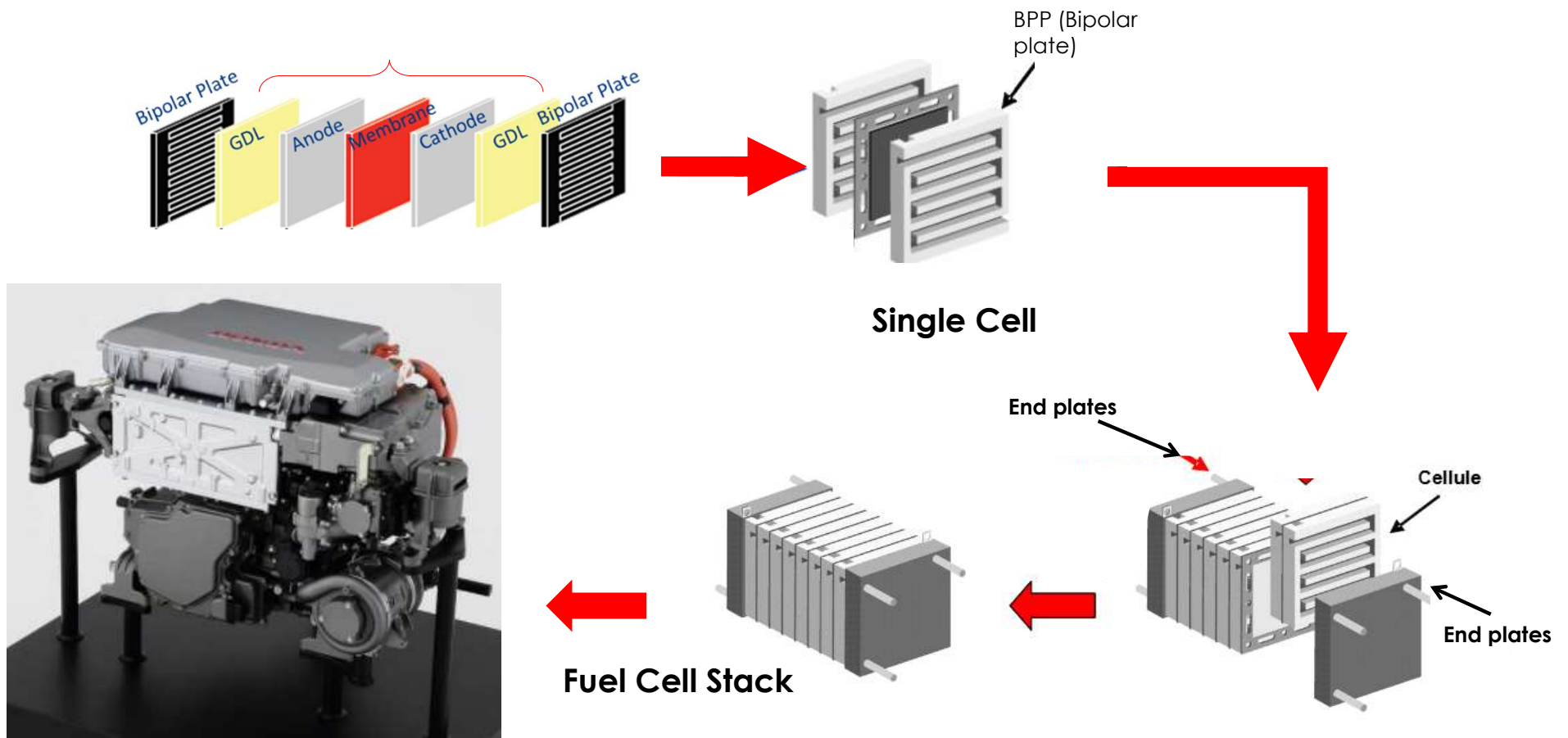
→ Standard potential (1 bar, 298 K)
 $E^{\circ}(\text{H}_2 / \text{O}_2) = 1,23 \text{ V}$

Losses

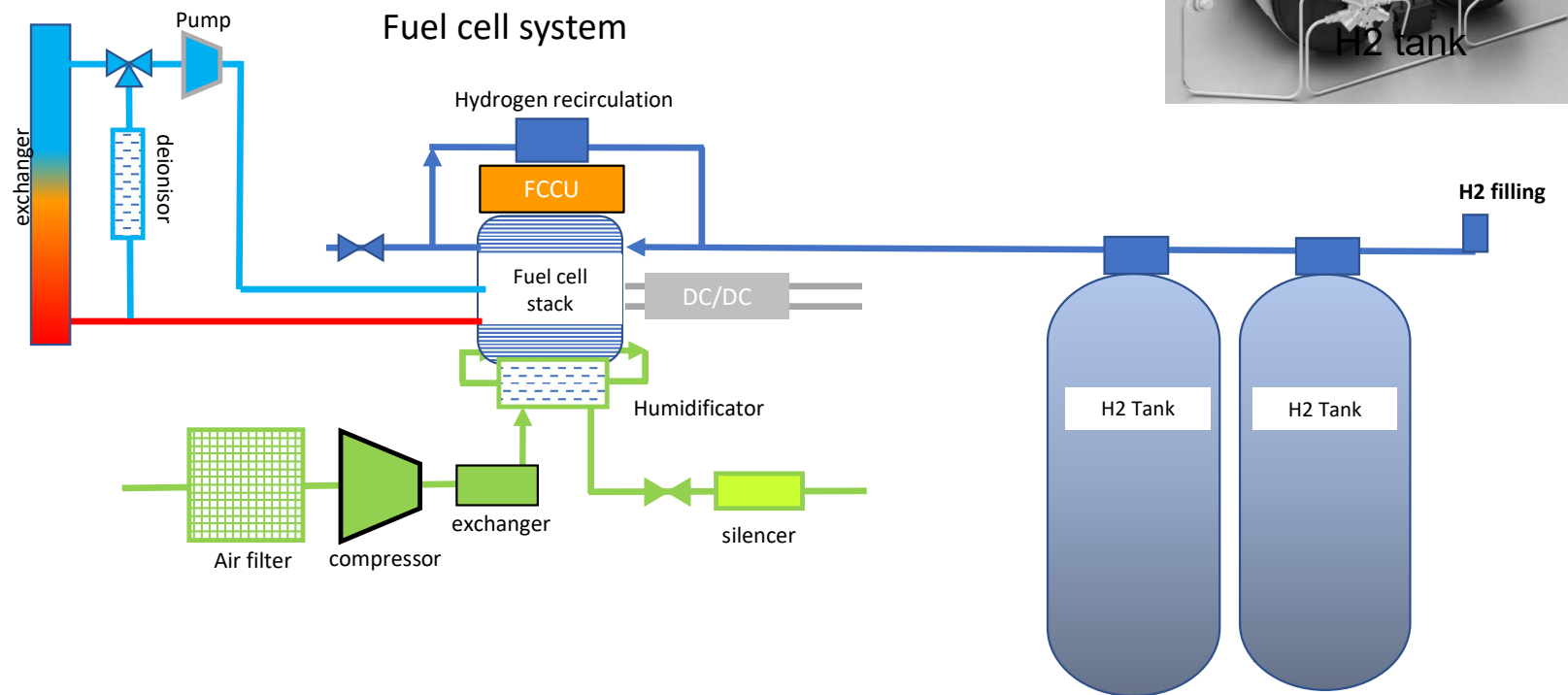
- Activation of reactions
- Ohmic
- Transport

3 Stack and System

FROM SINGLE CELL TO COMPLETE STACK



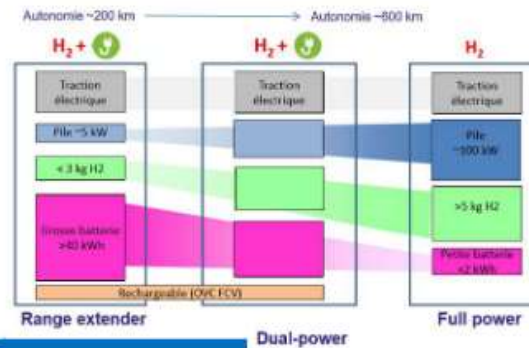
FUEL CELL SYSTEM



Air Compressor

4 Fuel cell vehicle

FUEL CELL VEHICLE : DIFFERENT ELECTRIC ARCHITECTURE



RENAULT MASTER 2022



1. 30 kW
 2. Battery 33 kWh
 3. 3-7 kg H_2
1. Fuel cell system power

STELLANTIS 2021



1. 45 kW
 2. Battery 10 kWh
 3. 4,4 kg H_2
2. battery energy

TOYOTA Mirai 2021



1. 128 kW
2. 1,6 kWh
3. 6 kg H_2

3. on-board H_2 storage capacity

HONDA Clarity 2017



1. 103 kW
2. 1,7 kWh
3. 5,6 kg H_2

HYUNDAI Nexo 2018



1. 120 kW
2. 1,5 kWh
3. 6,3 kg H_2

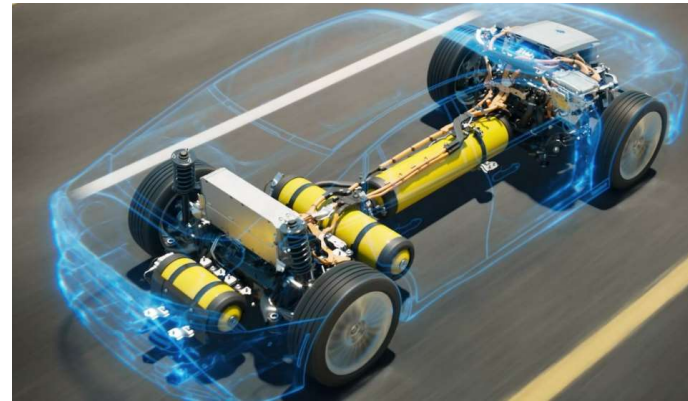
VEHICLE INTEGRATION ISSUES

Integration of H₂ tanks in vehicle

- Cylindrical tanks which are difficult to integrate.
- The rear seat / trunk roominess is reduced due to the installation of the hydrogen tanks.

Cooling performance

- Operating temperature too low : 70-80 ° C
- Size of the radiators to be increased.
- Front vehicle face to be opened to increase air speed & help cooling.



Toyota Mirai II



Toyota Mirai I



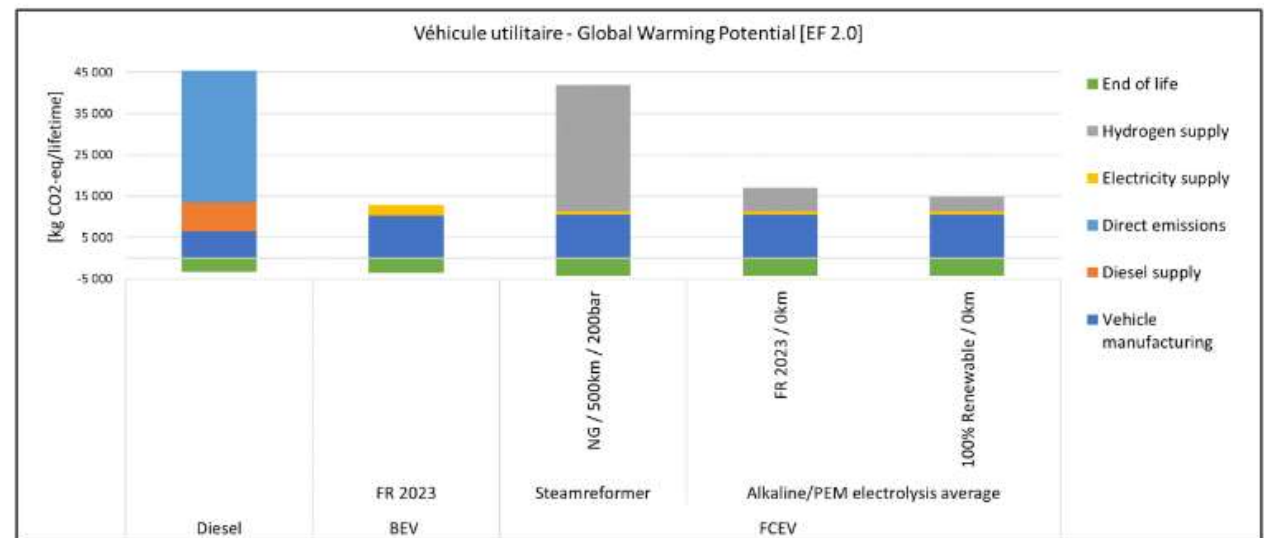
Hyundai Nexo

ENVIRONMENTAL IMPACTS : LCA



Global warming : CO₂ emissions

Resource depletion
Eutrophication of water
Acidification



Source : ADEME - 2020

Depends on electricity supply
Fuel Cell + Electrolysis : similar to BEV

5 Conclusion

CONCLUSION

1. Real benefits of Fuel Cell for Light Duty Vehicle and High Duty Vehicle :
 - Refuelling of H₂ in few minutes
 - Driving range
 - Mass
2. Key factor for success :
 - Deployment of H₂ infrastructure
 - H₂ cost
3. Improvements on fuel cell systems are expected :
 - Cost (mass production + technological progress)
 - Operating temperature (cooling)
 - Integration

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THANK YOU

