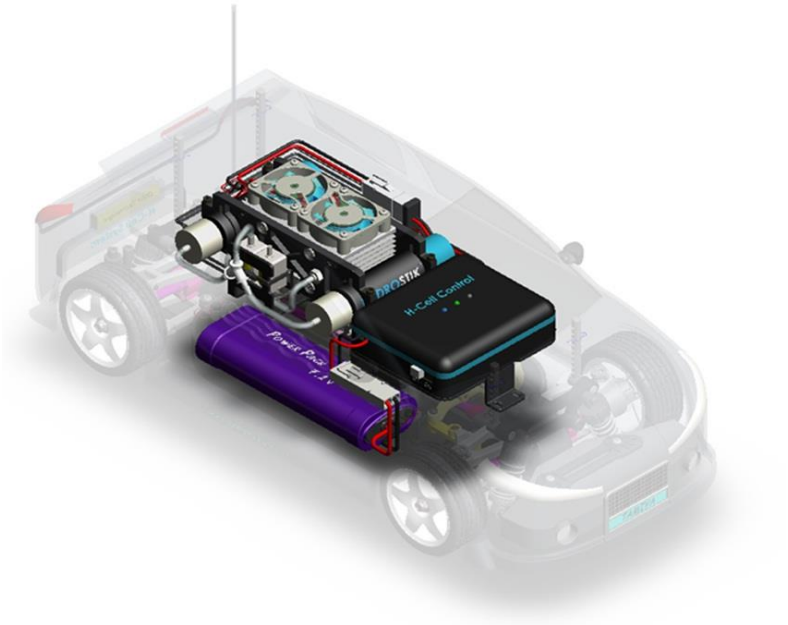
5 – Manufacturer's decisions

Does the current hybrid solution of the H-Cell system seem entirely logical, given the required performance and sustainable development considerations?



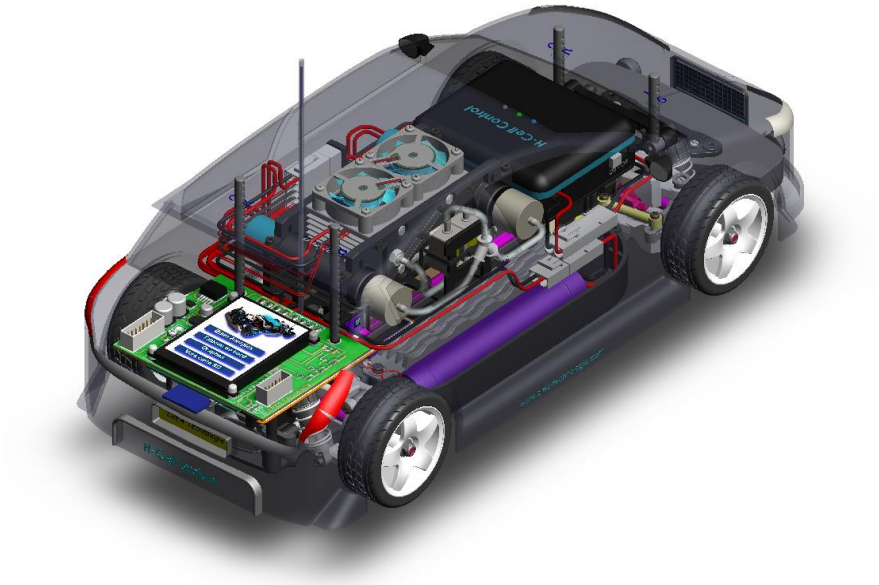
5 – Manufacturer's decisions

Does the current hybrid solution of the H-Cell system seem entirely logical, given the required performance and sustainable development considerations?

5.1 Making measurements on the track

Study direction

Time required: **1h**



Necessary equipment and resources:

Horizon Equipment:

- **FCAT H-Cell car with acquisitions' card**

Objectives:

We are going to test the FCAT model fitted with the H-Cell system under two test configurations that we will choose beforehand. (For example, starting: stationary start on a flat track, then on slope), in order to highlight, if possible, the capacity of the H-Cell system to operate efficiently, regardless of the resistance encountered, according to the limits imposed by the car's specifications.

5.1.1

Time required: 30 min

0:05

Comparative propulsion tests

Instructions:

Compare, using your equipment and track (max slope: 15 degrees) the two testing modes under different conditions, either in the driving speed, or in the nature of the terrain (hard-packed soil, asphalt or concrete). For this purpose, acquire the data by transfer from the SD card*.

Assemble the results in a spreadsheet and complete the results sheet on page 4.

*If the tests are impossible because of the weather or inadequate equipment, you may use an example of test in the "Example tests 5-1" folder

5.1.2

Time required: 25 min

0:35

Satisfaction index

Question:

Draw your conclusions as to the level of satisfaction for the hybrid solution offered by the manufacturer, considering the various points mentioned in the above table.

	Grade*	Comments
Performance in terms of speed		
Performance in terms of running time		
Size of the on-board system		
Environmental impact		

***Satisfaction index grades: 0: not satisfied/1: slightly satisfied/2: satisfied/3: very satisfied**

Results sheet for the comparison between the two propulsion testing modes		
	Test 1	**Test 2**
Further information about the ground chosen for the test **(concrete, asphalt, hardwood floor, carpeting, etc.)**		
Further information about the rate of propulsion imposed to the car by the pilot **(constant high or low speed, maximum or moderate acceleration, etc.)**		
On flat ground	**I average consumed by the engine**	
	I average, provided by the battery to the controller	
	I average, provided by the fuel cell to the controller	
	I average, provided by the fuel cell to the battery	
On a _____-degree slope	**I average consumed by the engine**	
	I average, provided by the battery to the controller	
	I average, provided by the fuel cell to the controller	
	I average, provided by the fuel cell to the battery	
Result	**The fuel cell alone provides the power supply to the propulsion system in the following cases:**	
	The fuel cell alone charges the battery in the following cases:	

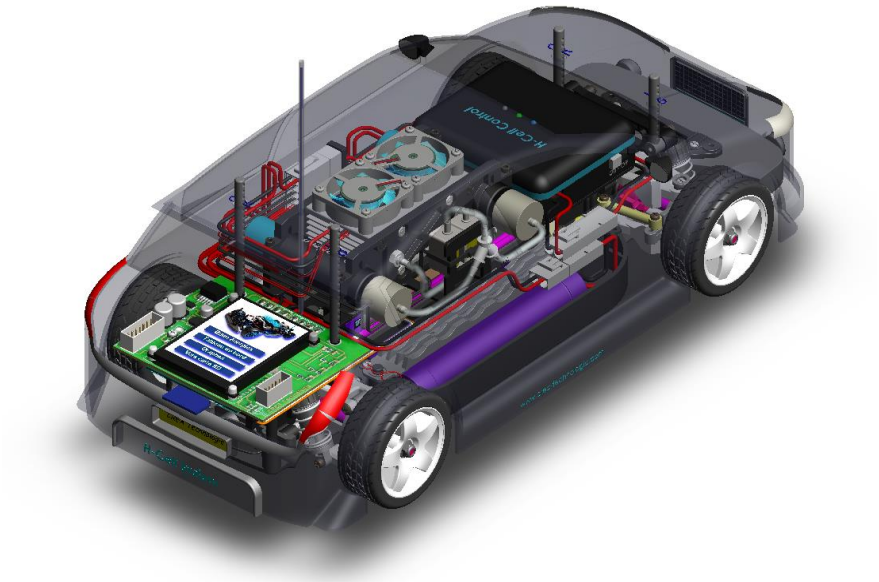
5 – Manufacturer's decisions

Does the current hybrid solution of the H-Cell system seem entirely logical, given the required performance and sustainable development considerations?

5.2 Making measurements on the charging bench

Study direction

Time required: **25min**



Necessary equipment and resources:

"CREA Technologie" material

- **FCAT H-Cell car with acquisitions' card**
- **Test bench**

Objectives:

We are now going to test the FCAT model fitted with the H-Cell system under two testing configurations on a test bench: with or without the car's moving inertia phenomena taken into account. We will use this to highlight, if possible, the capacity of the H-Cell system to operate efficiently, regardless of the resistance the car encounters.

5.2.1

Time required: 15 min

0:15

Comparative propulsion tests

Instructions:

Compare, on a test bench, the two testing modes under different conditions, as described below.

Then record the results in a spreadsheet and complete the results sheet below.

Results sheet for the comparison between the two propulsion testing modes on a test bench		
	Test 1: **start without equivalent inertia flywheels**	**Test 2:** **start with equivalent inertia flywheels**
Comparison	**I average consumed by the engine**	
	I average, provided by the battery to the controller	
	I average, provided by the fuel cell to the controller	
	I average, provided by the fuel cell to the battery	
Result	**The fuel cell alone provides the power supply to the propulsion system in the following cases:**	
	The fuel cell alone charges the battery in the following cases:	

5.2.2

Time required: 10 min

0:10

Satisfaction index

Question:

Draw your conclusions as to the level of satisfaction for the hybrid solution offered by the manufacturer, considering the various points mentioned in the above table.

	Grade*	Comments
Capacity of the fuel cell alone to enable the car to start		
Impact of the mass of the H-Cell system on energy consumption during the starting phase.		
Environmental impact		

***Satisfaction index grades:** **0: not satisfied/1: slightly satisfied/2: satisfied/3: very satisfied**

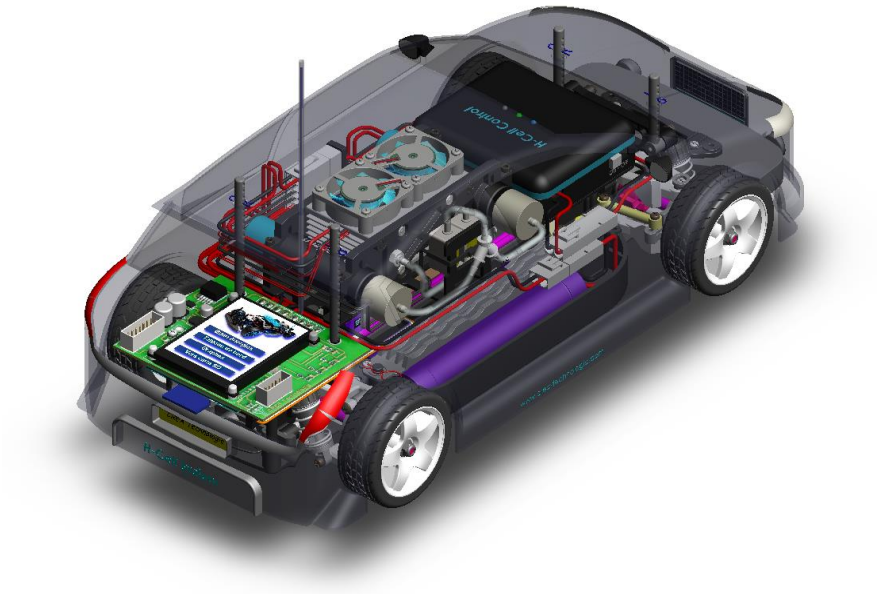
5 – Manufacturer's decisions

Does the current hybrid solution of the H-Cell system seem entirely logical, given the required performance and sustainable development considerations?

5.3 Energy consumption

Study direction

Time required: **1h**



Necessary equipment and resources:

Horizon Equipment:

- **FCAT H-Cell car with acquisitions' card**

Objectives:

We are now going to test the various means employed to charge the on-board power storage system, i.e. the battery and the hydrogen cartridges, so as understand the total quantity of energy spent by the car.

5.3.1

Time required: 20 min

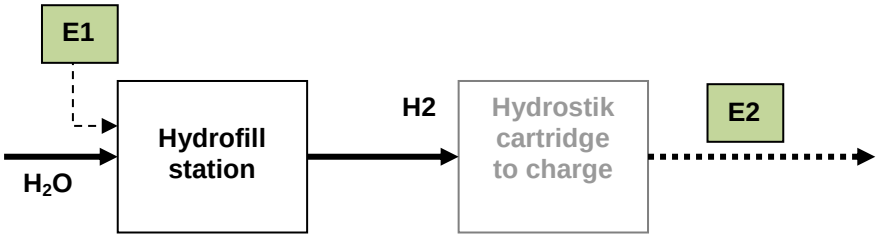
0:05

Text

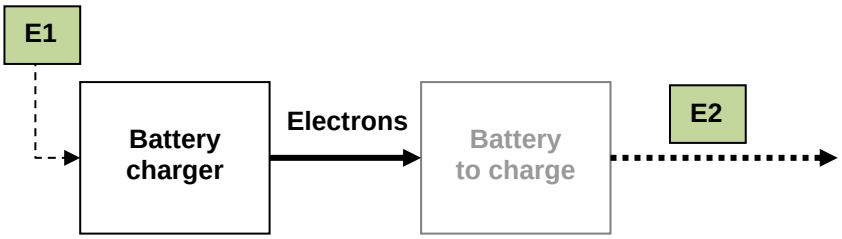
Instructions:

Developing a testing device for energy consumption “E1”, taken from the EDF network, concerning:

- The hydrogen cartridge charging system



- The battery charging system



	Charging system for hydrogen cartridges	Charging system for the accumulator
E1		
Total energy	$E_{charge} =$	

5.3.2

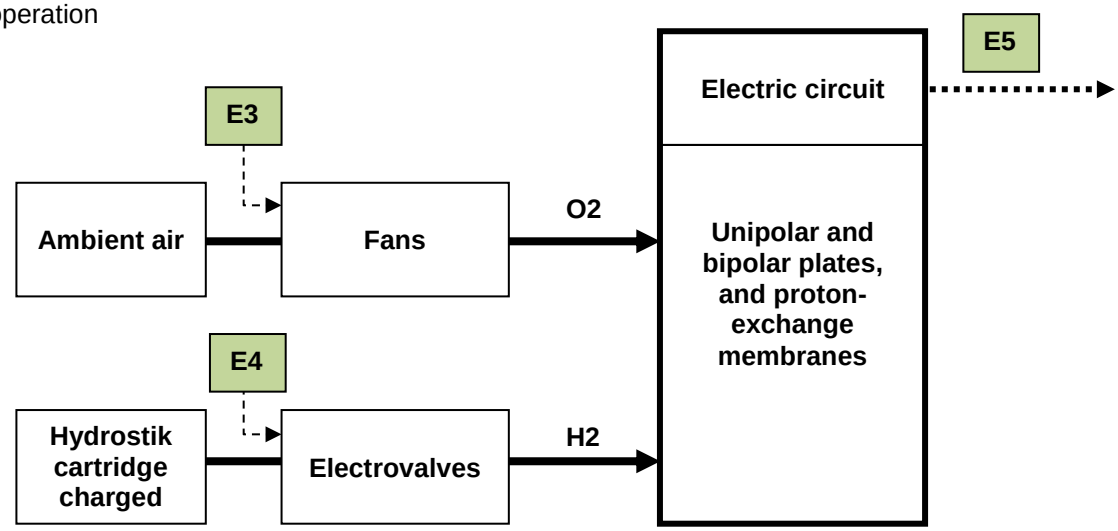
Time required: 20 min

0:25

PAC consumption

Instructions:

Develop a way to test the consumption of "E3" and "E4" energies provided by the fuel cell to ensure its own operation



	E3, for operation of the fans	E4, for operation of the electrovalves
Energy required for the operation of PAC		
Total energy	**E PAC operation =**	

5.3.3

Time required: 20 min

0:25

Consumption of the control unit

Instructions:

To develop a device to test the consumption of "E6" energy provided by the battery to power the control unit.

E conmmand unit supply =

5.3.4

Time required: 15 min

0:45

Result

Question:

Create an overall report about the magnitude of the various amounts of energy consumed to charge or operate the hybrid system, and give your opinion, using a satisfaction index, about the efficiency of the equipment.

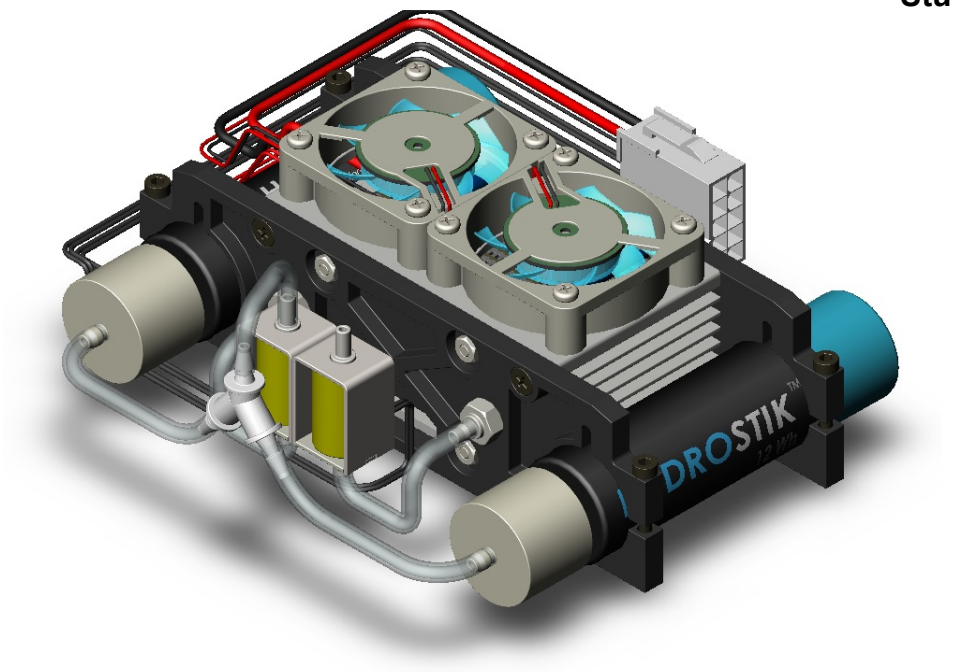
5 - the manufacturer's choice

The current H-Cell hybrid operating solution do you think it is fully consistent with required performance and willingness sustainable development?

5.4 Sustainable development

Recommended duration: **2h + oral presentation**

Study tracks



Equipment and resources required:

Material «Horizon Educational» :

- **Fuel cell**

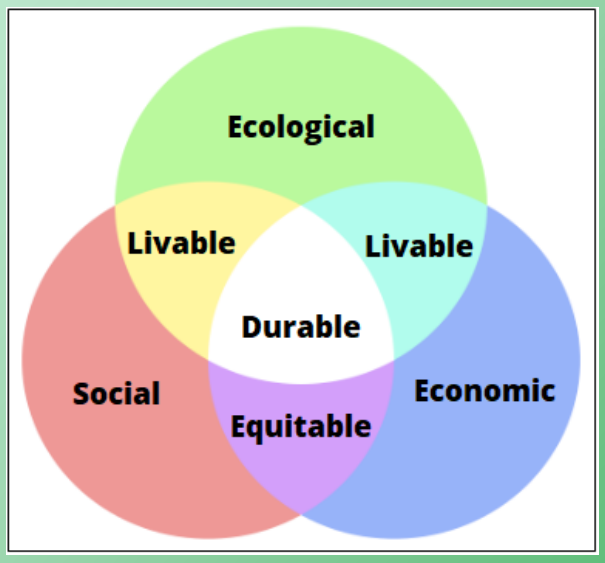
Global operating mode:

We are going to focus more specifically here on the internal structure of various elements that make up the fuel cell, in order to establish a global critique on various social, economic or ecological impacts arising from certain technological choices. We will also examine the different modes of hydrogen production by electrolysis of water, within the framework of sustainable development.

Go back to the source, just to preserve it...

Energy, matter… inexhaustible reserves?

To best meet a need for sustainable development, we will have to focus first on social, economic and ecological factors. For this we will be led, as far as possible, to go back to the source, in terms of energy production for example, but also in the production of components, from certain materials drawn from our reserves.



One of the most important issues today for our future:

It is therefore a question here of producing, storing, restoring energy, while preserving our environment as well as possible. This will then go through the most judicious choice of technologies and raw materials to best guarantee us "inexhaustible" durability. Even if it seems to be impossible even today, it is good for the future of our planet a real challenge to challenge.

A few tips, before we start...

We will study here two very distinct zones, which could possibly be assigned to two working groups:

Zone 1: Hydrogen production by electrolysis of water

Zone 2: The constitution of the fuel cell

It will then be necessary to carry out research at first, mainly on the Internet, for a period of 1 hour, during which you will be asked to take a record of the keywords used, the sites selected, and the main indications that you have could find there.

Some sites will be written on this subject in a foreign language (mainly in English) and will sometimes contain definitions that are part of the physics-chemistry program. In this case, it could be interesting to have yourself supervised by teachers specialized in these fields.

Regarding the restitution of your work, it would be interesting to practice it orally, in English or a foreign language, in the form of a mini presentation. The response documents then serve in this case as accompanying documents.

Instructions:

- Consult the documents provided in the appendix, then complete, depending on your study area, the response tables on pages 4 to 6.

- Specify on pages 5 and 9 the keywords used for your Internet searches, the sites selected, and the indications that you have used.

- Also write, if possible in a foreign language, on pages 6 and 10, a text summarizing your point of view on the subjects treated.

Zone 1: Hydrogen recharge by electrolysis of water (from table on page 12)

	Main solutions	Indices * of satisfaction concerning the sustainability of development, linked to the manufacture, use and end of life of constituents		
		Based on social factors *	Bases on economical factors*	Bases on ecological factors*
Electric power generation system for electrolysis				

Satisfaction index: 4: very good / 3: good / 2: moderate / 1: bad / 0: very bad

* Social factors: satisfying the user's need - safety, comfort
Economic factors: low cost
Ecological factors: non-polluting

Zone 1: Hydrogen recharge by electrolysis of water / Internet research

Key words	
Selected websites	
Indications used	

Zone 1: Hydrogen recharge by electrolysis of water

In summary :

Zone 2: Constitution of the H-Cell fuel cell (current version)

		Indices * of satisfaction concerning the sustainability of development, linked to the manufacture, use and end of life of constituents		
		Based on social factors*	Based on economical factors*	Based on ecological factors*
Fuel Cell	Bipolar plates			
	Proton exchange membranes			
	Ventilators			
	Solenoid valves			
Hydrostik	Lanthanum-nickel hydrides			

Satisfaction index: 4: very good / 3: good / 2: moderate / 1: bad / 0: very bad

* Social factors: satisfying the user's need - safety, comfort
Economic factors: low cost
Ecological factors: non-polluting

Zone 2: Opportunities for improvement proposal

Component	Evolution possibility ?	In what way? (suggest improvements)
Bipolar plates	YES NO	
Proton exchange membranes	YES NO	
Ventilators	YES NO	
Solenoid valves	YES NO	
Metal hydride	YES NO	

Zone 2: Constitution of a PEMFC fuel cell / Internet research

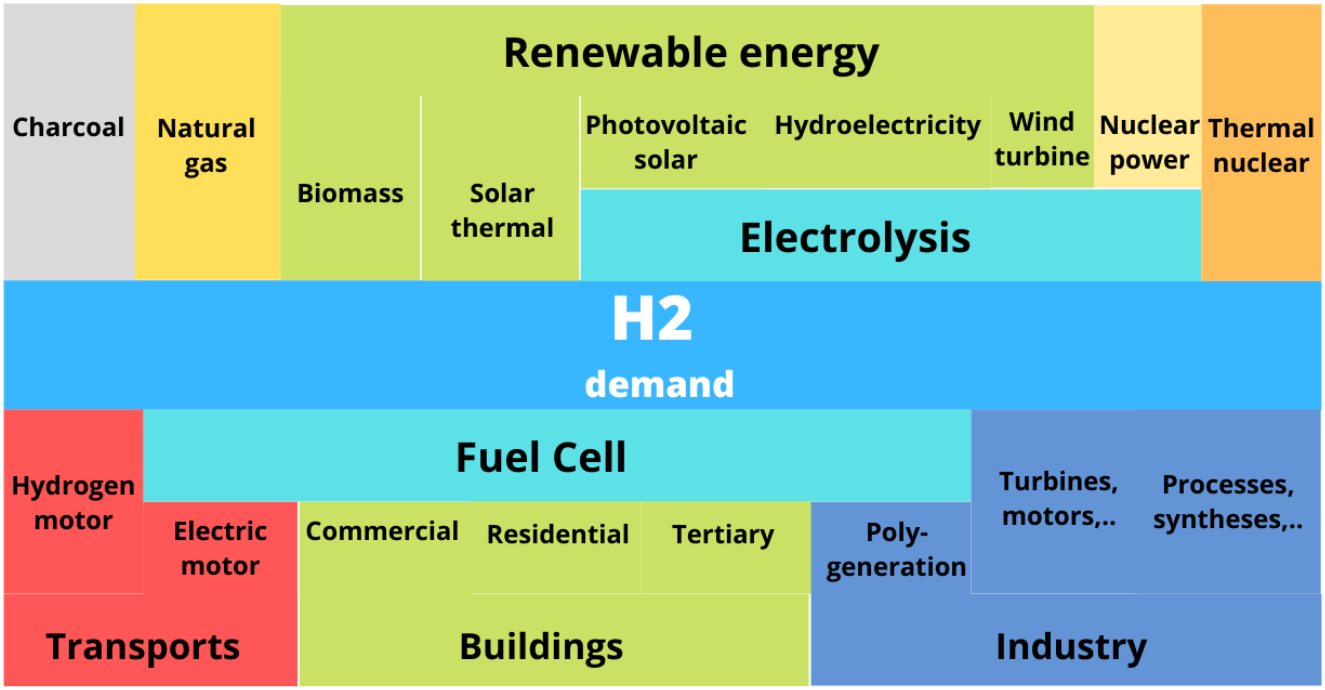
Key words	
Selected websites	
Indications used	

Zone 2: Constitution of a PEMFC fuel cell

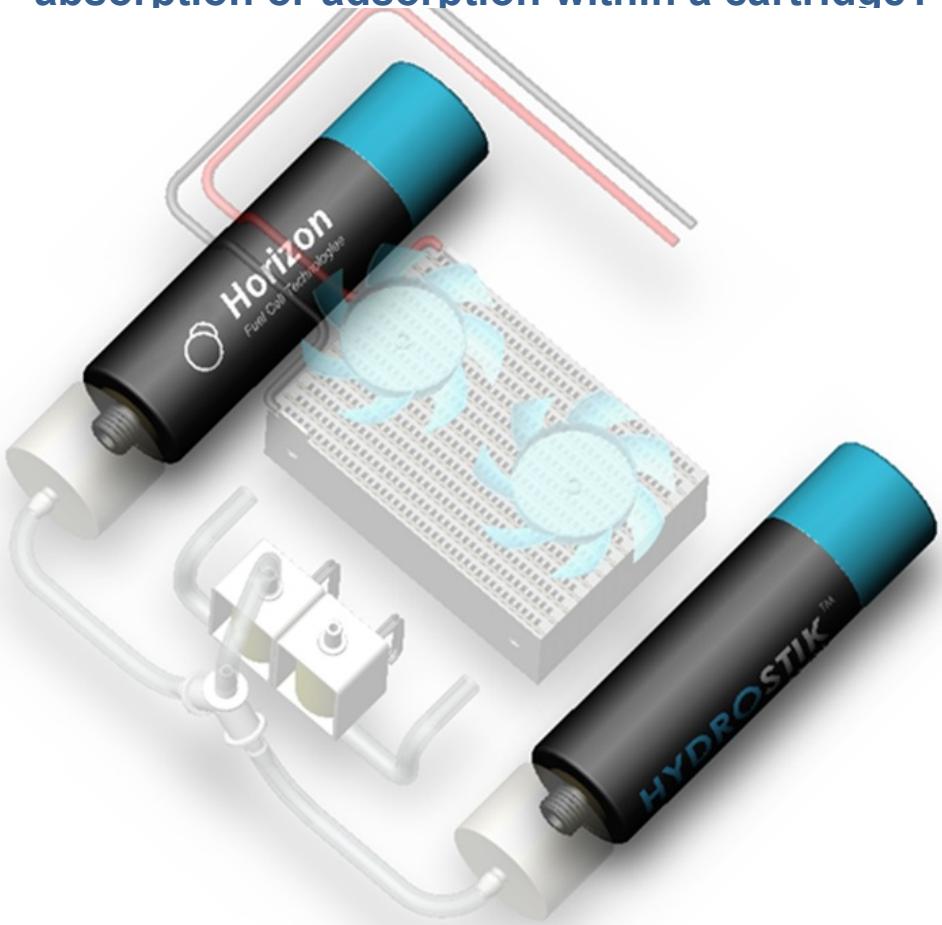
In summary :

Resource documents

1 - How to produce hydrogen? ... and for what purpose?



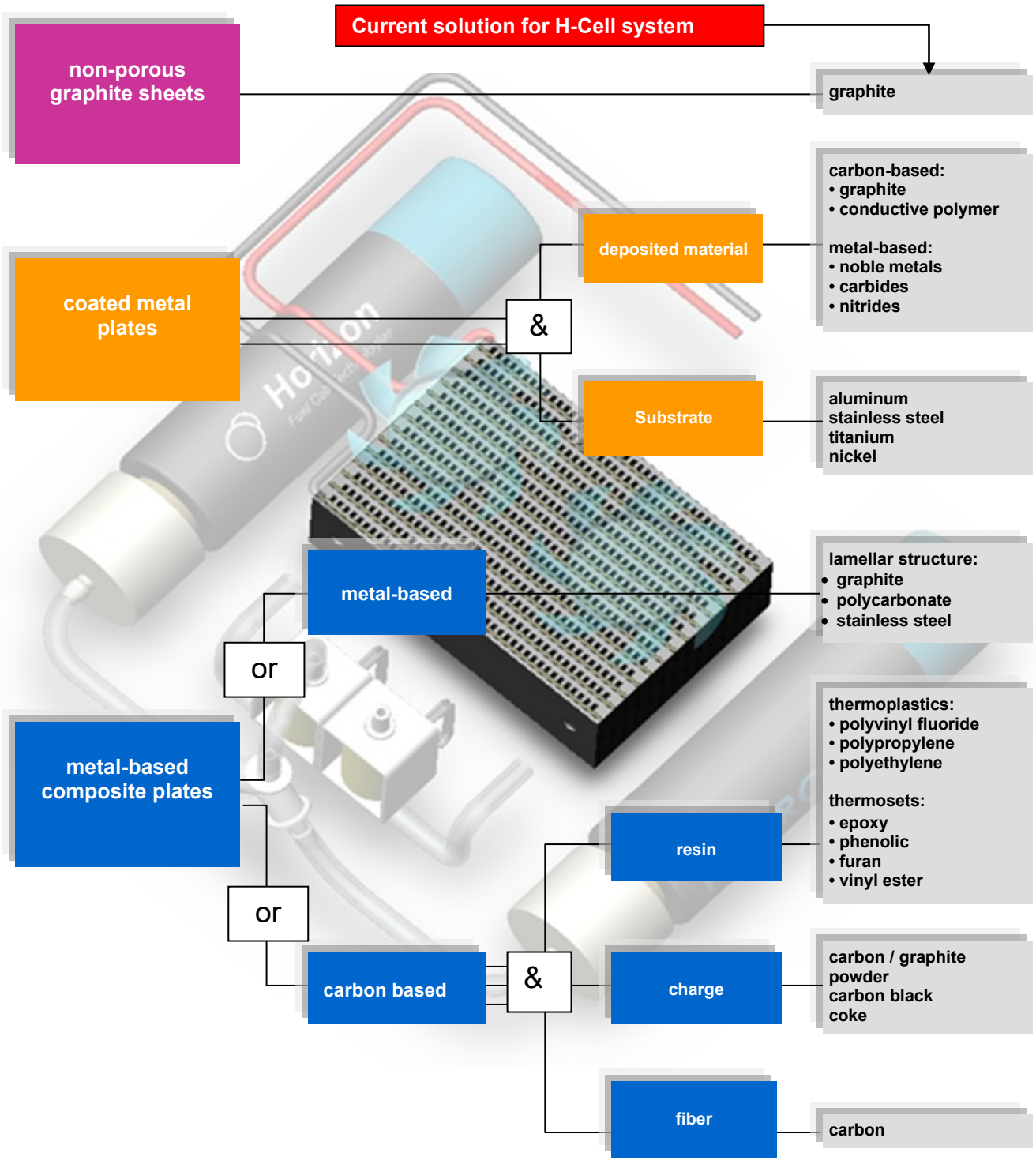
2 - What type of material should be chosen for storage by absorption or adsorption within a cartridge?



Examples of materials (or pairs of materials) usable today for the storage of hydrogen in solid form

- Lanthanum
- Nickel
- Zirconium
- Manganese
- Titanium
- Iron
- Magnesium
- Alanates

3 - What materials should be chosen for bipolar plates?



4 - What materials should be chosen for proton membranes?

- **Current version: Nafion (polymer produced by Dupont de Nemours)**
- **In research: Chitosan-Zeolite (see also Chitin and Zeolite)**