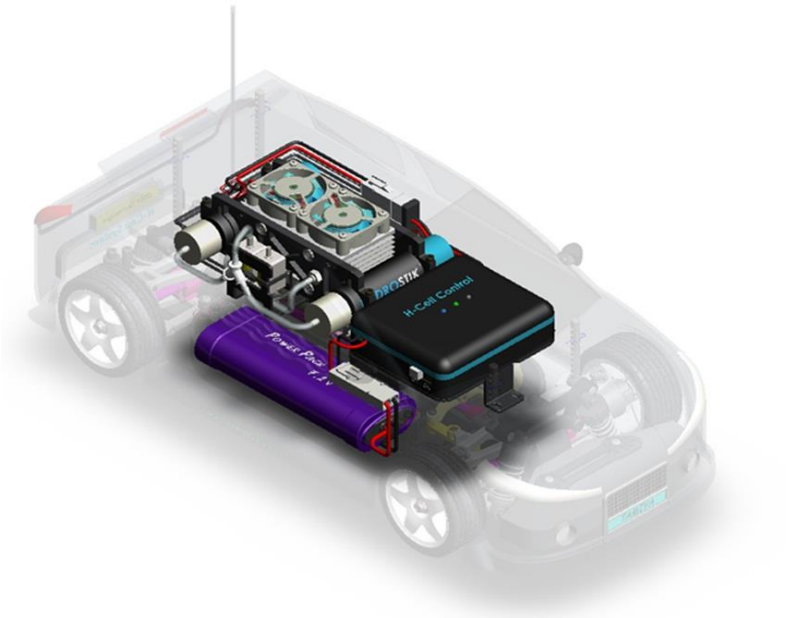
2 - The Role of Hydrogen

What are the pros and cons of using a hydrogen fuel cell, in terms of sustainability, compared with modern batteries?



2 - The Role of Hydrogen

What are the pros and cons of using a hydrogen fuel cell, in terms of sustainability, compared with modern batteries?

2.1 Understanding the hydrogen fuel cell

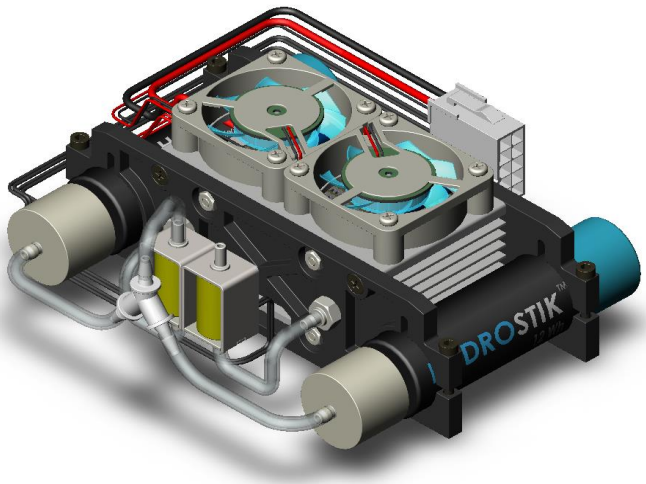
Study direction

Time required: 1h

Necessary equipment and resources:

Horizon Equipment:

- **Fuel cell**



Objectives:

In this activity, we will reading documents mainly sourced from internet sites in order to identify possible factors of environmental hazards associated with the fuel cell system, as well as its safe disposal and recycling.

Zero pollution: a utopian idea?

It is impossible to try to invent a system that poses no threat to our environment.

Pollution is an omnipresent part of a product's life cycle. As early as during the design phase we have to deal with materials and processes that are more or less damaging to our environment. During the production phase, we have to extract raw materials from the Earth, transform and transport them, make and assemble the components, distribute the product, maintain and repair it, and possibly get it back at the end of its working life to recycle it.

Furthermore, any system needs power to work. During its working life it will necessarily release all sorts of pollution, more or less harmful to our environment. These come in the form of overheating, air pollution, leaks, etc.

A rigorous report of all the forms of pollution created would be too complex to complete, due to the vast number of variables that need to be considered. In this case, we must first examine what seems to us to be the most urgent and have the highest priority, in order to best protect our environment.

This analysis tends to be rather global and simply qualitative, but for this activity it will be used to establish a preliminary comparison between two modern technologies (fuel cell vs. battery), which will enable us to focus on the main pros and cons of each solution.

Zero pollution may be a utopia, but it remains a goal that we must do everything to achieve.

Technologies...

PEM fuel cells and metal hydride cartridges

The PEM fuel cell

It is primarily made of:

- Electrode plates
- Proton membranes (or proton exchange membranes)

As is the case for research into electric batteries, fuel cell technology is still evolving today, for example in the use of cheaper and more efficient materials.

The metal hydride cartridge

It contains a metal alloy that captures, by the process of adsorption, hydrogen atoms inside the gaps in its crystal structure.

This represents significant progress in the field of hydrogen storage, improving reliability and safety of stored hydrogen.

Documentary research

Resources to use for further information: See the recommended internet sites in the “Additional Resources" document. If necessary, make other searches using suitable keywords that you can list below, writing the names of the sites and documents that you use.

2.1.1

Time required: 15 min

0:05

The fuel cell's internal structure

Question:

Given all the materials used in the general internal structure of the fuel cell in its current version, explain whether these materials risk being harmful to our environment in the mid- and long-term.

Internal structure	Main risk factors for the environment and health
Graphite, used for electrode plates	
Nafion, a polymer made by Dupont, used for the proton-exchanging membranes	

2.1.2

Time required: 5 min

0: 20

Internal structure of Hydrostik cartridges

Question:

Given all the materials used in the internal general structure of Hydrostik cartridges, explain whether these materials risk being harmful to our environment in the mid- and long-term.

Internal structure	Main risk factors for the environment and health
Lanthanum and nickel, used for storing hydrogen	

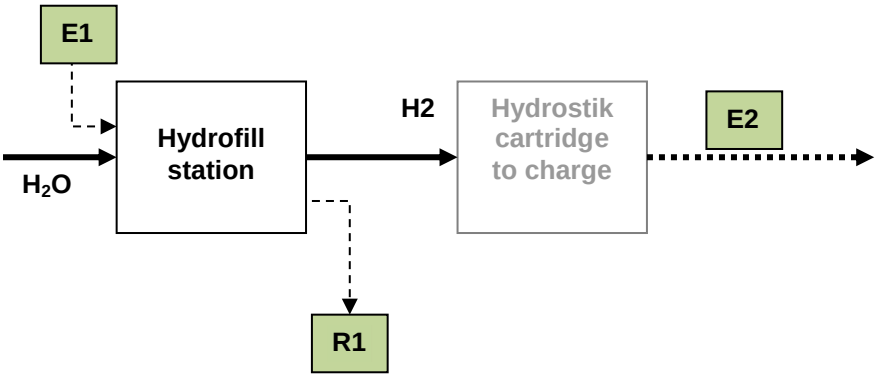
2.1.3

Time required: 5 min

0:25

Question:

Having examined the charging station for hydrogen cartridges and read its information sheets, complete the following description of its operation in terms of energy consumption and, if such data is available, in terms of emissions.



Form of energy consumption for operation	**E1:**
Form of emissions during operation	**R1**
Form of energy available	**E2:**

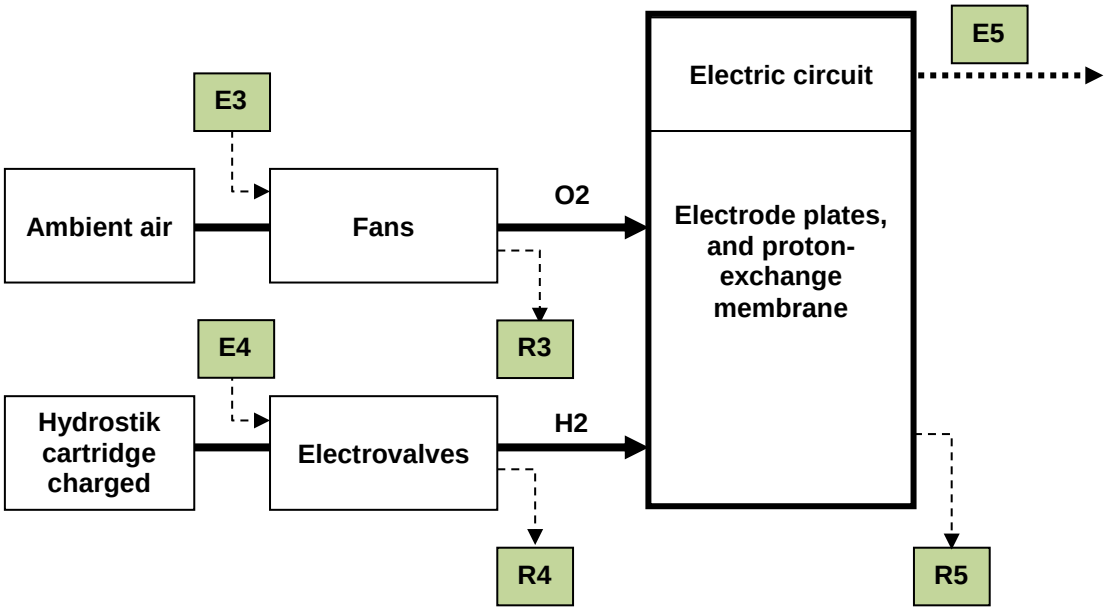
2.1.4

Time required: 10 min

0:30

Question:

Having examined the hydrogen fuel cell installed in the H-Cell car and studied its information sheets, complete the diagram below of its operation in terms of energy consumption and in terms of emissions.



Form of energy consumption for operation	**E3:**
	E4:
Form of emissions during operation	**R3:**
	R4:
	R5:
Form of energy available	**E5:**

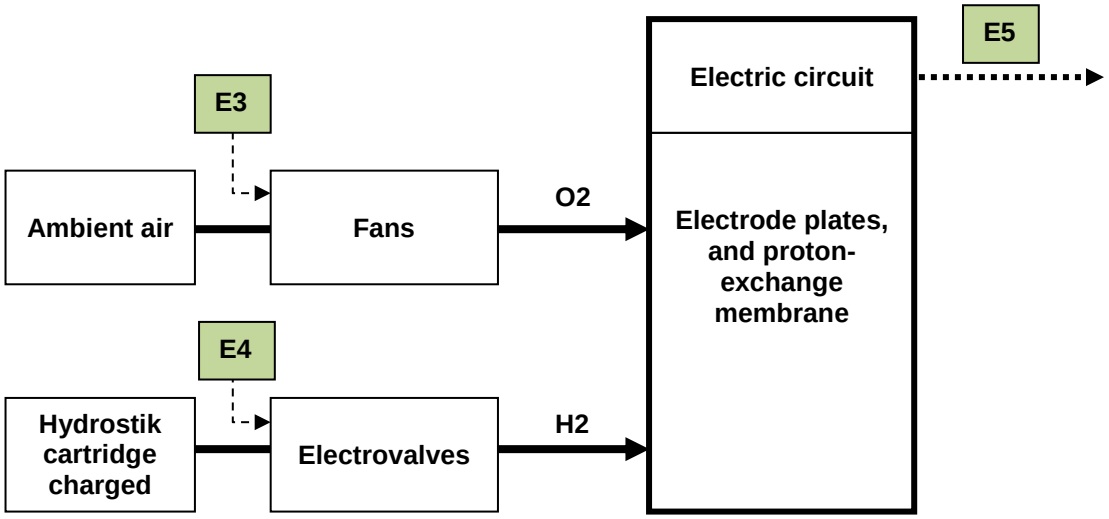
2.1.5

Time required: 5 min

0:40

Question:

Under what conditions could the report on energy consumption (E3 & E4) and available energy (E5) be deemed to be satisfactory?



2.1.6

Time required: 5 min

0:45

Question:

In general, what can be said about sustainable development, considering the energy resources useful to charge and operate the hydrogen fuel cell and its form of emissions?

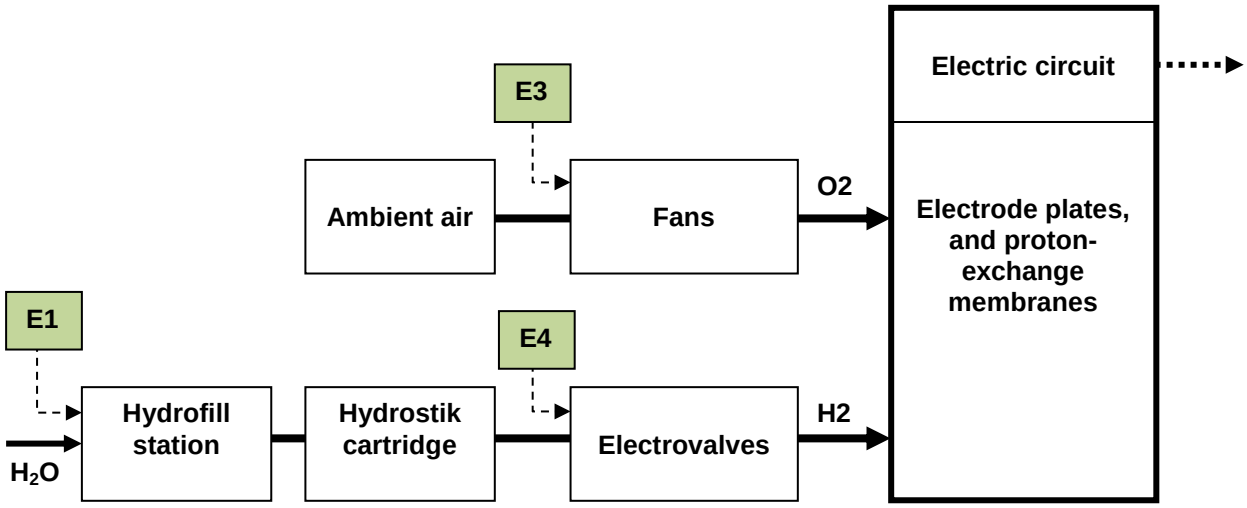
2.1.7

Time required: 10 min

0: 50

Question:

Considering the complete system (charging station - hydrogen cartridges - fuel cell), what can we say about the possibility of using forms of power to operate the system while taking care to protect the environment?



For E1:
For E3 & E4:

2 - The Role of Hydrogen

What are the pros and cons of using a hydrogen cell, in terms of sustainability, compared with modern batteries?

2.2 Understanding modern batteries

Study direction

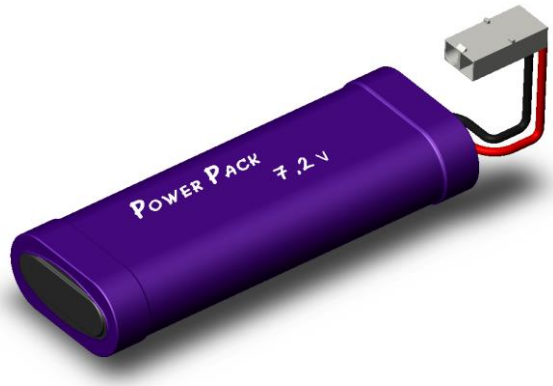
Time required:

1h

Necessary equipment and resources:

Horizon Equipment:

- **Battery Pack**



Objectives:

In this activity, we will be looking at documents mainly sourced from internet sites, in order to identify possible environmental hazards associated with the battery, as well as its proper disposal and recycling.

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Technology...
Electrochemical cells

Documentary research

Resources to use for further information: See the recommended internet sites in the “Additional Resources" document. If necessary, make other searches using suitable keywords that you can list below, writing the names of the sites and documents that you use.

2.2.1

Time required: 40 min

(including 20 minutes for documentary research)

0:10

Internal structure of an electrochemical cell (battery)

Question:

Read multiple sources in order to draft a complete list of materials, focusing on the general composition of different types of batteries. Detail, for the materials mentioned in the following table, what are the main risk factors for health and the environment. (We will limit ourselves to four materials)

Technologies	Main risk factors for the environment and health
Lead	
Ni-Mh or Ni-Cd	
Lithium	
Bromine	

2.2.2

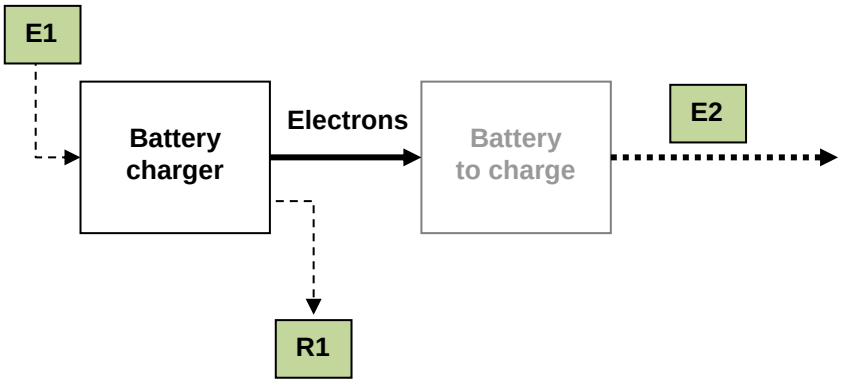
Time required: 5 min

0:50

Charging a battery

Question:

Having examined the battery charging system and studied its specifications, complete the following diagram of its operation in terms of energy consumption, available energy, and emissions.



Operating energy form: **E1:**
Operating emission form: **R1**
Available energy form: **E2:**

Time required: 5 min

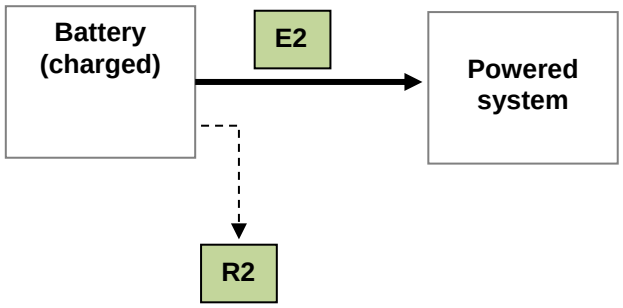
2.2.3

0: 55

Operation of a battery

Question:

Having examined the way a battery works and studied its specifications, complete the following diagram of its operation in terms of energy consumption, available energy, and emissions.



E2:
R2:

2 - The Role of Hydrogen

What are the pros and cons of using a hydrogen fuel cell, in terms of sustainability, compared with modern batteries?

2.3
Comparing sources of electricity

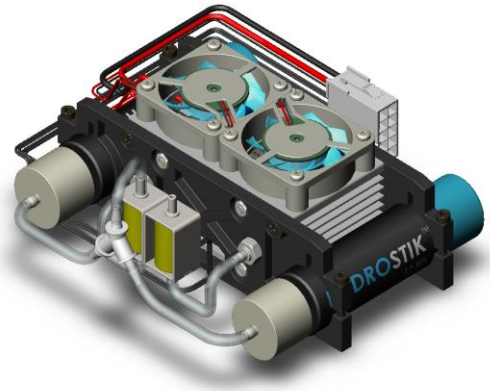
Study direction

Time required: 1h

Necessary equipment and resources:

Horizon Equipment:

- **Fuel cell**
- **Battery**



Objectives:

During this activity we will compare these two power storage technologies, considering their environmental impact.

Electrochemical batteries...
As opposed to a hydrogen fuel cell?

Making batteries obsolete... or working with them?

Will it one day be possible to do without batteries in our cars?

Why would we want to make fuel cells and electrochemical batteries work together in the same car?

What are the pros and cons of each of these devices that store energy and release it in the form of electric power?

How can we get these two concepts to work together, to eventually combine them in a single device?

For the moment, many questions remain unanswered, and many future innovations are still needed before we can come up with an ideal product.

An intermediary solution... until we find a better one

Of course, this is probably not THE ideal solution, as with many other technical and natural phenomena... let's just say that it is currently one of the most reasonable solutions, considering our expectations in terms of sustainable development: a "hybrid" power supply with a hydrogen fuel cell and electrochemical battery (lithium-ion for example).

In this section we will look at the various pros and cons of this solution, in the case of the H-Cell.

Time required: 15 min

2.3.1

0: 00

Question:

Based on the results of studies 2.1 and 2.2, compare, in terms of environmental impact, the choice of materials required for the internal structure of the components.

Comparative study "1" "internal structure materials"	
Electrochemical battery	**Fuel cell and Hydrostik cartridges**
Advantages:	**Advantages:**
Disadvantages:	**Disadvantages:**
Solution that has the most advantages: (check the box that best reflects your opinion)	

Time required: 15 min

2.3.2

0:15

Question:

Based on the results of studies 2.1 and 2.2, compare, in terms of environmental impact, the energy consumption and pollution associated with battery or Hydrostik cartridges.

Comparative study "2" "consumption and emissions for charges"	
Electrochemical battery	**"Hydrostik" cartridges**
Advantages:	**Advantages:**
Disadvantages:	**Disadvantages:**
Solution that has the most advantages: (check the box that best reflects your opinion)	

Time required: 15 min

2.3.3

0:30

Question:

Based on the results of studies 2.1 and 2.2, compare, in terms of environmental impact, the energy consumption and pollution associated with batteries or fuel cells.

Comparative study "3" "operating consumption and emissions"	
Electrochemical battery	**Fuel cell**
Advantages:	**Advantages:**
Disadvantages:	**Disadvantages:**
Solution that has the most advantages: (check the box that best reflects your opinion)	

Time required: 15 min

2.3.3

0:45

Questions:

A - Finally, what are the main assets of the "fuel cell + Hydrostik cartridges" system in terms of sustainable development?

B - If we were to imagine, for energy purposes (vehicle range, power required for propulsion, etc.), to combine under a hybrid power supply the two technologies of the hydrogen fuel cell and electrochemical battery, what do you think would be the pros and cons of that choice, compared with an electric vehicle powered only by a single battery?

A :
B :

Translation in a foreign language (additional study):

Give a verbal summary of the document, partially or in full, in order to propose a translation of the document in a foreign language. You can share the workload among the members of the work group.